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Quantum simulation of hadron scattering with NISQ devices

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Hamiltonian simulation of lattice gauge theories (LGTs) offers novel avenues for studying scattering processes in gauge theories. With the advent of quantum computers, it has become a reality. We present a digital quantum algorithm for simulating scattering in a 1+1D Z2 LGT on quantum hardware. The algorithm begins by preparing an initial scattering state composed of multiple well-separated wavepackets of hadrons. The hadronic eigenstates in this confined theory are constructed using an order-by-order improvable ansatz. We demonstrate the viability of our algorithm for the noisy intermediate-scale quantum (NISQ) hardware by preparing initial scattering states for system sizes up to 27 qubits on commercially available trapped-ion based quantum computers. We then implement a Trotterized time evolution algorithm to simulate the hadronic collision dynamics. Despite noise effects, symmetry-based noise mitigation during the post-processing provided results with significantly high fidelity, exceeding device benchmark expectations. Our results highlight the potential of quantum algorithms, enhanced by noise mitigation techniques, for simulating scattering processes, paving the way toward studying hadron scattering in gauge theories like QCD.

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