Theory and computation highlights in February, 2022
*(Contribution to the Director's Monthly Report to JSABOD)*

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The JAM collaboration presented the first global QCD analysis to extract polarized parton distribution functions (PDFs), unpolarized PDFs, and pion and kaon fragmentation functions, simultaneously [arXiv:2202.03372] by including the latest W-boson production data from polarized proton-proton collisions. These new data allow the first data-driven extraction of a nonzero polarized light antiquark asymmetry with minimal theoretical assumptions. This new effort allows for the first time a self-consistent set of polarized to unpolarized antiquark distribution ratios to be determined.

A new phenomenological tool has also been developed [arXiv:2201.12197] by the JAM collaboration to guide the analysis and interpretation of semi-inclusive deep-inelastic scattering measurements (SIDIS). The new tool, referred to as "affinity", helps physicists visualize and quantify the proximity of any experimental kinematic bin to a particular hadron production region, such as that associated with transverse momentum dependent factorization. As a first application, the affinity estimator has been used to analyze existing HERMES and COMPASS data, as well as expected SIDIS data from Jefferson Lab and the future Electron-Ion Collider.

A new paper by A. Szczepaniak and collaborators, titled "Pole analysis on the doubly charmed meson in D0D0π+ mass spectrum" has been accepted to be published in Physical Review Letters [arXiv:2108.06002]. They studied the scattering amplitudes of $D^0D^0\pi+$ and $D^{*+}D0$ coupled channels to investigate the property of the newly observed *X*-like $Tcc^+$ state by LHCb. Their analysis of analytical properties of the scattering amplitude suggests that it might be a virtual state rather than a genuine bound state.

Generalized parton distributions provide information on the three-dimensional quark and gluon substructure of the nucleon and other hadrons. A new paper by W. Melnitchouk and collaborators [arXiv:2202.00266] computes the GPDs of sea quarks in the proton from a nonlocal chiral effective theory, including one-loop contributions from intermediate states with pseudoscalar mesons, as well as octet and decuplet baryons. Flavor asymmetries for sea quarks at zero and finite momentum transfer, as well as strange form factors, are obtained from the calculated GPDs, and the results are compared with phenomenological extractions and lattice QCD calculations.

The US particle-physics community is currently engaged in the Community Planning Exercise, the so-called "Snowmass" exercise. Members of the Theory Center were key contributors to that process through a new paper [arXiv:2202.07193]. Here the importance of and challenges for lattice QCD studies in parton physics was articulated, emphasizing both how such calculations would have an important role in contributing to the particle-physics program over the next decade, and how future particle-physics experiments in concert with lattice QCD could contribute to our understanding of the internal structure of hadrons.

One of the goals of JLab's EIC science effort is to explore connections between EIC and the science programs at other particle accelerator facilities, in order to bring new people and expertise into the EIC community and enable synergistic physics studies. The recent workshop "Target fragmentation and diffraction physics with novel processes: Ultraperipheral, electron-ion and hadron collisions" at the Center for Frontiers in Nuclear Science at Stony Brook University, Feb 9-11, 2022, https://indico.bnl.gov/event/14009/ (Lead organizer C. Weiss, JLab Theory) considered novel measurements of proton fragmentation in high-energy scattering processes at LHC, RHIC, HERA, JLab 12 GeV and EIC and explored the synergies and complementarity between experiments using different energies and probes. The workshop brought together more than 70 researchers from the different facilities and enabled focused discussions and exchanges of new ideas. In particular, the workshop highlighted the potential of ultraperipheral heavy-ion collisions at LHC for performing QCD studies at significantly higher energies than EIC, and during the time when the EIC is still under construction.