Theory and computation highlights in October, 2018
(Theory and computation to Drector's Monthly Report to JSABOD)
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The interplay of first-principles lattice QCD calculations and experimental results can unveil nucleon properties to higher precision and accuracy than either theory or experiment alone can attain. In a recent paper [aXiv:1809.03509], the Theory Center staff, David Richards and postdoc, Raza Sabbir Sufian, along with Prof. Liu of Univ. of Kentucky, presented their new analysis by using a combination of the strange-quark electromagnetic form factors from lattice QCD and (anti)neutrino-nucleon neutral-current elastic scattering cross sections from the MiniBooNE experiments in a kinematic region $0.3 < Q^2 < 0.7$ GeV^2 to obtain the most precise determination of the weak neutral-current axial form factor with weak axial charge $G^A{}_Z(0)$ = -0.734(63)(20), and strange quark contribution to the proton spin $\Delta\mathbf{s}$ = -0**.**196(127)(41). As a check of the calculation, a successful reconstruction is made of the independent (anti)-neutrino-nucleon scattering cross section data from Brookhaven National Lab. This calculation can have a significant impact on disentangling nuclear effects in the analysis of data from upcoming neutrino-nucleus scattering experiments. The paper was submitted to Phys. Rev. Lett. For publication.

The Joint Physics Analysis Center (JPAC) at JLab has extended its hadron spectroscopy analysis to include the phenomenological description of relativistic 3 ⇔ 3 reaction amplitudes. Within the isobar approximation, the connected part of the 3 ⇔ 3 amplitude is first expressed as a sum over initial and final pairs and then is expanded into a truncated partial wave series. The resulting unitarity equation is automatically fulfilled by the **B**-matrix solution, which is an integral equation for the partial wave amplitudes, analogous to the **K**-matrix parameterization used to describe 2 ⇔ 2 amplitudes, and analogies are made with formalisms for extracting 3 ⇔ 3 scattering amplitudes in lattice QCD [arXiv:1809.10523].

A new JPAC paper [arXiv:1809.06123] compared the CLAS measurement of di-pion resonances with theoretical predictions. Assuming that the $\boldsymbol{\pi}+\boldsymbol{\pi}-$ photoproduction at forward angles and high energies is dominated by one pion exchange, they calculated the $\boldsymbol{\pi}+\boldsymbol{\pi}-$ mass distributions for low partial waves. Predictions of the model calculations agree well with the experimental data which indicate that the **S** and **D** waves are dominated by the f_0(980) and f_2(1270 resonances, respectively, possibly revealing their QCD components.

Predictions for future high-energy cross section measurements or asymmetries at JLab or elsewhere depend on our knowledge of the uncertainties on the underlying partonic distribution functions. However, the *correlations* of contributions of the various functions also play a significant role. In a new paper, Dr. Alex Prokudin, one of the Theory Center's bridged staff members, together with his collaborators, carefully examined the correlations between the Sivers transverse momentum dependent (TMD) parton distribution and Collins TMD fragmentation function were these functions were extracted from experimental data, from which they demonstrated how these correlations influence the predictions for the Sivers asymmetry in Drell-Yan lepton-pair production and the Collins asymmetry in electron-positron annihilation. The knowledge and the correlation of the Sivers and Collins functions are critically important for analyzing the semi-inclusive deep inelastic scattering data at JLab.