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Quantum simulation of entanglement and hadronization in jet production: lessons from the massive Schwinger model

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The possible link between entanglement and thermalization, and the dynamics of hadronization are addressed by studying the real-time response of the massive Schwinger model coupled to external sources. This setup mimics the production and fragmentation of quark jets, as the Schwinger model and QCD share the properties of confinement and chiral symmetry breaking. By using quantum simulations on classical hardware, we study the entanglement between the produced jets, and observe the growth of the corresponding entanglement entropy in time. This growth arises from the increased number of contributing eigenstates of the reduced density matrix with sufficiently large and close eigenvalues. We also investigate the physical nature of these eigenstates, and find that at early times they correspond to fermionic Fock states. We then observe the transition from these fermionic Fock states to meson-like bound states as a function of time. In other words, we observe how hadronization develops in real time. At late times, the local observables at mid-rapidity (such as the fermion density and the electric field) approach approximately constant values, suggesting the onset of equilibrium and approach to thermalization.

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