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Non-linear neutrino flavor transitions beyond the mean-field approximation

Large numbers of neutrinos are produced in several cosmological and astrophysical sites such as the early universe, core-collapse supernovae and neutron-star mergers. Neutrino self-interactions in such luminous neutrino backgrounds are believe to induce non-linear neutrino flavor transitions which transform the spectra of all species of neutrinos dramatically. Increased electron type neutrinos through neutrino flavor transitions enhance reaction rates of neutrino absorptions on free nucleons, which affects macroscopic hydrodynamics and nucleosynthesis. Therefore, a precise neutrino transport is required to reveal the mechanism of astrophysical phenomena. Previous numerical studies always assume the mean-field approximation and employ the effective one-body Hamiltonian. However, there is no quantitative discussion which guarantees the validity of such approximation.

In this presentation, we mention the equations of self-interacting neutrinos using exact two-body Hamiltonian. The higher order effects beyond the mean-field approximation are reduced to neutrino collisional terms. The sufficient condition of this approximation is revealed quantitatively. The order estimate shows that the mean-field approximation proves to be a good approximation in previous numerical studies.

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