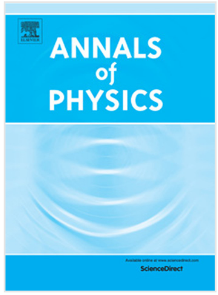

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Alireza Ahmadi, Shahnoosh Rafibakhsh

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Trivial Center Element and Coulombic Potential of the Thick Center Vortex Model

Alireza Ahmadi* and Shahnoosh Rafibakhsh†
Department of Physics, Science and Research Branch, Islamic Azad University, Tehran 14665/678, Iran
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The thick center vortex potentials in the $SU(3)$ gauge group have been calculated by means of the modified inter-quark potential which consists of two terms. One term is the result of the area law fall-off for the large Wilson loop which leads to the linear potentials. The second term represents vacuum fluctuations leading to the perimeter law fall-off believed to contain the trivial center element. We introduce a new Gaussian flux limited to vary in a finite region of space which causes the corresponding group factor to have only some small deviations from the trivial center element. So, this flux increases the role of the trivial center element and W_0 is enhanced in the induced potential of the model at small quark separations. Using both trivial and non-trivial center elements in the potential between static color sources, results in the correct 3-ality dependence at large quark separations and a very good agreement with Casimir scaling at short and intermediate distances. In fact, the ratios of the potential of each representation to that of the fundamental one have been improved -in comparison with the previous work on the short distance potentials, remarkably. So, one might use the thick center vortex model to describe the inter-quark potential of every regime.

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I. INTRODUCTION

Since Quantum Chromodynamics was accepted as a promising theory of hadrons, the interaction between heavy quarks has been investigated in different ways. An essential quantity to understand the phenomenology of inter-quark interactions is the potential between a static $q\bar{q}$ pair. Lattice calculations show a short-range Coulombic potential reflecting asymptotic freedom in the ultraviolet regime of QCD. In addition, a long-range linear term has been observed indicating confinement in the infrared regime [1, 2]. In this regime such a behavior of the gluonic excitations is expected in the color-singlet configuration of a quark-antiquark pair [3, 4]. Therefore, the potential between static color sources in representation r might be written in the form

$$V_r(R) = -\frac{A_r}{R} + \sigma_r R + B_r, \tag{1}$$

where A_r is the strength of the Coulombic potential, σ_r the string tension and B_r a constant term. The Coulombic term dominates at short distances and is a result of one gluon exchange. Numerical calculations show that potentials in different representations are proportional to the eigenvalues of the quadratic Casimir operators. In two dimensional gauge theories, Casimir scaling could be proven by calculating the Wilson loop perturbatively. This property could be generalized to higher dimensions based on the dimensional reduction procedure. On the other hand, one could use factorization technique to show that Casimir scaling is exact in the large N limit. However, approximate Casimir scaling could be observed at finite N and might be written as

$$\sigma_r = \sigma_F \frac{C_r}{C_F}, \tag{2}$$

where the index F denotes the fundamental representation and C_r is the eigenvalue of the quadratic Casimir operator in representation r. A non-vanishing second term in Eq. 1 indicates confinement, with colorful particles clustered to color-singlets.

Besides numerical calculations to the unsolved confinement problem of QCD, there is a wide variety of phenomenological models which try to understand how the vacuum acts to confine quarks providing a scheme leading to confinement. These models assume that the QCD vacuum is filled by topological excitations of some class. They cause the area law fall-off for large Wilson loops leading to the linear term in the inter-quark potential (1). Promising candidates for such vacuum configurations are center vortices, tubes of chromomagnetic flux forming surfaces in four dimensional space-time. In the vortex picture suggested by 't Hooft in the late seventies [5], it was shown that there is a correspondence between the chromomagnetic flux of center vortices and z_n, the n-th center elements of SU(N). The flux carried by vortices is quantized in terms of these center elements. Lattice simulations on thin vortices prove that the fluctuations in the number of center vortices are responsible for the asymptotic string tensions. In other words, if vortices are removed from the lattice configurations, the asymptotic string tension vanishes [6].

The generalization of the vortex picture to the thick center vortex model gives the correct N-ality dependence of the potentials at large distances and qualitative agreement with Casimir scaling at intermediate distances, in

* ahmadi.hep@gmail.com
† rafibakhsh@ut.ac.ir