Monitoring and modeling radio flares from microquasars

Sergei Trushkin, Elena Majorova and Nikolai Bursov

*Special Astrophysical Observatory of Russian AS*

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**Abstract.** We present results of long-term daily monitoring of a sample of Galactic radio-emitting X-ray binaries showing relativistic jets (RJXRBB): SS433, Cyg X-3, and GRS 1915+105, with the RATAN-600 radio telescope in the 0.6–22 GHz range.

We carried out the modeling calculations to understand the temporal (1–100 days) and spectral (1–22 GHz) dependence. We tested the finite jet segment models and we found that the geometry of the conical hollow jets is responsible for either a power law or an exponential decay of the flares.

SS433 was monitored for 100 days in 1997 and 120 days in 1999. From the quiescent radio light curves, we obtained clear evidence of a 6.04-day 10-15% modulation.

Three powerful flares (up to 13 Jy) from Cyg X-3 were detected in April 2000.

**Keywords:** microquasars, radio emission, synchrotron radiation

**Results of the multi-frequency daily monitoring**

Many (or all!) of the radio sources related with X-ray binaries have been resolved into relativistic jets, often with detectable proper motion of the radio-emitting blobs. We present results of long-term daily monitoring of a sample of these RJXRBs with the RATAN-600 radio telescope at 0.96, 2.3, 3.9, 7.7, 11.2 and 21.7 GHz. Many strong optically thin and thick flares were detected during the monitoring period (see Bursov and Trushkin, 1996; Trushkin, 1998). The basic model of the flares is the synchrotron emission evolution of two relativistic jets with conical geometry and an adiabatic expansion of the blobs, which are composed of relativistic electrons embedded in magnetic fields, moving away from the central source (Shklovskii, 1960; van der Laan, 1966; Hjellming and Johnston, 1988; Marti et al., 1992). The flare decay law is determined by the geometry of the conical hollow jets. The jet velocity, thermal and relativistic electron densities, and magnetic field intensity within the blobs can be derived from the fits.

Our monitoring of radio variability of RJXRB shows that the decay of a flare follows a power law, \( S_\nu = S_0 \nu^{-2p} \), as predicted by the Shklovskii and van der Laan models, or an exponential law \( S_\nu = S_0 e^{-\nu/\tau} \) (Fig.1), which is due to the initial exponential increase of the jet cone radius. Often \( \tau \sim \nu^{\beta} \), where \( \beta \) ranged from \(-0.8\) to \(-0.4\); these flares decay faster at higher frequencies (see current light curves and the spectra animation at http://cats.sao.ru/~satr/XB/).

We computed the power spectra of the daily light curves of SS433 in the 2.3–22 GHz range during the long quiescent periods May–July 1997 and May–August 1999. Both spectra show a mean harmonic at 0.165 ± 0.02 day$^{-1}$, which corresponds to a period of 6.04 ± 0.06 days.

We propose that Doppler boosting of the jet radiation could explain such modulation. The 5-elements kinematical model of the jets and ephemerides proposed by Vermeulen (1989) for the nodding motion of the jets and common formulas for boosting produce a modulation similar to the observed one. Thus we detect a 6-day modulation at the 10–15% level in the quiescent flux density, which is $S_0\text{[Jy]} = 1.2 \nu^0.6_{\text{GHz}}$.

Three powerful flaring events (up to 13 Jy) from Cyg X-3 were detected in April 2000. The daily spectra clearly show two components: i) a quasi-stable steep spectrum and ii) a very unstable flat spectrum.

In the wide range 0.6–22 GHz the optically thin spectrum of the detected strong flare of GRS 1915+10 (5 August, MJD 51751.85) is well fitted by the power law: $S_0\text{[Jy]} = 0.690 \nu^{-0.43}_{\text{GHz}}$.

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References