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Measurement-based quantum simulation of Abelian lattice gauge theories

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The digital quantum simulation of lattice gauge theories is expected to become a major application of quantum computers. Measurement-based quantum computation is a widely studied competitor of the standard circuit-based approach. We formulate a measurement-based scheme to perform the quantum simulation of Abelian lattice gauge theories in general dimensions. The scheme uses an entangled resource state that reflects the spacetime structure of each gauge theory. Sequential single-qubit measurements with the bases adapted according to the former measurement outcomes induce a deterministic Hamiltonian quantum simulation of the gauge theory on the boundary. Our construction includes the $(2+1)$-dimensional Abelian lattice gauge theory simulated on a 3-dimensional cluster state as an example and generalizes to the simulation of Wegner's lattice models that involve higher-form Abelian gauge fields. The resource state has a symmetry-protected topological order with respect to generalized global symmetries that are related to the symmetries of the simulated gauge theories on the boundary. We also propose a method to simulate the imaginary-time evolution with two-qubit measurements and post-selections.

Topical area

Quantum Computing and Quantum Information

Primary authors: Mr SUKENO, Hiroki (Stony Brook University); OKUDA, Takuya (University of Tokyo)

Presenter: OKUDA, Takuya (University of Tokyo)

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