On the Neutrino Self Refraction Problem from a Many-Body Perspective

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Neutrino self refraction is the process by which neutrino-neutrino interactions in a sufficiently dense neutrino gas alters the neutrino flavor oscillations in a way which is similar to the well known MSW effect. Such high neutrino densities are believed to exist in the Early Universe and in core collapse supernovae. Since neutrinos control n/p ratio which is a key parameter for r-process nucleosynthesis in those environments, the study of neutrino self refraction is an important problem.

Unlike the MSW effect, the neutrino self refraction is a nonlinear many-body phenomenon due to the fact that the refracting and the refracted particles are indistinguishable. So far, however, it is almost exclusively studied within the framework of effective one particle descriptions such as the random phase approximation (rpa.) Those few studies which took the many-body nature of the problem into account were carried out under overly simplified conditions (for example by ignoring vacuum mixing of neutrinos and by starting from very special initial conditions.)

In this talk we consider a self interacting dense neutrino gas as a many-body system and we include vacuum oscillations which were always ignored so far in many-body studies. We show that the many-body Hamiltonian describing the flavor oscillations of such a neutrino gas is very similar to the BCS pairing Hamiltonian and that the system has many constants of motion. These constants of motion enable us to easily diagonalize the neutrino many-body Hamiltonian both numerically and analytically. With the help of these diagonalization techniques, we calculate neutrino flavor oscillation profiles under various different initial conditions and we compare the results with those obtained with rpa method.