Monitoring of Microquasars with RATAN-600

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Abstract. The results of monitoring of some bright microquasars during the international program of studies of bright X-ray binary stars in different ranges of the electromagnetic spectrum are presented. Search and studies of correlations between variable X-ray, radio and gamma radiation is a key to understanding the formation of jet emission from accreting matter to a black hole (or neutron star). The results of daily multifrequency measurements on the RATAN-600 radio telescope during some periods of the flare activity in 2020 are discussed.

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1 Multi-Wavelength Observations of Microquasars

Researches of variable radio emission from X-ray binaries with relativistic jets provide a unique opportunity to find the relationship between the processes of accretion of matter onto a relativistic component (black hole or neutron star) flowing from a normal star. The processes of formation of jet ejections have not yet been unambiguously determined, although there are several theoretical models applicable to both stellar and extragalactic objects. Radio emission is a good tracer of periodic or sporadic processes of nonstationary accretion in objects of this type. The RATAN-600 radio telescope allows accurate measurements of flux densities in a wide frequency range from 1 to 30 GHz in daily observations of sources brighter than 20 mJy. An important element of modern astronomical researches are cooperative programs in different bands, from radio waves to Gamma-rays. That is why the data for the multi-frequency flux density, which we receive in the course of research with the RATAN-600 radio telescope, are so demanded by the world astronomical community.

1.1 SS433 in 2000

In 2020 the microquasar SS433 was investigated at several frequencies. In general, these data are a continuation of the long-term almost daily monitoring of the microquasar since 2011 at the RATAN-600 (Rushton et al. 2008). The light curves of the microquasar were measured for more than 2500 days, and the spectral indices (SpI) of synchrotron radiation in the range from 1 to 22 GHz were determined every day. As shown in joint (optics, X-ray, VLBI) programs, all the flare peaks in the light curves find their explanation in the nonstationary process of ejection of relativistic jet ejections of matter from the inner regions of the accretion disk around the black hole, which is probably compact object in the binary. In the recent multi-frequency monitoring of the Galactic microquasars with the RATAN-600 radio telescope we have detected some bright flares at 2.25-22.3 GHz. During the active period, the flux of flares increased by 2-3 times, while in a quiet state, the source flux variations did not exceeded 10 percent. These flares were characterized by an optically thin synchrotron power-law spectrum with change of the SpI from -0.2 to -0.7. Each outburst in SS433 is well described by a single short-term ($\sim$ a day) generation of relativistic electrons in a blobs of matter moving outward (0.26c) from the object, followed by the decline of radio emission due to the adiabatic expansion during 10-15 days.

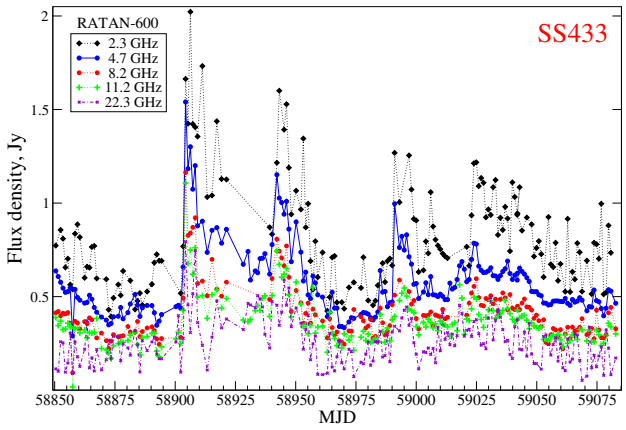

Fig. 1. The multi-frequency light curves of SS433 from January to September 2020, during the active period of the optically thin radio emission.

