Nucleon Structure from Quenched Lattice QCD with Domain Wall Fermions

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Domain wall fermions (DWF) are a new fermion discretization scheme with greatly improved chiral symmetry [1]. Our final goal is to study the nucleon spin structure through lattice simulation using DWF. In this talk, we present our current progress on two topics toward this goal: 1) the mass spectrum of the nucleon excited states [2] and 2) the iso-vector axial charges g_A of the nucleon [3].

Our quenched DWF calculation at $\beta = 6.0$ on a $16^3 \times 32$ lattice reproduces very well the large mass splitting between the nucleon $N(939)$ and its parity partner $N^*(1535)$ [2]. We have also calculated the mass of the first positive-parity excited state $N'(1440)$ by the diagonalization of a 2×2 matrix correlator and confirmed that it is heavier than the negative-parity excited state $N^*(1535)$ [2]. A remaining puzzle is whether or not a switching of N^* and N' occurs close to the chiral limit.

The nucleon axial charge g_A is a real good test of lattice QCD towards studying the nucleon structure functions. Nevertheless, either quenched or full QCD lattice calculations with Wilson fermion at finite lattice spacing ($a^{-1} \sim 2$ GeV) have not succeeded in reproducing this quantity so well with underestimation by about 20 % [4]. Our previous DWF calculation was employed with Wilson gauge action at the standard lattice volume ($\sim (1.6\text{fm})^3$) on this subject [5]. Indeed, we found that g_A had a fairly strong dependence on the quark mass in the lighter quark mass region. A simple linear extrapolation of g_A to the chiral limit yielded a quite small value comparing the experimental one [5].

We report our recent study of this issue. In particular, we investigate possible main errors arising from finite lattice volume, especially in the lighter quark mass region. We employ DWF calculation with a RG-improved gauge action (DBW2), which maintains a very good chiral behavior even on coarse lattice ($a^{-1} \sim 1.3$ GeV), in order to perform simulations at large physical volume ($\sim (2.4\text{fm})^3$) [3]. We utilize two lattice sizes ($8^3 \times 24$ and $16^3 \times 32$) to examine the finite volume dependence. The significant large effect on g_A is observed with respect to finite lattice volume [3].

References

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