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Basis Light-Front Quantization: Advancing a First Principles Approach for Hadrons

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Basis light-front quantization (BLFQ) is a fully relativistic and nonperturbative method based on a light-front quantized Hamiltonian with input from Quantum Chromodynamics (QCD), offering the potential for first-principle calculations. In our QCD applications, we incorporate a form of confinement derived from light-front holography and additional longitudinal confinement into the Hamiltonian. This approach ensures that BLFQ results align with both global fitting and experimental data for various hadronic properties. Recent progress includes expanding Fock spaces to include five-particle sectors, such as the five-quark and three-quark-two-gluon sectors, and incorporating relevant QCD interactions to replace the effective confining potential. By utilizing the light-front wave functions generated by BLFQ, we compute observables such as parton distribution functions (PDFs) of gluons and sea quarks at low-resolution scales and evolve them to higher scales in line with QCD, enabling comparison with experimental extractions. In conclusion, I will also discuss potential directions for future advancements.

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