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Post-explosion Hydrodynamics in 3D Neutrino-driven Supernova Models

After decades of intense research, the "neutrino-driven explosion mechanism" has meanwhile been established as the most promising and widely accepted paradigm for the majority of core-collapse supernovae (CCSNe). Nevertheless, the question remained whether the neutrino-driven mechanism can explain the characteristic properties of observed supernovae, such as explosion energies, nucleosynthesis yields, and neutron star (NS) and black hole (BH) kicks and spins. In my talk, I will address this question by presenting most recent results from a growing set of three-dimensional (3D) neutrino-hydrodynamics simulations of the Garching group that extend over timescales of many seconds, i.e., significantly beyond the times when the explosions are launched. I will show that the highly non-linear post-explosion dynamics of 3D CCSN models with coexisting in- and outflows enable the long-lasting growth of the explosion energy, the efficient production of radioactive isotopes such as ^{44}Ti and ^{56}Ni, and the development of large-scale ejecta asymmetries, with important implications for NS and BH natal kicks and spins. Our results demonstrate that state-of-the-art 3D models of neutrino-driven CCSNe —if evolved over sufficiently long timescales —can reproduce the typical explosion properties as deduced from astronomical observations. One of the major remaining uncertainties in CCSN theory concerns the nuclear equation of state (EoS). Based on our set of recent 3D simulations, I will also discuss the impact of the EoS on the explosion dynamics and the properties of the new-born NSs, such as the development of proto-NS convection and the growth of neutrino emission anisotropies.

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