Nonperturbative determination of the relativistic corrections to the static inter-quark potential at $O(1/m)$

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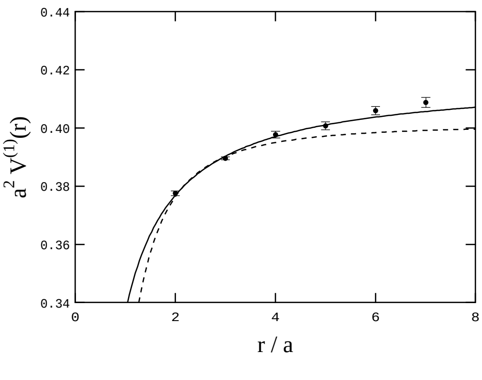
The effective field theory called potential nonrelativistic QCD (pNRQCD) provides us with a systematic framework to study the interquark potential. The potential is classified in powers of $1/m$, where m is the (heavy) quark mass. The static potential emerges as the leading-order contribution, followed by relativistic corrections. In pNRQCD, these corrections are expressed with the field strength correlators in the presence of heavy quark source [1].

We have measured the relativistic correction at $O(1/m)$ (denoted as $V^{(1)}(r)$, where r is the q-$\bar{q}$ distance) nonperturbatively by using lattice QCD Monte Carlo simulations for the first time [2]. The key strategy has been to employ the multi-level algorithm for measuring the field strength correlator on the Polyakov loop correlation function and to extract the potential by exploiting the spectral representation of the field strength correlators. This method allows us to obtain the potential with less statistical and systematic errors. In the Figure we show $V^{(1)}(r)$ evaluated at $\beta = 6.0$ ($a = 0.093$ fm) on the 20^4 lattice with the Wilson gauge action. Dashed and solid lines are the fit curves with the function motivated by the perturbation theory $V_{\rm pert}(r) = -\frac{c'}{r^2} + \mu'$ and the empirical one $V_{\rm emp}(r) = -\frac{c''}{r} + \mu''$, respectively. We have observed that the fit function $V_{\rm pert}(r)$ clearly deviates from the data at $r/a \geq 5$. From the fit coefficient c'', we found that the correction is comparable to the Coulombic term of the static potential when applied to charmonium and to be one-fourth of the Coulombic term for bottomonium.



We have also investigated the spin-dependent potentials at $O(1/m^2)$ with the same method [3]. We have obtained remarkably clean data compared to the previous works.

Simulations have been performed on the NEC SX5 at RCNP, Osaka University.

References

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