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Flavor Equilibration of Supernova Neutrinos: Exploring the Dynamics of Slow Modes

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Neutrinos experience collective flavor conversion in extreme astrophysical environments such as core-collapse supernovae (CCSNe). One manifestation of collective conversion is slow flavor conversion (SFC), which has recently attracted renewed interest owing to its ubiquity across different regions of the supernova environment.
In this study, we systematically examine the evolution of kinematic decoherence in a dense neutrino gas undergoing SFC, considering lepton number asymmetries as large as 30%.
Our findings show that the neutrino gas asymptotically evolves toward a generic state of coarse-grained flavor equilibration which is constrained by approximate lepton number conservation.
The equilibration occurs within a few factors of the inverse vacuum oscillation frequency, ω^{-1}, which corresponds to (anti)neutrinos reaching near flavor equipartition after a few kilometers for typical supernova neutrino energies.
Notably, the quasi-steady state of the neutrino number densities can be quantitatively described by the neutrino-antineutrino number density ratio $n_{\bar{\nu}_e}/n_{\nu_e}$ alone.
Such a simple estimation opens new opportunities for incorporating SFC into CCSN simulations, particularly in regions where SFC develops on scales much shorter than those of collisions.

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Compact Objects & Particles

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