# BLOB PARAMETERS OF ACCRETION STREAMS IN MAGNETIC CATACLYSMIC VARIABLES

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ABSTRACT. Results of investigations of the autocorrelation functions for two magnetic cataclysmic variables BY Cam and QQ Vul are presented. Significant variations of this characteristic are detected. They are interpreted as caused by variations of the blob length or by changes of the accretion column height. For the first time, the dependence "shot noise decay time - circular polarization" was discovered.

**Key words:** stars: close binaries: magnetic field; accretion: accretion discs; stars: cataclysmic, X-ray sources; individual: BY Cam, QQ Vul.

Here we describe some results of study of the fast optical and polarization variability of the magnetic cataclysmic variables with a synchronizing (BY Cam) and synchronous (QQ Vul) magnetic white dwarf.

Except quasi-periodic oscillations at a time scale of seconds (Langer, Chanmugam & Shaviv, 1982), the fast variability up to minutes is often described by a shot noise characterized by an exponential decay of the autocorrelation function (Andronov, 1998). This shot noise is interpreted as the product of inhomogeneous blob accretion (Aslanov, Kornilov & Cherepashchuk, 1978; Panek, 1980; Kuijpers & Pringle 1982; Beardmore & Osborne 1997). Asymmetry of the nonstationary 3-D accretion column may produce few types of the structure variations (Andronov, 1987).

In order to investigate these effects, the orbital and other hour-scale variability was removed from the light curve (Fig. 1a) by using a 3-rd order polynomial fit. The parameters which describe the emission, are the shot rate and the shot decay time $\tau$. It can be determined from the $1/e$ time-scale of the autocorrelation function (ACF) of the detrended data.

At the Fig. 1a, one can see the light curve of BY Cam, obtained at 2.6m Shain telescope by N.M.Shakhovskoy and S.V.Kolesnikov with a time resolution $\delta = 4.12$ sec. The solid line represents a 3-rd order polynomial fit. The detrended light curve (Fig. 1b) was subdivided into sections of uninterrupted sequences of data, which were used for calculation of autocorrelation functions. In the Fig. 2, the mean ACF from individual runs of length $n = 256$ is shown. The thick line is the AR2 model fit obtained taking into account the finite length of data run $n$ and trend removal according to Andronov (1994). The ratio "signal/(signal+noise)" is $r_0$=0.888. Corresponding root mean squared deviation of the observed ACF from the theoretical expectation is 0.055.

Such investigations were applied to BY Cam and QQ Vul, which were observed at 1.25m telescope AZT-11 (UBVRI and circular polarization) and at the 2.6m Shain telescope (WR - 0.5-0.75 micron filter + circular polarization). These observations cover a wide energy range and allow to investigate different sources and mechanisms of variability caused by accretion in magnetic cataclysmic variables.

If the shot time-scale $\tau$ represents the characteristic emitting time of a blob of length $L$, then $\tau$ is just the fall time needed for blob to pass through the emitting region. Thus one can estimate $L$ from

$$L \sim v_{\rm ff}\tau/4 \qquad (1)$$

where $v_{\rm ff}$ is the free-fall velocity at the shock front, and the factor of 1/4 arises from the strong shock conditions.

The shot decay time covers a wide range from 20 to 120 seconds. There are hour-to-hour variations which are observed at some nights of observations of BY Cam. However, in different colors, the differences of the shot decay times are not significant. Most interesting results were obtained from the investigations of the "polarization - shot noise decay time" dependencies. In the Fig. 3,4, the graphs for 2.6m Shain telescope observations

