Theoretical and Computational Physics highlights in February, 2024

JLab Theory and Center for Nuclear Femtography (CNF), jointly with the Quark-Gluon Tomography (QGT) Topical Collaboration, will host a Fall School on Tomography that will take place beginning September 16, 2024, and the organization has begun. The school, targeting early-career researchers, will encompass lectures covering the key experimental and theoretical topics needed to advance our understanding of the three-dimensional internal structure of hadrons.

Transversity Distributions and Tensor Charges of the Nucleon
The JAM collaboration performed the first global QCD analysis of dihadron production for a comprehensive set of world data and extracted simultaneously the transversity distributions of the nucleon and $\pi^+\pi^-$ dihadron fragmentation functions. This work demonstrated for the first time the universal nature of transversity distributions and tensor charges of the nucleon from all available information, resolving a long-standing incompatibility [Phys.Rev.Lett., 132 (2024) 091901].

First determination of the partial wave amplitudes of the sigma meson from LQCD
The knowledge of these partial wave amplitudes, including crossing symmetry, from the Lattice QCD program at JLab provides the much needed support to the Lab's major efforts on the extraction of the resonance properties of hadrons [Phys.Rev., D109 (2024) 034513].

Transverse polarization of Λ hyperons in unpolarized pp collisions
A phenomenological study of the spontaneous transverse polarization of Λ hyperons produced in unpolarized proton-proton collisions inside a jet was made by Dr. Marco Zaccheddu and collaborators [arXiv:2402.01612], using a transverse momentum dependent (TMD) theoretical framework. This allows the exploration of the universality properties of the quark polarizing fragmentation function and the role of gluons in Λ transverse polarization. Predictions based on the parametrizations of the Λ polarizing fragmentation function, as extracted from fits to Belle electron-positron scattering data, were compared against preliminary STAR data.

Simultaneous reweighting of TMDs
A new analysis [arXiv:2402.12322] by Dr. Alexei Prokudin and colleagues performed a simultaneous reweighting of the quark Sivers, transversity, and Collins TMD functions extracted from semi-inclusive deep-inelastic scattering and e^+e^- annihilation into hadron pairs. The analysis assumes a TMD factorized model, and uses data on transverse single spin asymmetries, A_N, for inclusive pion production in polarized proton-proton collisions measured at RHIC. The resulting functions exhibit enhanced precision at large parton momentum fractions, x, and the extracted tensor charges agree with previous analyses, including those by the JAM Collaboration.

Hard-scattering approach to strongly hindered electric dipole transitions between heavy quarkonia
The strongly hindered electric dipole (E1) transitions between heavy quarkonia were explored in a new paper [arXiv:2402.19413] by Dr. Jia-Yue Zhang and collaborators. The work enriches the traditional method based on the multipole expansion that has been used to understand these transitions when the radiated energy is similar to the momentum of the heavy quark. By using the new "hard-scattering" method, the authors conduct a detailed numerical comparison with the standard prediction for various bottomonia and charmonia E1 transition processes.

Transverse momentum moments

Dr. Alexei Prokudin and collaborators presented a new paper [arXiv:2402.01836], which establishes robust relations between TMDs and collinear distributions by defining weighted integrals of TMDs known as transverse momentum moments (TMMs). The paper demonstrates that TMMs are equal to collinear distributions evaluated in some minimal subtraction scheme. It discusses in detail the zeroth, first, and second TMMs, and provides phenomenological results for these based on current extractions of TMDs.