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The Various Proposed Mechanisms of Core-collapse Supernova Explosions: A Status Report

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The explosion mechanism for core-collapse supernova explosions has exercised theorists for more than four decades. During that time, much progress was made in understanding the basic physics and hydrodynamics, but no robust, definitive, and satisfactory solution emerged. Although, the neutrino-driven heating mechanism is still the favorite of most researchers, it has not been demonstrated to work generically, particularly in 1D and 2D simulations. Recently, an acoustic mechanism and magnetohydrodynamic jets have been added to the mix and it has been shown that the majority of gamma-ray bursts must be associated with a small subset of core collapses. Moreover, a new class of energetic supernovae ("hypernovae") have been discovered. As a result, the study of the supernova mechanism has assumed a far wider portfolio and a greater richness than ever in the past. In this talk, I will discuss the menu of explosion mechanisms now available, and the status of multi-dimensional numerical simulations of the death of massive stars, the birth of neutron stars and black holes, and the origin of the elements. A theme of this talk will be the synergistic roles played by both sophisticated numerical simulation and nuclear physics, in all its particulars, in one of nature's most dramatic and important phenomena.