Core Collapse Supernova Models

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In a self-consistent spherically symmetric model, we follow the evolution of a 13 $M_\odot$ star (Nomoto and Hashimoto '88) from core collapse and bounce through the neutrino heating phase. Emphasized are the effects of the main new ingredients in our models: detailed three-flavor Boltzmann neutrino transport combined with full general relativity. They lead to a very compact proto-neutron star that positions the region with tight feedback between matter accretion and neutrino heating deep in the gravitational potential. With our current "standard" implementation of weak interaction physics and the Lattimer-Swesty equation of state, no explosions are obtained. Possible conditions where general relativistic effects would favor a successful explosion are not reached.

A supernova explosion is a dramatic event that can outshine an entire galaxy. However, the basic scenario of stellar core collapse, bounce, and explosion is still not fully understood. The limits of computer hardware do not currently allow the consideration of all relevant physics in a single numerical model. We give an overview of other models and the facets and uncertainties they address in the rich diversity of physics present in core collapse supernovae. Self-consistent models are needed to quantify the explosion energy and the progenitor-dependent amount of ejected material. Undergoing explosive nucleosynthesis, the ejected material enriches the interstellar medium with heavy elements that are observed in remnants, metal-poor halo stars, and—after having been mixed with yields from other events and production sites—in the solar abundances.

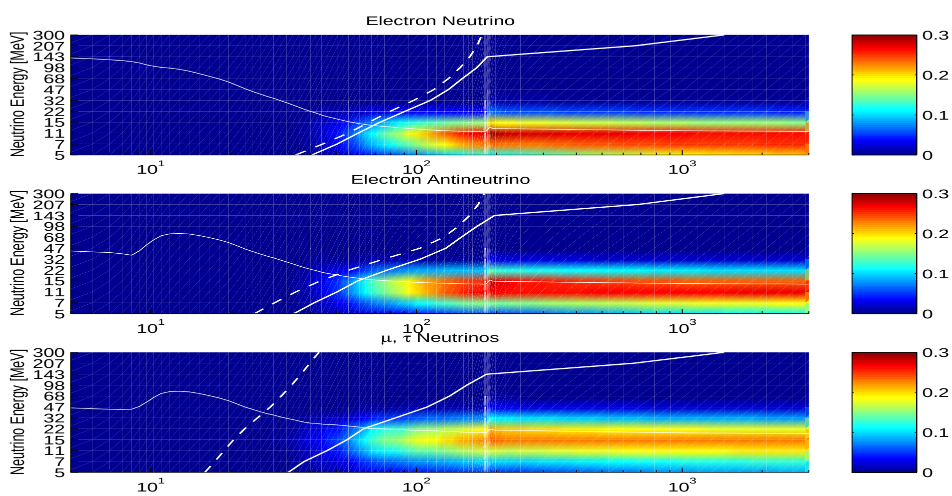

FIG. 1. At 100 ms after bounce, neutrinos radiate from the hot mantle of the proto-neutron star and heat the shock-dissociated infalling material behind the stalled shock wave (∼ 200 km radius). Shown is the energy-resolved flux factor multiplied by the neutrino number fractions, for each energy group. Also shown are the neutrinospheres for all included processes (thick solid line), the neutrinospheres for inelastic processes (thick dashed line), and the rms neutrino energies (thin solid line).

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