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Computational Models of Stellar Collapse, Core-Collapse Supernovae, and Black Hole Formation[1]

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I present an overview on the recent progress in the computational modeling of the core collapse of massive stars and the subsequent core-collapse supernova evolution. Despite many decades of theoretical and computational work, the precise mechanism driving core-collapse supernova explosions remains to be understood, but may involve (a combination of) post-core-bounce energy deposition by neutrinos, convective instability, the standing-accretion-shock instability (SASI), protoneutron star pulsations, rotational, and magneto-hydrodynamic effects. I introduce the ensemble of presently considered explosion mechanisms and show, on the basis of new Newtonian and general relativistic simulations, that gravitational waves emitted in a core collapse event can be used to distinguish between these proposed mechanisms. I go on to discuss the case in which the explosion fails and the neutron star is pushed over its maximum mass by continued accretion. I present new results on this process obtained with general relativistic hydrodynamics simulations of nonrotating and rotating stellar collapse and postbounce evolution using an approximate scheme for neutrino cooling and heating and a variety of microphysical finite-temperature equations of state.

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