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Real-time dynamics of lattice gauge theories with a few-qubit quantum computer

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Gauge theories are fundamental to our understanding of interactions between the elementary constituents of matter. However, computing the real-time dynamics in gauge theories is a notorious challenge for classical computational methods. This has recently stimulated theoretical efforts to devise schemes for simulating such theories on engineered quantum-mechanical devices. In this talk I will report on the experimental demonstration of a digital quantum simulation of a lattice gauge theory, by realizing quantum electrodynamics in one spatial dimension (the Schwinger model) on a few-qubit trapped-ion quantum computer. Of particular interest is the real-time evolution of the Schwinger mechanism, describing the instability of the bare vacuum due to quantum fluctuations, which manifests itself in the spontaneous creation of electron–positron pairs. This work represents a first step towards quantum simulation of high-energy theories using atomic physics experiments.

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