論文の内容の要旨

論文題目　Heavy quarkonium potential from lattice QCD
(格子QCDに基づく重いクォーコニウムポテンシャルの研究)

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We study properties of an interquark potential for the charmed meson systems in lattice QCD. In this thesis, we propose a new method to determine the interquark potentials together with quark kinetic mass from the equal-time $Q\bar{Q}$ Bethe-Salpeter (BS) amplitude through the effective Schrödinger equation. First, in order to investigate several systematic uncertainties on the interquark potential obtained from the BS amplitude, we carry out lattice QCD simulations using quenched gauge configurations generated with the single plaquette gauge action with three different lattice spacings, $a \approx 0.0931$, 0.0677 and 0.0469 fm, and two different physical volumes, $L \approx 2.2$ and 3.0 fm. For heavy quarks, we employ the relativistic heavy quark (RHQ) action which is a new formulation to control the large discretization error introduced from large quark mass. The interquark potential for the charmonium system shows the Coulomb plus linear behavior with a good scaling behavior and small volume dependence. As a more realistic calculation, we secondly present both spin-independent and spin-spin interquark potentials for charmonium states, which are calculated in 2 + 1 flavor dynamical lattice QCD using the PACS-CS gauge configurations at a lattice cutoff of $a^{-1} \approx 2.2$ GeV. Our simulations are performed with the RHQ action with nonperturbatively determined coefficients for charm quark at almost physical pion mass, $M_\pi = 156(7)$ MeV, in a spatial volume of $(3\ \mathrm{fm})^3$. We observe that the spin-independent charmonium potential is quite similar to the usual Cornell potential used in nonrelativistic potential models. The spin-spin potential, which is calculated in full lattice QCD for the first time, properly exhibits a finite-range repulsive interaction. Its r-dependence is different from the Fermi-Breit type potential, which is widely adopted in quark potential models. Thirdly we solve the non-relativistic Schrödinger equation with charmonium potentials derived from first principles of QCD as theoretical inputs. The resulting charmonium mass spectrum below the open charm threshold excellently agrees with well-established experimental data. Furthermore we confirm the agreement between our new

method and the standard lattice method, where the spectroscopy calculated by the two-point correlation functions. Finally we apply our method to calculate the D_S (cs^{bar} or sc^{bar}) meson systems. Our numerical results show an interesting possibility that the spin-spin potential for the charm-strange system exhibits a very weak attractive interaction in the intermediate region. The spectrum of the D_S mesons near DK threshold, calculated in our approach, likely show the importance of threshold effects. These studies of the interquark potentials at finite quark masses from lattice QCD provide a new way to explore properties of heavy quarkonium states, where very rich mass spectrum have been recently exposed in experiments.