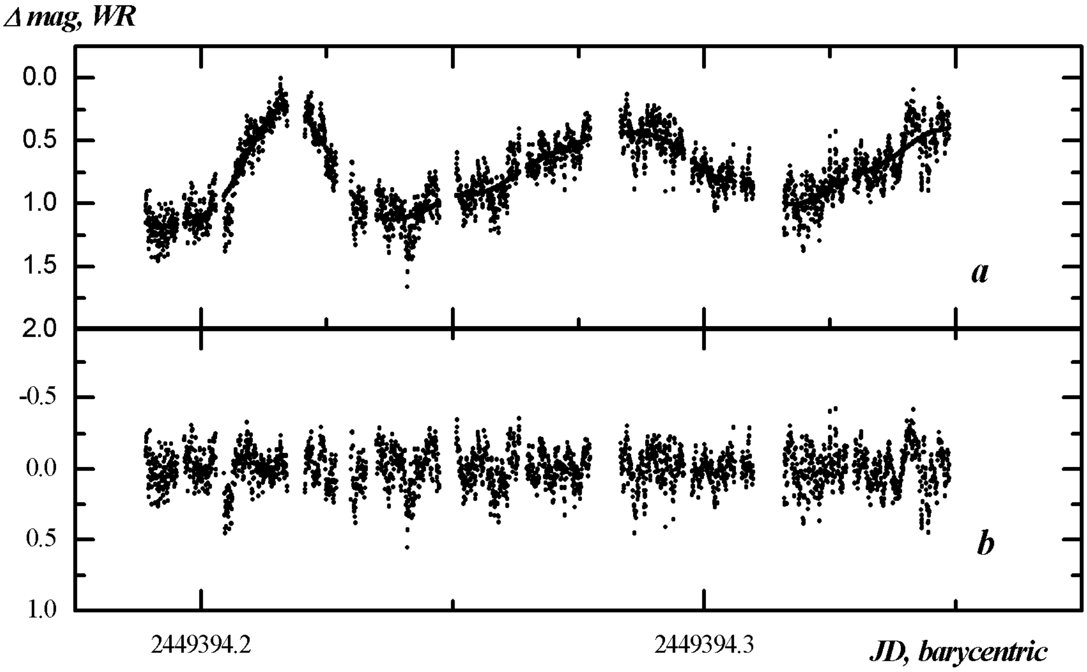


Figure 1: Original *(1a)* and detrended *(1b)* photometric data for BY Cam, obtained at the 2.6-meter Shain telescope.

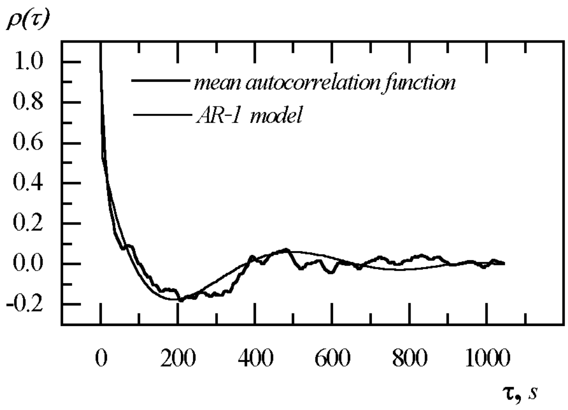


Figure 2: Mean autocorrelation function for current (fig 1b) run and its AR-1 model (Andronov, 1994).

of BY Cam and QQ Vul are shown.

It seems that in BY Cam (Fig. 3a) one may suggest two superimposed dependencies - the first is more smoothly decreasing from 60 to 10 seconds with an increase from negative to positive values of the polarization curve, and the second one is a sharp increase from 20 to 80 seconds with increasing positive polarization.

Similar properties were pointed out by Shakhovskoy, Andronov and Kolesnikov (1992) in a case of AM Her.

We associate two dependencies with two switching poles in this asynchronously rotating magnetic cataclysmic variable (Mason et al., 1998). To explain this phenomenon, we supposed next qualitative model for BY Cam. Two switching poles are not diametrically opposite, they have unequal magnetic field strength (Silber et al., 1992; Piirola et al., 1994), and, therefore, different character of accretion matter motion.

Above the more strong magnetic pole, the plasma freezes earlier to magnetic field. Dense blobs thread into magnetic field lines before the gas accelerates and the stream is shattered into small fragments. For a weak pole, on another hand, the gas arriving at $r_\mu$ is therefore suggested to consist predominantly of a spray of small blobs (typically with radii $< 10^8$ cm), with a small probability of some threaded larger blobs that survived intact.

In another figure (Fig. 3b) for QQ Vul, there is no any "decay time - polarization" dependence. This effect can be explained by a presence of weak magnetic pole with a higher Rayleigh-Taylor instability rate of stream, then for BY Cam.

In QQ Vul one may suggest only decade-scale variations of the orientation of the white dwarf in respect to the secondary filling its Roche lobe (Andronov and Fuhrmann, 1987), whereas in BY Cam the stream periodically switches from one pole to another (Mason et al., 1998) causing much larger changes of the structure of the accretion.

