

Effective Interactions and Operators in Nuclei within the No-Core Shell Model

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The No-Core Shell Model (*NCSM*) [1,2] has had considerable success in describing the binding energies, excitation spectra and other physical properties of light nuclei, $A \leq 16$. One of the principal reasons for these successes is that one can exactly calculate the effective interactions and operators to be used in a given model space, using a *unitary transformation* approach [3,4,5,6] in a given cluster approximation, *e.g.*, usually for two-body or three-body clusters.

For a short-range operator, such as the nucleon-nucleon potential, this unitary-transformation method works extremely well at the two-body cluster level and good results are obtained for the binding energies and excitation spectra of light nuclei ($A \leq 16$). However, for long-range operators, such as the radius or the quadrupole moment, performing this unitary transformation at the two-body cluster level, does not include the higher-order correlations needed to renormalize these long-range operators adequately [7]. To do this, one must perform the unitary transformation at a higher-cluster level and/or perform the *NCSM* calculations in a larger model space. But both of these approaches become more and more difficult to carry out, as one increases the cluster level or the model-space size, respectively. Alternate possible approaches for including more higher-order correlations in small model spaces will be discussed.

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[†]Supported in part by NSF grant PHY-0244389.

[‡]This work was partly performed under auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

^{*}Supported in part by USDOE grant DE-FG-02-87ER40371.