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REMARKS ON THE TOPOLOGY OF GAUGE FIELDS*

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In contrast to the short distance behavior of quantum chromodynamics (QCD), which is within the scope of perturbation theory and thus can be subjected to quantitative tests, the large distance or strong coupling regime of QCD is not well understood yet even qualitatively. An overriding problem of interest in quark confinement, and various theoretical schemes have been put forward to show that the quarks can indeed be confined. These schemes, though varying from one to another in detail, rely on the idea that the growing coupling constant at large distances plays a key role. It is not clear yet, however, whether confinement is a natural consequence of QCD alone, or it requires some independent and extraneous assumptions.

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Another important aspect of gauge fields is the existence of topologically nontrivial configurations such as vortices, monopoles and instantons. They may be regarded as natural consequences of gauge physics. Most likely these configurations also are crucial to the understanding of confinement as is claimed by a number of recent papers. For this reason I have planned this session to be organized mainly around the topological problems.

My own remarks on these questions will be very brief:

1. Action versus Free Action

There is a formal analogy between statistical mechanics and the Feynman formulation of quantum field theory, which seems to become especially relevant in gauge theories. This analogy was emphasized by the Princeton group[1] who made use of the concept of entropy. Let us write down the Feynman integral (in the Euclidean form) for a gauge field

$$Z = \int \exp\left[-\frac{1}{4g^2}\int F_{\mu\nu}F_{\mu\nu}\,d^4x\right] D(A_\mu) \tag{1}$$

where the coupling constant does not enter the definition of $F_{\mu\nu}$. The functional measure is not clearly defined, but we intend to integrate over the A_μ without imposing special gauge conditions. For a given value of the action, there is a corresponding phase space volume which we write symbolically as exp S :

$$\begin{aligned} Z &= \int \exp\left[-\frac{1}{g^2}I + S(I)\right] dI \\ &= \exp\left[-\Theta/g^2\right], \\ \Theta &\approx (I - g^2 S)_{\min}. \end{aligned} \tag{2}$$

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