The second possibility of the shot decay time variations is the effect of accretion column height changes. When $(r + h)$ increases by 10 times, $v_{ff}$ decreases by about 3.16 times, as a square root of $(r + h)$:

$$v_{ff} = \sqrt{2GM/(r + h)}. \quad (2)$$

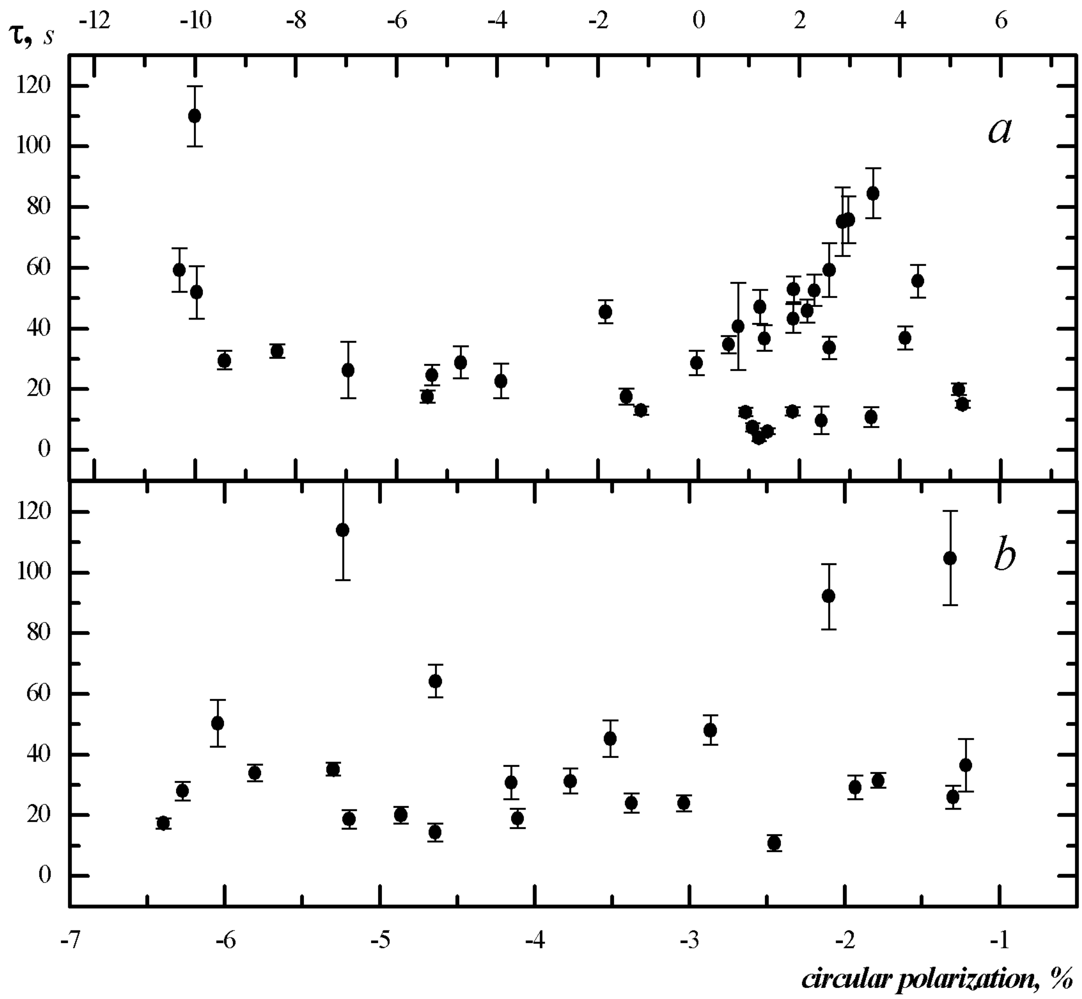


Figure 3: "Polarization - exponential decay time" dependence for BY Cam *(a)* and QQ Vul *(b)*.

Here $r$ is the white dwarf radius and $h$ is the radiative shock height which may be estimated in the case of bremsstrahlung cooling (Yi, 1994) as

$$h \approx (3 \times 10^7 \mathrm{cm}) s_0 m^{23/14} r^{3/2} \mu_{33}^{-4/7} \dot{m}^{-5/7} \qquad (3)$$

In this equation $s_0$ is some effective column area, $m \equiv M_{wd}/M_{\odot}$ - white dwarf mass in solar masses, $\dot{m} = \dot{M}/10^{18}$ g s$^{-1}$ is scaled accretion rate and $\mu_{33} = \mu/10^{33}$ G cm$^3$ is scaled white dwarf magnetic moment.

One more mechanism, which can provide shot decay time variations within one orbital cycle is the changes of orientation of the accretion column (cf. Andronov, 1987). In this case we can see different parts of accretion structure in different orbital phases. It means that different parts of accretion column correspond to different effective blob lengths or shock height.

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