Theory and computation highlights in July, 2019
(August 1, 2019)

JLab, in partnership with FNAL and BNL, is deploying computing facilities under two LQCD facilities initiatives. These resources are shared amongst members of the USQCD collaboration for calculations that support the HEP and NP missions of DOE. The HEP portion of the facility program, underwent a review July 9-10. A panel of 7 theorists and experimentalists reviewed the program, and recommended funding the program for another five years at the requested amount - $2M/year. The JLab is also the center point of the ASCR/NP SciDAC-4 project on Lattice QCD. The annual PI meeting was held July 16-18, and the members of the project made presentations to DOE program managers as well as PI-s of the other SciDAC projects.

A major milestone was recently completed under the Exascale Computing Project related to work centered at JLab. Namely, the computations of Euclidean Correlation functions of many-body systems, including nuclei, is the essential quantities need to determine the scattering properties of nucleon-meson systems, as well as two nucleon and three nucleon systems. The new algorithmic improvements will be essential to carry out calculations of baryon spectroscopy and nuclear structure, including matrix elements within these systems - a major goal of the LQCD ECP project.

JPAC submitted the paper “Double Polarization Observables in Pentaquark Photoproduction” [arXiv:1907.09393], which was motivated by the recently discovered new pentaquark states by LHCb. It is an example of an intense cooperation between theory and experiment. JPAC for the first time presented a study of the polarization observables KLL and ALL in hidden charm pentaquark photoproduction due to their higher sensitivity to the signal when compared to data on differential cross sections. This research already produced a Letter of Intent for the SBS experiment in Hall A.

A collaboration of researchers from Jefferson Lab, NCSU, Beijing and Adelaide recently completed a comprehensive phenomenological analysis of quark flavor asymmetries in the proton, derived from a nonlocal realization of SU(3) relativistic chiral effective theory [arXiv:1907.08551 [hep-ph]]. Using finite-range regularization, with parameters constrained from inclusive baryon production in proton-proton collisions, the asymmetries between anti-down and anti-up quarks and between strange and anti-strange quarks in the proton were computed. The magnitude of the anti-down and anti-up asymmetry was found to be compatible with that extracted from the Fermilab E866 Drell-Yan measurement, with no indication of a sign change at large values of the parton momentum fraction, x. This behavior will be soon tested with new data from the Fermilab *SeaQuest* Drell-Yan experiment at higher x. The strange-antistrange asymmetry, on the other hand, is predicted to be positive at $x > 0$, with compensating negative delta-function contributions at $x=0$ needed to restore strangeness conservation.

JLab's EIC design will enable novel measurements of high-energy electron scattering on the polarized deuteron with detection of forward-moving spectator protons ("spectator tagging"). Developing the theory of such measurements and studying their physics potential has been a priority of the Theory Center in the last years. In a recent work, C. Weiss (JLab Theory) and W. Cosyn (Ghent U., Belgium) calculated the spin observables in deep-inelastic scattering on the longitudinally polarized deuteron with spectator tagging and studied their potential for neutron spin

structure extraction [arXiv:1906.11119, submitted to Physics Letters B]. They showed that the measured spectator proton momentum can be used to eliminate the D-state depolarization and other nuclear binding effects, enabling precise determination of the free neutron spin structure functions. The results of this study can be used for next-generation simulations of spectator tagging processes with EIC, whose feasibility was demonstrated in a JLab LDRD project in FY2014/15. Efforts are on-going to extend the theoretical calculations to spectator tagging with transversely and tensor polarized deuterons and explore the unique physics potential of such measurements.