Recent developments in ab-initio calculations*

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A long-standing goal in nuclear theory has been to arrive at a fully microscopic description for the properties nuclei based on the fundamental interactions between the constituent nucleons. Because of the advent of large-scale computing and recent theoretical developments, this is ideal is now beginning to be realized. The prospects for the future look bright indeed, as it is likely that within the next decade, we will arrive at fully ab-initio descriptions not only for low-lying structure, but also reactions, for nuclei ranging up to Oxygen. In addition, these ab-initio approaches will provide essential guidance for effective interactions to describe heavier nuclei. In this presentation, I will describe the present status of ab initio approaches. The starting point is the interaction between the constituent nucleons. In addition to empirical potentials, one very promising avenue is effective-field theory (EFT) based on the chiral symmetries of quantum chromo-dynamics. The power of EFT is that it offers a consistent framework to determine the two-body, three-body, and even four-body elements of the nuclear Hamiltonian. These new potentials can then be utilized in many-body methods, such as Green's Function Monte Carlo, the No-core Shell Model, or Coupled Clusters to describe the structure of light nuclei. We now know that in addition to providing more overall binding for nuclei, the three-body interaction is also responsible for much of what we would call spin-orbit physics in nuclei. Indeed, the three-body interaction is responsible for the ordering of levels for p-shell nuclei heavier than ^{10}B and the magnitude of Gamow-Teller transition amplitudes. I will also outline recent attempts to describe reactions. One such is a melding of the No-core Shell Model with the Resonating Group Method, which presents us with the ability to compute S-factors for light-ion fusion reactions relevant to stellar evolution.

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