Theory and computation highlights in June, 2020
(Contribution to the Director's Monthly Report to JSABOD)
July 8, 2020

June was a busy month for JLab's Theory Cetner. **Nobuo Sato**, our current Nathan Isgur Fellow in Nuclear Theory was awarded a 2020 DOE Early Career Award. This five-year award will be used to develop the most advanced theoretical and phenomenological tools to visualize the internal landscape of nucleons and nuclei with unprecedented resolution by integrating modern developments in nuclear theory, data science and artificial intelligence. **Antoni Woss**, a graduate student in Cambridge, was awarded this year's JSA Thesis prize with citation of his work done in collaboration with Theory Center's Jo Dudek and Robert Edwards, and gave an invited presentation at Annual JLab Users Organization Meeting in June. **Nathan Sherrill**, a Ph.D. student currently supported by Theory Center and supervised by Adam Szczepaniak, was awarded a fellowship by the Indiana University Space Grant Consortium. The **HadStruct Collaboration**, centered at the Theory Center as a multi-disciplinary team dedicated to understanding hadron structure through lattice gauge calculations, was awarded 100,000 node hours on the Summit supercomputer at Oak Ridge. This award follows a successful submission, led by Theory Center's Kostas Orginos, entitled "Hadron Structure from Lattice QCD" in response to the ASCR Leadership Computing Challenge (ALCC) call for proposals. The award will enable calculations exploring the 1D and 3D structure of the nucleon and pion.

J/ψ production has been a focus of theoretical and experimental interest since its discovery more than 45 years ago. The J/ψ transverse momentum distribution at the future EIC was evaluated in a new paper by Theory Center's Qiu and collaborators [arXiv:2005.10832] at both leading and next-to-leading order in the strong coupling in a new formalism involving both QCD, QED and nonrelativistic-QCD factorization. It was predicted that J/ψ's produced at the EIC are likely to be unpolarized, and the production is an ideal probe for the gluon distribution in the colliding hadron (or nucleus). It was also found that the J/ψ production at the EIC is dominated by the color-octet channel, providing an excellent probe for studying color propagation in large nuclei.

The EIC will enable novel experiments in high-energy electron scattering on the deuteron with polarized beams and detection of the "spectator" nucleon emerging from the nuclear breakup (spectator tagging). Such experiments offer unique opportunities for measuring the spin-dependent quark structure of the neutron and studying the effects of nuclear interactions. In a recent comprehensive article [arXiv:2006.03033], Theory Center's C. Weiss and his collaborator developed the theoretical framework for spectator tagging measurements with the polarized deuteron and studied the physics applications at EIC. It was shown that tagging allows one to control the effective neutron polarization in the deuteron and reveal novel nuclear binding effects (so-called tensor polarization). Simulations of such experiments are currently being performed as a part of on-going EICUG's effort for producing the EIC Yellow Report, using the theoretical framework developed by C. Weiss et al.

In a new paper [arXiv:2006.12543], Theory Center's W. Melnitchouk and collaborators from U. Manitoba used a new dispersive approach to compute the two-photon exchange correction to elastic electron-proton scattering, including contributions from hadronic $J^{PC} = 1/2^{+-}$ and $3/2^{+-}$ resonant intermediate states. The calculation used new exclusive meson electroproduction data

from CLAS at $Q^2 < 5$ GeV^2 for the resonant transition amplitudes, and explored the effects of fixed and dynamic resonant widths. The results were in good agreement with recent e^+p to e^-p cross section ratio and polarization transfer measurements, and provided compelling evidence for a resolution of the electric to magnetic form factor ratio discrepancy.