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Renormalization and temperature dependence of dimension 6 gluon operators

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Understanding the temperature dependence of the gluon condensate in the purge gauge theory offers a useful picture on the nature of the QCD phase transition. In a recent work[1], we identified the independent dim 6 twist 4 gluon operators($O_1 = D_\beta G^a_{\mu\nu} D_\alpha G^a_{\mu\nu}, O_2 = D_\mu G^a_{\alpha\mu} D_\nu G^a_{\beta\nu}, O_3 = D_\beta G^a_{\alpha\mu} D_\nu G^a_{\mu\nu}$) and calculated their renormalization upto one loop order in the pure gauge theory. We found the scale invariant operators are given as follows:
\begin{equation}
\phi_1=\alpha_s^{-9/11}\left\langle O_1\right\rangle ,\\
\phi_{2,3}=\alpha_s^{-(15 \mp \sqrt{17})/44}\left\langle \frac{-653 \pm 21\sqrt{17}}{424}O_1+\frac{1 \mp \sqrt{17}}{8}O_2+O_3\right\rangle.
\end{equation}
Together with the dim 6 scalar operators whose renormalization has been worked out before[2],
our result completes the calculation of renormalization of all the dim 6 gluon operators, hence is a first step toward identifying their mixing and thus a systematic analysis in the operator product expansion (OPE) of heavy quark correlation functions up to dimension 6. After using the equation of motion in the purge gauge theory, only O_1 remains nonzero.

As an application, we rewrite the dim 6 scalar and twist 4 operators as $f^{abc} B^a \cdot (B^b \times B^c)$ and $f^{abc} B^a \cdot (E^b \times E^c)$ and estimate their temperature dependence using inputs of dim 4 electric and magnetic condensate extracted from lattice gauge theory. We then improve the previous QCD sum rules for J/Ψ mass near the T_c based on dim 4 operators, by including the contribution of the dim 6 operators to the OPE. We find an enhanced stability in the sum rule and confirm that the J/ψ will undergo an abrupt change in the property across T_c.

[1]H.J.Kim and S.H.Lee, arXiv:1503.02280[hep-ph]

[2]S.Narison and R.Tarrach, Phys.Lett.B 125 217 (1983)

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