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Variational ansatz inspired by quantum imaginary time evolution and its application to the Schwinger model

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An effective way to design quantum algorithms is by heuristics. One of the representatives is Farhi et al.'s quantum approximate optimization algorithm (QAOA), which provides a powerful variational ansatz for ground state preparation. QAOA is inspired by the adiabatic evolution of a quantum system, and the ansatz can encode the real time evolution of the system Hamiltonian. In this work, we provide a guidance to design the variational ansatz, which can encode general quantum evolution, including the quantum real time evolution (QRTE) and quantum imaginary time evolution (QITE). These heuristic variational ans\"atze preserve symmetries of the target quantum system. We construct the symmetry-preserving QITE-inspired and QRTE-inspired ans\"atze for the Schwinger model and Fermi-Hubbard model. We show the advantage of the QITE-inspired ans\"atze for the ground state preparation of these two models, compared to the one inspired by QRTE in the accuracy and efficiency. We demonstrate that the ground state and excited state properties of the Schwinger model can be studied using the QITE-inspired ansatz.

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