Color-Coulomb instantaneous potential and Faddeev-Popov operator

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In the Gribov-Zwanziger confinement scenario, the singular behavior of the color -Coulomb potential in the infrared region is governed by the near-zero modes of the Faddeev-Popov (FP) operator. We here have calculated the eigenvalue distribution of the FP operator in Coulomb gauge using quenched SU(3) lattice gauge simulations[1, 2]. In the confinement phase, the FP eigenvalue density near $\lambda = 0$ increases with lattice volumes. Moreover, the lattice simulations reveal the behavior of the average Laplacian near $\lambda = 0$. We conclude that the confinement criterion proposed by Greensite et al. is satisfied in the infinite volume limit in the SU(3) lattice gauge simulations[3]. This supports the Gribov-Zwanziger confinement scenario[4]. The results we obtained are qualitatively consistent with those of the SU(2) lattice simulation carried out by Greensite et al.

The behaviors of the FP eigenvalue density and the average Laplacian in the deconfinement phase are qualitatively same as in the confinement phase. Accordingly, the confinement criterion is satisfied even in the deconfinement phase in SU(3) lattice gauge theory. It is not surprising that the spectrum of the FP operator is insensitive to temperature, because the FP operator is a spatial quantity. We note that the criterion is not a sufficient but the necessary condition for the confinement. Namely, the color-Coulomb energy is not the ground state energy but the excited state energy of color charges. If we take the non-instantaneous interaction into account when discussing in the deconfinement phase, the energy of an isolated color charge will be finite in the infrared and an isolated color charge can exist.

The spectrum of the FP operator does not change drastically above the critical temperature. This would indicate that confining features survive even in the deconfinement phase. Actually, it is known that the spatial Wilson loop which is a gauge invariant quantity shows the area law behavior above the critical temperature. Therefore, we expect that further studies in Coulomb gauge provide some insight into the understanding of the strongly correlated quark-gluon plasma.

The color-Coulomb potential can be obtained by calculating the FP eigenvalues and the eigenvectors. It is valuable to see whether the lowest eigenmodes of the FP operator produce the linearly rising behavior of the color-Coulomb potential for large quark separations. We address this issue in our future investigation.

The simulations were performed on SX-5(NEC) vector-parallel computer at the RCNP of Osaka University.

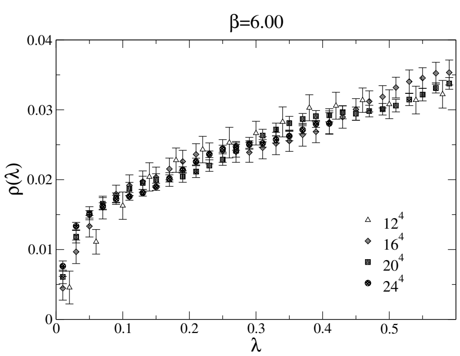

Figure 1: Eigenvalue distribution of Faddeev-Popov operator in the confinement phase

References

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