Contributions to the NUCLEI SciDAC-3 Project
Nuclear Theory Group, Michigan State University
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This is the Final Report for Michigan State University for the NUCLEI SciDAC-3 project. The NUCLEI project, as defined by the scope of work, has developed, implemented and run codes for large-scale computations of many topics in low-energy nuclear physics. Physics studied included the properties of nuclei and nuclear decays, nuclear structure and reactions, and the properties of nuclear matter. The computational techniques used included Configuration Interaction, Coupled Cluster, and Density Functional methods. The research program emphasized areas of high interest to current and possible future DOE nuclear physics facilities, including ATLAS at ANL and FRIB at MSU (nuclear structure and reactions, and nuclear astrophysics), TJNAF (neutron distributions in nuclei, few body systems, and electroweak processes), NIF (thermonuclear reactions), MAJORANA and FNPB (neutrinoless double-beta decay and physics beyond the Standard Model), and LANSCE (fission studies).

The main goals of the work carried out at MSU under the NUCLEI project have been: (i) To provide input microscopic interactions and operators needed for *ab initio* structure and reaction calculations; (ii) Perform independent *ab initio* calculations of nuclei and nuclear matter using the in-medium similarity renormalization group (IM-SRG); (iii) Develop modern computational infrastructure for nuclear density functional theory (DFT) to calculate observables (global properties and spectroscopy); (iv) Define the form of energy density functional (EDF) and optimize it to theoretical and experimental data; (v) Develop technologies to estimate theoretical uncertainties, in particular when extrapolating to unknown regions; and (vi) Through advanced computations guide experimental efforts.

During the course of this project, four Ph.D. theses were awarded: Erik Olsen (2014), Titus Morris (2016), Chunli Zhang (2016), and Nathan Parzuchowski (2017). Below we briefly review the results achieved by NUCLEI project and list NUCLEI publications and talks.

We are pleased to report substantial progress in all areas of the program. One measure of this progress is publications and invited material. Our research resulted in 81 journal publications, including 2 Nature Physics and 11 Phys. Rev. Letters. We presented our research in 70 invited and contributed talks at international meetings and 38 colloquia and seminars.