Theory and computation highlights in January, 2020
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A collaboration between Theory Center staff and computer scientists from Old Dominion University and Davidson College has applied generative adversarial network (GAN) technology to build an event generator that simulates particle production in electron-proton scattering, free of theoretical assumptions about underlying particle dynamics. The first publication from the project [arXiv:2001.11103], supported by Jefferson Lab's LDRD program (LDRD20-18), described the development of a GAN that selects a set of transformed features from particle momenta that can be generated easily by the generator, and uses these to produce a set of augmented features that improve the sensitivity of the discriminator. The new Feature-Augmented and Transformed GAN (FAT-GAN) is able to faithfully reproduce the distribution of final state electron momenta in inclusive electron scattering, without the need for input derived from domain-based theoretical assumptions. The developed technology can play a significant role in boosting the science of the Jefferson Lab 12 GeV program and the future Electron-Ion Collider.

The pion, the lightest hadron, plays a pivotal role in our understanding of QCD, and the exploration of its structure forms a key element of both the experimental and theoretical programs at Jefferson Lab, and at facilities worldwide. In a new paper [arXiv:2001.04960], submitted to Physical Review Letters, members of the Theory Center and their collaborators performed a first-principles calculation of the valence Parton Distribution Function using lattice QCD, including an investigation of the systematic uncertainties inherent in such calculations. They found good agreement with the experimentally extracted Parton Distribution Function across the range of longitudinal momentum fraction x, with a small preference for a softer distribution at large x where the greatest theoretical interest lies.

Hadron resonances appear in scattering amplitudes which can be obtained from the discrete spectrum of states calculated in lattice QCD. In the case of multiple coupled-channels, practically implementing the relationship is challenging. Theory joint staff, J. Dudek and collaborators developed a pragmatic solution method to make use of a eigenvalue decomposition of the finite-volume quantization condition [arXiv:2001.08474]. This new approach makes possible QCD calculations of the kind of resonances observed in GlueX and CLAS which can decay into many final states.

In recent years Dalitz decays, in particular those of heavy mesons, revealed signatures of several exotic hadrons. There has been, however, no uniformity in amplitude analyses performed by various experiments which makes estimation of systematic uncertainties difficult. In a recent paper [Phys. Rev. D (in press), arXiv:1910.04566], JPAC clarified the use of helicity and LS formalisms in analysis of Dalitz decays, and their approach can be used as a gold standard and is already been adopted in several LHCb analyses.