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Multi-angle quantum many-body collective neutrino-flavor oscillations

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In core-collapse supernovae and merging of neutron stars a very large number of neutrinos are produced and impact the subsequent evolution of these compact objects. In this work I study neutrino flavor oscillations under the influence of the self-energy induced by neutrino-neutrino interactions, called collective oscillations. I study the flavor evolution of a dense neutrino gas by considering vacuum contributions, matter effects and neutrino self-interactions. Assuming a system of two flavors in a uniform matter background, the time evolution of the many-body system in discretized momentum space is computed. The multi-angle neutrino-neutrino interactions are treated exactly and compared to both the single-angle and mean field approximations. The many body treatment reveals collective oscillations and non-negligible entanglement entropy which results in rapid flavor equilibration, not found in the mean field treatment. This is just a first step, and more work will be required in the future to tackle larger and larger systems. The problem, as described here, could be easily implemented and benefit from emerging technologies like quantum computing. For more details, the interested reader can access the article at Phys. Rev. C 101, 065805 (2020).

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