GENERAL RELATIVISTIC BOLTZMANN NEUTRINO TRANSPORT AND CORE COLLAPSE SUPERNOVAE

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It is clear that realistic simulations of core collapse supernovae must include the effects of general relativity on both the core hydrodynamics and neutrino transport. Recent simulations[5] seem to suggest that general relativistic effects conspire to make obtaining explosions more difficult than in the Newtonian limit. The core collapses to a more compact structure, and the inflow velocity of the postshock matter is increased by as much as a factor of 2. Additionally, the emerging neutrino radiation field is gravitationally redshifted to lower energies, and the luminosities are reduced due to curvature and redshift effects. Although it was found in Ref. 5 that the core configurations were sufficiently different that no firm conclusions could be drawn about the effect of general relativity on the explosion outcome, the differences seen were dramatic enough to demand investigation.

The ORNL supernova group has initiated a collaboration to perform fully general relativistic hydrodynamic simulations in one dimension implementing exact neutrino transport. A general relativistic, moving mesh, Lagrangian hydrodynamics code[6] will be coupled to a fully general relativistic Boltzmann solver for neutrino transport. The hydrodynamics code has already been used in simulations of coalescing neutron star binaries.[7] The Boltzmann transport algorithm used in BOLTZTRAN will be extended for general relativity and solution on a moving spatial mesh. The combination of exact neutrino transport and the adaptive quality of the moving mesh will allow for reliable determination of shock dynamics and neutrino heating behind the shock. We have successfully implemented a realistic equation of state for nuclear matter[8] in the moving mesh hydrodynamics code and are currently performing adiabatic collapse simulations (i.e., with no neutrino transport) for comparison with our current Lagrangian hydrodynamics code.

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