Many-body quantum state preparation on quantum devices: current standpoint of variational methods and outlook

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Quantum computing platforms have been drawing much attention over the past few years in quantum chemistry and condensed matter [1]. In these domains a possibly large number of particles interact and exhibit quantum effects which are hard to tackle classically. Whereas the first prototypical quantum devices that are being built now are still greatly error-prone, the adoption of a variational appraoch (Variational Quantum Eigensolver - VQE [2]) as well as error mitigation strategies [3] has sparked the hope to leverage such devices in the near term to make computations escaping the reach of classical methods.

In this talk, I will be presenting an overview of the current situation regarding VQE, with a focus on the impact of noise onto the procedure. After a general overview, I will present an entropy-based framework [4] which allows to benchmark the viability of the VQE scheme in respect to a given optimization task and use it to shed light on the requirements for competitive ground state energy estimation for the Fermi-Hubbard model of strong electronic correlations. Then I will introduce a strategy we have put forth in order to reduce the requirements over the variational circuit depth with ideas borrowed from quantum chemistry, namely making use of the compacity associated with the representation of states in their natural basis [5, 6]. I will conclude with perspectives to reconcile the task of state preparation with the restricted capacities of near-term quantum computers.

References

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