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Euclidean Monte Carlo informed ground state preparation for quantum simulation

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Quantum simulators offer great potential for investigating the dynamical properties of quantum field theories. However, a key challenge is the preparation of high-fidelity initial states for these simulations. In this study, we focus on ground states and explore how information about their static properties, which can be efficiently obtained using classical methods such as lattice-based path-integral Monte Carlo performed on classical computers, can help identify suitable initial states. For the scalar field theory in 1+1 dimensions, we demonstrate variational ansatz families that yield comparable ground state energy estimates but exhibit distinct correlations and local non-Gaussianity. The simulation of quantum dynamics is expected to be highly sensitive to such initial state moments beyond the energy. We show that it is possible to optimize the behavior of selected ansatz moments using known ground state moments to address specific simulation needs. Drawing inspiration from the scalar field theory, our ultimate goal is to utilize existing lattice quantum chromodynamics (QCD) data to inform the preparation of the QCD ground state on quantum simulators.

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