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Strategies for the Determination of the Running Coupling of $(2+1)$-dimensional QED with Quantum Computing (II): Numerical Setup on Quantum circuits and Results

The Ansatz for studying 2+1-dimensional QED on a quantum computer is described. This comprises the transposition of the system onto a quantum circuit, and the Jordan-Wigner transformation for the numerical implementation of fermionic degrees of freedom. In order to find the low-lying eigenvalues of a given Hamiltonian and hence the mass-gap, we discuss an extension of the Variational Quantum Eigensolver algorithm, the so called Variational Quantum Deflation method. Instead of constructing the Ansatz such that only physical, i.e. gauge invariant states are expressed, we define penalty terms in the Hamiltonian that suppress unphysical contributions on the final states. Tests in the pure gauge system are presented and first results for the mass gap and the plaquette expectation value in the full theory, including fermionic matter are given.

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