

Peer Review

Review of: "Towards Quantum Simulation of Lower-Dimensional Supersymmetric Lattice Models"

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The paper "Towards Quantum Simulation of Lower-Dimensional Supersymmetric Lattice Models" explores the quantum simulation of $0 + 1$ -dimensional supersymmetric quantum mechanics (SQM) using gate-based quantum computing. The authors demonstrate how these systems, which are computationally prohibitive for classical methods due to the sign problem and exponential scaling of resources, can be efficiently encoded on quantum hardware. They employ the variational quantum eigensolver (VQE) algorithm to calculate ground-state energies, examining supersymmetry breaking or preservation. By using the Jordan-Wigner transformation for fermions and truncating bosonic operators to a finite number of modes, they map the model onto qubits, achieving significant computational savings.

The paper includes simulations with and without shot noise, highlighting its impact on detecting supersymmetry breaking. Preliminary results confirm the method's validity for certain superpotentials (e.g., Harmonic Oscillator and Double Well), but also reveal challenges in handling noise and convergence.

The work is sound and rigorous, provides insights into supersymmetric quantum simulations, and benchmarks NISQ-era algorithms. However, details on the VQE circuit depth and structure are absent, and real quantum hardware experiments were not conducted. Adding these elements would significantly strengthen the paper. The authors are encouraged to test their approach on IBM quantum hardware for small qubit systems if accessible.

All in all, I recommend the publication of the paper with minor revisions. Ensure the paper includes detailed VQE circuit specifications, its depth, and if possible, results from real hardware experiments

for small-scale systems. These additions would enhance the paper's comprehensiveness and practical relevance.

Declarations

Potential competing interests: No potential competing interests to declare.