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Quantum Algorithms for Simulating the Lattice Schwinger Model

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The Schwinger model is a testbed for the study of quantum gauge field theories. We give scalable, explicit digital quantum algorithms to simulate the lattice Schwinger model in both NISQ and fault-tolerant settings. In particular, we analyze low-order Trotter formula simulations of the Schwinger model, using recently derived commutator bounds, and give upper bounds on the resources needed for simulations. We give scalable measurement schemes and algorithms to estimate observables which we cost in both settings by assuming a simple target observable: the mean pair density. Finally, we bound the root-mean-square error in estimating this observable via simulation as a function of the diamond distance between the ideal and actual CNOT channels. This work provides a rigorous analysis of simulating the Schwinger model, while also providing benchmarks against which subsequent simulation algorithms can be tested.

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