Theory and computation highlights in March, 2021

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Understanding the nature of the newly observed XYZP particles is a major challenge. Dr. Albaladejo of the Theory Center and collaborators computed the modifications of the DDbar* scattering amplitude when the system is in a medium of finite nuclear density (up to 0.17 fm-3) [arXiv:2102.08589]. By studying these modifications, they can also predict the in-medium modifications of the X(3872). In their calculations, they considered very general interactions for the DDbar* system, allowing to explore a large range of possibilities in which the X(3872) is a molecule, a compact quark state, or an admixture.

Dr. A. Accardi of the Theory Center, Dr. T. Hobbs of the EIC2, and collaborators have compared the impact of deuteron structure corrections on unpolarized PDFs fitted in two QCD global analysis frameworks [arXiv:2102.01107], with the aim of distinguishing data-driven features from methodological choices. The most recent CTEQ-TEA (CT18) and CTEQ-JLab (CJ15) analyses were supplemented by a number of procedural adjustments, and the recently-developed L2 sensitivity method used to analyze effects of deuteron corrections on pulls of data sets on the fitted PDFs. Deuteron corrections were seen not only to impact the large-momentum partonic structure of the proton, but also to significantly influence the accuracy of the extracted PDFs for TeV-scale analyses at hadron colliders.

A major challenge in lattice QCD calculations of hadron structure expressed as the matrix elements of operators separated along the light cone is the demand of having a sufficient reach in momentum to relate the quantities computed on the lattice to the important measures of hadron structure such as the Parton Distribution Functions and Generalized Parton Distributions. In a recent paper [Phys.Rev. D103 (2021) 034502], C. Egerer et al. of the Theory Center demonstrated that the combination of the distillation framework that allows both a more complete sampling of the gauge configurations and a computationally efficient use of the variational method, and of so-called momentum phasing that sensitivity to states in motion, can enable a far greater range in momentum to be achieved compared to more traditional approaches. This method is now core to the program of calculations of Parton Distribution Functions and of Generalized Parton Distributions by the HadStruc Collaboration.

A new Monte Carlo QCD analysis of pion parton distributions has been performed by the JAM Collaboration, led by Dr. N. Sato and Dr. W. Melnitchouk, including for the first time the transverse momentum dependent pion-nucleus Drell-Yan cross sections together with transverse momentum integrated Drell-Yan and leading neutron electroproduction data from HERA [arXiv:2103.02159]. The study assesses the sensitivity of the Monte Carlo fits to kinematic cuts, factorization scale and parametrization choice, and discusses the impact of the various data sets on the pion's quark and gluon distributions. The work provides the necessary step toward the simultaneous analysis of collinear and transverse momentum dependent pion distributions and the determination of the pion's three-dimensional structure.

A new global fit has been performed by Dr. A. Prokudin and collaborators from polarized semi-inclusive DIS, polarized pion-induced Drell-Yan, and W/Z boson production data up to next-to-next-to-next-to-leading order accuracy of the transverse momentum dependent evolution [arXiv:2103.03270]. The analysis has enabled the Sivers function to be extracted for up, down and strange quarks.