APR18-2018-000951

Abstract for an Invited Paper
for the APR18 Meeting of
the American Physical Society

Coupled-cluster calculations of atomic nuclei

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The past few decades have seen remarkable progress in our ability to describe atomic nuclei from first principle. It was only a few years ago that the lightest oxygen isotopes defined the absolute limits of our capabilities. Today, we set those limits in the tin isotopes and have already set our sights on heavier nuclei like lead and those beyond. Although a part of the reason for these advances lie in the ever-increasing capacity of high performance computing systems, we owe most of our progress to the introduction of many-body methods that scale polynomially with the number of particles in the system and to new interaction models that are based on the symmetries of quantum chromodynamics (QCD), the quantum field theory of the strong nuclear force. In this talk I will present some of our latest results in medium-mass nuclei obtained within the coupled-cluster framework. This framework consists of a series of methods to calculate properties of many-body systems to various degrees of precision. I will discuss a study of the charge, neutron and weak size of neutron-rich calcium isotopes and the structure of nickel-78, a doubly-magic closed-shell isotope of nickel that has an extreme neutron-to-proton ratio with 28 protons and 50 neutrons. The highlight will be a solution to the quenching puzzle of beta decays, a long-standing problem in nuclear physics where the observed beta-decay rates of nuclei are systematically smaller than theoretical predictions. All of these calculations has been performed using two- and three-body interactions obtained from chiral effective field theory, an interaction model of the nuclear force based on the symmetries of QCD.