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Abelian Gauge Theories in 1+1D with Correlated Cluster Algorithms

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The Hamiltonian formulation of lattice gauge theories offers a pathway to new quantum and classical simulation techniques, providing new ways to circumvent different sign problems.In this work, we address different formulations of various Abelian gauge theories within the Hamiltonian framework in 1+1 dimensions. Using Correlated Cluster Algorithms, we exactly solve Gauss's law for $\mathbb{Z}_n$, truncated link, and quantum link models. This approach enables the efficient exploration of systems at finite θ-angle and with multiple flavors, avoiding the sign problem.

We leverage these algorithms to analyze different formulations of the theory, investigate their behavior at finite θ-angle, and examine their approach to the continuum limit. Our numerical results demonstrate that $\mathbb{Z}_n$ and truncated link models serve as more effective truncation schemes, offering improved convergence towards the infinite Hilbert space limit at each gauge link.

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