

Lattice QCD Determination of Transverse Force Distributions in the Proton

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Transverse force tomography [1] is a field still in its infancy and offers a new approach to our understanding of forces in Quantum Chromodynamics (QCD). A “Colour-Lorentz” force law can be constructed in the infinite momentum frame, describing the average transverse force experienced by a quark struck by a virtual photon in a Deep Inelastic Scattering (DIS) experiment [2]. These transverse forces offer a new perspective on colour-confinement and allow us to overcome the shortcomings of the static quark potential.

Such experiments, including the upcoming Electron Ion Collider at Brookhaven National Laboratory, offer an avenue to explore “higher twist” effects within the nucleon. Twist-2 parton distribution functions (PDFs) contain information about the longitudinal momentum distribution of partons, whereas these twist-3 PDFs contain information about quark-gluon correlations [3]. It is within these quark-gluon correlations that we can extract information about the transverse forces acting on the quarks. Lattice QCD provides a natural method for extracting the relevant off-forward matrix elements necessary for computing these forces.

We have performed an exploratory lattice QCD calculation of the spatial distribution of these “Colour-Lorentz” forces acting in the proton. We present the first lattice results of these transverse force distributions. Future calculations of these distributions will aim to refine the lattice systematics, bringing the results closer to the physical point.

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