Theory and computation highlights in April, 2022
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The pion is one of the most important particles in nature, yet three-quarters of a century after its discovery fundamental questions remain about its properties and behavior. A new paper [arXiv:2204.00543] by JLab Theory, jointly with the JAM and HadSpec collaborations, reports on the extraction of the pion parton distribution functions (PDFs) in a Monte Carlo global QCD analysis of experimental data, together with pseudo-PDFs and matrix elements generated from lattice QCD. By including both experimental and lattice QCD data, the analysis was able to rigorously quantify both the uncertainties of the pion PDFs and the systematic effects intrinsic to the lattice QCD observables. Consistent with recent phenomenological determinations, the behavior of the valence quark distribution of the pion at large momentum fractions is found to be $\sim(1-x)^{\beta}$, where β=1.0-1.2.

Hadron transverse densities have emerged as a key concept in nucleon structure physics. The functions $\rho 1,2(b)$ describe the transverse coordinate distributions of charge and current in the nucleon at fixed light-front time $x^+ = x^0 + x^3$ and provide a spatial representation appropriate to the relativistic nature of the dynamical system. In a new paper [arXiv:2204.11863], JLab theorist, Weiss and collaborator, computed the densities at peripheral distances $b = O(M^{-1}\pi)$, where they are generated predominantly by the two-pion states in the dispersive representation, and quantified the uncertainties. They computed and discussed the light-front current distributions in the polarized nucleon, and obtained accurate densities at all distances $b > 0.5$ fm, with correct behavior down to $b \to 0$. They concluded that peripheral nucleon structure can be computed from first principles using DIχEFT. Their method can be extended to generalized parton distributions and other nucleon form factors.