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Modern Quests in Nuclear Astrophysics

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Exotic nuclei and their properties play an important role in many astrophysical scenarios. During the supernova collapse electron captures on protons in neutron-rich nuclei is the dominating weak-interaction process. Here decisive progress has been achieved due to large-scale shell model calculations, constrained by data obtained from charge-exchange measurements on nuclei. Recently nuclear deexcitation by neutrino pair emission has been explored for the first time in supernova simulations. It has little effect on the dynamics, but is the major source of muon and tau neutrinos during the collapse phase. Important progress has also been achieved to describe inelastic neutrino-nucleus scattering on nuclei at the finite temperature of the collapse. Finally supernovae are also the site of explosive nucleosynthesis. This site as well as the mergers of two neutron stars are explored as the potential sites of the astrophysical r-process.

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