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The results of the solar neutrino experiments of Davis et al.[1] could be explained if there is a severe attenuation in the high-energy solar neutrino flux in its traversal of the sun. The results of other neutrino experiments show that the interaction of neutrinos with ordinary matter is too small to explain the effect. However, a strong neutrino-photon interaction ($\sigma_{\nu\gamma} > 10^{-32}$ cm^2) could cause the observed attenuation in the high-energy neutrino flux. Although a strong neutrino-photon interaction is ruled out by conventional quantum field theory, a direct experimental test (using neutrinos from a reactor and a dense photon target such as a laser) seems very worthwhile.

The solar neutrino experiments of Davis et al.[1] concerning the reaction

(1) $$\nu + Cl^{37} \rightarrow A^{37} + e^-$$

indicate that the solar neutrino flux reaching the earth is about a factor of 10 lower than that predicted by the best calculations and it is consistent with zero.[2] The threshold for process (1) is 0.81 MeV and therefore only neutrinos with energies above 0.81 MeV are detected in these experiments. Several explanations for this unexpected result have been proposed.[2,3]

For ordinary matter to attenuate neutrinos in the sun, the neutrino mean free path λ_ν would have to be less than the solar radius R or

(2) $$\lambda_\nu = (\sigma n)^{-1} < 7 \times 10^{10} \text{cm}.$$

Taking n equal to the central solar density, we find that the neutrino interaction cross section with matter must be greater than 10^{-37} cm^2, which is ruled out by neutrino experiments.[4,5]

We know of no measurements regarding the interaction of neutrinos with a photon medium although a dense photon medium is the environment in which the high-energy solar neutrinos are created.

We shall now estimate what neutrino-photon cross section is required to reduce the high-energy solar neutrino flux by a factor of 10. In estimating the cross section we shall assume that one interaction

(3) $$\nu + \gamma \rightarrow \nu + \gamma$$

between a high-energy (MeV) neutrino and a low-energy (~1 keV) photon will reduce the neutrino energy below the 0.81 MeV detection threshold. (If it requires more than one interaction to reduce the neutrino energy below the detection threshold, this will just raise the required neutrino-photon cross section.)

The photon density of a blackbody is

(4) $$n_\gamma = \int_0^\infty \frac{8\pi \nu^2}{c^3} \frac{d\nu}{\exp(h\nu/kT) - 1}$$

which results in $n_\gamma \approx 20\ T^3$ where n_γ is the number of photons/cm^3 and T is in degrees Kelvin. The mean free path for a high-energy neutrino in the sun is then,

(5) $$\lambda_\nu = (\sigma_{\nu\gamma} n_\gamma)^{-1} \approx (20\ T^3\ \sigma_{\nu\gamma})^{-1}\ .$$

The temperature of the sun varies[6] from 13.6×10^6 °K in the center to 2.8×10^6 °K at 0.5 R. The high-energy neutrinos are created[7] predominantly in the hot interior of the sun, $r < 0.1$ R. For the high-energy neutrinos to be attenuated by a factor of 10 we estimate that the cross section for process (3)

(6) $$\sigma_{\nu\gamma} > 10^{-32}\ \mathrm{cm}^2.$$

Fortunately, one can determine by experiment whether or not process (3) occurs. If one takes the antineutrino flux from a reactor and lets it pass through a dense photon medium, process (1) will result in the formation of some high-energy (MeV) gamma rays whose momentum would be along the direction of the antineutrino flux. To be more quantitative with an antineutrino flux[5] $n_\nu v_\nu$ of $3 \times 10^{13}\ \mathrm{cm}^{-2}\ \mathrm{sec}^{-1}$ and a photon target (CO_2 laser[8] or large blackbody source, for example) with $N_\gamma = 10^{16}$ photons, the number of gamma rays produced would be

(7) $$(n_\nu v_\nu)\ \sigma_{\nu\gamma} N_\gamma > 0.003/\mathrm{sec} \approx 10/\mathrm{hr}.$$

The occurrence of a neutrino-photon interaction with a cross section greater than $10^{-32}\ \mathrm{cm}^2$ is in disagreement with conventional quantum field theory because if process (3) occurs then quantum field theory predicts that two more interactions must also occur:

(8) $$\nu + e^- \rightarrow \nu + \gamma + e^-$$

(9) $$\nu + e^- \rightarrow \nu + e^-\ .$$

In field theory these processes arise from the interaction of the neutrino with a virtual photon emitted by the electron, and their cross section should be given approximately by $\alpha\, \sigma_{\nu\gamma}$ and $\alpha^2 \sigma_{\nu\gamma}$ respectively, where $\alpha = e^2/\hbar c$. The cross section for reactions (8) and (9) have been shown to be very small by experiment[4, 5] and they would require $\sigma_{\nu\gamma} << 10^{-32}$. Therefore, the experiment suggested above is also a test of quantum field theory concerning its prediction with regard to the interaction of neutrinos and virtual photons.

Besides explaining the solar neutrino experimental results of Davis et al.[1] there are some theoretical suggestions of a neutrino-photon interaction. In connection with work on the neutrino theory of light, Bandyopadhyay[9] has suggested that neutrinos must interact weakly with photons. We disagree with Bandyopadhyay on the strength of the interaction that is required. For a composite neutrino-anti-neutrino pair to simulate photon processes there must be a fundamental neutrino-antineutrino interaction [according to the neutrino theory of photons[10]] which is relatively strong, characteristic of the photon coupling constant α. In this theory, neutrino-photon and photon-photon processes should occur directly through the neutrino-antineutrino interaction and their cross sections should be comparable.

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