Heavy-light meson decay constant in quenched anisotropic lattice QCD

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We investigate the $O(a)$ improved quark action on anisotropic lattices as a potential framework for the heavy quark, which may enable precision computation of hadronic matrix elements of heavy-light mesons [1, 2, 3, 4]. One of the main problems in simulating heavy quarks on the lattice is that the discretization effect of $O(am_Q)$, where a and m_Q are the lattice spacing and the heavy quark mass, gives large uncertainties to the matrix elements. It is indeed found that the discretization errors of the heavy quark in conventional relativistic approach becomes uncontrollable for $am_Q > 0.3$. The hope in the anisotropic lattice is that by taking the lattice spacing in the temporal direction a_τ smaller than the spatial one a_σ, one may reduce this error substantially. To this end, it is crucial to verify that the anisotropic lattice calibrated nonperturbatively at the massless limit can indeed describe the heavy quark for a much larger range in $a_\sigma m_Q$. As a first step, we tuned the bare anisotropic parameter nonperturbatively on quenched lattices to 2% level of statistical accuracy and observed the relativity relation and the decay constant of heavy-light mesons. For the former, we found that the relativity relation indeed holds within 2% accuracy in the quark mass region $a_\sigma m_Q \leq 1.2$ [3].

The present report focuses on the computation of the heavy-light decay constant [4]. Numerical simulations are performed on two quenched lattices with $a_\sigma^{-1} \simeq 1.6$ and 2.0 GeV and $a_\sigma/a_\tau = 4$. For the light quark mass, we use three values which cover the range m_s–$1.5m_s$ and perform a linear chiral extrapolation. Since the currents are matched only at the tadpole tree-level and the $O(a)$ improvement terms are tuned also only at the tadpole tree-level, the present calculation contains rather large renormalization uncertainty as well as the cutoff dependence. In order to suppress these errors, we compute the ratio of decay constants in which the mass independent errors can largely cancel. Our preliminary results are: $f_D/f_\pi =$ 1.566(43) ($\beta = 5.95$), 1.515(43) ($\beta = 6.10$), and $f_{D_s}/f_D = 1.140(14)$ ($\beta = 5.95$), 1.142(14) ($\beta = 6.10$), which are consistent with previous works on isotropic lattices [5], in particular, with an elaborated work by ALPHA Collaboration which took the continuum limit with the nonperturbatively improved clover quark action on fine and large lattices. For a comparison of decay constants themselves, the renormalization of axial current is essential. Perturbative calculation of such renormalization coefficients is in progress.

In conclusion, the results of numerical simulations in quenched lattices are encouraging for further development in this direction. Further improvements necessary for achieving the desired accuracy, such as nonperturbative tuning of the clover coefficients, are in progress.

The simulation has been done on NEC SX-5 at Research Center for Nuclear Physics, Osaka University and Hitachi SR8000 at KEK (High Energy Accelerator Research Organization).

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