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Real-time evolution for quantum fields with quantum computers[1]

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Calculating the real-time evolution of strongly interacting quantum systems is very challenging. Important applications include collisions of hadrons and nuclei, out of equilibrium processes in many electron systems and information paradoxes in quantum gravity. Importance sampling in lattice Quantum Chromodynamics (QCD) is very effective to study static properties of hadrons but not for the study of unitary evolution at real (Minkowski) time. Quantum computations/simulations could fill this gap. We review new tensorial methods used to reformulate lattice gauge theories in a way suitable for quantum computing and compatible with existing global and local symmetries. We discuss concrete proposals of quantum simulation experiments with cold atoms for the Abelian Higgs model and other simple models in 1+1 dimensions. We report recent calculations for real time scattering for the quantum Ising model. We provide a Trotter procedure to implement the evolution on existing quantum computers and discuss the errors. We propose specific benchmarking procedures and apply them to three IBM machines. This shows steady progress as new devices become available. We discuss estimations of phase shifts from real time evolution.

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