Neutrino magnetic moment and the shock wave revival in a supernova explosion

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In a modelling of the supernova explosion, two main problems arise.

- The mechanism of the **damped shock wave stimulation** has not been developed completely yet.
- Even in the case of the "successful" theoretical supernova explosion, the energy release turns out to be essentialy less than the observed kinetic energy of the envelope $\sim 10^{51}$ erg **(FOE problem)**.

Could sterile ν_R's stimulate the supernova explosion?

It is necessary for the self-consistent description of the explosion dynamics, that the neutrino flux, outgoing from the supernova core, could **transfer by some mechanism** the energy $\sim 10^{51}$ erg to the supernova envelope.

Could sterile ν_R's stimulate the supernova explosion?

The mechanism first proposed by *A. Dar, 1987*, with the **neutrino magnetic moment** being not too small.

A part of **left-handed electron neutrinos** ν_e produced in the collapsing supernova core could convert into **right-handed neutrinos** due to the interaction of the **neutrino magnetic moment** with plasma electrons and protons.

It was shown earlier (*A.K., N.M., JCAP, 2007*) that the obtained ν_R luminosity **was large enough** to influence essentially on the supernova explosion dynamics.

These ν_{eR}'s (sterile to the weak interaction), freely escape from the central part of the supernova, if the neutrino magnetic moment is not too large, $\mu_\nu < 10^{-11}\,\mu_{\rm B}$.

Could sterile ν_R's stimulate the supernova explosion?

In the supernova envelope, a part of these neutrinos can **flip back to ν_{eL}'s** due to the interaction of the neutrino magnetic moment with a **magnetic field,** which could achieve the critical value $B_e = m_e^2/e \simeq 4.41 \times 10^{13}$ G.

These ν_{eL}'s being absorbed in **beta-processes,** $\nu_e n \to e^- p$, can transfer an **additional energy** to the supernova envelope.

Results

We have analysed **quantitatively** the two-step conversion of the neutrino helicity, $\nu_L \to \nu_R \to \nu_L$, under the supernova conditions. This process could provide an additional energy $\sim 10^{51}$ erg to be injected into the region between the neutrinosphere and the shock-wave stagnation area, $R_\nu < R < R_s$, during the typical stagnation time of the order of some tenths of a second. **This energy could be sufficient for stumulation of the damped shock wave.**

The conditions for the realization of this scenario appear to be **not very rigid.** The Dirac neutrino magnetic moment should belong to the interval $10^{-13}\,\mu_{\rm B} < \mu_\nu < 10^{-12}\,\mu_{\rm B}$, and the magnetic field $\sim 10^{13}$ **G** should exist in the region $R_\nu < R < R_s$.