Heavy quark action on anisotropic lattices

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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].

To this end, it is crucial to verify that a mass independent and nonperturbative tuning of the parameters is possible. As a first step, we observe the dispersion relation of heavy-light mesons on a quenched lattice using the action which is nonperturbatively tuned only for the leading terms [3]. On a lattice with the spatial cutoff $a_\sigma^{-1} \simeq 1.6$ GeV and the anisotropy $\xi = 4$, the relativity relation holds within 2% accuracy in the quark mass region $a_\sigma m_Q \leq 1.2$ with the bare anisotropy parameter tuned for the massless quark.

This result tells us that the framework can be applied to charmed heavy-light meson systems. As a first application, we compute the heavy-light decay constants [4, 5]. Numerical simulations are performed on two quenched lattices with $a_\sigma^{-1} \simeq 1.6$ and 2.0 GeV and with the renormalized anisotropy $\xi = 4$. For the light quark mass, we use three values which cover the range m_s–$1.5 m_s$. The chiral limit is taken by a linear extrapolation. The matching to the continuum theory is at the tadpole-improved tree-level. We find that the heavy quark scaling of $f\sqrt{m}$ is consistent with the results on isotropic lattices. 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 [6].

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).

References

[1] J. Harada, A. S. Kronfeld, H. Matsufuru, N. Nakajima and T. Onogi, Phys. Rev. D 64 (2001) 074501.
[2] H. Matsufuru, T. Onogi and T. Umeda, Phys. Rev. D 64 (2001) 114503.
[3] J. Harada, H. Matsufuru, T. Onogi and A. Sugita, Phys. Rev. D 66 (2002) 014509.
[4] J. Harada, H. Matsufuru, T. Onogi and A. Sugita, Nucl. Phys. B (Proc. Suppl.) 111 (2002) 282-284; hep-lat/0209090.
[5] J. Harada, H. Matsufuru, T. Onogi and A. Sugita, in preparation.
[6] S. Ryan, Nucl. Phys. B (Proc. Suppl.) 106 (1994) 839.