Theory and computation highlights in January, 2023
(Contribution to the Director's Monthly Report to JSABOD)
February 10, 2023

Nucleon resonance contributions to the polarized proton g_1 and g_2 structure functons were computed in a new paper [arXiv:2212.11952] by Theory staff, Dr. Melnitchouk with theory and experimental collaborators, using resonance electroexcitation amplitudes extracted from CLAS exclusive meson electroproduction data. Including resonances in the mass range up to 1.75 GeV, and taking into account the interference between excited states, the resonant contributions are compared with the polarized proton structure func5on data from Jefferson Lab 6 GeV measurements. Comparing the resonance contribu5ons with the g_1 and g_2 structure func5ons computed from parton distribution functions extrapolated from the deep-inelas5c region, the paper also quantifies the degree to which quark-hadron duality holds for g_1 and g2 and their moments.

A major challenge in the LQCD calculation of the internal structure of hadrons is the calculation of the contribution of the so-called disconnected diagrams that conrtribute to the sea-quark an isosinglet distributions. In a new paper [arXiv:2212.04430] written by Jefferson Lab members in collaboration with computer scientists at William and Mary, the method of Frequency Splitting as a method of noise reduction in their calculation of disconnected diagrams is explored, demonstrating significant speedups versus other methods.

The confined motion of quarks and gluons inside a bound hadron is encoded in various transverse momentum dependent distributions of quarks and gluons, known as TMDs. They are connected to physical observed cross sections via QCD factorization. Typically, a production of a particle with a small transverse momentum in hadron-hadron collisions is described by CSS-based TMD factorization at moderate Bjorken $x_B \sim 1$, and by k_T-factorization at small x_B. Recently, Dr. Balitsky, a joint staff, has been developing a uniform description valid for all x_B by rapidity-only TMD factorization and achieved this at the tree level. In a new paper [arXiv:2301.01717], he extended the rapidity-only TMD factorization for particle production by gluon fusion to the one-loop level.

DOE Office of Nuclear Physics recently announced awards to five nuclear theory topical collaborations. Theory Center staff and joint staff are either lead or actively participate in four of the five awarded topical collaborations. The 3D Quark-Gluon structure of hadrons: mass, spin Tomography (QGT) collaboration with Co-PI from JLab will try to determine generalized parton distributions (GPDs) by combining theory, lattice QCD and experimental data analysis, and to explore the role of GPDs in understanding hadron mass, spin and tomography. The Nuclear Theory for New Physics (NTNP) collaboration with a bridged position to ODU/JLab will provide nuclear structure input for new physics searches, such as neutron/nucleus decays, neutrino-nucleus scattering, EDM and CP-violation, etc. The Heavy Flavor Theory for QCD matter (HEFTY) collaboration with key investigator from JLab will develop theoretical framework for using heavy flavors as probes of hot and cold QCD matter, including production, propagation and hadronization of heavy flavors. The Coordinated theoretical approach for exotic hadron spectroscopy (ExoHad) collaboration with PI and Co-PI from JLab (joint)staff will enable coordinated approach to exotic meson spectroscopy combining methods of amplitude

analysis, lattice QCD, and analysis of experimental data. The Saturated Glue Topical Collaboration (SURGE) does not include active investigator from JLab.