Diagonalizing large many-body systems on a quantum processor using quantum Krylov

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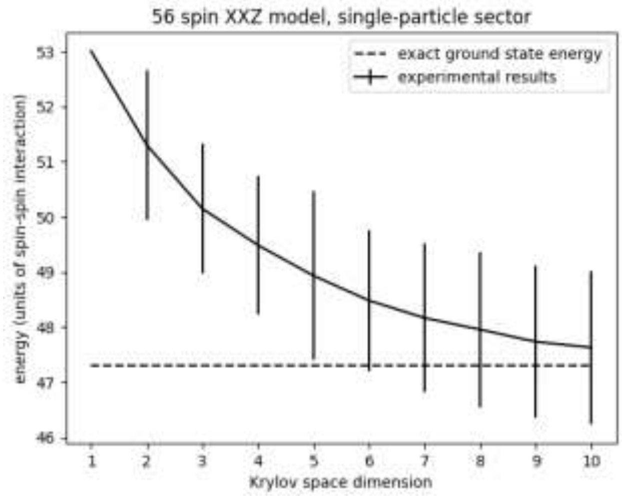
Abstract

In this talk, I will present experimental results on the simulation of ground state energies of Heisenberg XXZ models on a quantum computer. The method used is the quantum Krylov algorithm [1], a recently developed technique for approximating low-lying eigenenergies on near-term quantum computers without requiring a variationally-optimized quantum circuit. We show how symmetries of the model can be exploited to further simplify our circuits, and combined with the intrinsic noise resilience of the quantum Krylov algorithm and error mitigation techniques developed for large-scale simulations on superconducting quantum processors, we are able to show convergence to the ground state energy on two-dimensional systems of 50+ spins. The problem is parameterized such that one may seamlessly interpolate from the classically tractable regime to the classically intractable regime. Although effects of noise prevent us from reaching the latter in the current generation of experiments, this opens a clear and continuous path to demonstrating quantum advantage for ground state problems.

References

[1] Robert M. Parrish, Peter L. McMahon, "Quantum Filter Diagonalization: Quantum Eigendecomposition without Full Quantum Phase Estimation," arxiv:1909.08925 (2019).

Figures



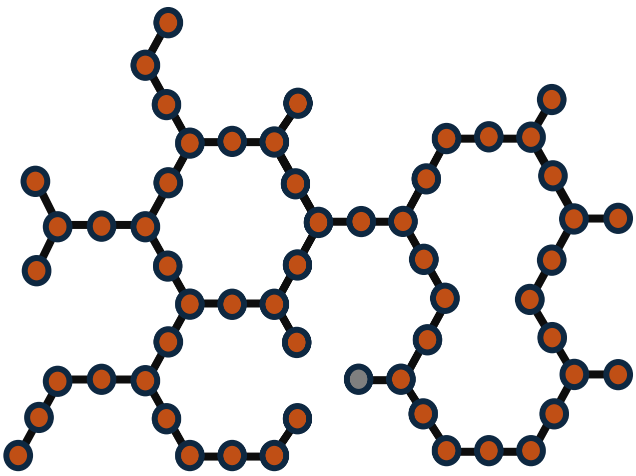


Figure 1: (top) results of quantum simulation of a 2D, 56-spin XXZ model in the single-particle sector using a quantum computer. (bottom) layout, including control qubit (gray).