Staggered quark action on anisotropic lattices

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Anisotropic lattices have been realized as an useful tool in lattice QCD simulations in which a large temporal lattice cutoff plays an essential role, such as finite temperature QCD, heavy quark physics, and various hadronic correlators whose signal-to-noise ratio quickly grows. So far the anisotropic lattice has been developed mainly for the gauge field and for the Wilson-type quark actions. However, the staggered quark formulation has several advantages; remnant of chiral symmetry, relatively low cost in dynamical simulations, and so on. It is therefore worth to investigate the anisotropic staggered quarks as an alternative to the Wilson-type quarks.

In anisotropic lattice actions, one has anisotropy parameters which are to be tuned in general nonperturbatively and whose systematic errors should be controlled. In this work, we study calibration procedures of the staggered quarks on anisotropic lattices in the quenched approximation [1, 2, 3] and in $N_f = 2$ dynamical simulations [1].

In the quenched approximation, numerical simulations are performed at three values of lattice spacing ($a_\sigma^{-1} = 1$–2 GeV) with the anisotropy $\xi = a_\sigma/a_\tau = 4$, where a_σ and a_τ are the spatial and temporal lattice spacings, respectively. The bare anisotropy γ_F in the quark action is numerically tuned through the ratio of meson masses in the fine and coarse directions, and through the dispersion relation of the pseudoscalar meson, so that the renormalized fermionic anisotropy coincides with that of the gauge field. The discrepancy between these two calibration schemes provides an estimate of the finite lattice artifact, which is found to be sizable in the range of cutoff explored in this work. We also compute the meson masses using correlators with the wall source at the tuned anisotropy parameter. The flavor symmetry breaking effect smoothly decreases as β increases. The effect of uncertainty in γ_F on the meson masses are also examined.

The anisotropic staggered quark in dynamical simulations is studied with two degenerate flavors using R-algorithm. For the calibration conditions we adopt the ratios of the hadronic radii r_0 (for the gauge field) and the meson masses (for the quark field) in the temporal and spatial directions. In dynamical simulations, we determine the anisotropy parameters γ_G and γ_F simultaneously within 1% statistical accuracy at renormalized anisotropy $\xi = a_s/a_t = 4$.

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

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