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Monte Carlo shell model towards *ab initio* nuclear structure

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One of the major challenges in nuclear physics is to describe nuclear structure and reactions from *ab initio* calculations with nuclear forces based on nucleon degrees of freedom. Such calculations have recently become feasible for nuclear many-body systems beyond $A = 4$ due to the rapid evolution of computational technologies. Together with the Green's Function Monte Carlo and Coupled Cluster Theory, the No-Core Shell Model (NCSM) is one of the relevant *ab initio* methods and is now available for the study of nuclear structure and reactions in the p-shell nuclei. As the NCSM treats all the nucleons democratically, computational demands for the calculations explode exponentially as the number of nucleons increases. Current computational resources limit the direct diagonalization of the Hamiltonian matrix using the Lanczos algorithm to basis spaces with a dimension of around 10^{10}. In order to access heavier nuclei beyond the p-shell region with larger basis dimensions, many efforts have been devoted to the NCSM calculations. One of these approaches is the Importance-Truncated NCSM where the basis spaces are extended by using an importance measure evaluated using perturbation theory. Another approach is the Symmetry-Adapted NCSM where the basis spaces are truncated by the selected symmetry groups. Similar to these attempts, the no-core Monte Carlo Shell Model (MCSM) [1,2] is one of the promising candidates to go beyond the Full Configuration Interaction (FCI) method which is a different truncation of the basis states that commonly used in the NCSM. Here, we report recent developments of the MCSM and its application to the no-core calculations [1]. It is shown that recent developments enable us to apply the MCSM to the shell-model calculations without a core. Benchmarks between the MCSM and FCI methods demonstrate consistent results with each other within estimated uncertainties. No-Core Full Configuration (NCFC) results are also presented as full *ab initio* solutions extrapolated to the infinite basis limit.

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