LONG DISTANCE BEHAVIOUR OF SUPERSYMMETRIC QCD AND DEBYE SCREENING IN INSTANTON VACUUM

A. V. Yung

The dynamics of gauge theories in the long distance limit is one of the most important long-standing unsolved problems in field theory. Of particular interest are attempts to nonperturbative approach to this problem. In refs. /1,2/ the instanton vacuum structure is investigated in the simplest SU(2) SUSY gauge theory with one flavour of matter in the fundamental representation of the gauge group (SQCD).

In ref. /1/ the binary instanton-antiinstanton interaction is calculated in the Higgs phase of this theory. At long distances it turns out to be of the long-range Coulomb type:

$$U_{II} = \frac{8\pi^2\rho_1^2\rho_2^2}{R_{12}^2}\left[2(u_1u_2)^2 - 1\right]. \qquad (1)$$

Here ϱ_1,ϱ_2 are sizes of instanton and antiinstanton, R_{12} is the distance between them and $u_{1\mu}$, $u_{2\mu}$ are their orientation vectors. It is the scalar field in SQCD that is actually responsible for the long-range behaviour of potential (1).

In ref. /2/ the role of the Coulomb potential (1) in instanton vacuum and its physical consequences for the long-distance behaviour of SQCD is investigated. In the presence of the Coulomb potential (1) the usual dilute gas approximation is not valid due to infrared troubles. After the summing of all the infrared divergent processes is carried out, the instanton vacuum of SQCD looks like a plasma. All the correlation functions show an exponential fall-off $e^{-\mu|x|}$ at long distances, where μ is the Debye mass, being proportional to the instanton density. In particular, a light (Debye mass μ) pole contribution to the correlation function $<G^2_{\mu\gamma}(x),\ G^2_{\alpha\beta}(y)>$ is predicted. It can be interpreted as a 'glueball' state.

The analysis of the instanton Coulomb system is convenient to perform in terms of equivalent field theory. This method, suggested by Polyakov for three-dimensional plasma, can be generalized on instanton plasma of the four-dimensional supersymmetric theory, and leads to the theory of chiral superfield with the superpotential

$$F(\Phi) = -2\frac{M^5}{g^4}e^{-(8\pi^2/g^2)}\int\frac{d^2\Theta}{(v+\Phi/\sqrt{2})^2}. \qquad (2)$$

Here M is an ultraviolet cut-off, v is vacuum expectation value of the scalar field and Φ is the superfield imitating long-range Coulomb forces in the instanton vacuum. The superpotential (2) turns out to coincide with the effective low-energy Lagrangian from ref. /3/. The latter was obtained using symmetry considerations. The point is that the symmetry group in SQCD is large enough to fix uniquely the form of low-energy Lagrangian. The dynamical approach enables us to see this Lagrangian as an effect of the Debye screening phenomenon in the instanton vacuum. This approach is general and can be applied to more usual gauge-Higgs theories where symmetry considerations are insufficient to determine the low-energy physics.

REFERENCES

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2. *Yung A. V.* Preprint LNPI-1494. Leningrad. 1989. 54 p.
3. *Affleck I., Dine M., Seiberg N.* Nucl. Phys., B241. 1984. 493.