The joint virtual event of the
African Light Source AfLS4-2022
and the
African Physical Society AfPS2022

Contribution ID: **22** Type: **not specified**

Photon Neutrino Interaction in a charged neutral Magnetized Medium

In the standard model the null electric charge of neutrinos are protected by the absence of gauge anomaly. However in the extension of standard model neutrinos can have intrinsic charge but we are not considering the same here. We are estimating the induced charge on ν due to medium effects. In
the astrophysical context the rotating dipole field of stars generate an electric field. The neutrinos can interact with this electric field through their induced charge. Thus screening the same. On the other hand, if this is true then the electric field of bare strange star may get screened by in medium charged neutrinos. There may be other astrophysical or cosmological implications of the same but we do not discuss them here.
Intuitively as a neutrino moves inside a thermal medium composed of electrons and positrons, they interact with these background particles. The background electrons and positrons themselves have interaction with the electromagnetic fields, and this fact gives rise to an effective coupling of the neutrinos to the photons. Under these circumstance's the neutrinos may acquire an "effective electric charge" through which they interact with the ambient plasma.
The effective charge of the neutrino has been evaluated previously in [1,2,3].
In this paper we concentrate upon the effective neutrino photon vertex coming from the vectorial part of the interaction.
From there we estimate the effective charge of the neutrino inside a magnetised medium.
The effective neutrino photon interaction in the effective Lagrangian becomes possible due to the polarisation tensor $\Pi_{\mu\nu}$, which we have used in this estimates.
For momenta small compared to the masses of the W and Z bosons the leading order expression of the vertex Γ_ν in Fermi constant, G_F is given by:
\begin{eqnarray}
\Gamma_{\nu} = - \frac{1}{\sqrt{2}e} G_F \gamma^{\mu} (1 - \gamma_5) \,(g_{\rm V} \Pi_{\mu \nu} + g_{\rm A} \Pi_{\mu \nu}^5) \,,
\end{eqnarray}
Where the coupling constants for electron neutrinos,
\begin{eqnarray}
g_{\rm V} &=& 1 - (1 - 4 \sin^2 \theta_{\rm W})/2, \\
g_{\rm A} &=& -1 + 1/2;
\end{eqnarray}

The effective charge of the neutrinos is defined in terms of the vertex function by the following relation [1]:

\begin{eqnarray}
e_{\rm eff} = \frac{1}{2q_{0}} \bar{u}(q) \Gamma_{0} (k_{0}=0, {\bf k}\to 0) u(q).
\label{chargedef11}
\end{eqnarray}

For massless Weyl spinors this definition can be rendered into the form:

\begin{eqnarray}
e_{\rm eff} = {1\over{2 q_0}} \, \mbox{Tr} \left[\Gamma_0(k_0=0, {\bf k}\rightarrow 0) \, (1+\lambda \gamma^5) \, \rlap/q \right]
\label{nec1}
\end{eqnarray}

where $\lambda = \pm 1$ is the helicity of the spinors.\\
\indent
Now the coulomb force on neutrino due to this effective charge, in the magnetosphere of the compact astrophysical star is $F_C = e_{eff} E_{||}$, where the expression of the electric field $E_{||}$ is given by [4]:
\begin{align}
{{E}{||}} \sim \frac{1}{8\sqrt{3}}\left(\Omega R{NS} \right)^{\frac{5}{2}} {B}
\sqrt{\frac{2R_{NS}}{r}}.
\label{eparallel2}
\end{align}
In eqn.~\eqref{eparallel2}, B is the surface magnetic field of the compact object.
The average plasmon decay rate in $\nu, \bar{\nu}$ pairs due to intrinsic neutrino charge is [5]:
\begin{eqnarray}
\Gamma_{\gamma \to \nu, \bar{\nu}} = \frac{\pi}{9}\epsilon^{2} \alpha^{2}T.
\end{eqnarray}

On the other hand $\nu, \bar{\nu}$ pair production rate due to the electric field produced due to rotating dipolar magnetic field in a compact star via Schwinger mechanism would be given by [6]:
\begin{eqnarray}
\Gamma_{\gamma \to \nu, \bar{\nu}}= \frac{e^{2}{eff} E{\parallel}B}{4\pi^{2}} \coth\left(\frac{\pi B}{E_{\parallel}}
\right) e^{-\frac{\pi m^{2}{\nu}}{e{eff}E_{\parallel}}}
\end{eqnarray}

For an old compact object like hypothetical strange star, these medium induced neutrino charge stands a chance to screen the electric field ($E_{||}$) of the star.

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Session Classification: Partner

Track Classification: Partner