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SNAQs - Spin-Network Algorithms for Q-deformed Gauge Theories

Tuesday 5 March 2024 10:30 (1 hour)

The real-time dynamics of gauge theories is one of the most promising applications for quantum devices where future quantum simulations are expected to provide a practical advantage over classical computers. However, it remains an outstanding challenge to reformulate non-abelian lattice gauge theories in a way that is tailored to quantum information processing.
In this talk, I will present a new approach to this problem using a generalisation of the Kogut-Susskind Hamiltonian formulation, where the defining non-abelian Lie algebra is q-deformed to a quantum group. For the example of pure SU(2) lattice gauge theory in 2+1D, I will demonstrate that this formulation enables a controlled truncation on a finite dimensional Hilbert space that is naturally represented on a register of gauge-invariant spin-network states. Most importantly, the q-deformed Kogut-Susskind formulation preserves symmetry-related properties that allow us to construct efficient quantum circuits for Trotterized real-time evolution by analytically diagonalizing the plaquette operators using local changes of the spin-network basis. Additionally, our approach aligns well with tensor network methods and we numerically find that a simple variational ansatz already captures salient features of the continuum theory. Our work thus points to a new class of efficient quantum and classical algorithms to simulate non-abelian lattice gauge theories.

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