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PHOTOMETRICAL INVESTIGATIONS OF LOW-MASS X-RAY BINARIES WITH HIGH TIME RESOLUTION

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I. Introduction

We were searching for ultrafast optical variability among 11 LMXBs (Low-Mass X-ray Binaries) — X0422+32, A0620-00, X1728-169, X1813-14, X1957+11, 2S0921-630, 4U1543-475, 4U1636-536, 4U1559-487, MXB 1735-44, 4U1822-371. Observations have been carried out with the hard- and software photometrical complex MANIA (Multichannel Analysis of Nanosecond Intensity Alterations) on the 6-m telescope of SAO RAS and 2.15-m telescope of CASLEO, Argentina, with $10^{-7}s$ time resolution.

The main goal of MANIA experiment is to study a possible very fast optical variability of astrophysical objects on a time scale from 10^{-7} - $10^{2}s$. The observational data were analyzed by means of special y_2 – – and d_2 – – functions technique (Shvartsman 1977; Plokhotnichenko 1983).

Analysis of the data by these techniques has shown the absence of any brightness variations on the time scale 10^{-7} - $10s$ for all objects with the exception of A0620-00, MXB 1735-44 and GRO J0422+32 (Nova Per 1992).

II. A 0620-00

It is an X-ray nova (Elvis et al. 1975) with the mass of the compact component more than $3M\odot$. The five millisecond flashes were detected (aperture - 4".3, without a filter) at February 13, 1986 (see Fig. 1). The first two had durations of 3 and 5 ms and their rising times were 1 - 2 ms. The other three events lasted 0.4 - 0.5 ms and their rising times were about 0.1 ms. Amplitudes of the flares were 40 (limiting intensity) and low limits of brightness temperatures were $5 \cdot 10^9$ K for the first two and $5 \cdot 10^{11}$ K for the other three.

III. MXB 1735-44

It is a burster of type II. Two flares with durations of about 0.25 s were detected during the observation (aperture - 12" with grey filter) on May 9, 1991(see Fig. 2). Front edges of this flares were 110 and 120 ms with the amplitudes 32 and 17, steep part of front edges was about 60 ms. The brightness temperatures for front edges were $7.5 \cdot 10^7$ K and $3.5 \cdot 10^7$ K and for steep part of front edges they were $2 \cdot 10^8$ K. In order to study a fine structure of these events the detailed light curve, $I(t)$, was analyzed by the "splash method" (Beskin et al. 1994). This method showed the both flares have a

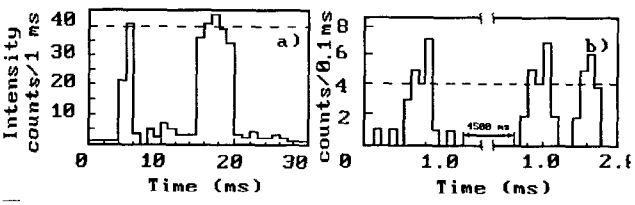

Fig. 1.— The ultrashort flares of A0620-00 on February 13, 1986, aperture - 4".3, seeing - 1".5, without a filter (– – – level of maximal intensity corresponding to the limiting transfer rate into the computer PDP-11).

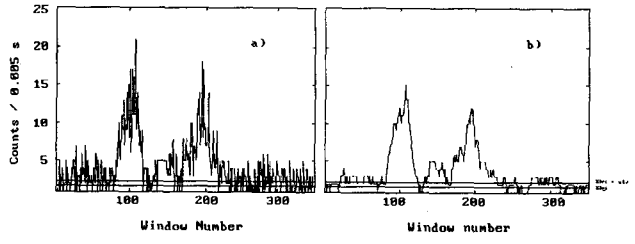

Fig. 2.— The light curves of two flares of MXB1735-44.

fine structure on time scales of 5 – 10ms (see Fig. 2a). The low limits of the brightness temperatures of the fine structure were $2 \cdot 10^{10}$ K.

IV. GRO J0422+32

It is an X-ray Nova discovered in 1992 (Pasiesas & Briggs, 1992). The object showed a strong variability in its high state ($V < 15^m.5$) near X-ray and Opt. maxima. Stochastic variability was detected on times from 10^{-3} s to 10^2 s in U,B,V,R bands. An example of a short flare with a rise time of 4 ms is shown in Fig. 3. Power spectrum of the variations is close to flat one. Brightness temperatures of shortest flashes exceed 10^8 K for distance to the object more than 2 kpc. These results indicate a fragmental structure of gas accreting onto compact object and nonthermal origin of some flashes at least near nova maximum.

For all the detected events the low limits of the brightness temperatures were estimated by the formula:

$$T_b = 10^8 \rho_m t^{-2} f^{-2} D^2, \qquad (1)$$

where t – rising time in ms, f – the average frequency

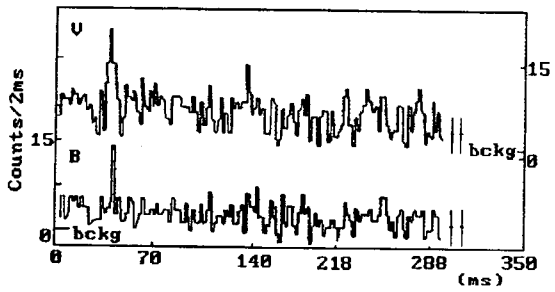

Fig. 3.— Flash of Nova Per with a rise time of 4 ms in V(top) and B(bottom) bands (Jan.18, 1993)

of observation (10^{15} Hz is assumed as unity),ρ_m – the flux in mJy and D – the distance in kpc (Shvartsman et al. 1989, Beskin et al. 1994, Bartolini et al. 1994).

It seems very possible that the shortest detected events have nonthermal origin since for the brightness temperatures in optical range exceeding 10^8 – 10^{10} K it is very difficult to propose a thermal machanism for the generation of the photons. If we use a thermal mechanism to explain these events then X–ray luminosities would be very high ($> 10^{39}$ – 10^{40} erg) which contradict the X–ray data being obtained almost simultaneously with the optical observations. It can be an evidence that there should exist some departures from the standard model of hydrodynamical accretion onto compact objects.

It is important to mention that for A0620-00 and MXB 1735-44 such events are very rare while for Nova Per they are quite frequently.

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