# Dirac neutrino magnetic moment and the shock wave revival in a supernova explosion

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The neutrino chirality-flip process under the conditions of the supernova core is investigated in detail with the plasma polarization effects in the photon propagator taken into account, in a more consistent way than in earlier publications (Barbieri, Mohapatra, 1988; Ayala et al., 1999). It is shown in part that the contribution of the proton fraction of plasma dominates. The supernova core luminosity for $\nu_R$ emission, $Q_{\nu_R}$, is calculated.

Assuming that the right-handed neutrino luminosity is less than the left-handed neutrino lumosity at the time $\sim 0.1$ sec after the collapse, $Q_{\nu_R} < 10^{53}$ ergs/s, we obtain a new upper bound on the Dirac neutrino magnetic moment,

$$\mu_\nu < (0.7 - 1.5) \times 10^{-12}\, \mu_{\mathrm{B}}.$$

As the analysis shows, the limit obtained appears to be rather stable with respect to the variation of the supernova core parameters, when the product of the average value of the electron fraction $Y_e$ on the core mass is fixed. By this means, the upper bound on the neutrino magnetic moment from SN1987A is improved by the factor of 2.

Using this new approach to the neutrino chirality-flip process in the supernova core, the process of the two-step conversion of the neutrino helicity, $\nu_L \to \nu_R \to \nu_L$ (A. Dar, 1987, unpublished), is reanalysed in the supernova conditions. Here, the first stage, $\nu_L \to \nu_R$, is realized due to the interaction of the neutrino magnetic moment with the plasma electrons and protons in the supernova core. The second stage, $\nu_R \to \nu_L$, is caused by the neutrino

resonant spin-flip in a magnetic field of the supernova envelope. Given the neutrino magnetic moment within the interval $10^{-13}\,\mu_{\rm B} < \mu_\nu < 10^{-12}\,\mu_{\rm B}$, and under the condition of existence of the magnetic field at the scale $\sim 10^{13}$ G between the neutrinosphere and the shock-wave stagnation region, it is shown that an additional energy of the order of $10^{51}$ erg can be injected into this region during the time of the shock-wave stagnation. This energy could be sufficient for stumulation of the damped shock wave.

# References


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