$O(a)$ improved Wilson quark action in anisotropic lattice QCD

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The $O(a)$ improved Wilson quark action on the anisotropic lattice is investigated [1, 2, 3]. The anisotropic lattice is drawing more attention as a useful technique of the lattice QCD simulation in various physics such as the spectroscopy of exotic states [4], finite temperature QCD [3, 5] and the heavy quark physics.

We carry out numerical simulations in the quenched approximation 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 the temporal lattice spacings, respectively. The bare anisotropy γ_F in the quark field action is numerically tuned by the dispersion relation of mesons so that the renormalized fermionic anisotropy coincides with that of gauge field. This calibration of bare anisotropy is performed to the level of 1 % statistical accuracy in the quark mass region below the charm quark mass. The systematic uncertainty in the calibration is estimated by comparing the results from different types of dispersion relations, which results in 3 % on our coarsest lattice and tends to vanish in the continuum limit. In the chiral limit, there is an additional systematic uncertainty of 1 % from the chiral extrapolation.

Taking the central value $\gamma_F = \gamma_F^*$ from the result of the calibration, we compute the light hadron spectrum. Our hadron spectrum is consistent with the result by UKQCD Collaboration on the isotropic lattice. We also study the response of the hadron spectrum to the change of anisotropic parameter, $\gamma_F \to \gamma_F^* + \delta\gamma_F$. We find that the change of γ_F by 2 % induces a change of 1 % in the spectrum for physical quark masses. Thus the systematic uncertainty on the anisotropic lattice, as well as the statistical one, is under control.

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