## Exploring Phase structure of the Schwinger model on superconducting Quantum Computers

We explore the phase structure of the lattice Schwinger model in the presence of a toplogical  $\theta$ -term, a regime in which conventional Monte Carlo simulations suffer from the sign problem, using the variational quantum eigensolver (VQE). Constructing a suitable variational ansatz circuit for the lattice model using symmetrypreserving 2-qubit gates, we perform classical simulations showing that the ansatz is able to capture the relevant physics. In particular, we observe the remnants of the well known first-order phase transition at  $\theta = \pi$  occurring in the continuum model for large enough fermion masses. Furthermore, we implement our ansatz on IBM's superconducting quantum hardware. Using state-of-the art noise suppression techniques, namely readout error mitigation, dynamical decoupling, Pauli twirling, and zero-noise extrapolation, we are able to explore the phase structure of the model directly on quantum hardware with up to 12 qubits. We study two regimes on the hardware device, a fermion mass well below the transition point and a fermion mass well above. In both cases, our ansatz performs well and we obtain data, which are in good agreement with exact diagonalization.

**Primary authors:** Mr ANGELIDES, Takis (DESY Zeuthen, Institut für Physik Humboldt-Universität zu Berlin); Ms CRIPPA, Arianna (DESY Zeuthen, Institut für Physik Humboldt-Universität zu Berlin); Prof. JANSEN, Karl (DESY Zeuthen, The Cyprus Institute); Dr KÜHN, Stefan (DESY Zeuthen); Mr NAREDI, Pranay (The Cyprus Institute); Prof. TAVERNELLI, Ivano (IBM Quantum, IBM Research –Zurich); Dr WANG, Derek S. (IBM Quantum, IBM T. J. Watson Research Center)

Presenter: Mr NAREDI, Pranay (The Cyprus Institute)

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