Theoretical and Computational Physics highlights in November, 2023

EVOLUTION OF PDFs IN THE SHORT-DISTANCE FACTORIZATION SCHEME

The scale dependence of parton distribution functions (PDFs) is a critical part of QCD analyses of partonic structure of the nucleon and other hadrons, both from experiment and lattice QCD. In a new paper [arXiv:2310.19926] paper, Drs. Dutrieux, Karpie, Monahan, and Orginos discuss a nonperturbative approach to evaluating the evolution of parton pseudo-distributions, which are calculable in lattice QCD. A dedicated lattice QCD study of these evolution kernels at smaller volumes and lattice spacings is advocated in order to explore and extend the range of applicability of this technique.

GLUON HELICITY FROM GLOBAL ANALYSIS OF EXPERIMENTAL AND LATTICE DATA

A new global analysis [arXiv:2310.18179] of spin-dependent parton distributions by the JAM and HadStruc collaborations includes experimental data and lattice QCD simulations of Ioffe time pseudo-distributions sensitive to the gluon helicity distribution, Δg. The analysis focuses on the constraining ability of lattice data on the sign of Δg at intermediate parton momentum fractions x, which was recently brought into question by analysis of data in the absence of parton positivity constraints. The study finds that present lattice data cannot discriminate between positive and negative Δg solutions, although significant changes in the solutions for both the gluon and quark sectors are observed.

TOPOLOGICAL QUANTUM FLUCTUATIONS & GLUONIC STRUCTURE OF THE PROTON

The theory of QCD suggests that space-time is populated by quantum fluctuations of the gluon fields of so-called topological character, "winding," which generate most of the proton mass and produce many observable effects in hadron structure. A recent theoretical study [arXiv:2310.16890] by Drs. Kim and Weiss has computed the effect of these fluctuations on the short-distance structure of the proton measured in high-energy electron scattering (generalized parton distributions). The methods developed in this work enable a systematic characterization of the gluon degrees of freedom in hadrons in the nonperturbative domain covered in 12 GeV experiments at Jefferson Lab.

DOUBLE DISTRIBUTIONS & PSEUDO-DISTRIBUTIONS

A new approach to the extraction of generalized parton distributions (GPDs) has been formulated by Dr. Radyushkin based on the alternative definition of GPDs in terms of the so-called double distributions (DDs) and on the pseudo-distribution framework for lattice matrix elements [arXiv:2311.06007]. The advantage of using the DD formalism is that GPDs obtained in this way automatically have the necessary polynomiality property, and it also treats the important D-term contribution as an independent entity. This approach is already being used in ongoing lattice extractions of GPDs at Jefferson Lab.

NEW INSIGHTS INTO THE BOUBLY CHARMED EXOTIC MESONS

The nature of charmed XYZ states observed experimentally is critically important for our understanding of hadron spectrum in QCD. In a new paper [arXiv:2311.16938], Dr. Szczepaniak and collaborators analyzed the $D^0D^0\pi^+$, $\bar{D}^0D^0\pi^0$ and $D^0\bar{D}^{\star 0}$ invariant mass spectra, and gained further insights into the nature of the $T^+_{c\bar{c}}$ and $\chi^0_{c1}(3872)$ exotic hadrons by performing a simultaneous analysis of these doubly charmed and charm-anti-charm states. They found that both states lie below the respective open-charm $DD^\star/D\bar{D}^\star$ thresholds and both resonances are likely to be genuine bound states. They also predict the decay rates for their possible charge partners.