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How to describe all nuclei at polynomial cost in the ab initio framework

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A strong effort will be dedicated in the coming years to extend the reach of ab initio nuclear-structure calculations to heavy doubly open-shell nuclei. In order to do so, the most efficient strategies to incorporate dominant many-body correlations at play in such nuclei must be identified. With this motivation in mind, the present work pedagogically analyses the inclusion of many-body correlations and their impact on binding energies of Calcium and Chromium isotopes. Employing an empirically-optimal Hamiltonian built from chiral effective field theory, binding energies along both isotopic chains are studied via a hierarchy of approximations based on polynomially-scaling expansion many-body methods. The spherical mean-field approximation is shown to display specific shortcomings in Ca isotopes that are efficiently corrected via the consistent addition of low-order dynamical correlations on top of it. While the same setting cannot appropriately reproduce binding energies in doubly open-shell Cr isotopes, allowing the unperturbed mean-field state to break rotational symmetry permits to efficiently capture the static correlations responsible for the phenomenological differences observed between the two isotopic chains. Eventually, the present work demonstrates in a pedagogical way that polynomially-scaling expansion methods based on unperturbed states that possibly break (and restore) symmetries constitute an optimal route to extend ab initio calculations to heavy closed- and open-shell nuclei.

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