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Hamiltonian Lattice Formulation of Compact Maxwell-Chern-Simons Theory

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Chern-Simons theory is a topological quantum field theory with numerous applications in condensed matter and high-energy physics, including the study of anomalies, fermion/boson dualities, and the fractional quantum Hall effect. The lattice formulation of pure Chern-Simons theory faces a doubling problem, which can be resolved by incorporating a Maxwell term, resulting in Maxwell-Chern-Simons theory. While the Lagrangian formulation for Euclidean spacetime lattices has been recently derived, a Hamiltonian formulation remains absent.

In this work, we address this gap by deriving a Hamiltonian lattice formulation of compact Maxwell-Chern-Simons theory using the Villain approximation. We analytically solve this theory and show that the mass gap in the continuum limit matches the well-known continuum formula. The inclusion of fermions necessitates numerical methods, but standard Monte Carlo simulations cannot simulate the theory due to the sign problem. Our Hamiltonian formulation of Maxwell-Chern-Simons theory lays the groundwork for future Hamiltonian-based simulations of the theory on classical and quantum computers.

Primary authors: PENG, Changnan (MIT); DIAMANTINI, Cristina (University of Perugia); FUNCKE, Lena (University of Bonn); HASSAN, Syed Muhammad Ali (Cyprus Institute); JANSEN, Karl (DESY); KÜHN, Stefan (DESY); LUO, Di (MIT); METLITSKI, Maxim (MIT); NAREDI, Pranay (Cyprus Institute); ROSANOWSKI, Emil Otis (HISKP, University of Bonn)

Presenter: FUNCKE, Lena (University of Bonn)

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