Hamiltonian and Lindbladian Learning with randomised Pauli states and measurements

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In the work, we propose a scalable Lindbladian measurement protocol for multi-qubits systems.
A generic characterization protocol for the Lindbladian, i.e. one that does not rely on strong assumptions about its form, is crucial in quantum computing and simulation platforms.
Following [1], we prepare the qubits in a random Pauli state, time-evolve under a Lindbladian (Hamiltonian and additional dissipation), and measure in a random Pauli basis.
We repeat the experiment multiples times, for various random configurations (set of initial states and measurement basis) and evolution times.
Using the randomness of the data [2], we reconstruct the time evolution of Pauli observables, $\langle O(t)\rangle = \mathrm{tr}[\rho O(t)]$, where ρ is an effective mixed state [1]. We then extract the derivatives at $t = 0$ via polynomial interpolation.
By choosing particular states ρ, we can isolate a few parameters in the Lindbladian and construct a small linear system of equations to determine them.
Following the “Divide and Conquer” algorithmic ideas, we learn the full Lindbladian parts by parts, which makes the protocol scalable with the system size.

We will show both numerical and experimental results on systems of 10 and 51 qubits, subject to power law interactions.

References

[1] Stilck França, D., Markovich, L.A., Dobrovitski, V.V. et al. Nat Commun 15, 311 (2024).
[2] Elben, A., Flammia, S.T., Huang, HY. et al. Nat Rev Phys 5, 9–24 (2023).

Figures

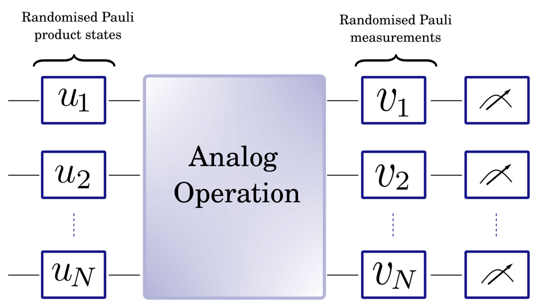

Figure 1: Schematic of the experimental setup

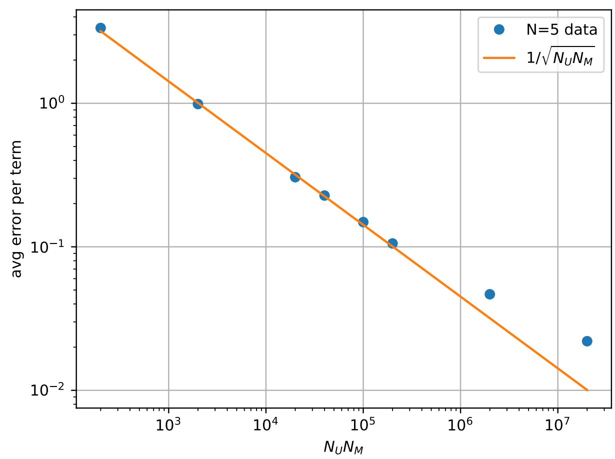

Figure 2: Error convergence with the number of experiments