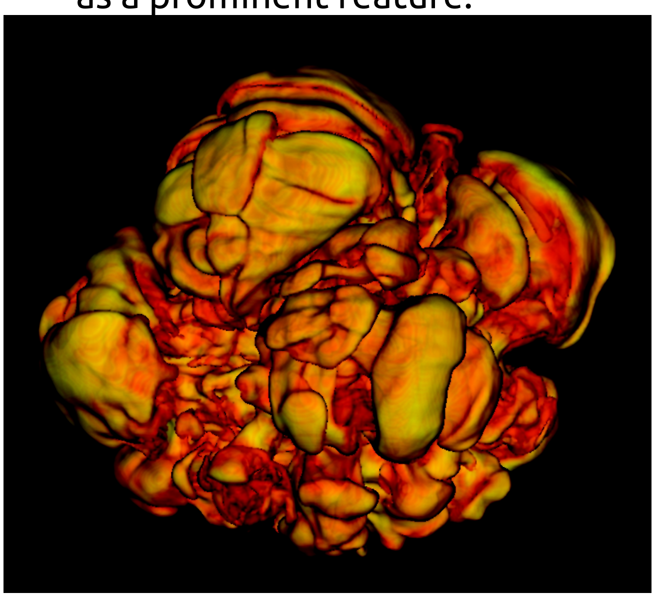
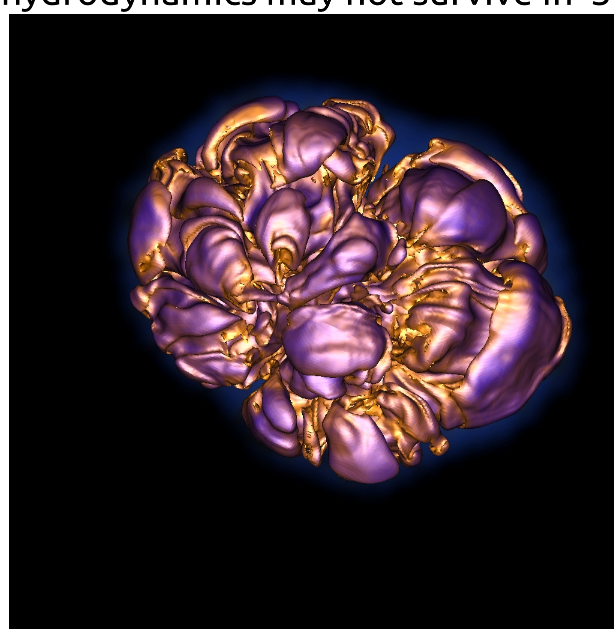
Dimension as a Key to the Neutrino Mechanism of Core-Collapse Supernova Explosions

Nordhaus et al. (2010a) explored the dependence on spatial dimension of the viability of the neutrino heating mechanism of core-collapse supernova explosions. They found that the tendency to explode is a monotonically increasing function of dimension, with 3D requiring ~40-50% lower driving neutrino luminosity than 1D and ~15-25% lower driving neutrino luminosity than 2D. Moreover, they found that the delay to explosion for a given neutrino luminosity is always shorter in 3D than 2D, sometimes by many hundreds of milliseconds. The magnitude of this dimensional effect is much larger than the purported magnitude of a variety of other effects, such as nuclear burning, inelastic scattering, or general relativity, which are sometimes invoked to bridge the gap between the current ambiguous and uncertain theoretical situation and the fact of robust supernova explosions. Since real supernovae occur in three dimensions, their finding may be an important step towards unraveling one of the most problematic puzzles in stellar astrophysics. In addition, even though in 3D we do see pre-explosion instabilities and blast asymmetries, unlike the situation in 2D, they do not see an obvious axially-symmetric dipolar shock oscillation. Rather, the free energy available to power instabilites seems to be shared by more and more degrees of freedom as the dimension increases. Hence, the strong dipolar axisymmetry seen in 2D and previously identified as a fundamental characteristic of the shock hydrodynamics may not survive in 3D as a prominent feature.





Contact: Adam Burrows, Department of Astrophysical Sciences, Princeton University, Princeton, NJ
Researchers: J. Nordhaus, A. Burrows, A. Almgren, & J. Bell
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