Neutrino-Nucleon Scattering Rate in the Relativistic Random Phase Approximation

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We present a calculation of the neutrino-nucleon scattering cross section which takes into account the nuclear correlations in the relativistic random phase approximation. Our approach is based on a quantum hadrodynamics model with exchange of σ, ω, π, ρ and δ mesons. In view of applications to neutrino transport in the final stages of supernova explosion and protoneutron star cooling, we study the evolution of the neutrino mean free path as a function of density, proton-neutron asymmetry and temperature.
Special attention was paid to the issues of renormalization of vacuum fluctuations, residual interactions in the tensor channel and meson mixing. In contrast with the results of other authors [1],[2], it is found that RPA corrections with respect to the mean field approximation amount to only 10% to 15% at high density [3].
In addition to the usual σ-ω meson mixing, new mixing channels open in asymmetric matter. When meson mixing is fully taken into account, the reduction factor is found to be even smaller. This is illustrated in the following figure, where the reduction factor was calculated in matter with trapped neutrinos relevant for supernova collapse and protoneutron stars.

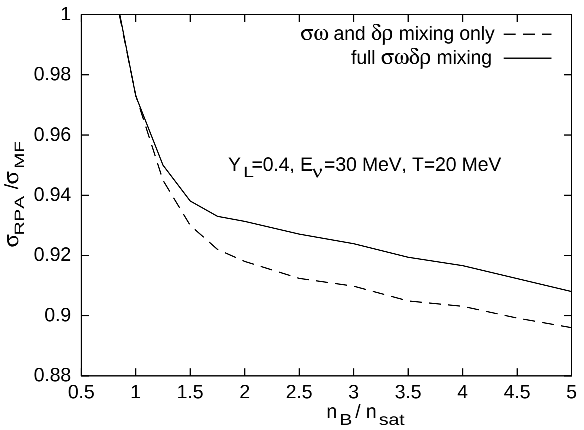

Figure 1: Reduction factor in matter with trapped neutrinos, as a function of density.

References

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