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Neutrino Oscillations In Supernovae[1]

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Neutrinos play very important roles in core-collapse supernovae as they constitute 99% of the total energy budget of the collapse. Because the charged-current neutrino processes are flavor dependent, neutrino flavor transformation or neutrino oscillations, depending on where it occurs and how it occurs, can also be important to supernova dynamics, supernova nucleosynthesis, etc. Tracking neutrino oscillations in supernovae is more difficult than solving the solar neutrino problem because: (1) both neutrino mass-squared differences are important, (2) matter density profiles are dynamical and far from smooth, and (3) flavor transformation of different neutrinos can become coupled. The last difficulty was not widely appreciated until recently, and rapid progress is made towards a full understanding of this issue. It is now clear that neutrino oscillations near the proto-neutron star can become collective because of the large neutrino fluxes. A clear signature of spectral swaps/splits can show up in supernova neutrino signals if this is the case. The onset radius of collective neutrino oscillations has an nontrivial, i.e. not well understood, dependence on the initial neutrino energy spectra at the neutrino sphere(s), but has a rather simple relation with neutrino luminosities and the neutron star radius.

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