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Non-equilibration of topological charge and its effects

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[MILC collaboration}

In QCD simulations at small lattice spacings the topological charge Q evolves very slowly, and if this quantity is not properly equilibrated it could lead to incorrect results for physical quantities, or incorrect estimates of their errors. We use the known relation between the dependence of masses and decay constants on the QCD vacuum angle θ and the squared topological charge Q^2 together with chiral perturbation theory results for the dependence of masses and decay constants on θ to estimate the size of these effects and suggest strategies for dealing with them. For the partially quenched case, we sketch an alternative derivation of the known χPT results of Aoki and Fukaya, using the nonperturbative correct chiral theory worked out by Golterman, Sharpe and Singleton. With the MILC collaboration's ensembles of lattices with four flavors of HISQ dynamical quarks, we measure the Q^2 dependence of masses and decay constants and compare to the χPT forms. The observed agreement gives us some confidence that we can reliably estimate the errors from slow topology change, and even correct for its leading effects.

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