Quantum Simulation of QED in 1D: Evidence of a Phase Transition

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We study a lattice and finite version of QED in 1+1 dimensions, where the gauge group U(1) is discretized with $\mathbb{Z}_n$. The model is obtained by requiring that the unitary character of the minimal coupling structure is preserved and has therefore the property of formally approximating lattice quantum electrodynamics in the large-n limit. The numerical study of such approximated theories is important to determine their effectiveness in reproducing the main features and phenomenology of the target theory. We perform a careful scaling analysis, by means of a DMRG code that exactly implements the Gauss law, and show that, in absence of a background field, all $\mathbb{Z}_n$-models exhibit a phase transition which falls in the Ising universality class, with spontaneous symmetry breaking of the CP symmetry. We then perform the large-n limit and confirm that the zero-charge sector of lattice U(1)-model has a phase transition at a negative critical value of the mass parameter, that we calculate.

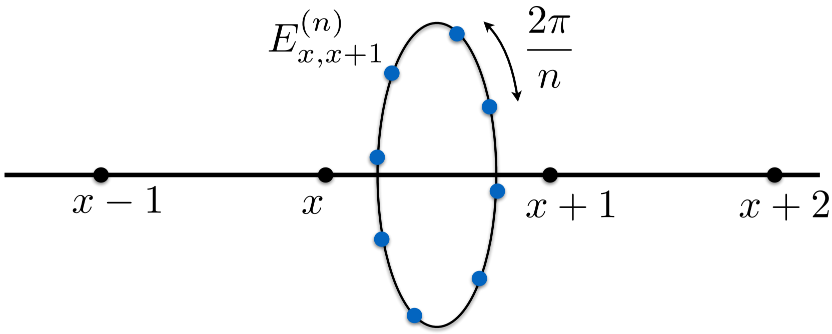

Figure 1. Discretization of QED in 1+1 dimensions (Schwinger model). Fermionic matter lives on sites x. The electric field $E^{(n)}_{x,x+1}$ lives on links and takes discrete values.

[1] Elisa Ercolessi, Paolo Facchi, Giuseppe Magnifico, Saverio Pascazio and Francesco V. Pepe, "Quantum Simulation of QED in 1D: Evidence of a Phase Transition", arXiv:1705.11047 [quant-ph] (2017).