論文の内容の要旨

論文題目

Polyakov loop correlations in quark-gluon plasma from lattice QCD simulations

~~(~~格子 QCD シミュレーションによるクォーク・グルーオン・プラズマ中のポリヤコフ・ループ相関の研究~~)~~

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Thermal properties of the quark-gluon plasma are studied from the Polyakov-loop correlations in two-flavor QCD simulations with the RG-improved gluon action and the clover-improved Wilson quark action on a $16^3 \times 4$ lattice. From the line of constant physics at $m_{PS}/m_V = 0.65$ and 0.80, we extract the heavy-quark free energies, the effective running coupling $g_{eff}(T)$ and the Debye screening mass $m_D(T)$ for various color channels of heavy quark-quark and quark-antiquark pairs above the critical temperature. The free energies are well approximated by the screened Coulomb form with the appropriate Casimir factors at high temperature. The magnitude and the temperature dependence of the Debye mass are compared to those of the next-to-leading order thermal perturbation theory and to a phenomenological formula in terms of $g_{eff}(T)$. We make a comparison between our results with the Wilson quark action and the previous results with the staggered quark action.

The magnetic and Debye screening masses are also calculated from correlations between the Polyakov-loop operators with restriction of symmetries under the Euclidean time reflection and the charge conjugation. The magnitude of the Debye mass turns out to be larger than that of the magnetic mass (m_M), but smaller than twice of m_D. This substantiates that the color-singlet channel of the heavy-quark free energy well describes the Debye screening properties. We also find that the screening ratio, m_D/m_M, shows a good agreement with a prediction from AdS/CFT correspondence.

We also calculate the Taylor expansion coefficients of the heavy-quark free energy with respect to

the quark chemical potential (μ_q) up to the second order. By comparing the expansion coefficients of the free energies between quark and antiquark, and between quark and quark, we find a characteristic difference at finite μ_q due to the first order coefficient of the Taylor expansion.