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One-loop QCD propagators in CFDJ gauge

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Content

The study of QCD correlation functions in covariant gauges beyond the Landau gauge is an important step towards a more complete understanding of strong-interaction dynamics and its low energy properties. In the Landau gauge, massive extensions of the Faddeev–Popov action such as the Curci–Ferrari model [1] have provided a remarkably successful perturbative description of Yang–Mills correlators deep down to the infrared, in good agreement with lattice simulations [2–7]. These results motivate the exploration of other gauge choices.

A particularly interesting class is provided by the Curci–Ferrari–Delbourgo–Jarvis (CFDJ) gauges [8], which are renormalizable and possess non-renormalization theorems that simplify the analysis of correlation functions. In particular, the CFDJ gauges admit a formulation as an extremization problem, allowing for a direct implementation on the lattice [9]. This makes them promising candidates for future nonperturbative simulations in QCD with dynamical quarks.

In the present work, we extend previous studies on both the unquenched CF model at one-loop in the Landau gauge fixing [10] and on purely gauge CFDJ model at one-loop [11] as well, taking now into consideration both dynamical matter and gauge fields in the CFDJ gauge fixing at one-loop for a general gauge parametre. Our calculations shows that quark fluctuations tend to increase the IR saturation value of the propagators – both for gluons and ghosts – without changing the overall qualitative behaviour.

On the other hand, there seems to be a major difference between the Landau gauge fixing at one-loop and general CFDJ gauge fixing on the quark sector. Firstly, the constituent mass of the quark seems to decrease as the gauge parameter is increased. Secondly, and perhaps more interestingly, the dressing function of the quark shows a change of concavity when one varies the gauge parametre, from Landau gauge (zero value) to general CFDJ gauges (finite values). This could indicate a richer behaviour at one-loop than that reported in the Landau gauge fixing at one-loop – where an unexpected discrepancy with lattice calculations appears at one-loop [10], with the corresponding dressing functions have opposite concavities and profiles towards the IR. This suggests that the CFDJ behaves better at a lower order of the loop expansion than the Landau gauge – at least for this quantity – since to solve this issue in Landau, a two-loop calculation is required [12].

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