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Toward precise ξ gauge fixing for the lattice QCD

Lattice QCD provides a first-principles framework for solving Quantum Chromodynamics (QCD). However, its application to off-shell partons has been largely restricted to the Landau gauge, as achieving high-precision ξ-gauge fixing on the lattice poses significant challenges. Motivated by a universal power-law dependence of off-shell parton matrix elements on gauge-fixing precision in the Landau gauge, we propose an empirical precision extrapolation method to approximate high-precision ξ-gauge fixing. By properly defining the bare gauge coupling and then the effective ξ, we validate our ξ-gauge fixing procedure by successfully reproducing the ξ-dependent RI/MOM renormalization constants for local quark bilinear operators at 0.2\% level, up to $\xi \sim 1$.

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