Theory and computation highlights in June, 2021
(Contribution to the Director's Monthly Report to JSABOD)
July 8, 2021

As the PI of a JLab QIS LDRD project, Robert Edward of Theory Center is working with the UVA/AMO group to extend its Quantum Computing system for calculations important to Nuclear Physics. The system is novel in that is uses a laser-based interferometer system for its quantum computing modes. The project is investigating a new technology for the detection of photons, and is acquiring two channels of a Superconducting Nanowire Single Photon Detector (SNSPD-s) system from Quantum Opus. This technology was developed at Duke University, and the company Quantum Opus is the sole licenser. The acquisition time of the
SNSPD-s is in the 10's of nanoseconds, and about 1000x faster than the existing superconducting Transition Edge Sensors used in the current system. The project will evaluate the new technology and aims to extend the photon-number resolving capability of the existing Quantum Computing system.

Transverse momentum dependent (TMD) parton distributions are an important focus of the JLab 12 GeV program to map out the 3D internal structure of the nucleon, and can be access in processes such as semi-inclusive lepton-nucleon deep-inelastic scattering or Drell-Yan (DY) lepton-pair production in hadronic reactions. The DY process was studied in a new paper [arXiv:2105.13391] by Dr. I. Balitsky in the framework of TMD factorization at high energies, corresponding to recent LHC experiments with lepton-pair mass (Q) of order of the Z-boson mass, and transverse momentum (q_T) of a few tens GeV. In the limit of a large number of colors and qT << Q, the resulting hadronic tensors were found to depend on two leading-twist TMDs: f_1, which is responsible for the total cross section, and the Boer-Mulders function, $h_1^\perp$. The corresponding qualitative and semi-quantitative predictions for the DY angular coefficients were computed and found to agree with the LHC data at the corresponding kinematics.

Two new papers by the Theory Hadstruc collaboration advanced the theoretical framework for computing Parton Distribution Functions (PDF) and Generalized Parton Distributions (GPDs) within lattice QCD. In [arXiv:2106.03875], a new method to compute the Wilson coefficients that enter into the calculation of the PDFs was proposed, and applied to the extraction of PDFs from extant lattice computations. In [arXiv:2106.01916], the framework and steps needed to extract the gluon PDF from calculations within the pseudo-PDF approach was further developed, providing key input to our on-going computations of the flavor-singlet structure of hadrons. An important computational challenge in the study of flavor-singlet hadron structure is the calculation of the so-called disconnected diagrams; an improved probing method was proposed in [arXiv:2106.01275], promising the prospect of an order-of-magnitude speedup of this part of the computation.

Colin Egerer, a William-and-Mary graduate student working at Jefferson Lab as a member of the Hadstruc Collaboration, successfully defended his PhD thesis Forward and Off-Forward Parton Distributions from Lattice QCD, in early June. Colin will be joining Jefferson Lab in a post-doctoral position in the Fall.