Vacuum type of SU(2) gluodynamics in maximally Abelian and Landau gauges

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The vacuum type of $SU(2)$ gluodynamics is studied using Monte-Carlo simulations in maximally Abelian (MA) gauge and in Landau (LA) gauge, where the dual Meissner effect is observed to work. The dual Meissner effect is characterized by the coherence and the penetration lengths. Correlations between Wilson loops and electric fields are evaluated in order to measure the penetration length in both gauges. We show that the coherence length could be derived directly from the measurement of the monopole density around a chromomagnetic flux spanned between a static quark-antiquark pair. We use the dual Ginzburg-Landau effective theory of infrared $SU(2)$ gluodynamics, evaluate the monopole density around the flux theoretically and compare it with the value obtained numerically. It is also shown numerically that a dimension 2 gluon operator $A^+A^-(s)$ and the monopole density has a strong correlation as suggested theoretically. Such a correlation is observed also between the monopole density and $A^2(s) = A^+A^-(s) + A^3A^3(s)$ condensate if the remaining U(1) gauge degree of freedom is fixed to U(1) Landau gauge (U1LA). The coherence length is determined numerically also from correlations between Wilson loops and $A^+A^-(s)$ and $A^2(s)$ in MA + U1LA gauge. Assuming that the same physics works in the LA gauge, we determine the coherence length from correlations between Wilson loops and $A^2(s)$. Penetration lengths and coherence lengths in the two gauges are almost the same. The vacuum type of the confinement phase in both gauges is near to the border between the type 1 and the type 2 dual superconductors.

Quantity	gauge	ζ [fm]	c_1	c_2	$\chi^2/d.o.f.$
$\langle W^3E^3\rangle$	MA + U1LA	0.140(3)	0.044(2)	0	3.06
$\langle \lvert k_\mu\rvert (A^+A^-)_u\rangle$	MA	0.0606(9)	1.08(3)	−0.0103(2)	0.003
$\langle Wk^2\rangle$	MA	0.10(1)	0.016(7)	0.014300(8)	1.35
$\langle W(A^+A^-)_u\rangle$	MA	0.094(8)	0.04(1)	0.40967(2)	0.006
$\langle W(A^+A^-)_\theta\rangle$	MA + U1LA	0.106(9)	0.12(4)	0.49068(4)	0.01
$\langle W^3E^3\rangle$	LA	0.139(1)	0.038(1)	0	1.88
$\langle WA^2_\theta\rangle$	LA	0.118(4)	0.09(1)	0.74023(4)	0.003

Table 1: The best fit parameters corresponding to the fits of various quantities by the function $f(r) = c_1\exp(-r/\zeta) + c_2$. We indicate the gauge where the quantity is calculated and the figure number where the quantity is plotted. We set $c_2 = 0$ when the best fit value of c_2 is consistent with zero.

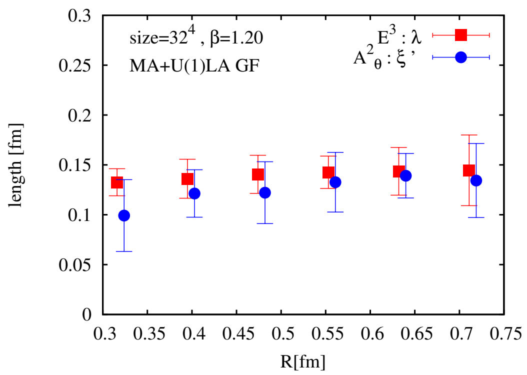

Figure 1: The coherence lengths of dimension 2 gluon operator and the penetration length in MA + U1LA gauge for various R.

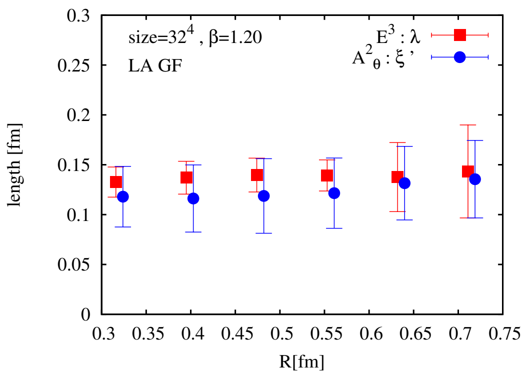

Figure 2: The coherence lengths of the dimension 2 gluon operator and the penetration length in the Landau gauge for various R.