New Horizons in Ab Initio Nuclear Structure Theory

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Low-energy nuclear theory has entered an era of ab initio nuclear structure and reaction calculations based on input from QCD. One of the most promising paths from QCD to nuclear observables employs Hamiltonians constructed within chiral effective field theory as starting point for precise ab initio studies. However, the full inclusion of chiral two- plus three-nucleon (NN+3N) interactions in exact and approximate many-body calculations beyond the few-body domain poses a challenge. I discuss recent breakthroughs that allow for ab initio calculations for ground states and spectra of nuclei throughout the p- and the lower sd-shell with full 3N interactions using consistent Similarity Renormalization Group (SRG) transformations and the Importance-Truncated No-Core Shell Model (IT-NCSM) [1,2]. This framework allows for predictions of nuclear structure phenomena of experimental relevance from QCD input as well as for a validation of the fundamental theoretical ingredients by confrontation with experimental nuclear structure data. I present a few highlights illustrating this two-way link between QCD and nuclear structure. Moreover, I discuss extensions of these ab initio calculations to heavy nuclei within coupled-cluster theory [3,4], to low-energy reactions of astrophysical relevance, and to p-shell hypernuclei.

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