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The three-gluon vertex from quenched lattice QCD in Landau gauge

The three-gluon vertex plays a central role in the infrared dynamics of Quantum Chromodynamics (QCD). Gluon self-interaction is the main difference between this theory and others like quantum electrodynamics (QED); namely its non-abelian nature. The appearance of a three-gluon vertex in the QCD Lagrangian is intimately linked to both asymptotic freedom and confinement in QCD. The study of its non-perturbative features has attracted attention for the last decades in both Dyson-Schwinger and lattice simulations [Alkofer:2004it, Cucchieri:2006tf].

The three gluon vertex depends on the incomimg momenta, q, r and p, with the kinematical constrain $q + r + p = 0$. Most lattice studies focus in the symmetric ($q^2 = r^2 = p^2$) and soft-gluon ($p = 0$, and thus $q^2 = r^2$) cases where there is a single momentum scale [Boucaud:2017obn, Aguilar:2021lke, Aguilar:2021okw]. Both kinematics exhibit an infrared zero-crossing which can be understood as a consequence of the gluon-mass generation while the ghost remains massless [Aguilar:2021uwa].

In this work, we present recent results [Pinto-Gomez:2022brg] for the three-gluon vertex from quenched lattice-QCD in extended kinematics, i.e., beyond the limiting symmetric and soft-gluon ones. We have employed a special tensorial basis, whose form factors are naturally parametrized in terms of individually Bose-symmetric variables, in order to study both, the previously studied kinematics and the new ones, including the bisectoral case ($q^2 = r^2$) and the completely general case.

From our lattice results, two outstanding features of the non-perturbative three-gluon vertex emerge:

- the form-factor associated to the tree-level tensor is clearly dominant over the others.
- the scalar form factors depend almost exclusively on the symmetric variable $s^2 = (q^2 + r^2 + p^2)/2$. Thus, all kinematical configurations lying on a plane with constant s^2 in the coordinate system (q^2, r^2, p^2) share, to a high degree of accuracy, the same values of the form factors, a property that we denominate planar degeneracy.

Being its study of paramount theoretical relevance by itself, the three-gluon vertex is also a central component in a variety of phenomenological studies in the continuum. In particular, the outstanding feature of infrared suppression [Cucchieri:2006tf, Huber:2012zj] displayed by its main form factors is instrumental for the formation of bound states with the right physical properties. This ongoing search, based on the profitable synergy between lattice simulations and continuum methods, has afforded a firmer grip on delicate underlying patterns, establishing prominent connections with the emergence of a mass-scale in the gauge sector of the theory [Aguilar:2021okw, Aguilar:2008xm, Boucaud:2008ky].

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