Quantum Technology Initiative Journal Club

Report of Contributions

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Alexander Miessen (IBM)

Thursday 19 September 2024 16:00 (40 minutes)

TITLE: Benchmarking digital quantum simulations using quantum critical dynamics
Link to the paper: https://arxiv.org/abs/2404.08053

Abstract:
The real-time simulation of large many-body quantum systems is a formidable task, that may only be achievable with a genuine quantum computational platform. Currently, quantum hardware with a number of qubits sufficient to make classical emulation challenging is available. This condition is necessary for the pursuit of a so-called quantum advantage, but it also makes verifying the results very difficult. In this manuscript, we flip the perspective and utilize known theoretical results about many-body quantum critical dynamics to benchmark quantum hardware and various error mitigation techniques on up to 133 qubits. In particular, we benchmark against known universal scaling laws in the Hamiltonian simulation of a time-dependent transverse field Ising Hamiltonian. Incorporating only basic error mitigation and suppression methods, our study shows reliable control up to a two-qubit gate depth of 28, featuring a maximum of 1396 two-qubit gates, before noise becomes prevalent. These results are transferable to applications such as Hamiltonian simulation, variational algorithms, optimization, or quantum machine learning. We demonstrate this on the example of digitized quantum annealing for optimization and identify an optimal working point in terms of both circuit depth and time step on a 133-site optimization problem.

Presenter: MIESSEN, Alexander (IBM)

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