Theory and computation highlights in May, 2021
(Contribution to the Director's Monthly Report to JSABOD)
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The impact of future EIC data for parity-conserving and parity-violating polarization asymmetries on the quark and gluon helicity distributions in the proton was addressed in a new study by Drs. N. Sato and W. Melnitchouk of the Theory Center, together with several students and postdocs, based on the JAM Monte Carlo global QCD analysis framework [arXiv:2105.04434]. The study explored the role of the extrapolation uncertainty and SU(3) flavor symmetry constraints in the simulated double-spin asymmetry A_{LL} at small parton momentum fractions x and its effect on the extracted parton polarizations. Different assumptions about A_{LL} extrapolations and SU(3) symmetry were found to have significant consequences for the integrated quark and gluon polarizations, for polarized proton, deuteron and 3He beams, while for the parity-violating asymmetry, A_{UL}, the study found the potential impact on the polarized strange quark distribution was ultimately limited by the EIC machine luminosity.

Electroweak transition processes involving multi-hadron channels in the final state play an important role in a variety of experiments, regardless if one is interested in accessing the excited spectrum of hadrons or testing the standard model of particle physics. Presently the primary theoretical tool with which one can study such reactions is lattice QCD, which is defined in a finite spacetime volume. In a new work [arXiv:2105.02017], Drs. Briceno, Dudek and Leskovec of the Theory Center investigated the feasibility of implementing existing finite-volume formalism in realistic lattice QCD calculation of reactions in which a stable hadron can transition to one of several two-hadron channels under the action of an external current. They provided a conceptual description of the coupled-channel transition formalism, a practical roadmap for carrying out a calculation, and an illustration of the approach using synthetic data for two non-trivial resonant toy models. Their results provide a proof-of-principle that such reactions can indeed be constrained using modern-day lattice QCD calculations, motivating explicit computation in the near future.

Theorists of Theory Center and the JPAC, together with experimentalists of Hall B have explored nucleon resonance contributions to inclusive proton structure functions [arXiv:2105.05834] computed from resonance electroexcitation amplitudes in the mass range up to 1.75 GeV that was extracted from CLAS exclusive meson electroproduction data. Taking into account interference effects between different excited states, the resonance contributions were compared with inclusive proton structure functions evaluated from $(e,e'X)$ cross section data and the longitudinal to transverse cross section ratio, with contributions from resonances remaining substantial up to photon virtualities $Q^2 < 4$ GeV^2. The structure functions in the resonance region were also compared with those computed from parton distribution functions extracted by fitting deep-inelastic scattering data and extrapolated to the resonance region, providing new quantitative assessments of quark-hadron duality in inclusive electron-proton scattering.