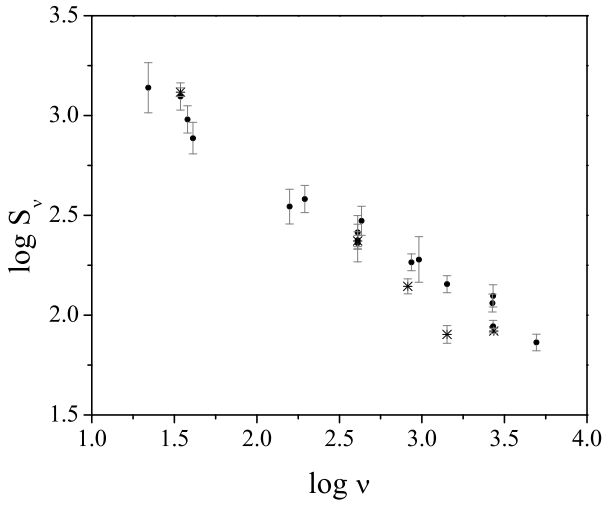

Fig. 11. Spectrum of Cygnus Loop: flux versus frequency for additional different frequencies, obtained from all available flux density values (values are given in Table 3 in Uyaniker et al. 2004) and from values calculated in this paper. We identify our values by asterisks.

5. CONCLUSIONS

The main result is to use a method for determining the brightness temperature given in Borka (2007) which is developed for large radio loops, and to show here that this method is applicable for much smaller loops, e.g., the Cygnus loop. We check the method by applying it to the Cygnus radio loop over a wide range of frequencies. It is in good agreement with the method of $T-T$ graphs and with results obtained with other methods. This method is quite simple because we use a brightness temperature isoline to define the border of the Cygnus loop. Other authors are using different square or rectangular areas to determine the area of the loop and to calculate spectral indices, brightness temperatures and the flux density of the loop (Uyaniker et al. 2004, page 917, and Leahy & Roger 1998, page 786). Also, we calculate the flux for the Cygnus loop and compare our results with those of other authors in different ranges of frequencies. We show that our results are in good agrement with other work.

We estimate the temperatures and brightness of the Cygnus loop SNR on the basis of observations of the continuum radio emission at the frequencies: 2720, 1420, 820, 408 and 34.5 MHz (this paper and Borka Jovanović & Urošević (2009a). The sensitivity of the brightness temperatures are: 5 mK for 2720 MHz, 50 mK for 1420 MHz, 0.2 K for 820 MHz, 1.0 K for 408 MHz and about 700 K $T_{\rm b}$ for 34.5 MHz. At a frequency of 2720 MHz the measurements are the most precise (they have the smallest relative errors) so positions of the brightness temperature contours of the loop are the most realistic for this frequency.

The borders between the five frequencies are somewhat different for this SNR, probably due to small, random and systematic errors in the calibrated data. Also, we suppose that there are uncertainties of about $(2 \times \Delta T)$ 10 mK for 2720 MHz, 100 mK for 1420 MHz, 0.4 K for 820 MHz, 2.0 K for 408 MHz and about 1400 K $T_{\rm b}$ for 34.5 MHz, in the border due to measurement errors, and there is a tiny difference in the absorption of radio emission in the interstellar medium at different wavelengths (Pacholczyk 1970).

We determine the average brightness temperature for the Cygnus radio loop region, after subtraction of a background level. Our values (when all reduced to 1000 MHz for comparison) are in good agreement with the earlier results. We present the radio continuum spectrum of the Cygnus loop using average brightness temperatures at five different frequencies. As can be seen from Figures 7 and 8, the linear fit provides a reliable spectral index. We present the $T-T$ plots which also enable the calculation of spectral index.

Also, from our results it can be concluded that the Cygnus loop evolves in a low density environment and that the initial energy of SN explosion was relatively low. This can be read off after superposing the position of this loop onto a theoretical $\Sigma-D$ diagram from Berezhko & Völk (2004), which was derived from non-linear kinetic theory of diffuse shock acceleration mechanism.

We show that our method for defining a loop border and for determining the values of temperature and brightness, which was developeded for main Galactic loops I-VI, could be applicable to all SNRs.

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