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Neutrino Quantum Kinetics in Compact Objects

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Neutrinos play a critical role of transporting energy and changing the lepton density within core-collapse supernovae (CCSNe) and neutron star mergers. The possibility of flavor or angular instabilities in the neutrino distributions have the potential to revolutionize our understanding of the CCSN explosion mechanism and neutrino signals. However, understanding these effects will require yet-undeveloped technology to simulate the neutrino quantum kinetic equations (QKEs). I will present a method for extending existing neutrino interaction rates long used in CCSN/merger simulations to full QKE source terms for use in numerical calculations. To demonstrate the effects of a complete set of neutrino interaction physics, I will show the results of simulations of the full isotropic QKEs in conditions relevant to CCSNe and neutron star mergers. I will demonstrate that in isotropic calculations, electron scattering, nucleon-nucleon bremsstrahlung processes, and four-neutrino processes dominate flavor decoherence in the protoneutron star (PNS), absorption dominates near the shock, and all of the considered processes except elastic nucleon scattering are relevant in the decoupling region. Finally, I will present an effective decoherence opacity that at most energies predicts decoherence rates to within a factor of 10 in our model PNS and within 20% outside of the PNS.

Keywords

Neutrinos

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