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A Quantum Oracle for Constraint Preservation in SU(3) Lattice Gauge Theory Simulations

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Quantum simulation of non-Abelian gauge theories like QCD requires an efficient encoding of physical degrees of freedom that respects gauge invariance. The Loop-String-Hadron (LSH) formulation offers a promising path, significantly reducing the number of qubits required to represent the SU(3) invariant states in 1+1 dimensions compared to traditional approaches. While the LSH basis automatically satisfies the non-Abelian Gauss laws, remnant local constraints on flux numbers must still be upheld. During time evolution on noisy quantum hardware, errors can accumulate, taking the system out of the valid physical Hilbert space. To address this, we present the construction of a quantum oracle designed to check these local constraints on the qubit register. This talk will detail the LSH mapping for SU(3) and the design of the constraint-checking oracle. We will present a resource analysis, quantifying the costs in terms of qubit count, gate operations, and circuit depth, providing a crucial tool for error mitigation in future quantum simulations of QCD.

Parallel Session (for talks only)

Quantum computing and quantum information

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