Lattice simulation of the heavy quark potential at finite density

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Temperature (T) dependence of the heavy quark potential has been studied by lattice QCD (LQCD) in order to understand the confinement mechanism and properties of QGP [1, 2]. For chemical-potential (μ) dependence of the heavy quark potential, however, only few studies were made so far because of the sign problem. Namely the quark determinant becomes complex and cannot be interpreted as a probability density at finite μ. To avoid this problem, we perform LQCD simulations at imaginary chemical potential ($\mu = i\mu_I$) where the sign problem is absent. As a first step to derive the heavy quark potential at real μ from at imaginary μ, we calculate the heavy quark potentials at finite μ_I. The heavy quark potential can be defined with the correlator of the Polyakov-loop operator. One can define the heavy quark potential in various color channels separately, making the gauge fixing [5]. In the present analysis, we take the Coulomb gauge fixing.

We employ the renormalization group improved Iwasaki gauge action and the 2-flavor clover-improved Wilson quark action and generate full QCD gauge configurations on $16^3 \times 4$ by the hybrid Monte Carlo method [3]. The hopping parameter κ is 0.137716 at $\beta = 1.95 (T/T_{\rm pc} = 1.20)$, where $T_{\rm pc}$ is the pseudocritical temperature at $\mu = 0$. The relation between κ and β was obtained as a line of constant physics with the ratio of pseudoscalar meson mass to vector meson mass $m_{\rm PS}/m_{\rm V} = 0.80$ by CP-PACS Collaboration [4].

Figure 1 shows the μ_I/T dependence of the heavy quark potential in (a) the color-singlet and -octet channel and (b) the color-sextet and -antitriplet channel for $T/T_{\rm pc} = 1.2$, where the potential energy is set to zero at large distance. At $\mu_I/T = 0$, the color-singlet and color-antitrplet potentials are attractive, while the color-octet and color-sextet potentials are repulsive. These properties are enhanced with respect to increasing μ_I/T from 0 to 1.

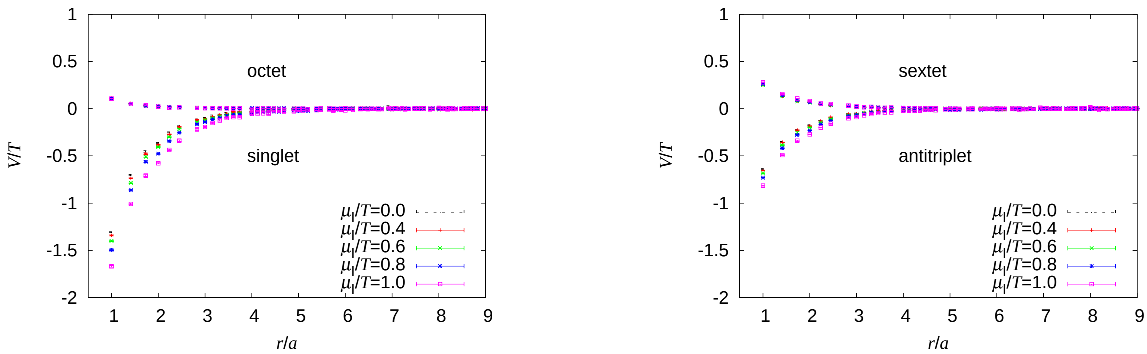

Figure 1: The μ_I/T dependence of the heavy quark potential in (a) the color-singlet and -octet channel and (b) the color-sextet and -antitriplet channel for $T/T_{\rm pc} = 1.2$.

Numerical calculation of the work has been performed on SX-8 and SX-9 at the RCNP of Osaka University.

References

[1] A. Nakamura and T. Saito, Prog. Theor. Phys. **111**, 733 (2004); A. Nakamura and T. Saito, Phys. Lett. B **621**, 171 (2005)

[2] Y. Maezawa et al. (WHOT-QCD Collaboration), Phys. Rev. D **75**, 074501 (2007); Y. Maezawa et al. (WHOT-QCD Collaboration), arXiv:1112.2756 [hep-lat], (2012).

[3] S. Ejiri et al. (WHOT-QCD Collaboration), Phys. Rev. D **82**, 014508 (2010).

[4] A. Ali Khan et al. (CP-PACS Collaboration), Phys. Rev. D**63**, 034502(2000); A. Ali Khan et al. (CP-PACS Collaboration), Phys. Rev. D**64**, 074510(2001).

[5] S. Nadkarni, Phys. Rev. D **34**, 3904 (1986).