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Quantum simulation of string breaking in Schwinger model as open quantum system

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Currently there exists no viable "ab initio" approach to simulate QCD dynamics at the LHC/RHIC that is universally applicable. This profoundly limits our understanding of the formation, real-time evolution and hadronization of the quark-gluon plasma in heavy ion collisions. Quantum computing may provide a potential solution to efficiently simulate these real-time dynamics within the Hamiltonian formulation of QCD.

In this talk, we discuss a formulation to simulate hard probes of the QGP, such as heavy quarks or jets, on quantum computers through the formalism of open quantum systems [1]. As a start, we present quantum simulation of an open system described by a toy quantum field theory, by studying the non-equilibrium behavior and thermalization of the U(1) gauge theory in 1+1D, i.e., the Schwinger model [2]. We simulate string breaking of fermion pairs in the presence of a thermal environment, which provides a real-time picture of the microscopic dynamics of deconfinement and quarkonium dissociation. We report simulations both on classical simulators as well as quantum devices from IBM, using state-of-the-art error mitigation techniques. These formulations provide the groundwork to extend to QCD and simulate the dynamics of hard probes in the QGP, and we will discuss the prospects of doing so.

[1] de Jong, Metcalf, Mulligan, P\l osko\'n, Ringer, Yao: arXiv 2010.03571
[2] de Jong, Lee, Mulligan, P\l osko\'n, Ringer, Yao: arXiv 2106.08394

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