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The Effects of General Relativity on Core Collapse Supernovae

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Abstract. The effects of general relativity (GR) on the hydrodynamics and neutrino transport are examined during the critical shock reheating phase of core collapse supernovae. We find that core collapse computed with GR hydrodynamics results in a substantially more compact core structure out to the shock, the shock radius at stagnation being reduced by a factor of 2. The inflow speed of material behind the shock is also increased by a factor of 2 throughout most of the evolution. We have developed a code for general relativistic multigroup flux-limited diffusion (MGFLD) in static spacetimes and compared the steady-state neutrino distributions for selected time slices of post-bounce models with those computed with Newtonian MGFLD. The GR transport calculations show the expected reductions in neutrino luminosities and rms energies from redshift and curvature effects. Although the effects of GR on the hydrodynamics and neutrino transport seem to work against shock revival, the core configurations are sufficiently different that no firm conclusions can be drawn, except that simulations of core collapse supernovae using Newtonian hydrodynamics and transport are not realistic.

1. Introduction

General relativity (GR) is an essential component in the realistic modeling of core collapse supernovae because of the very strong gravitational fields in the vicinity of the collapsed core of a star. Hydrodynamics and neutrino transport are closely connected in this problem, and as we will show, GR can have a profound effect on each of these, especially in the critical phase of shock reheating. The detection of neutrinos from supernova 1987A (Bionta *et al.* 1987, Hirata *et al.* 1987) and the hope of detecting neutrino signatures from future supernovae, with next-generation detectors, is additional motivation for an accurate general relativistic treatment of the neutrino transport in numerical simulations.

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