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Ab initio nuclear mass model and the emergence of nuclear magicity

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How the nuclear magicity emerge from the underlying nuclear forces? Conventional understanding is based on the picture of the mean field, in which the nucleons move individually around onion-like orbits. Such a picture lacks the important many-body correlations and the connection to the bare nucleon-nucleon forces is obscure. We present a lattice nuclear force model capturing the essential elements of the nuclear binding and emergence of the magicity. Our model contains five adjustable parameters fitted to binding energies of medium-mass nuclei and can be solved non-perturbatively with sign-problem-free quantum Monte Carlo techniques. We obtain precision nuclear binding energies for A<=56 with an accuracy comparable with the state-of-the-art mean field models. Based on these numerial results, we discuss the dual role of the spin-orbit coupling in NN scattering and nuclear shell evolution.

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