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**Tom W. Bonner Prize in Nuclear Physics Talk: Nuclear Forces and the Universe**[1]

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A major goal in nuclear physics is to understand how nuclear binding, structure, and reactions can be obtained from the underlying interactions between individual nucleons. Significant progress in formulating realistic Hamiltonian descriptions of nuclear interactions, and in accurately solving the many-nucleon Schrödinger equation, has been made over the past two decades. This includes the development of a number of two-nucleon ($NN$) potentials that accurately reproduce elastic $NN$ scattering data and deuteron properties, as well as consistent three-nucleon ($3N$) potentials and multi-nucleon charge and current operators. Using sophisticated many-body theory, such as the quantum Monte Carlo (QMC) methods described in the following talk, we find that realistic Hamiltonians can indeed reproduce the structure and reactions of light nuclei extremely well. The interactions that reproduce $NN$ scattering are quite complicated, including central, spin, isospin, tensor, and spin-orbit terms. One-pion exchange between nucleons and iterated two-pion exchange with intermediate-$\Delta$ excitations, which contributes to both $NN$ and $3N$ potentials, are crucial components. Using fully realistic potentials and progressively simplified versions in our QMC calculations, we have studied what elements of these forces are necessary to get some key features of nuclear structure, like the absence of stable five- and eight-body nuclei. This absence is important for primordial nucleosynthesis and the long-lived stability of stars like our sun. We can also study the sensitivity of nuclear binding to possible variations in hadronic masses. Thus we can address several questions about how "fine-tuned" our universe is.

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