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Simulating spin glass criticality of entanglement: theory, experiments, and algorithms

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Many elusive quantum phenomena emerge from the interaction of a quantum system with its classical environment. Quantum simulators enable us to program this interaction by using measurement operations. Measurements generally remove part of the quantum entanglement built between the qubits inside a simulator. While in simple cases entanglement may disappear at a constant rate as we measure qubits one by one, the evolution of entanglement under measurements for a given class of quantum states is generally unknown. In this talk, I will show how consecutive measurements of the qubits in a quantum processor can lead to entanglement criticality. Specifically, partial measurement of the qubits prepared in an entangled superposition of ground states to a classical spin model drives the qubit array into a spin glass phase of entanglement. Our theory is verified on quantum processors with up to 48 qubits, allowing us to experimentally estimate the vitrification point and its critical exponent, which obey spin glass theory exactly. Finally, I will discuss the potential to exploit the new physics discovered for the development of quantum algorithms.

Keyword-1

Entanglement

Keyword-2

Criticality

Keyword-3

Quantum computation

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