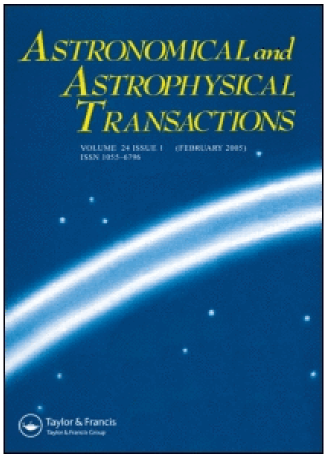

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NON THERMAL RADIO EMISSION OF SUPERNOVAE STROMGREN ZONES AND ACCELERATION OF COSMIC RAYS

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NON THERMAL RADIO EMISSION OF SUPERNOVAE STROMGREN ZONES AND ACCELERATION OF COSMIC RAYS

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It is shown that the minimal value of the synchrotron emission brightness temperature at the frequency 408 MHz in the directions of second type supernovae remnants and pulsars increases sharply in the first thousand years after the supernovae explosions, and then it decreases up to the background value during a time of order of one million years. The cosmic rays acceleration is discussed as a possible reason of such a strong enhancement of the synchrotron emission intensity at the initial stage of supernovae's Stromgren zone evolution.

Keywords: Interstellar medium; Pulsars; Supernovae remnants

It was shown in papers (Pynzar' and Shishov, 2001; 2002) that the young pulsars and the type II supernovae remnants are surrounded by a ionized gas zones with a sizes of order of 50 pc. According to the conclusions of Pynzar', and Shishov, 2001; 2002, the H II zones are the fossil Stromgren zones. It was also shown in the paper (Pynzar' and Shishov, 2002), that the level of turbulent fluctuations $\langle(\Delta\ N_e)^2\rangle$ of electron density in the Stromgren zone is dependent on time after the supernovae explosion. As it was noted in more previous paper (Pynzar', 1991, Shishov *et al.*, 1995), the value of radio waves scattering angle Θ_0 in the interstellar plasma is correlated in the Galaxy plane with the value of brightness temperature T_B at 408 MHz. Similar correlation was found between the emission measure EM and T_B (Shishov *et al.*, 1995). For this reason one should expect the enhanced non thermal radiation from supernovae Stromgren zones.

The brightness temperature T_B of radiation at the frequency 408 MHz to the pulsar directions was found using the maps of paper (Haslam *et al.*, 1982). The background brightness temperature around the supernovae remnants was also estimated. The total diagram of the dependence of brightness temperature T_B on the age of pulsars or supernovae remnants, t has the same qualitative shape as the similar diagram for the emission measure EM (Pynzar' and Shishov, 2001; 2002), they both reveal the pronounced lower boundary. The data for T_B and for EM near the lower boundaries are related to the same objects. These data for $T_{B,\ \min}$ normalized to $T_0 = 500^\circ$ are presented in Figure 1 by triangles.

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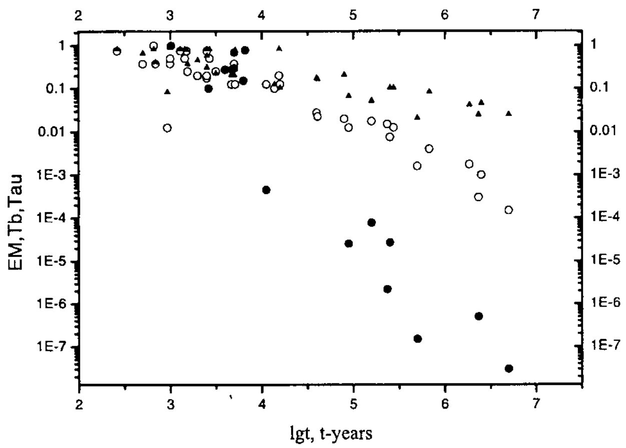

FIGURE 1 The dependence of minimal values of brightness temperature T_B ($f = 408$ MHz), emission measure EM and pulse broadening time $\tau(f = 300$ MHz) in the directions to type II supernovae remnants and pulsars on the age of these objects, t. The normalized values for $T_B/T_0(T = 500^\circ K)$ are shown by triangles, for EM/EM_0 ($EM_0 = 4000\,pc/cm^6$) – by open circles, for $\tau/\tau_0(\tau_0 = 20\,s)$ – by solid circles.

The values of the emission measure EM_{min} normalized to $EM_0 = 4000\,pc/cm^6$ are represented by open circles.

As the emission measure EM, which is proportional to the brightness temperature of the thermal radiation, shows more fast decrease with time than the temperature T_B, we can conclude that T_B is defined by non thermal synchrotron radiation. Solid circles in Figure 1 correspond to the dependence of the pulsars pulse broadening time τ on the pulsar age for the same objects as for data on T_B and EM mentioned above. The parameter τ characterizes the level of turbulent electron density fluctuations in the directions to the pulsars.

The data of show clearly that the Stromgren zone is formed, around II type supernovae during the first thousand years after it's explosion. The sharp increases of the emission measure, the synchrotron radiation intensity and the level of turbulent fluctuations are typical for Stromgren zone at this first stage of evolution. After that, the above parameters approach to the background values for a time of order of one million years.

Below we discuss in more details the cause of the enhancement of synchrotron radiation level after the supernovae explosion. If the energy distribution of relativistic electrons can be represented in power law form with exponent γ, then the brightness temperature of synchrotron radiation at the frequency f is described by the relation

$$T_B \propto \int_0^L dlKH^{(\gamma+1)/2} f^{-(\gamma+3)/2}, \qquad (1)$$

where L is the size of the Stromgren zone (Ginzburg and Syrovatskii, 1964). The power exponent γ for the Galaxy background radiation is approximately equal to $\gamma \cong 3$. Sharp enhancement of the brightness temperature after supernovae explosion can be connected with two factors: with the increase of average magnetic field energy $\langle H^2 \rangle$ or with the increase on relativistic electrons number density.

In the first case, the local magnetic field strength in magnetic irregularities should increase 30 times in comparison with the initial background value. It is difficult to find a reasonable explanation for very slow magnetic field irregularities relaxation together with very fast density irregularities relaxation.

In the second case, the increase of relativistic particles number density can be connected with the electrons acceleration by the factor F. The acceleration process shifts the whole electron energy spectrum to higher energies. Correspondingly, the number density of particles with a given energy increases by the factor $F^{(\gamma-1)}$. To explain the observed brightness temperature T_B increase after supernovae explosion it is necessary to assume that $F \cong 5$. The temporal relaxation of the brightness temperature described by the relation [1] can be explained by one-dimensional relativistic particles diffusion from the supernovae Stromgren zone. The conditions for the acceleration of relativistic particles take place at the initial stage of the supernovae Stromgren zone evolution. Indeed, as it follows from the papers (Pynzar and Shishov, 2001; Shishov, 2001), the chain of successive supernovae explosions in the individual region of interstellar medium results due to the heat instability in the fragmentation of interstellar gas into the dense neutral gas clouds with the sizes about 0.1 pc embedded in the less dense hot plasma. Ionized radiation appeared after supernovae explosion (as a result of the supernovae envelope collision with the envelope formed by pre supernovae at the stage of super giant) is absorbed by neutral hydrogen clouds, that leads to the expansion of the hot dense clouds. The Fermi acceleration of the first order as well as the adiabatic acceleration (Berezinskii *et al.*, 1984) can be realized effectively at this initial stage of the clouds expansion. As an example, the value of factor $F \cong 5$ corresponds to 30 times magnetic field compression in the case of the adiabatic acceleration.

Acknowledgements

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