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Title: Ab Initio Nuclear Structure Calculations of Light Nuclei

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The theory of the atomic nucleus focuses on predicting and explaining extensive classes of phenomena that occur in nuclei. These phenomena are important in the birth of the universe, in astrophysical settings, in energy generation via fission and fusion, and in industrial and medical applications via use of stable isotopes and radioisotopes. Several ab initio methods have now emerged that provide nearly exact solutions for the structure of light nuclei. In the ab-initio no-core full configuration (NCFC) approach, the nuclear wavefunction is expanded in Slater determinants of single-nucleon wavefunctions (Configurations), and the many-body Schrodinger equation becomes a large sparse matrix problem. The eigenvalues of this matrix are the binding energies, and the corresponding eigenvectors the nuclear wave functions, which can be employed to evaluate experimental quantities. In order to reach numerical convergence for fundamental problems of interest, the matrix dimension often exceeds two billion; obtaining the lowest eigenvalues and eigenvectors of such large sparse matrices poses significant challenges even on today's leadership class facilities. I discuss different strategies for distributing and solving this large sparse matrix on current multicore computer architectures, including methods to deal with with memory bottleneck. Several of these strategies have been implemented in the code MFDn, which is a hybrid MPI/OpenMP fortran code for nuclear structure calculations. With this code, we have been able to predict properties of the unstable nucleus 14F, which have since been confirmed by experiments; to explain the microscopic origins of the anomalously suppressed beta decay of 14C to the ground state of 14N using two- and three-nucleon forces from chiral effective field theory; and to describe the Be-isotopes, including emerging collective phenomena such as rotational band structures.