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Scattering and reactions in ab initio nuclear theory[1]

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Over the past decade, much progress has been made toward understanding nuclei as collections of neutrons and protons, taking into account all of the complications of their interactions. Precise characterizations of the those interactions together with vast increases in computer power now allow ab initio calculations of many nuclear energy levels. Several ab initio computational methods are being pursued by different groups, and each has a distinct set of advantages and disadvantages. I will discuss the Argonne v_{18} interaction, the Illinois three-body interactions, and the quantum Monte Carlo computational methods. I will describe their past successes and the efforts currently under way to apply them to nuclear scattering and reactions. These methods have significant advantages in describing unbound states, because they involve no spatial basis functions and therefore do not require recourse to specialized bases or generator coordinate methods. Our results so far include radiative capture calculations in $A = 6$ and $A = 7$ systems, and a set of scattering calculations for $A = 5$. Our initial calculation of low-energy ^{4}He-neutron scattering has been particularly successful. General single-channel scattering and electroweak capture reactions for $A \leq 12$ are within grasp, and prospects for computing nucleon-transfer cross sections are good. A truly predictive ab initio description of reactions, if we can achieve it, will be a great boon to astrophysics as a supplement to cross section data from difficult laboratory experiments and as a source of reliable information about processes not observable in the laboratory. It will also greatly expand the range of laboratory tests for the nuclear potentials.

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