Chiral Extrapolation of Moments of Parton Distribution Functions Calculated in Lattice QCD

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The insights into non-perturbative hadron structure offered by the study of parton distribution functions makes this an extremely interesting research challenge. It is made even more important and timely by the new experimental possibilities opened by facilities such as HERMES, COMPASS, RHIC-spin and JLab. Lattice QCD offers the only practical method to actually calculate hadron properties within non-perturbative QCD and is therefore vital to test how well it describes existing data. Because current limitations on computer speed restrict these lattice simulations to quark masses that are a factor of 6–10 too large, one must be able to reliably extrapolate the lattice data to the physical quark (or pion) mass in order to compare with experiment.

Traditionally such extrapolations have been made using a naive linear extrapolation as a function of m_π^2 (or quark mass). In Ref.[1], Detmold *et al.* showed that it was essential to include the leading non-analytic behaviour of chiral perturbation theory in this extrapolation procedure. Only then was the existing experimental data for the moments of the unpolarised parton disribution functions in agreement with the experimental moments. Here we have confirmed this conclusion by calculating the next-to-leading non-analytic behaviour within a chiral quark model, including the Δ-isobar, and showing that it led to precisely the same conclusion.

We have also investigated the variation of the moments of the polarised parton distributions to next-to-leading order. In this case the inclusion of the Δ-isobar makes a dramatic difference. Indeed, once the Δ is included the polarised moments show little curvature as the chiral limit is approached. We propose a convenient formula which suitably builds in the non-analytic behaviour in both the unpolarised and the polarised cases. The value of g_A (at the physical pion mass) extracted from the new extrapolation procedure is within 10% of the experimental value. Given the sensitivity of this quantity to lattice size (current simulations use quite a small lattice) and quark action (Domain Wall Fermions tend to give a larger value of g_A than Wilson fermions), we consider this a very satisfactory result.

References

[1] W. Detmold, W. Melnitchouk, J. W. Negele, D. B. Renner, and A. W. Thomas, Phys. Rev. Lett. **87** (2001) 172001; arXiv:hep-lat/0103006.