The color-electric flux tube in Abelian-projected SU(2) gauge theory

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The formation of a color-electric flux tube between quark and antiquark explains why a quark cannot be isolated as a free particle: it leads to a linearly rising potential such that a quark cannot be separated infinitely from an antiquark spending a finite amount of energy. Such a mechanism occurs if the vacuum has the property of a *dual* superconductor as described by the dual Ginzburg-Landau (DGL) theory.

It is known that lattice Monte-Carlo simulations of Abelian-projected (AP) gauge theory (with lattice fields fixed to the maximally Abelian gauge (MAG)) show a flux-tube profile, which has a shape very similar to the classical flux-tube solution of the DGL theory [1, 2, 3, 4]. Motivated by this qualitative resemblance, the determination of the mass parameters of the DGL theory has been attempted by comparison between simulation results and the DGL solutions.

However, we have realized [5] that before doing this one important aspect needs to be clarified which has been overlooked in the past. The duality relation between the AP and the DGL flux tubes and, correspondingly, the composed structure of the flux tubes have to be considered more in detail. Furthermore, concerning the AP simulations, one has carefully to assess the importance of lattice Gribov copy effects (associated with the MAG fixing procedure) for the AP flux-tube profile and to check the scaling property (*i.e.* β independence) of the profile on a sufficiently large lattice volume. These are systematic effects which potentially could spoil the physical meaningfulness of the emerging DGL parameters.

In order to answer these questions, we have reconsidered the AP flux tube [6, 7] within SU(2) lattice gauge theory at $\beta = 2.3$, 2.4, 2.5115, and 2.6 on a 32^4 lattice, applying the over-relaxed simulated annealing (OR-SA) algorithm for the purpose of MAG fixing. The central idea to reveal the structure of a flux-tube configuration is to measure correlation functions of the type

$$\langle \mathcal{O}(s) \rangle_J = \frac{\langle W_A \mathcal{O}(s) \rangle_0}{\langle W_A \rangle_0},$$

where W_A is some Abelian Wilson loop. $\mathcal{O}(s)$ are local operators describing the internal flux-tube structure: the Abelian field strength $\bar{\theta}_{\mu\nu}(s)$ and the monopole current $2\pi k_\mu(s)$ ($k_\mu \in \mathbb{Z}$). A typical flux-tube profile is shown in Fig. 1.

We have established that the AP flux tube possesses the same composed internal structure as the DGL flux tube, consisting of Coulombic and solenoidal electric fields. This has been achieved by decomposing the full Abelian Wilson loop into its photon and

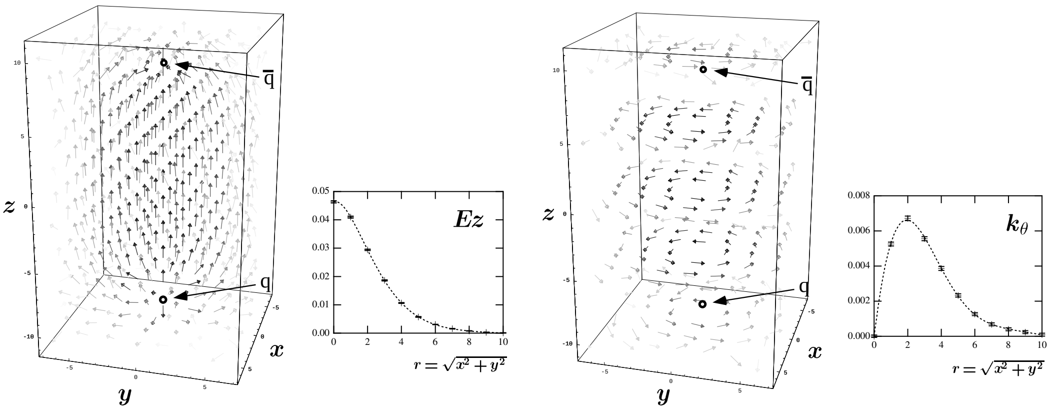

Figure 1: Profiles of electric field (left) and monopole current (right).

monopole parts and the evaluation of the corresponding correlators with field strength and monopole current. This decomposition has been suggested by the path-integral duality transformation leading from the AP gauge theory to the DGL theory [5].

We have found that the flux-tube profile is very sensitive to the lattice Gribov copy problem in the MAG. The monopole-related parts of the profiles are particularly affected. The monopole current profile and the solenoidal field are overestimated if one uses a non-improved gauge fixing algorithm or just one single gauge copy. We have obtained significantly corrected profile data by virtue of the OR-SA algorithm using a moderate number of gauge copies.

We have confirmed the scaling property of the flux-tube profile. Interpreting the results we have to take into account the finite q-$\bar{q}$ distance properly. In fact, the flux-tube profile is strongly depending on the size (R and T) of the Abelian Wilson loops $W(R,T)$. At finite q-$\bar{q}$ distance R, the photon part of the flux-tube profile is crucially contributing to the total Abelian electric field measured at any distance from the external charges. It cannot be neglected in a fit by means of the DGL solution.

Preliminary results have been presented in Refs. [5, 6] The quantitative comparison between the AP and the DGL flux tubes is in progress [7]. All calculations have been done on the Vector-Parallel Supercomputer NEC SX-5 at RCNP, Osaka University.

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