Linear confinement in QCD: Temperature Dependence of Gluon and Quark Condensates

A.N. Mitra[⋆] [*] **and W-Y. P. Hwang** [†]

Center for Academic Excellence on Cosmology and Particle Astrophysics,

Department of Physics, National Taiwan University,

Taipei 106, Taiwan, R.O.C.

[⋆]Permanent address: 244 Tagore Park, Delhi-110009, India

A new formulation of QCD is proposed, one in which linear confinement is explicitly incorporated through a simple process of differentiation: The gluon field A_ν in the basic QCD interaction is modified as $\mu\partial_m A_\nu$ where μ is a scale parameter, and m goes to zero after the necessary differentiations in a given Feynman diagram. This modifies the perturbative propagator k^{-2} to $2\mu^2 k^{-4}$ which corresponds to *linear* confinement. The gluon condensate is investigated with a gauge invariant gg kernel made up of the direct (D), exchange (X), and contact(C) QCD interactions in the lowest order [1], except that the perturbative propagator k^{-2} is now replaced by the non-perturbative $2\mu^2 k^{-4}$ form arising from the indicated differentiations. Similarly for the quark condensate, the $q\bar{q}$ kernel has the non- perturbative gluon propagator $2\mu^2 k^{-4}$ as above. Next we show how the gluon and quark condensates may be obtained by 'looping' up the gluon and quark lines in the standard manner. Dimensional regularization (DR) [2] is then employed to yield the condensates plus temperature corrections, assuming a common scale parameter μ for both. For gluons the exact result is

$$< GG >= 36\mu^4\pi^{-3}\alpha_s(\mu^2)[2-\gamma-4\pi^2T^2/(3\mu^2)]$$

Evaluation of the quark condensate is preceded by an approximate solution of the SDE for the mass function $m(p)$, giving a recursive formula, with convergence achieved at the third iteration. Setting the scale parameter μ equal to the universal Regge slope $1\,GeV$, the gluon and quark condensates at $T=0$ are found to be $0.586\,GeV^4$ and $(270\,MeV)^3$ respectively, in fair accord with QCD sum rule values. Next we proceed to determine the temperature dependence of both condensates, decreasing with the temperature of order T^2 in both cases, using the finite-temperature field theory a la Matsubara [3].

REFERENCES

[1] S. R. Choudhury and A. N. Mitra, Phys. Rev. **D28**, 2201 (1983).

[2] G. 't Hooft and M. Veltman, Nucl. Phys. **B44**, 189 (1972).

[3] T. Matsubara, Prog. Theor. Phys. **14**, 351 (1955

[*]e.mail: ganmitra@nde.vsnl.net.in

[†]e.mail: wyhwang@phys.ntu.edu.tw