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Nuclear Forces for ab Initio Nuclear Theory

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Predictive power requires the ability to quantify theoretical uncertainties. While it is true that theoretical error estimates are difficult to obtain, the pursuit thereof plays a pivotal role in science. Reliable theoretical errors can help to determine to what extent a disagreement between experiment and theory hints at new physics, and they can provide input to identify the most relevant new experiments. In this talk I will show that nuclear theory is at a stage where such questions can be addressed.
Chiral effective field theory can be used to systematically bridge the gap from low-energy quantum chromodynamics to nucleons and pions as effective nuclear-physics degrees of freedom. Following this avenue we have made the quantification of theoretical uncertainties possible through the incorporation of state-of-the-art statistical and computational tools. In particular, we employ two different approaches to determine the coupling constants of chiral nuclear interactions: (1) The simultaneous optimization of nucleon-nucleon, pion-nucleon and few-nucleon data, and (2) In-medium optimization for which binding energies and radii of selected isotopes of carbon and oxygen are also used as input data. I will present results from both of these different approaches that together provide important steps towards our understanding of nuclear forces.

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