Core-collapse Supernovae: Current Successes and Future Challenges

Organizers:
Christian Y. Cardall (cardallcy@ornl.gov), ORNL
Eirik Endeve (endevee@ornl.gov), ORNL

Abstract

Core-collapse supernovae are complex astrophysical events whose simulation presents many mathematical and computational challenges. World-class simulations elucidating the explosion mechanism of core-collapse supernovae have been performed with the multi-physics and multi-solver code CHIMERA. A next-generation core-collapse simulation code, GenASiS, is currently under development and is aimed in particular at the challenge of neutrino radiation transport.

Session 1:

- **Speaker:** *Bronson Messer* (bronson@ornl.gov), ORNL

  Title: Core-collapse Supernovae: Overview and CHIMERA Results

  Abstract: We present an overview of four ab initio axisymmetric core-collapse supernova simulations employing detailed spectral neutrino transport computed with our CHIMERA code and initiated from Woosley & Heger (2007) progenitors of mass 12, 15, 20, and 25 $M_{\odot}$. All four models exhibit shock revival over ~ 200 ms (leading to the possibility of explosion), driven by neutrino energy deposition.

- **Speaker:** *Eric Lentz* (elentz@utk.edu), ORNL

  Title: The Core-collapse Supernova Code CHIMERA

  Abstract: CHIMERA is a parallel, multi-physics code built specifically for multidimensional simulation of CCSNe. It is a combination of separate codes for hydrodynamics and gravity; neutrino transport and opacities; and nuclear EoS and reaction network, coupled by a layer that oversees data management, parallelism, I/O, and control.

- **Speaker:** *Christian Cardall* (cardallcy@ornl.gov), ORNL

  Title: The Developing Core-collapse Supernova Code GenASiS

  Abstract: GenASiS (General Astrophysical Simulation System) is a new code being developed initially and primarily, though by no means exclusively, for the simulation of core-collapse supernovae on the world's leading capability supercomputers. Using the features of Fortran 2003 that allow for object-oriented programming, its classes are grouped into three major divisions: (1) Basics, which contains some basic utilitarian functionality for large-scale simulations on distributed-memory supercomputers; (2) Mathematics, which includes generic mathematical constructs and solvers that are as agnostic as possible with regard to the specifics of any particular system; and (3) Physics, which sets up physical spaces associated with various theories of spacetime (including gravity), defines various forms of stress-energy, and combines these into 'universes.'

- **Speaker:** *Eirik Endeve* (endevee@ornl.gov), ORNL

  Title: Approaches to Supernova Neutrino Radiation Transport

  Abstract: We derive conservative, multidimensional, energy-dependent moment equations for neutrino transport in core-collapse supernovae and related astrophysical systems, with particular attention to the consistency of conservative four-momentum and lepton number transport equations. After taking angular moments of conservative formulations of the general relativistic Boltzmann equation, we specialize to a conformally flat spacetime, which also serves as the basis for four further limits. Finally we address discretization and closure of these moment equations.