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Towards determining the (2+1)-dimensional Quantum Electrodynamics running coupling with Monte Carlo and quantum computing methods

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In this project we examine a compact U (1) lattice gauge theory in (2 + 1) dimensions and present a strategy for studying the running coupling and extracting the non-perturbative Lambda-parameter.
The methodology involves a series of sequential steps (i.e., the step scaling function) to bridge results from small lattice spacings to non-perturbative large-scale lattice calculations.
We propose variational Ansatz circuits adapted to gauge degrees of freedom and demonstrate that these quantum circuits are able to capture the relevant physics with a future plan to extend them to fermionic matter fields. In the latter case, one can study phenomena like confinement and asymptotic freedom.
In fact, QED in these dimensions has similarities with Quantum Chromodynamics (QCD) and it can thus be used as a test bed for future QCD studies.
In this work, we study the expectation value of the plaquette operator, for matching with corresponding Monte Carlo simulations
and also present results for the static potential and static force, which can be related to the renormalized coupling.
One advantage we see in a quantum approach is that it does not suffer from autocorrelation problems for small values of the bare coupling towards the continuum limit, as in the case with the classical Monte Carlo method.

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