Charmonium near the deconfining transition on the lattice

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It is widely believed that the Quantum Chromodynamics (QCD) exhibits a phase transition at some temperature T_c, and quarks and gluons confined in the low temperature phase are liberated to form "quark gluon plasma". In spite of various theoretical approaches, we are still far from definite understanding of hadron properties near the transition and the fate of hadronic states in the plasma phase. We investigate the structure of hadronic correlators at finite temperature using lattice QCD simulation. In this work, we focus on the charmonium states, which are payed much attention from a phenomenological point of view.

The lattice QCD study of hadron structure at finite temperature encounters a difficulty due to severe limitation of information of the correlators in the Euclidean temporal direction. To circumvent this problem, we use an anisotropic lattice, on which the temporal lattice spacing is smaller than the spatial one [1, 2]. This enables us to take sufficient numbers of temporal degrees of freedom while keeping total computational cost relatively modest.

In Refs [1, 2], from observation of q-$\bar{q}$ correlations in the Coulomb gauge, it was pointed out that the hadronic correlators still have nontrivial structure and may contain a bound state-like structure even above T_c. On the other hand, a significant change of behavior was also reported in the case of the charmonium correlator [1].

In this work, we analyze the spectral functions of charmonium correlators [3]. The extraction of the spectral function from the correlator measured on lattice has essential importance. We attack this subject with two procedures: the maximum entropy method, and fits with ansatz for a shape of the spectral function. We apply them to the correlators at finite temperatures as well as at zero temperature with restricted numbers of points of correlators for a check of reliability of these methods. Then the results of two methods are compared with each other to confirm a consistency.

The numerical simulation is performed on quenched lattices with sizes $20^3 \times N_t$, where $N_t = 160$ ($T \simeq 0$), 32 ($0.9T_c$) and 26 ($1.1T_c$), and the spatial lattice cutoff $a_\sigma^{-1} \simeq 2$ GeV and the anisotropy $\xi = a_\sigma/a_\tau = 4$. We apply the smearing technique, which enhances the low energy part of the correlator. Preliminary result indicates no significant change of the spectral function at $T = 0.9T_c$ from that at $T = 0$. At $T = 1.1T_c$, the result shows that the spectral function still has a strong peak at almost the same place as below T_c while with finite width. This again indicates a nontrivial structure of correlator slightly above the deconfining phase transition.

The simulation has been done on NEC SX-5 at Research Center for Nuclear Physics, Osaka University and Hitachi SR8000 at KEK (High Energy Accelerator Research Organization).

References

[1] T. Umeda *et al.*, Int. J. Mod. Phys. A 16 (2001) 2215.
[2] QCD-TARO Collaboration (Ph. de Forcrand *et al.*), Phys. Rev. D 63 (2001) 054501.
[3] T. Umeda, K. Nomura and H. Matsufuru, in preparation.