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Simulating (1+1)d Abelian Gauge Theories with Cluster Algorithms

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The Hamiltonian formulation of lattice gauge theories offers a pathway to new quantum and classical simulation techniques. Given the finite number of degrees of freedom in quantum simulators, it is necessary to make the Hilbert space for each link finite. In this talk, we discuss common approaches to achieve finite Hilbert spaces per link for (1+1)d Abelian gauge theories.
By adding constraints to a Meron cluster algorithm, we solve Gauss'law exactly for $\mathbb{Z}_n$, truncated link, and quantum link models. For the first two theories, we observe fast convergence when increasing the size of the Hilbert space, even for small couplings and moderate temperatures. However, quantum link models require larger Hilbert spaces per link. This provides insights for resource-efficient quantum simulations. Additionally, it facilitates taking a continuum limit through Monte Carlo simulations at finite theta without encountering a sign problem.

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