RADIO EMISSIONS OF THE SUN–LIKE STARS

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The results of flare star observations at UTR-2 are presented. The brightness temperatures of radio bursts observed are found and their possible radiation mechanisms are discussed.

For the first time, the decameter radio emission from a flare of red dwarf star V371 Orion has been detected at 19.7 MHz by Slee *et al.* [1]. It was observed at the beginning of the flare and had flux 23000 Jy that corresponded to the very high brightness temperature $10^{20}\,K$ (for comparison, the Sun maximum brightness temperatures of sporadic radio emissions are $T_b < 10^{16}\,K$). This fact gave rise to doubts.

In this paper we present the results of the observations and their analysis of dMe flare stars at 20 and 25 MHz frequencies. The observations were carried out episodically from 1986 to 1998 with UTR-2 radiotelescope [2, 3]. They were accompanied by photometric patrol in U–band at AZT-11 telescope of the Crimean Astrophysical Observatory. The photometric data of the other observatories were used in same cases as well. Durations of observations for each star were in the range from 4 to 6 successive hours and were a little larger than the rotational period of a star. To discriminate against terrestrial interferences the DKM radio observations were carried out simultaneously by two separate beams at two different frequencies in ON/OFF regime. Besides, spectral and temporal features of signals, polarity of radiotelescope response and correlation DKM radio bursts with optical flares were taken into account.

In 1986–1989 the efforts to detect sporadic DKM bursts from the flare star EV Lac were made by means of radiometers with temporal resolution of ≈ 5 s. From time to time single short bursts and groups of such bursts were observed. On September 12, 1986 and September 13, 1986 the rate of appearance of the bursts was about twice or three times higher than that for free optical flare intervals. It is significant that there were three flares with apparent U–magnitude 0.5–0.75 mag on September 12, 1986 and one powerful flare with 2.8 mag on September 13, 1986. Later the two two-channel radiometers with the temporal resolution of 0.2 s were used for observations of short bursts at 20 MHz and 25 MHz. On September 1–2, 1992 the four groups of short bursts from EV Lac star were observed [3]. Durations of the bursts were < 1 s and their flux densities were in the range $250 - 900$ Jy. All these events were accompanied by optical flares and observed on the decay phase of the flare.

As to other six stars only one burst from YZ CMi was detected for 210 hours of observations. The burst was observed 2.5 minutes before optical flare in the B–band detected at the Stephanio Observatory (Greece). Observations were conducted during 2 hours and 44 minutes simultaneously in the optical and radio bands and these events were the only ones detected. The probability of accidental coincidence of radio burst and optical flare is very low. So, we conclude that the burst had a stellar origin. It should be noted that although optical stellar flares usually precede radio bursts by some minutes opposite situations they have been detected as well.

The very high brightness temperatures of the stellar bursts found at DKM range, $T_b = (1-6)\times 10^{18}\,K$, need coherent mechanism of radiation, plasma or electron cyclotron maser emissions [4].

Electron cyclotron maser emission can be observed on the condition that the optical depth of the region with negative absorption is $\tau > 1$ and high gyroresonance layers are transparent. Assuming the electron density $n_e = 10^{12}$ cm^{-3}, the magnetic field in the footpoints of a magnetic loop where radio emission coming from is equal to 4 G and the radiation occurs at the third harmonic of Larmor frequency with the brightness temperature $10^{19}\,K$. The estimations show that absorption in the fourth gyroresonance layer is very strong (the optical depth is $\tau = 30$). Thus, the brightness temperature of leaving emission will be much lower than that observed.

For plasma mechanism of radio emission the high brightness temperature can be explained under condition that the efficiency of the conversion of the plasma waves into electromagnetic waves is maximum, the velocity of the electron beam equals to 10^{10} cm/s and electron beam density is $n_b/n = 10^{-4}$.

So, we conclude that the most probable mechanism of radio emission for bursts from flare stars at decameter wavelengths is the plasma one.

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