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Key issues regarding neutrinos and nucleosynthesis in core collapse supernovae[1]

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Neutrino interactions are a key component of the mechanism for supernova explosions and also play an important role in the associated nucleosynthesis. Nevertheless, a number of issues remain to be resolved. For one the role of neutrino heated convection in the outer envelopes may be crucial to generating an explosion. This talk will summarize some of the current issues regarding neutrino interactions in the core and outer envelopes as a supernova progresses. In addition to the neutrino transport issues, we will review some current topics in neutrino induced nucleosynthesis (the ν process) and how neutrino oscillations and nucleosynthesis might modify the explosion dynamics and/or constrain the neutrino mass hierarchy. We will also review the current conundrum regarding the prospects for the nucleosynthesis of heavy elements in the neutrino energized wind above the nascent neutron star. Subtle nuclear physics issues will be summarized. We also review the critical role of neutrinos in the high temperature accretion disk around the black hole of a failed supernova (*collapsar* model). This collapsar scenario is a model for long-duration gamma ray bursts (GRBs) is a possible site for r-process nucleosynthesis. We present numerical r-process calculations in the context of a MHD + neutrino pair heated collapsar simulation. Neutrino heating of the jet is crucial for achieving the required relativistic outflow and at the same time generating material with a high neutron excess. This model begins with relativistic magnetohydrodynamic simulations including ray-tracing neutrino transport to describe the development of the black hole accretion disk and the heating of the funnel region to produce a relativistic jet. The late time evolution of the jet then utilizes axisymmetric special relativistic hydrodynamics to follow the temperature, entropy, electron fraction, and density for representative test particles flowing with the jet from temperatures of 9×10^9 to 3×10^8 K. The evolution of nuclear abundances from nucleons to heavy nuclei for representative test particle trajectories was solved in a large nuclear reaction network. We show that a r-process-like abundance distribution is formed within neutrino heated regions of the relativistic outflowing jet and argue that sufficient mass is ejected within the flow to account for the observed r-process abundance distribution along with the large dispersion in r-process elements observed in metal-poor halo stars. Finally, we discuss the nuclear physics issues and possible role of relic supernova neutrinos in resolving the supernova rate problem.

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