Charmonium near the deconfining transition on the lattice

Takashi Umeda[a], Hideo Matsufuru[b] Osamu Miyamura[c] and Koji Nomura[c]

[a] *Center for Computational Physics, University of Tsukuba, Tsukuba 305-8577, Japan*
[b] *Yukawa Institute for Theoretical Physics Kyoto University, Kyoto 606-8502, Japan*
[c] *Department of Physics, Hiroshima University, Higashi-hiroshima 739-8526, Japan*

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 the hadronic states in the plasma phase. We investigate the structures 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 the phenomenological viewpoint. Present simulation is performed in quenched approximation.
The lattice QCD study of hadron structure at finite temperature ($T > 0$) encounters a difficulty due to the severe limitation of the information of 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 number of temporal degree of freedom while keeping total computational cost relatively modest. This technique is also suitable for description of heavy quark whose mass is of the order of lattice cutoff [1].
We investigate the charmonium correlator at $T > 0$ with the following approaches.
(1) Analysis of the spectral function. 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 shapes of the spectral function. We apply them to the correlators at $T > 0$ as well as at zero temperature ($T = 0$) with restricted numbers of points of correlators, and quantitatively evaluate the reliability of these methods. Then the results are compared with each other to confirm the consistency. Based on this approach, we investigate the spectral function of charmonia below and above T_c and discuss changes from the $T = 0$ result.
(2) Analysis of the q-$\bar{q}$ correlation. Some indirect quantities give us hints on the structure of charmonium correlators. We here consider the q-$\bar{q}$ spatial correlation in the Coulomb gauge [1,2]. Observing the (Euclidean) t-dependence of the q-$\bar{q}$ correlation and comparing with the free quark case, we can discuss whether quark and antiquark still tends to stay together. In contrast to naive expectation, we find strong correlation between quark and antiquark even above the T_c.
(3) Potential model analysis. We also analyze the charmonium state with potential model, just as the original idea for the "J/ψ suppression", using the static quark potential obtained from lattice simulation.

References

[1] T. Umeda, R. Katayama, O. Miyamura and H. Matsufuru, Int. J. Mod. Phys. A 16 (2001) 2215.
[2] QCD-TARO Collaboration (Ph. de Forcrand *et al.*), Phys. Rev. D 63 (2001) 054501.