Digital Quantum Simulation of Quantum Many-Body Dynamics on NISQ Devices

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In this talk I address the complex issue of utilizing Noisy Intermediate-Scale Quantum (NISQ) devices for simulating quantum many-body dynamics. Recent attempts to demonstrate quantum utility in this domain have been met with skepticism, as advanced tensor network methods quickly refuted these claims. The field faces a significant challenge: simulations requiring low entanglement are well within the grasp of tensor network approaches, but those needing deeper circuit depths encounter the 'universal attractor' of noise, leading to the loss of quantum coherence. In this context I will discuss some of our recent results using Trotterized time evolution [1], demonstrating the key problem and how far we can come with error mitigation. Then I will focus on two methods to tackle these issues in non-equilibrium systems like Floquet Hamiltonians. We have developed variational algorithms for approximating Floquet eigenstates [2] and a quantum-classical feedback scheme to stabilize discrete time crystals on NISQ devices, considering the impact of noise [3]. These approaches aim to navigate the delicate balance between entanglement, circuit depth, and noise in NISQ devices.

References

[1] B. Fauseweh and J.-X. Zhu, "Digital Quantum Simulation of Non-Equilibrium Quantum Many-Body Systems," *Quantum Inf. Process.*, **20**, 138, 2021

[2] B. Fauseweh and J.-X. Zhu, "Quantum computing Floquet energy spectra," *Quantum* **7**, 1063, 2023

[3] G. Camacho, B.Fauseweh, "Prolonging a discrete time crystal by quantum-classical feedback", arXiv:2309.02151, 2023

Figures

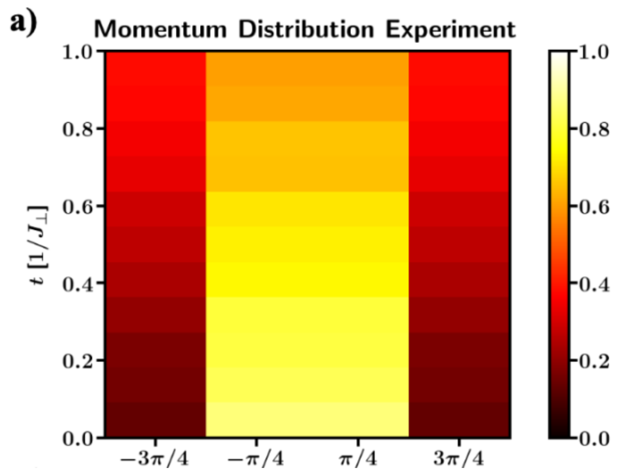

Figure 1: Simulation of a quantum quench in a fermionic system. Investigation into the thermalization of complex quantum matter through quantum simulation.

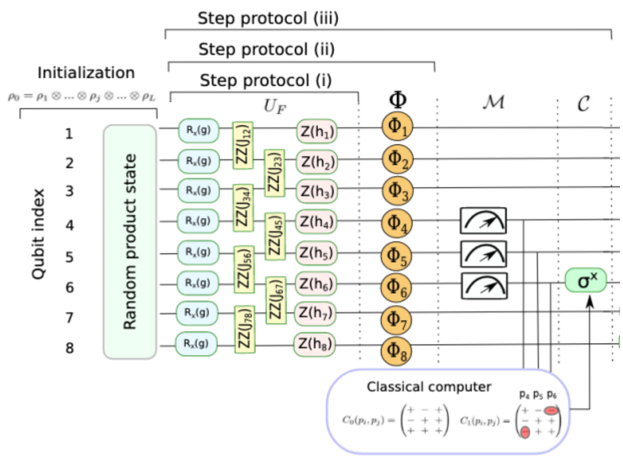

Figure 2: Quantum-Classical feedback scheme to stabilize a many-body localized discrete time crystal on a NISQ device.