Theory and computation highlights in September, 2020
(Contribution to the Director's Monthly Report to JSABOD)
October 5, 2020

Theory Center staff organized two workshops in last month. As the principal organizer, Dr. Weiss organized the well-attended CFNS workshop on "Target fragmentation physics with EIC" [September 28-30, 2020, https://indico.bnl.gov/event/9287/overview]. Dr. Szczepaniak and colleagues of JPAC organized a Workshop on Light Hadron Exotics as part of the Snowmass planning process [https://indico.fnal.gov/event/45338/]. The workshop was attended by over 60 participants and featured presentation from JPAC, GlueX, BESII, LHCb, and others.

Theory staff and collaborators reported the first determination directly from QCD of the hadronic decays of the light exotic resonance, the π_1 [arXiv:2009.10034v1], which provides important information for the searching effort of such exotic resonance at JLab. Using lattice QCD, the finite-volume spectrum of QCD on multiple volumes were used to constrain a scattering system featuring eight coupled channels. Lattice QCD calculations necessarily most determine the full scattering matrix, and cannot restrict to sub-channels. The couplings and width reveal that the dominant decay mode is to b1*pi with much smaller decays into f1*pi, rho*pi, eta'*pi and eta*pi. The calculations suggest that that there is a single pi_1 pole corresponding to the resonance which is broad ~500MeV. The prediction of the mass and width is potentially in agreement with the experimental $\pi_1(1564)$ candidate state, which has been observed in eta*pi and eta'*pi, which they suggest maybe highly suppressed decay channels.

Theory staff presented the first nonperturbative determination of an energy-dependent three-hadron scattering amplitude using lattice QCD [arXiv:2009.04931v1]. Over 30 finite-volume energy levels with the quantum numbers of three pions were determined and subsequently used to constrain the three-body K matrix. The latter was then used as an input for three-body integral equations, which were solved numerically to obtain the full scattering amplitudes illustrated in two Dalitz-like plots.

Dr. Melnitchouk of Theory Center and collaborators performed a comprehensive study of the spin carried by strange quarks in the proton [arXiv:2008.11902v1] in the framework of chiral effective field theory. By matching hadronic and quark level operators, generalized convolution formulas were obtained for the quark distributions in the proton in terms of hadronic splitting functions and quark distributions in the hadronic configurations. Within the limits of parameters of the Pauli-Villars regulators derived from inclusive hyperon production, the polarized strange quark distribution was found to be rather small and mostly negative. The predictions are consistent with phenomenological results from global QCD analyses, such as those performed by the JAM (JLab Angular Momentum) Collaboration, within currently large uncertainties.

DOE has recently announced funding of the program "US-Japan exchange program for studies of hadron structure and QCD" [DOE Proposal Nr. 000255515], with the aim to support scientific collaboration between the US and Japanese hadronic physics communities in areas relevant to the experimental programs with JLab 12 GeV, J-PARC, and the future EIC. The 3-year program, which was proposed jointly by Kyungseon Joo (University of Connecticut, PI), Ken Hicks (Ohio University, Co-Investigator), and Christian Weiss (JLab Theory Center, Co-Investigator), will

support visits of US scientists to Japan and has a funding volume of $75K per year. Dr. Weiss will coordinate the scientific management of the exchange program (application review, communication, programmatic development) as part of his regular duties at JLab. A particular aim of the exchange program is to realize synergies between the hadronic physics studies with electromagnetic probes at JLab 12 GeV and with hadronic probes at J-PARC, both operating in the same multi-GeV energy range. Topics of common interest include the quark/gluon structure of hadrons, baryon and meson spectroscopy, and hyperons and hypernuclear physics. Their Japanese colleagues have expressed their intent to initiate a reciprocal program on their side, supporting visits of Japanese scientists at US institutions.