The heavy-heavy-light quark potential in lattice QCD

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We perform the first study for the heavy-heavy-light quark (QQq) potential in SU(3) lattice QCD, and investigate the quark motional effect on the inter-two-quark potential in baryons [1].

In lattice QCD, the quark-antiquark ($Q\bar{Q}$) potential and the static three-quark ($3Q$) potential are already studied [2]. In this study, we investigate the effect of finite-mass valence quarks, which is not included in these static potentials. Consider the QQq system which is constructed from two infinitely heavy quarks and a finite-mass light quark. The QQq potential is defined as the energy of the QQq system in terms of the inter-heavy-quark distance R. This QQq potential includes not only the gluonic effect but also the nontrivial light-quark effect.

The QQq potential is obtained from the expectation value of the "QQq Wilson loop", which includes the light-quark propagator. For the statistical error reduction, we use the wall-to-wall quark propagator, and the Coulomb-gauge-fixing procedure, and focus on the long-range behavior of the QQq potential, which is not affected by the gauge fixing [3].

We find that the QQq potential is well described as

$$V_{QQq}(R) = \sigma_{\rm eff} R - \frac{A_{\rm eff}}{R} + C_{\rm eff}, \tag{1}$$

and that the effective string tension $\sigma_{\rm eff}$ is reduced compared to the standard value of the string tension,

$$\sigma_{\rm eff} < \sigma \simeq 0.89 \text{ GeV/fm}. \tag{2}$$

Typically, when the light-quark constituent mass is about 500 MeV, the effective string tension $\sigma_{\rm eff}$ is 0.73(3) GeV/fm. The string tension σ is the confining force of the flux tube in $Q\bar{Q}$ or $3Q$ systems [2]. This result means that the inter-two-quark confining force in QQq systems is reduced by the light-quark effect.

In another work, we confirm that a geometrical difference between the flux-tube length and the inter-two-quark distance R is essential for the reduction of the effective string tension $\sigma_{\rm eff}$ [4]. This property relates to the charasteristic structure of the flux tube in baryons.

The Monte Carlo simulations are performed on NEC SX-8R at Osaka University.

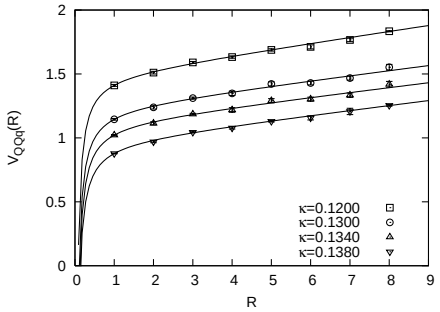

Figure 1: The lattice QCD data of the Coulomb-gauge-fixed QQq potential V_{QQq} plotted against the inter-heavy-quark distance R for the different four values of κ. The solid curves are the best-fit functions of Eq. (1). All the scales are measured in lattice unit.

References

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