Multidimensional Core-Collapse Supernova Simulations with Neutrino Transport

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Abstract

We present multi-dimensional core-collapse supernova simulations using the Isotropic Diffusion Source Approximation (IDSA) for the neutrino transport [1] and a modified potential for general relativity [2] in two different supernova codes: FLASH [3,4,5] and ELEPHANT [6]. The Isotropic diffusion source approximation (IDSA) assumes that the distribution function of transported neutrinos can be decomposed into a streaming and a trapped neutrino distribution function. The two components are evolved separately and linked by a source term $\Sigma$. The left figure shows the schematic representation of two fluid elements in the IDSA. Streaming particles can be absorbed in the matter and trapped particles are converted to streaming particles at the rate $\Sigma$. Within fluid elements, matter emits and absorbs trapped particles [1].

The Isotropic Diffusion Source Approximation

Effective GR Potential Correction

We have implemented the effective general relativity (GR) potential correction described by [2] (Case A) in both FLASH and ELEPHANT codes. The figures below indicate a comparison of simulations with progenitors s15 and s20 from Woosley et al. 2007 with and without GR correction. As reported by O’Connor and Couch (2016), the explosions are helped by the GR effects.

Supernova Codes

We have ported the IDSA module to both the FISH code [6] and the publicly available FLASH code [3,4,5]. FISH + IDSA (or ELEPHANT) is a three-dimensional magneto-hydrodynamics code based on an equidistant mesh in Cartesian coordinates [Liebendörfer et al., in prep.]. The outer layers of the progenitor star are evolved in spherical symmetry by Agile-IDSA [1]. FLASH is a parallel, multi-dimensional hydrodynamics code based on block-structured Adaptive Mesh Refinement. Our current setup supports core-collapse supernova simulations in 1D spherical coordinates, in 2D cylindrical coordinates, and in 3D Cartesian coordinates.

References


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