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SPECIAL FIELDS OF THE GALAXY RADIO EMISSION

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ABSTRACT. The brightness temperatures of radio emission were measured with the UTR-2 low-frequency radio telescope at frequencies 12.6, 14.7, 16.7, 20 and 25 MHz for the following Galaxy regions: the North Pole, the area of minimum radio brightness and the anticenter region. The brightness temperature spectrums of the galactic background radiation were constructed for the selected areas using the data at other different wavelengths. The brightness temperature spectral indices were determined for these areas at wavelengths ranging from meter to decameter.

Keywords: Galaxy: structure – radio continuum – spectral index: ISM – radiation mechanisms: non-thermal

1. Introduction

Large amount of sky surveys in a wide radio frequency range (see for example, Haslam et al., 1981; Roger et al., 1999; Wielebinski, 2004) showed that the radio emission is concentrated in the galactic plane with a maximum near the Galactic center and is extended up to high galactic latitudes, where demonstrates a sufficiently high intensity, especially at low frequencies. If not taking into account the 'spurs' and loops , the radio emission of the Galaxy can be divided into two components - the disk and the halo ones, symmetric with respect to the galactic plane. One can distinguish several specific areas of the galactic radio emission: the anticenter region, which characterizes the radiation of the Galaxy disk component, the areas of the minimum radiation and the Galactic poles, where the radio emission is mainly due to the Galaxy spherical halo. The knowledge of the radio emission spectral characteristics in these areas is extremely important for understanding the distribution and propagation of relativistic electrons and magnetic fields in the Galaxy.

As known, the brightness temperature (T) frequency (ν) dependency is $T(\nu) \sim \nu^{-\beta}$: where β is the spectral index. The spectra were constructed by Bridle (1967), Cane (1979), Guzman et al. (2011) in these areas at different frequencies bands. Bridle (1967) has obtained the total background radiation spectral index β = 2.55 ± 0.04 between 13.15 and 404 MHz for the Galaxy North Pole. The same value of the total background average spectral index (β = 2.55 ± 0.03) was obtained by Cane (1979) for the Galaxy poles at frequency range from 6 to 100 MHz. Based on these results Cane (1979) has constructed the radio sky model consisting only of two components, one of which is the disc of the uniform emission and absorption and another is the extragalactic background. Guzmán et al. (2011) determined the following spectral indices of the galactic radio emission brightness temperature: in the anticenter region $\beta \approx 2.48$ between 10 and 1420 MHz; in the Northern sky minimum radio emission region $\beta \approx 2.41$ at the same frequencies and for the Galaxy North Pole $\beta \approx 2.53$ for frequencies between 2.3 and 1420 MHz. Guzmán et al. (2011) then used these results to evaluate and correct zero level offsets of the 408 MHz Haslam et al. (1981) and their all-sky 45 MHz surveys.

Here we present the constructed brightness temperature spectrum of the galactic radio emission at frequencies below 408MHz in the highlighted Galaxy regions, namely the anticenter region, the North Pole, and the Northern sky minimum radio brightness area. We used our Northern sky observational results at frequencies 12.6, 14.7, 16.7, 20 and 25 MHz (Vasilenko et al., 2006) and from the literature for the spectral studies.

2. The background spectrum of the Galaxy specific fields.

The brightness temperature of the sky in studied areas was obtained at decameter wavelengths using the UTR-2 radio telescope (Vasilenko et al., 2006). The angular resolution at frequencies 12.6, 14.7, 16.7, 20, and 25 MHz in the zenith direction is near 65′ to 28′ respectively. Also we used the brightness temperatures of these regions at frequencies below 408 MHz from the Guzmán's list (2011). We added to analysis the brightness temperatures from Haslam et al. (1981), Roger et al. (1999), Guzmán et al. (2011). The Metagalaxy brightness temperature $T_M(\nu)$ was excluded from the sky total temperature using the expression (see Guzmán et al. (2011), Appendix A):

