Contribution ID: **20** Type: **Oral**

Simulating Parton Fragmentation on Quantum Computers

Monday, 25 November 2024 16:30 (20 minutes)

Parton fragmentation functions (FFs) are indispensable for understanding processes of hadron production ubiquitously existing in high-energy collisions, but their first principle determination has never been realized due to the insurmountable difficulties in encoding their operator definition using traditional lattice methodology. We propose a framework that makes a first step for evaluating FFs utilizing quantum computing methodology. The key element is to construct a semi-inclusive hadron operator for filtering out hadrons of desired types in a collection of particles encoded in the quantum state. We illustrate the framework by elaborating on the Nambu-Jona-Lasinio model with numeral simulations. Remarkably, We show that the semi-inclusive hadron operator can be constructed efficiently with a variational quantum algorithm. Moreover, we develop error mitigation techniques tailed for accurately calculating the FFs in the presence of quantum noises. Our work opens a new avenue for investigating QCD hadronization on near-term quantum computers.

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Session Classification: Parallel-2