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

A collaboration between Theory Center nuclear physicists and computer scientists has resulted in a new strategy [https://arxiv.org/abs/2008.03151] for using artificial intelligence to build the first A.I.-based Monte Carlo Event Generator (MCEG) capable of faithfully generating the final state particle phase space in lepton-hadron scattering, without assumptions about the underlying femtometer-scale physics. As the first steps toward this goal, the new work presents a case study for inclusive electron-proton scattering using synthetic data from the PYTHIA MCEG for testing and validation purposes. The quantitative results validate the proof of concept, and demonstrate the predictive power of the trained models, suggesting new possibilities for data preservation to enable future QCD studies of hadrons structure at Jefferson Lab and the future Electron-Ion Collider.

The CLAS collaboration published the first measurement of exclusive reaction: $\gamma p \rightarrow a_2(1320)^0 p$ in the photon energy range 3.5-5.5 GeV in a recent paper [arXiv:2004.05359], written in collaboration with theorists from JPAC, which has been accepted for publication as a Rapid Communication in Physical Review C. The a_2 resonance was detected by measuring the reaction: $\gamma\, p \rightarrow \pi^0\, \eta\, p$ and reconstructing the $\pi^0\, \eta$ invariant mass. The most prominent feature of the differential cross section is a dip at $-t \approx 0.55$ GeV^2. This can be described in the framework of Regge phenomenology, where the exchange degeneracy hypothesis predicts a zero in the reaction amplitude for this value of the four-momentum transfer.

A new approach to QED radiative corrections (RCs) has been proposed in a Theory Center paper [arXiv:2008.02895], using a novel factorized scheme that puts radiation from leptons and quarks on the same footing. The method allows the systematic resummation of the logarithmically enhanced RCs into factorized lepton distribution and fragmentation (or jet) functions that are universal for all final states. The new method provides a uniform treatment of RCs for the extraction of parton distribution functions (PDFs), transverse momentum dependent distributions, and other partonic correlation functions from inclusive and semi-inclusive lepton-hadron scattering data.

Members of the Theory Center are actively participating in and contributing to the on-going Snowmass 2021 exercise, through contributions to various Letters of Interest, thereby providing input to the future of high-energy physics. Notably, Chris Monahan of the lattice QCD hadron structure group was the lead author of "Towards global fits of three-dimensional hadron structure from lattice QCD", a topic that is central to the future activities of the Jefferson Lab lattice group. "A recent paper calculating the PDF of the pion in lattice QCD [arXiv:2001.04960] has been accepted for publication in Physical Review D.