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Enhancing quantum field theory simulations on NISQ devices with Hamiltonian truncation

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Quantum computers can efficiently simulate highly entangled quantum systems, offering a solution to challenges facing classical simulation of quantum field theories (QFTs). In this talk, we present an alternative to traditional methods for simulating the real-time evolution in QFTs by leveraging Hamiltonian truncation (HT). As a use case, we study the Schwinger model, systematically reducing the complexity of the Hamiltonian via HT while preserving essential physical properties. The HT approach converges quickly with the number of qubits, allowing for the vacuum persistence probability to be computed efficiently. Identifying the truncated free Hamiltonian's eigenbasis with the quantum device's computational basis avoids the need for complicated and costly state preparation routines, reducing the algorithm's overall circuit depth and required coherence time. As a result, the HT approach to simulating QFTs on a quantum device is well suited to noisy-intermediate scale quantum devices, which have a limited number of qubits and short coherence times. We validate our approach by running simulations on a noisy-intermediate scale quantum device, showcasing strong agreement with theoretical predictions. We highlight the potential of HT for simulating QFTs on quantum hardware.

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Short summary

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