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Exploring the Hadron Partonic Structure by Quantum Computing

We present a systematic quantum algorithm, which integrates both the hadronic state preparation and the calculation of dynamical light front correlation functions, to study the parton distribution functions (PDFs). As a proof-of-concept, we realize the first direct simulation of the PDFs in the 1+1 dimensional Nambu-Jona-Lasinio (NJL) model. We show the results obtained by numerical diagonalization and by quantum computation using classical hardware. The agreement between these two distinct methods and the qualitative consistency with the extracted pion PDFs validate our proposed quantum algorithms. Our work demonstrates the feasibility of calculating the hadron PDFs on current and near-term quantum devices. The quantum algorithms presented in this work can be extended to many applications in high energy particle and nuclear physics.

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