# Quark Confinement Physics in Quantum Chromodynamics

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We study the quark confinement physics [1-9] in term of the dual superconductor picture, using the dual Ginzburg-Landau (DGL) theory [1-5] and the lattice QCD Monte Carlo simulation in the maximally abelian (MA) gauge [8,9]. In the MA gauge, QCD is reduced into an abelian gauge theory including color-magnetic monopoles.

1. We find the effective mass generation of off-diagonal gluon components in the MA gauge using the SU(2) lattice QCD [8]. The off-diagonal gluon mass is evaluated as $M_{\rm off} \simeq 1$ GeV in the MA gauge. Therefore, in the MA gauge, the off-diagonal gluon does not contribute to the long-distance QCD physics such as confinement [9] and chiral-symmetry breaking, which predicts general infrared abelian dominance in the MA gauge. In fact, QCD in the MA gauge is found to resemble the strong-coupling compact QED at the larger scale than $M_{\rm off}^{-1} \simeq 0.2$fm [8].

2. Using the SU(2) lattice QCD, we numerically extract the dual gluon field $B_\mu$ from the monopole world-line appearing in the MA gauge, and investigate the dual Wilson loop and the inter-monopole potential. As the evidence of the dual Higgs mechanism by color-magnetic monopole condensation, we find the dual gluon mass as $m_B \simeq 0.5$ GeV in the lattice QCD [8]. This supports the DGL theory as a realistic infrared effective theory of QCD, and $m_B \simeq 0.5$ GeV provides the key paremeter of the DGL theory.

Thus, in the MA gauge, the off-diagonal gluon contribution can be neglected and monopole condensation occurs at the infrared scale of QCD. Therefore, the QCD vacuum in the MA gauge can be regarded as the dual superconductor described by the DGL theory as shown in Figure 1 [8], and quark confinement can be understood with the dual Meissner effect [1-5].

# References

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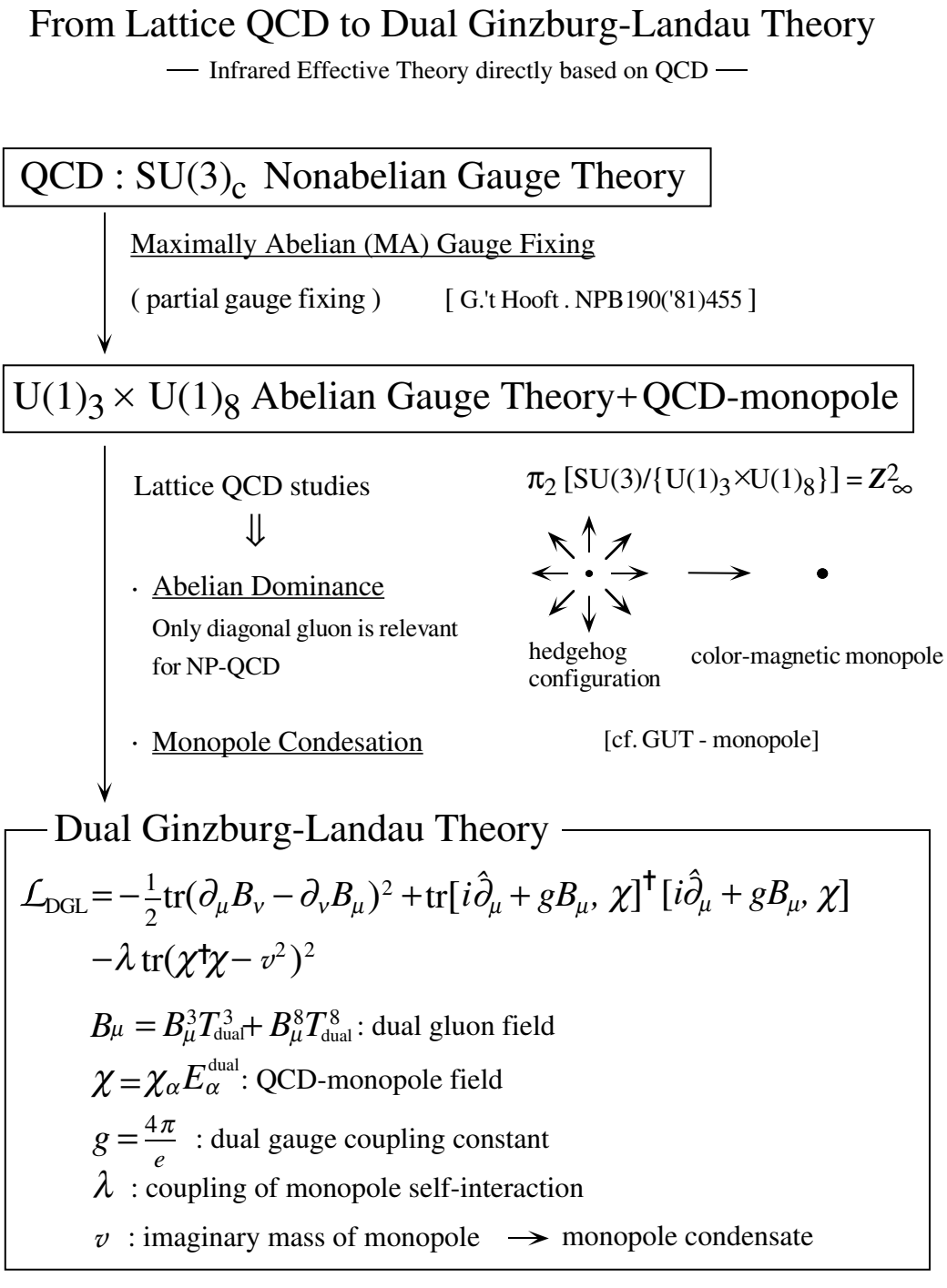


Figure 1: Construction of the dual Ginzburg-Landau (DGL) theory from the lattice QCD in the maximally abelian (MA) gauge.