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Toward Realistic Supernova Models: Surprises in Three Dimensions[1]

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There is a growing body of evidence that core-collapse supernova explosions are inherently asymmetric. The origin of this asymmetry may arise in the first few hundred milliseconds after core collapse, when the nascent shock wave is susceptible to the spherical accretion shock instability (SASI), rapid neutrino heating drives large-scale convective flows, and distortions in the shock lead to non- uniform nuclear burning. We will present results from recent large-scale 2D and 3D simulations that are providing new surprises in this decades-old problem, including self-consistent explosions. The first high-resolution 3D simulations of the post- bounce accretion shock in core-collapse supernovae revealed the existence of a robust spiral mode of the SASI. The post-shock flow generated by this new mode leads to the accretion of angular momentum on the central proto-neutron star, suggesting a new mechanism for generating the rapid spin of young radio pulsars. The first 2D simulations to include a nuclear reaction network to track the energy generation at the stalled, aspherical shock front produce self-consistent explosions. When the oxygen shell of the progenitor star reaches the shock a few hundred ms after bounce, the energy generated by oxygen burning at the shock amplifies the non-spherical flows and drives a highly asymmetric explosion.

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