ONE-DIMENSIONAL NEWTONIAN BOLTZMANN NEUTRINO TRANSPORT AND CORE COLLAPSE SUPERNOVAE

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The shock revival mechanism of core collapse supernovae is powered by neutrino and anti-neutrino absorption behind the stalled shock.[3,4] The heating produced by this absorption depends sensitively on the neutrino luminosities, spectra, and flux factors (the ratio of the neutrino flux and neutrino energy density at any point in the radiation field).[5] The reliable determination of these quantities and, therefore, the viability of the shock revival mechanism requires the use of sophisticated neutrino transport coupled to core hydrodynamics. Recent results by the ORNL supernova group[5] suggest it may be possible to obtain explosions in spherically symmetric radiation hydrodynamic simulations employing multi-group Boltzmann neutrino transport (MGBT), obviating the need to invoke multidimensional effects like convection. Failing this, the enhanced heating rates produced with MGBT would likely lead to more vigorous neutrino-driven convection behind the shock than was seen in Ref. 6, perhaps producing explosions. The use of realistic transport schemes may also be important in predicting some of the observable neutrino signatures of core collapse supernovae. The luminosity rise time and maximum during the neutronization burst, produced as the shock propagates through the neutrinospheres, are neutrino signatures that can be predicted reliably only by sophisticated transport methods.

We are currently pursuing simulations of stellar core collapse, rebound, and shock propagation using one-dimensional hydrodynamics coupled to MGBT. The radiation hydrodynamics code, BOLTZTRAN, has been developed to this end. The code has already been used in simulations of core collapse[7,8,9] and in comparisons of MGBT and MGFLD in static postbounce environments.[5] BOLTZTRAN couples one-dimensional, Lagrangian, Newtonian gravity, O(v/c) hydrodynamics to three-flavor, Boltzmann neutrino transport. These studies will ultimately determine whether or not multidimensional effects such as convection are necessary to explain explosions and will be the starting point for any future Boltzmann simulations employing additional microphysics or general relativity.

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