Abelianization of QCD in the Maximally Abelian Gauge and the Nambu-'t Hooft Picture for Color Confinement

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We study the Nambu-'t Hooft picture [1,2] for color confinement in terms of the abelianization of QCD and monopole condensation in the maximally abelian (MA) gauge [3]. In the MA gauge in the Euclidean metric, the off-diagonal gluon amplitude is strongly suppressed, and then the off-diagonal gluon phase shows strong randomness, which leads to a large off-diagonal gluon mass [4]. Using SU(N_c) lattice QCD with $N_c = 2, 3$, we study the effective off-diagonal gluon mass $M_{\rm off}$ through the Euclidean gluon propagator $G^{ab}_{\mu\nu}(x-y) \equiv \langle A^a_\mu(x) A^b_\nu(y) \rangle$ in the MA gauge with U(1)$_3$($\times$U(1)$_8$) Landau gauge [5]. From the slope analysis of $\ln\{r^{3/2} G_{\mu\mu}(r)\}$, we find a large effective mass of the off-diagonal gluon in the MA gauge as $M_{\rm off} \simeq 1.2$ GeV in SU(2) lattice QCD with $2.2 \leq \beta \leq 2.4$ and $12^3 \times 24$, 16^4, 20^4, $M_{\rm off} \simeq 1.1$ GeV in SU(3) lattice QCD with $\beta = 5.7$ and $12^3 \times 24$. In the MA gauge, due to the large effective mass $M_{\rm off} \simeq 1$GeV, off-diagonal gluons can propagate only within a short range as $r < M_{\rm off}^{-1} \simeq 0.2$fm, and becomes *infrared inactive* like weak bosons in the Standard Model, which leads to well abelianization of infrared QCD in the MA gauge like nonabelian Higgs theories.

Using SU(2) lattice QCD, we study also the inter-monopole potential and the dual gluon propagator in the monopole part in the MA gauge, and find a direct evidence of the *dual Higgs mechanism by monopole condensation* as the *longitudinal magnetic screening* with the dual gluon mass $m_B \simeq 0.5$ GeV in the infrared region.

To conclude, QCD in the MA gauge exhibits *infrared abelian dominance* and *infrared monopole condensation*, which lead to the Nambu-'t Hooft picture for color confinement.

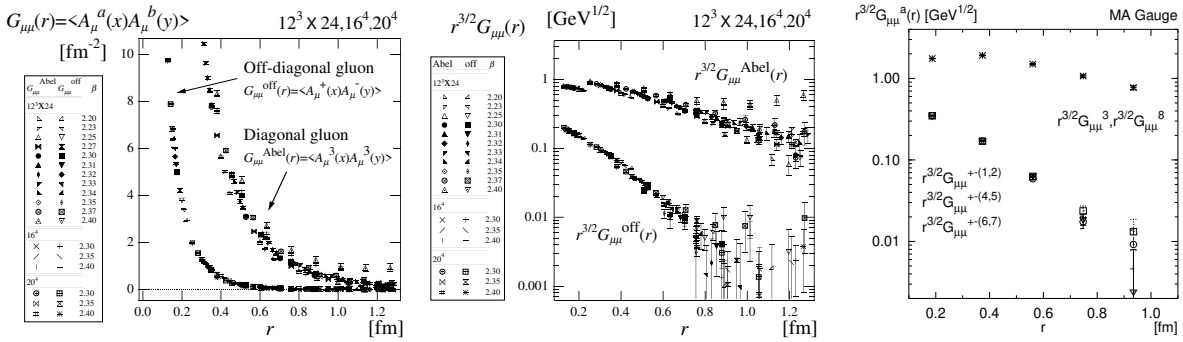

Figure 1: (a) The scalar-type gluon propagator $G^a_{\mu\mu}(r)$ v.s. 4-dim. distance r in the MA gauge in SU(2) lattice QCD. (b) The logarithmic plot of $r^{3/2} G^a_{\mu\mu}(r)$. (c) The logarithmic plot of $r^{3/2} G^a_{\mu\mu}(r)$ on the gluon propagator $G^a_{\mu\nu}(r)$ in the MA gauge in SU(3) lattice QCD.

References

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