COUPLED-CLUSTER APPROACH TO NUCLEI*

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Given that present nuclear structure research facilities and the proposed Rare Isotope Accelerator will open significant territory into regions of medium-mass and heavier nuclei, it becomes important to investigate theoretical methods that will allow for their description. These nuclei pose significant challenges to existing nuclear structure models, especially since many of them will be unstable and short-lived. How to deal with weakly bound systems and coupling to resonant states is an unsettled problem in nuclear spectroscopy.

The ab initio coupled cluster theory is a particularly promising candidate for such endeavors due to its enormous success in quantum chemistry. Refs. [1, 2] describe applications of coupled cluster techniques to nuclear structure. The coupled-cluster methods are very promising, since they allow one to study ground- and excited-state properties of nuclei with dimensionalities beyond the capability of present shell-model approaches, with a much smaller numerical effort when compared to the more traditional shell-model methods aimed at similar accuracies. For the weakly bound nuclei to be produced by the proposed Rare Isotope Accelerator, it is almost imperative to increase the degrees of freedom under study in order to reproduce basic properties of these systems.

Here we present several results from recent calculations with singles, doubles, and noniterative triples and their generalizations to excited states applied to the ^{4}He and ^{16}O nuclei. A comparison of coupled cluster results with the results of the exact diagonalization of the Hamiltonian in the same model space shows that the quantum chemistry inspired coupled cluster approximations provide an excellent description of ground and excited states of nuclei. The bulk of the correlation effects is obtained at the coupled cluster singles and doubles level. Triples, treated noniteratively, provide the virtually exact description. Extensions to open-shell nuclei will also be discussed.

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