Casimir scaling hypothesis on the nonperturbative force in QCD vs. dual superconducting scenario of confinement

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Recently, the ratio of forces at intermediate distances (~ 1 fm) associated with various dimensional representations of color charges have been investigated within the quenched SU(3) lattice gauge theory [1, 2]. They have found an interesting behavior of the ratio, which seems to realize the Casimir scaling hypothesis. This hypothesis tells that the ratio of forces is determined by that of eigenvalues of the quadratic Casimir operator for each representation. Following these results, there arises a strong argument that this scaling can provide a test of QCD-vacuum model which refers to quark confinement mechanism [3].

It might be natural to expect that Casimir scaling takes place in the short distance region as described by one-gluon exchange, since the coupling is nothing but the quadratic Casimir operator. However, it is not easy to imagine why such scaling appears up to intermediate distance where the nonperturbative effects set in. We therefore expect that there should be nonperturbative dynamics, rather than Casimir factor, which makes the lattice results mimic Casimir scaling phenomenon accidentally.

We shall present that the dual superconducting scenario of confinement, as described by the dual Ginzburg-Landau (DGL) theory, is promising idea to explain the mechanism hidden behind the lattice data. In this scenario, quark confinement is realized by the formation of flux tube through the dual Meissner effect, which leads to lineally rising potential between the quark and the antiquark.

In fact, we shall show that the string tensions of flux tubes associated with static charges in various SU(3) representations calculated systematically with the Weyl symmetric formulation of the DGL theory [4, 5], can provide consistent ratios with lattice data [6, 7]. This seems to suggest that it is still premature to use the word "Casimir" for the observed scaling on lattice and to regard the Casimir scaling hypothesis as a criterion of quark confinement models.

References

[1] S. Deldar, Phys. Rev. D62 (2000) 034509.
[2] G. S. Bali, Phys. Rev. D62 (2000) 114503.
[3] V. I. Shevchenko, Y. A. Simonov, Phys. Rev. Lett. 85 (2000) 1811.
[4] Y. Koma, H. Toki, Phys. Rev. D62 (2000) 054027.
[5] Y. Koma, E.-M. Ilgenfritz, T. Suzuki, H. Toki, Phys. Rev. D64 (2001) 014015.
[6] Y. Koma, E.-M. Ilgenfritz, H. Toki, T. Suzuki, Phys. Rev. D64 (2001) 011501.
[7] Y. Koma, M. Koma, hep-ph/0109033.