Spin-light of neutrino efficiency in Gamma-Ray Bursts

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Introduction

The spin light of neutrino (SL\textsubscript{ν}) \cite{1,2} is a new possible mechanism of electromagnetic radiation emitted by a massive neutrino (with a nonzero magnetic moment) moving in external media. Although this effect is very weak due to smallness of the neutrino magnetic moment \cite{3}, it can be of interest for astrophysical environments involving compact relativistic objects because its efficiency is higher, the higher the neutrino energy and background matter density \cite{4}. The most suitable astrophysical site for manifestation of this phenomenon is represented by the Gamma-Ray Bursts (GRBs) where generation of ultra-high-energy neutrinos is anticipated and the matter density can reach values of the order of the nuclear. In this work we investigate the principal possibility for the SL\textsubscript{ν} to be effectively radiated in connection with the process threshold, competing processes and low production rate.

The SL\textsubscript{ν} basics and main properties

\[ n_\text{m} = 0 \Rightarrow \Phi = 0 \]

- photon is coupled via the magnetic moment \cite{2}
- neutrino state in matter is helicity-dependent \cite{2}
  \[ \left\{ \begin{array}{l} \left| \Sigma \times \hat{n} \right| = 0 \ 	ext{or} \ \left| \Sigma \times \hat{n} \right| = 1 \end{array} \right. \]

- helicity matter density parameter for electron
  \[ \Sigma_{\text{e}} = \sqrt{\nu - m_e^2} = \sqrt{\nu - m_e^2} \]

SL\textsubscript{ν} in neutron matter of real astrophysical objects \cite{4}

\textbf{Q: Plasma effects} \cite{5}
- Photon dispersion with plasma mass in the degenerate electron gas
  \[ \omega = \sqrt{k^2 + m_\text{e}^2} \]
- Threshold condition for the SL\textsubscript{ν} \cite{10}:
  \[ \left( \nu_\text{\text{c}} / m_\text{e} \right)_{\text{c}} = 4.2 \]
- Neutrino matter
  (antimeutrinos act)
  \[ E > 0.2 \text{MeV} \Rightarrow \Gamma \sim \nu_\text{\text{c}} / m_\text{e} \sim 9.2 \text{MeV} \]

\[ n_\text{e} = 10^4 \text{cm}^{-3} \Rightarrow \Gamma \sim \nu_\text{\text{c}} / m_\text{e} \sim 9.2 \text{MeV} \]

\[ \nu_\text{\text{c}} = 10^4 \text{cm}^{-3} \Rightarrow \Gamma \sim \nu_\text{\text{c}} / m_\text{e} \sim 9.2 \text{MeV} \]

- Mean photon energy near the threshold:
  \[ \langle \omega \rangle = \Gamma / \Gamma \approx \Gamma \approx \nu_\text{\text{c}} \]

For most favorable conditions as low density of the charged matter component is needed as possible

\textbf{W boson production} \[ \nu \rightarrow e^+ e^- \]

\[ E_{\text{nu}} \text{ production} \]

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\textbf{W-boson threshold energy}
\[ \nu_\text{\text{c}} = \nu_{\text{\text{c}}} \approx 5.77 \text{MeV} \]

The SL\textsubscript{ν} photon energy for vacuum photon dispersion:

\textbf{The rate and power of the SL\textsubscript{ν} from relativistic neutrino in dense matter:}

- Cosmic flux of neutrino energy is carried away by the SL\textsubscript{ν} photon:
  \[ \Gamma = 1 / \Gamma = \nu_\text{\text{c}} / \nu_\text{\text{c}} \approx 9.2 \text{MeV} \]

- For high matter density the SL\textsubscript{ν} is completely circular-polarized:

\textbf{SL\textsubscript{ν} in short Gamma-Ray Bursts (SGRBs)}

Factors for best SL\textsubscript{ν} generation efficiency:
- High neutrino energy and density
- High background neutral matter density
- Low density of the charged matter component
- Low temperature of the charged component
- Considerable extension of the medium

SL\textsubscript{ν} radiation by ultra high-energy neutrino in the diffuse neutrino wind blown during neutron stars merger

References

3. C. Giunti and A. Studenikin, Rev. Mod. Phys. 87 (2015) 531