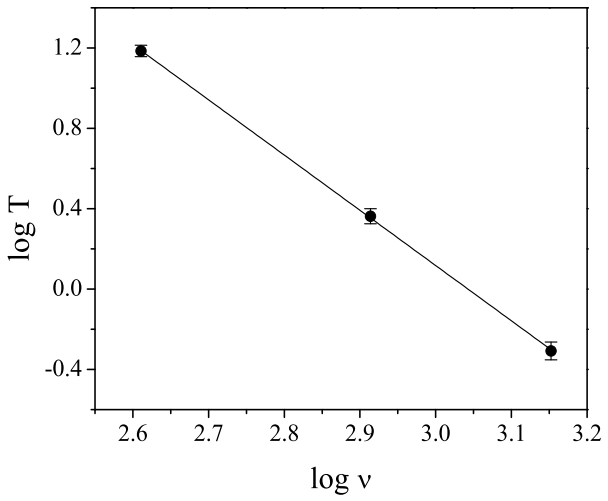

Fig. 7. Cygnus loop spectrum: temperature versus frequency, for three measurements (at 408, 820 and 1420 MHz).

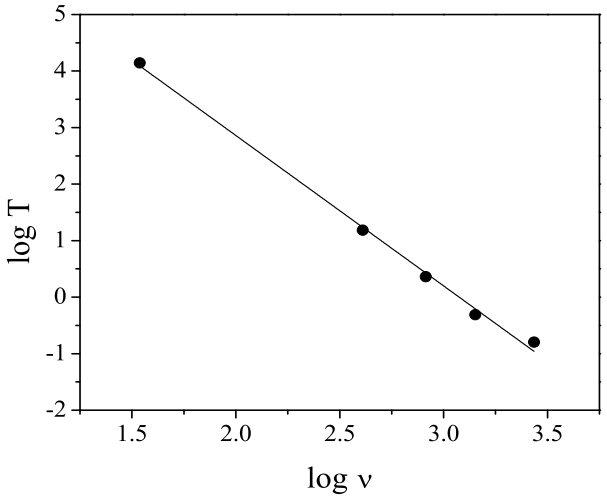

Fig. 8. Cygnus loop spectrum: temperature versus frequency, for five measurements (at 34.5, 408, 820, 1420 and 2720 MHz).

3.1. *Spectrum*

The spectrum was generated using mean temperatures at five different frequencies. The best-fit straight line spectrum enables the calculation of the spectral index as the negative value of the line's direction coefficient. In Figure 7 we show the spectrum for the three middle frequencies: 1420, 820 and 408 MHz because they are very well fitted with a straight line (see Figure 7). Frequencies 2720 and 34.5 MHz, lie on the very high and very low ends of the spectrum, as presented in Figure 8. If for the calculation of the spectral index we take only three frequencies 1420, 820 and 408 MHz, the result would be $\beta_3 = 2.76 \pm 0.03$. From a linear fit to all five frequencies 2720, 1420, 820, 408 and 34.5 MHz, we obtain $\beta_5 = 2.66 \pm 0.09$. It is a steeper spectral index in comparison to the average value for Galactic SNRs $\beta = 2.5$ (in Green's catalogue (Green 2009) the adopted value for the spectral index is not given because of its variability). The Cygnus loop is relatively old SNR. The shock wave has to be weak for evolved SNRs. The steeper spectral indices of SNRs should be expected for the smaller shock wave velocities. This is a result obtained from the diffuse particle acceleration theory (Bell 1978a,b). Additionally, the Cygnus loop probably expands in a low density environment. It looks like the large Galactic radio loops – evolved SNRs with steep spectral indices, immersed in a low density environment (see Borka 2007; Borka et al. 2008, and references therein).

The values we obtain, $\beta_3 = 2.76 \pm 0.03$ (from three frequencies), $\beta_5 = 2.66 \pm 0.09$ (from all five frequencies), are greater than 2.2 and confirm the non-thermal origin of the Cygnus loop emission. From Figure 8 it can be noticed that a linear fit is quite satisfactory. The value for the brightness temperature spectral index of the Cygnus loop is rather steep. This is at the high end of the spectral index distribution for SNRs as suggested in Clark & Caswell (1976).

3.2. $T - T$ *plot*

The measured data have different resolutions for different frequencies (see § 2.1), and therefore in order to obtain $T - T$ plots the data were retabulated: the higher resolution maps are convolved to the resolution of the lowest resolution map. In this way, we convolved data at 2720, 1420, 408 and 34.5 MHz to $0^\circ.5 \times 0^\circ.5$ resolution, which is the sampling rate of the 820 MHz survey. These retabulated data are presented in Figure 9 for the following frequencies: 2720 MHz (top left), 1420 MHz (top right), 820 MHz (middle left), 408 MHz (middle right) and 34.5 MHz (bottom). Then, for each frequency pair we used only the common points [with the same (l, b)] which belong to the loop area at both frequencies. In this way, we reduced the loop area to the same area for different frequencies. The obtained $T - T$ plots for five pairs of frequencies enabled the calculation of the spectral indices. We calculated two β values for each of these pairs: between 2720–1420, 2720–820, 2720–408, 2720–34.5, 1420–820, 1420–408, 1420–34.5, 820–408, 820–34.5 and 408–34.5 MHz. They are presented in Table 2.