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Benchmarking variational quantum eigensolvers for detection of many-body Hamiltonian entangled ground state

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Variational quantum algorithms (VQA) has emerged in recent years as a promise to obtain quantum advantage in Noisy Intermediate Scale Quantum (NISQ) devices and processes. These task-oriented algorithms work in a hybrid loop where a quantum processor runs a parametrized quantum circuit and its outputs are evaluated on a classical computer. (1) The outputs guide the optimization process of the circuit parameters to reach the minimum value of the cost function where the solution for the studied problem is encoded. Variational quantum eigensolvers (VQE) are VQA systems where the cost function minimization gives the Hamiltonian ground state or spectra. (2) Using the VQEs we choose some parametrized quantum circuits to benchmark them at entangled ground state detection for many-body systems described by Heisenberg Hamiltonian. Due to the existence of entangled ground state of the Hamiltoninan, there is a set of entangled states that could be detectable using an energy-based entanglement witness. (3) Circuits with gates inspired in the Hamiltonian interactions presented faster cost function convergence than circuits where the Hamiltonian doesn't guide the gate selection.

Palavras-chave: Variational quantum algorithm. Entanglement. Quantum circuits.

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