Fundamental Physics with Nuclei

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Abstract

Next-generation experiments are poised to explore lepton-number violation, discern the neutrino mass hierarchy, understand the particle nature of dark matter, and answer other fundamental questions aimed at testing the validity and extent of the Standard Model. Nuclei are used for these high-precision tests of the Standard Model and for searches of physics Beyond the Standard Model. Without a thorough understanding of nuclei, including electroweak structure and reactions, we will not be able to meaningfully interpret the experimental data nor can we disentangle new physics signals from underlying nuclear effects. To describe nuclear properties, I use many-body nuclear interactions and electroweak currents derived in chiral effective field theory, and Quantum Monte Carlo methods to solve for the nuclear structure and dynamics of the many-body problem for nuclei. This microscopic approach yields a coherent picture of the nucleus and its properties, and indicates that many-body effects are essential to accurately explain the data. In this talk, I will report on recent progress in Quantum Monte Carlo calculations of electron and neutrino interactions with nuclei in a wide range of energy and momentum transfer and their connections to current experimental efforts in fundamental symmetries and neutrino physics.