Color confinement due to restoration of the residual local gauge symmetry

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All colored particles including dynamical quarks and gluons are confined if the color confinement criterion proposed by Kugo and Ojima is satisfied. The criterion was obtained under the gauge fixing of the Lorenz type. However, it was pointed out that the Kugo-Ojima criterion breaks down for the Maximal Abelian gauge, which is quite strange in view of the fact that quark confinement has been verified according to the dual superconductivity caused by magnetic monopole condensations. In order to make a bridge between color confinement due to Kugo and Ojima and the dual superconductor picture for quark confinement, we reconsider the color confinement criterion to obtain the unified picture for confinement. We show that the restoration of the residual local gauge symmetry which was shown by Hata to be equivalent to the Kugo-Ojima criterion in the Lorenz gauge occurs also in the Maximal Abelian gauge for the SU(N) Yang-Mills theory in two-, three- and four-dimensional Euclidean spacetime once the singular topological configurations of gauge fields are taken into account. This result indicates that the color confinement phase is a disordered phase caused by non-trivial topological configurations irrespective of the gauge choice. As a byproduct, we show that the compact U(1) gauge theory can have the disordered confinement phase, while the non-compact U(1) gauge theory has the deconfined Coulomb phase.

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