Phases of quantum information on a noisy quantum processor

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Measurement plays a peculiar role in quantum mechanics: beyond revealing properties of a system, it can also affect its state in nontrivial ways and give rise to striking new phenomena. Among such phenomena are novel phases defined by the structure of quantum correlations (such as entanglement) in many-body systems away from equilibrium. I will discuss the experimental realization of these measurement-induced phases of quantum information on Google Quantum AI's superconducting processor [1]. By using a hybrid quantum-classical order parameter that correlates experimental data with classical simulation, we obtain signatures of distinct entanglement phases on up to 70 qubits; one of these phases exhibits emergent quantum teleportation, where the non-locality of measurements enables correlations beyond the standard causal “light cone” of unitary dynamics. Furthermore, we show that noise, an inevitable limitation of near-term quantum hardware, can in fact be used to our advantage as an independent probe of the phases.

References

[1] J. C. Hoke, M. Ippoliti, V. Khemani, and Google Quantum AI, Nature 622 (2023), 481-486

Figures

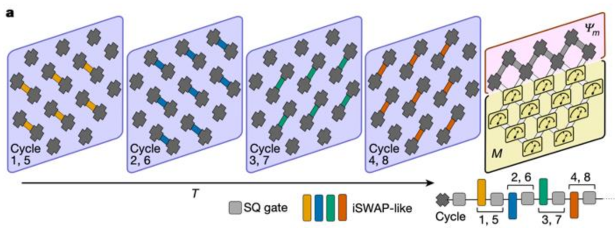

Figure 1: Quantum circuit implemented on Google Quantum AI’s superconducting processor.

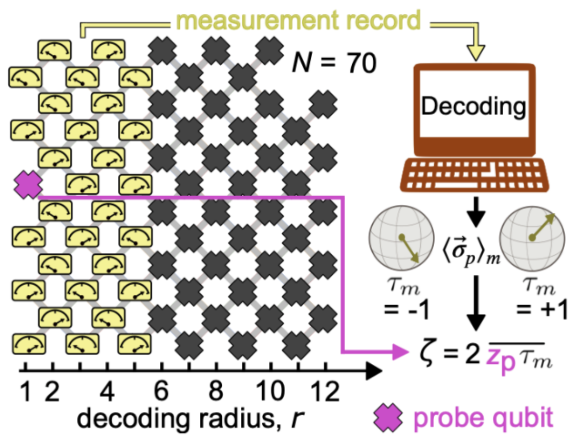

Figure 2: Quantum-classical order parameter to detect measurement-induced entanglement on a 70-qubit array.