COLLECTIVE NEUTRINO FLAVOR OSCILLATIONS AND APPLICATION TO SUPERNOVA NUCLEOSYNTHESIS

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Nonlinear neutrino flavor oscillations are expected to play an important role in several astrophysical sites such as the early Universe, the core-collapse supernovae, and possibly the central engines of gamma-ray bursts. Among them, the flavor oscillations of energetic neutrinos emitted from core-collapse supernovae are of particular interest because these could affect the explosive nucleosynthesis such as the r-process of heavy elements or the neutrino-process of several specific isotopes like Li7, B11, Nb92, La138, and Ta180. The explosion mechanism is also affected remarkably by the neutrino-flavor oscillations through the shock reheating or cooling due to the interactions with supernova matter.

Taking three active neutrinos, we first discuss the flavor evolution of neutrinos undergoing "collective flavor oscillations" associated with the forward coherent-scatterings of self-interacting neutrinos from core-collapse supernovae for various luminosities and temperatures. We find that, even starting from Fermi-Dirac energy distributions for e-, μ- and τ-neutrinos and their anti-particles, the calculated energy spectra eventually turn out to be swapped due to the the nonlinear effects of neutrino flavor oscillations. Having calculated these energy spectra, we secondly apply them to the r-process and neutrino-process nucleosynthesis in order to look for the observable signals of the collective neutrino-flavor oscillations.