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Simultaneous Matter-Enhanced Transformation of Neutrinos and Antineutrinos in Astrophysical Environments

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The neutrino flavor evolution problem in supernovae is notoriously difficult. We point out a simple neutrino energy-independent solution in a specific limiting case that corresponds closely to some of the "synchronization" solutions seen numerically. Neutrino-neutrino forward scattering produces both flavor diagonal and off-diagonal potentials for neutrinos propagating coherently above the proto-neutron star in supernovae and in the early universe. We show that both the active neutrinos (ν_e,ν_μ,ν_τ)and the corresponding antineutrinos can be maximally mixed in medium over broad ranges of neutrino energy when the flavor off-diagonal potential is large compared to the neutrino-matter potential. With this simple criterion we can identify epochs in the evolution of the supernova environment where large neutrino and antineutrino mixing can occur. We discuss the effects of this on shock re-heating and r-process nucleosynthesis models and on the expected neutrino signal.