PROPAGATION AND OSCILLATION OF NEUTRINOS WITH MAGNETIC MOMENT INSIDE THE SUN.

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Abstract: The VVO mechanism suggests that the existence of a neutrino magnetic moment would lead to variations of the observed solar neutrino flux with the magnetic activity of the Sun. The MSW mechansm suggests neutrino oscillations in the dense plasma solar interior. Assuming a non-vanishing neutrino magnetic moment and a magnetic field gradient increasing towards the solar core as required in some dynamo models, the combined effect of the oscillation and the flipping on neutrino propagation in the solar interior is studied. The effect of charge screening in scattering cross-section is also considered.

The required value of $\sim 10^{-10}\mu_B$ for the VVO mechanism is just below the experimental bound from neutrino scattering and constraints from SN 1987 A already appear to rule out such a large value[1]. The MSW mechanism involves a density dependent oscillationlength. However if in addition to an electron density varying with depth we have a magnetic field gradient increasing towards the solar core then the combined effect of the varying density and magnetic field on the neutrino propagation has to be studied. A large magnetic field ($\sim 10^5$G) if present in the solar core would cause the neutrinos to flip helicity over a distance $\sim 3 \times 10^5$ m., so that one would detect only half of the emerging flux. For combined presence of varying electron density and Field, the oscillation length is:

$$l_{osc} = 2\pi/[(\mu_{12} B_{\perp})^2 + [(2m_2^{\,2}-m_1^{\,2})/2E - 2^{1/2}\, G_F\, N Y_e F]^2\,]^{1/2}$$

The quantities N and B are defined in the radial sense in the above equations:

$$\langle N \rangle = (1/R)\int_0^R dr\; n(r), \quad B = (1/R)\int_0^R dr\; B(r),$$

where gradients are taken into account. Estimates give $B \simeq 10^8\ (\Delta m/\Delta\mu)$G, Δm is in ev and $\Delta\mu$ in units of μ_B ev/G. Again charge screening takes place in the solar plasma where the virtual photon acquires a mass $m_\gamma = [(4\pi\alpha/\langle kT\rangle)\Sigma\, ni]$, ni is species present. The neutrino mfp

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is $\langle \ell \rangle = [\sum \sigma_i (m_i)]^{-1}$ where σ_i is spin flip C.S. Result is $\langle \ell \rangle \gg l_{osc}$. Spin flip probability by scattering on nuclei is only ~ 0.1. These effects are, however, very important for supernova neutrinos[1].

References:

1. Sivaram,C. 1989. 'Proc. of Third ESO-CERN Symposium" - n.Caffo et al ed. Kluwer Acad. p.471.

2. Voloshin, M. et al 1986. Sov. J. Nucl. Phys. 44, 440.

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