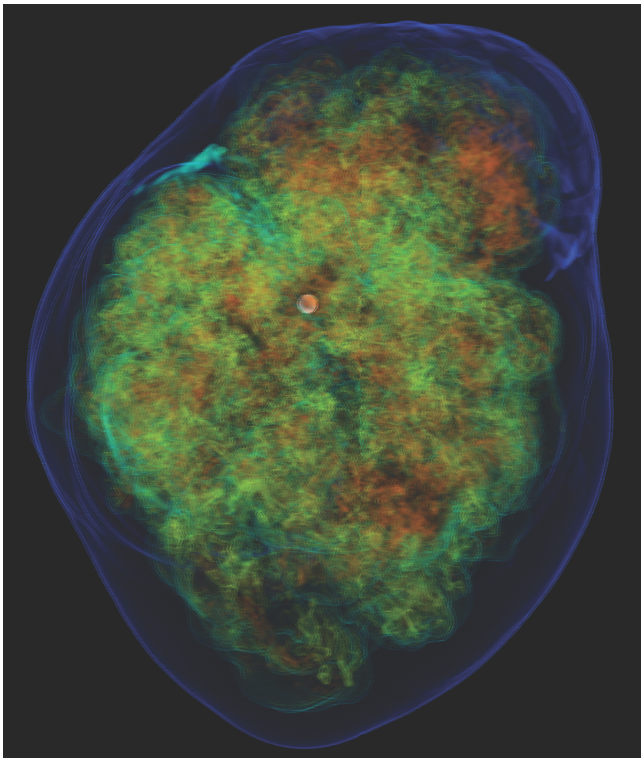
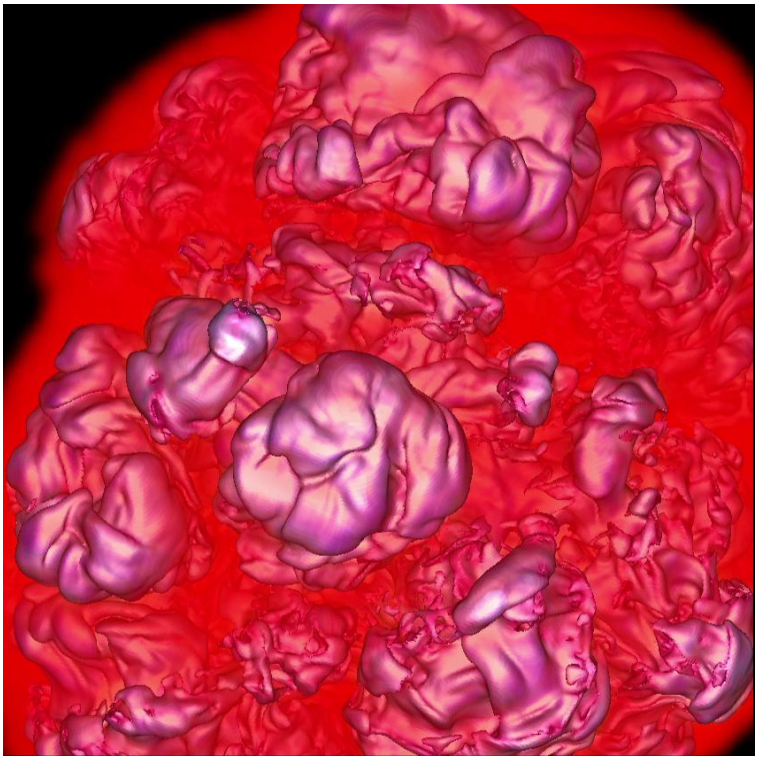
Dimensional Dependence of Supernova Modeling

Burrows, Dolence, & Murphy (Ap.J., 759, 5, 2012) investigated the structure of the stalled supernova shock in both 2D and 3D and explored the differences in the effects of neutrino heating and the standing accretion shock instability (SASI). They found that the explosions obtained by other groups in two-dimensions (2D) were likely artifacts of the axial symmetry imposed and of the approximation of ray-by-ray transport that artifically and unphysically reinforces the axial sloshing seen only in 2D. They continued this analysis in Dolence, Burrows, & Murphy (Ap.J., 765, 110, 2013) with a detailed investigation of two- and three-dimensional (3D) core-collapse supernova models, with the goal of comparing the character of the multidimensional hydrodynamics in setups that differ only in dimension. They again found that imposing axisymmetry leads to qualitatively different (and incorrect) dynamics, artificially producing conditions that have been critical in the success of previous 2D explosion models. Completing this series of studies on the 2D/3D differences, Murphy, Dolence, & Burrows (Ap.J., 771, 52, 2013) found that buoyancy-driven convection dominates post-shock turbulence, particularly when the neutrino luminosities were high enough to lead to explosions. The upshot of this series of papers was that the SASI instability is sub-dominant to neutrino-driven buoyant convection when supernova explosions are obtained, that the axial sloshing seen in 2D and touted as important by some groups is most likely an artifact of the 2D assumption and has been misleading the community for a decade, and that 3D simulations are crucial to the proper exploration of the hydrodynamics of core-collapse supernovae. This positions the Princeton group, under the JINA umbrella, to embark upon a new series of 3D radiation/hydrodynamic simulations with fully 3D transport that avoids the numerical pitfalls of the past and the artifacts of 2D approaches. The current state of play in supernova theory is summarized in the cover story of Review of Modern Physics (Rev. Mod. Phys. 85, 245, 2013), by co-I A. Burrows.





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Publications: See text