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Quantum Simulation of Large N Lattice Gauge Theories

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A Hamiltonian lattice formulation of lattice gauge theories opens the possibility for quantum simulations of the non-perturbative dynamics of QCD. By parametrizing the gauge invariant Hilbert space in terms of plaquette degrees of freedom, we show how the Hilbert space and interactions can be expanded in inverse powers of Nc. At leading order in this expansion, the Hamiltonian simplifies dramatically, both in the required size of the Hilbert space as well as the type of interactions involved. Adding a truncation of the resulting Hilbert space in terms of local energy states we give explicit constructions that allow simple representations of SU(3) gauge fields on qubits and qutrits to leading order in large N. This enabled a simulation of the real time dynamics of a SU(3) lattice gauge theory on a 8x8 lattice with a superconducting quantum processor.

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