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Extending the No-core Shell Model to heavier nuclei¹

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The No-Core Shell Model (NCSM) has had considerable success in describing the binding energies, excitation spectra and other physical properties of light nuclei, $A \leq 16$, *e.g.*, [1]. The big challenge facing future NCSM investigations is how to perform such calculations for heavier nuclei, for which the model spaces become unmanageable with existing computers. Our current studies involve the development of new many-body approaches for achieving this goal, such as the idea of successive unitary transformations, so as to include the effects of *all* nucleons, as proposed by Navrátil, *et al.*[2]. We construct effective one-body, two-body and three-body interactions for the p -shell by performing $N_{max}\hbar\Omega$ *ab initio* NCSM calculations for $A = 5$, $A = 6$ and $A = 7$ nuclei, respectively, with $N_{max} = 2, 4, \dots, 12$ and projecting the many-body Hamiltonians onto the $0\hbar\Omega$ space. We show how the averaged many-body correlations modify the p -shell two-body Hamiltonian and explore the dependence of the effective one-body and two-body matrix elements on N_{max} . We will present the results of standard shell-model calculations using the derived effective Hamiltonian for p -shell nuclei with $A > 6$ and compare them to the exact NCSM results. The same procedure can be used for determining other effective operators within the p -shell, such as EM operators and transition operators.

[1] P. Navrátil, J. P. Vary and B. R. Barrett, Phys. Rev. C **62**, 054311 (2000).

[2] P. Navrátil, M. Thoresen and B. R. Barrett, Phys. Rev. C **55**, R573 (1997).

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