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Simulating fermionic scattering using a digital quantum computing approach (remote)

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Collider experiments play a central role in understanding the subatomic structure of matter, as well as developing and verifying the fundamental theory of elementary particle interactions. However, comprehending scattering processes at a fundamental level in theory remains a significant challenge. The necessarily involved time evolution and the with time rapidly increasing bond dimension in Tensor Networks make simulating the scattering process with this classical method challenging. On the other hand, quantum computers hold great promise to efficiently simulate real-time dynamics of lattice field theories. In this work, we take the first step in this direction towards simulating fermionic scattering using a digital quantum computing approach. Specifically, we propose a method based on Givens rotation to prepare the initial state of the fermionic scattering process, which consists of two fermionic wave packets with opposite momenta. With a time evolution operator based on the underlying Hamiltonian acting on the initial state, the two fermionic wave packets propagate and eventually interact with each other. Using the lattice Thirring model as the test bed, monitoring the particle density and the entropy produced during the scattering process, we observe an elastic scattering between fermions and anti-fermions in the strong interaction region. In addition, we perform a small-scale demonstration on IBM's quantum hardware, showing that our method is suitable for current and near-term quantum devices.

Presenter: Ms YAHUI, Chai (DESY)