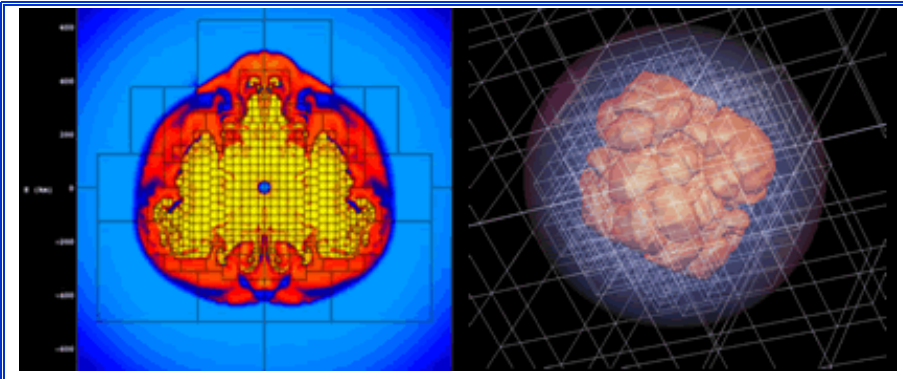
3D - The Next Crucial Step in Core-Collapse Supernova Simulations



The mechanism by which the cores of massive stars as they die launch supernova explosions has been studied for many years, but has not been unambiguously determined. At the confluence of nuclear, particle, and gravitational physics, and a numerical challenge of the first order, this puzzle has confounded theorists in no small measure due to its complexity. Some of this complexity is due to its multi-dimensional character - the dynamics experiences many hydrodynamic instabilites and the explosions are not spherical. Hence, the associated computational complexity of multi-dimensional simulations has retarded progress, but with the recent advent of fast and large parallel computers the multi-dimensional character of core-collapse supernovae may soon be captured. Whereas in the past, 1D and 2D simulations could be performed, 3D simulation capabilities are emerging. The movies here of early 3D simulations provide a glimpse at the character of the results to come.

The movie entitled "entropy_density_rot.mov" depicts an iso-entropy contour of an exploding shell of the core of the star. The fracturing into small structures is evident to a degree not readily apparent in corresponding 2D simulations, suggesting the importance of 3D effects. At the end of the simulation, the camera rotates the debris to reveal its heterogeneity.

The movie "vel_vr.mpeg" is of the same simulation, but depicts the shell of material moving at a positive (hence exploding) speed of 5000 kilometers per second. The matter interior to it is moving more slowly, while that exterior to it is moving faster. The tattered character of this interface demonstrates the gross asphericities created during explosion, and the camera rotation of the structure at the end of the movie reveals the nested character of the speed contours. 2D simulations could not reveal this behavior.

See Powerpoint
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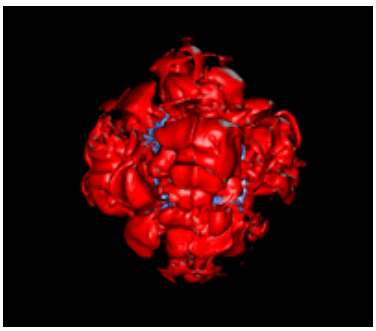

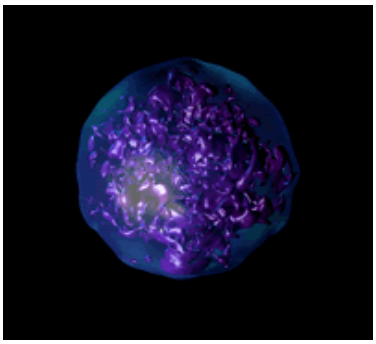

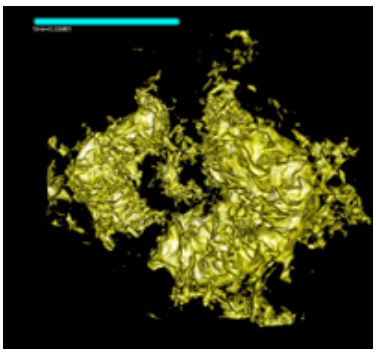

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