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3+1D Topological θ-Term in the Hamiltonian Formulation of Lattice Gauge Theories for Quantum and Classical Simulations

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Quantum technologies offer the prospect to efficiently simulate sign-problem afflicted phenomena, such as topological terms, chemical potentials, and out-of-equilibrium dynamics. In this work, we derive the 3+1D topological θ-term for Abelian and non-Abelian lattice gauge theories in the Hamiltonian formulation, paving the way towards Hamiltonian-based simulations of such terms on quantum and classical computers. We further study numerically a 3+1D U(1) lattice gauge theory with the θ-term via exact diagonalization. Our results suggest the occurrence of a phase transition at constant values of θ, as indicated by an avoided level-crossing and abrupt changes in the plaquette expectation value, the electric energy density, and the topological charge density.

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