$$\log T_M(\nu) = 7.66 - 2.79 \log\left(\nu/_{MHz}\right).$$

To study the spectral properties of the nonthermal radio emission at low frequencies we have limited to the frequency range from 9 to 408 MHz. At frequencies below 9 MHz the observations were made with very low resolution and there is more pronounced absorption effect. We have analyzed the spectra at the following frequency bands: 9÷408 MHz, 9÷100 MHz and 9÷45 MHz to search for changes in the spectral index with a decreasing frequency. Brightness temperature spectra for each selected field were constructed at the above frequency bands at two stages: a) first, excluding brightness temperatures at decameter waves, which were defined by us and b) then with these brightness temperatures taken into account. The spectra were fitted with the least squares method. Figures 1a), b), c) show the spectrum in the log-log scale and fitted line for the three selected Galaxy regions in the frequency range 9÷100 MHz. As can be seen in this figures the brightness temperatures obtained by us and Roger, R. S. et al.(1999) are somewhat lower than the observed at similar frequencies, we assume that this is due to the telescopes low-resolution on which observations are made. The spectral indices of the galactic radio emission in the 9÷408 MHz range are greater than in the 9÷100 MHz range for all selected regions. The spectral indices taking into account our data, are less than without them in all these areas. The difference between spectral indices is greater for high-latitude regions - the North Pole and the minimum radiation area. The changes in the spectral index with a decreasing frequency may be due to changes of the spectrum of the extragalactic background with frequency. We show a significantly different Metagalaxy radiation spectrum with $\beta_M \approx 2.41$ (Vasilenko et al., 2015) compared with $\beta_M \approx 2.79$ Guzmán et al. (2011). The spectral indexes at frequencies between 9 and 45 have large errors than in other ranges. Spectral indices are shown in Table 1.

Table 1. The spectral indexes of the galactic brightness temperature.

Frequency band (MHz)	9÷408	9÷100	9÷45
Anticenter	2,48±0,04	2,44±0,03	2,35±0,14
North Pole	2,56±0,03	2,45±0,06	2,68±0,10
Min. North	2,51±0,09	2,37±0,09	2,4±0,15

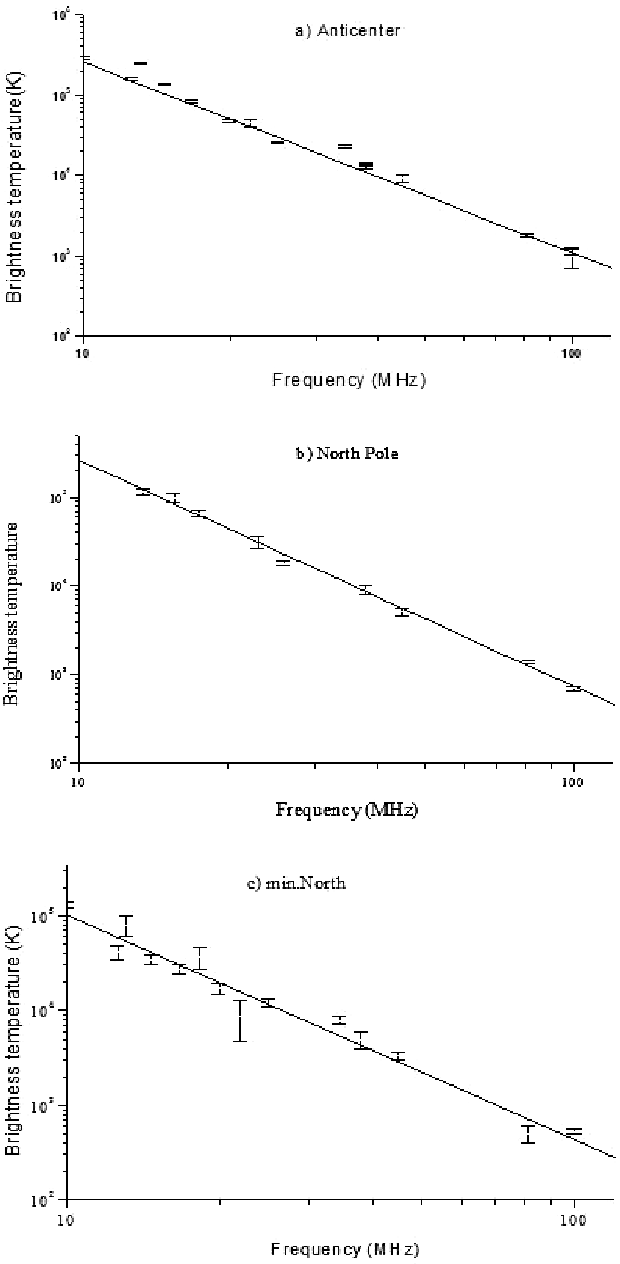

Figure 1: Brightness temperature spectra of the galactic radio emission and fitting of the line for three selected fields at frequency range 9÷100 MHz.

3. Conclusions

Our spectral studies allow us to speak about existence of significant tendencies of change of the galactic radio emission spectral index with decreasing frequency. We assume that this may be due to changes in the spectrum of the extragalactic background. This work reveals the lack of ground-based high-resolution observations at low frequencies which does not allow identifying a possible break in the spectrum of the radio emission of the Galaxy in this frequency range.

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