1.2 Flares of Cygnus X-3 during 2020

Multi-frequency daily observations of the Cygnus X-3 are continue with RATAN-600 during more than 10 years (Trushkin et al. 2017). In 2000 we have measured light curves of their radio emission at 2-30 GHz and we have detected a giant flare in February just before so-called 'hyper-soft' X-ray state. The flux density at 4.7 GHz increased to 10 Jy on MJD 58887.35 with the optically thin spectrum at frequencies higher 4.7 GHz, having the spectral index −0.28. Before on MJD 58885.5 hard X-ray flux (Swift/BAT) increased. That means that the binary entered in a soft state and later in a hard state. The flaring radio activity of Cygnus X-3 went on, probably it is related with the gamma-ray flaring activity from Cygnus X-3. In the peak, the flux density were grow up to 19.1 Jy at 4.7 GHz (MJD 58990.4). Cygnus X-3 was in the beginning of jets ejection that is usually characterized by two regimes: an optically thick one at frequencies lower 4.7 GHz and by an optically thin one at frequencies higher 8.2 GHz. The Swift/BAT data and the Fermi gamma-ray data well associated with two last radio flares detected with RATAN-600.

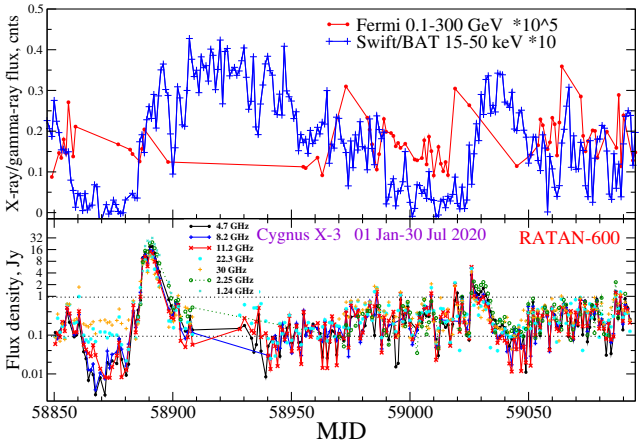

Fig. 2. This light curves during from January to September 2020 from Cygnus X-3. There were two bright flares, and first one was a typical giant optically thin flare.

1.3 Bright Flares from GRS1915+105

GRS1915+105 is the proto-type of the microqasars with very short-term variability in X-rays and at radio waves and clear periods of flaring activity (Rushton et al. 2008). From January to May of 2020 year we have detected four very bright optically thick flares with maxima at 11.2 GHz. The flux densities in maxima were 625 mJy (MJD 58881.3), 635 mJy (MJD 58944.8), 645 mJy (MJD 58950.8) and 620 mJy (MJD 58965.8) at 11.2 GHz. From Jule to August we have detected two optically thin flares with fluxes: 535 mJy (MJD 59046.9) and 640 mJy (MJD 59068.9) at 4.7 GHz. These flares can be associated with noticeable changes in the soft X-ray flux (MAXI 2-20 keV). On the other hand, there is no an apparent correlation with the hard X-ray flux (Swift/BAT 15-50 keV).

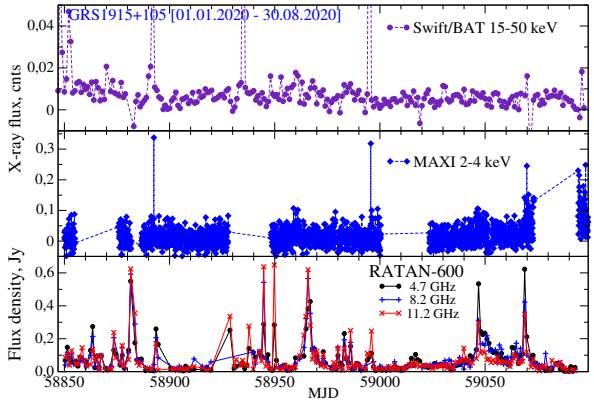

Fig. 3. The light curves of GRS1915+105 in the soft and hard X-rays (MAXI 2-4 keV and Swift/BAT 15-50keV) and at three frequencies (RATAN) in 2020.

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