The polarized EMC effect†

I. C. Cloet,*1 W. Bentz,*2 and A. W. Thomas*1

[NUCLEAR STRUCTURE FUNCTIONS, Spin dependence, Effective Quark Theories]

Recent works[1)] have shown that the EMC effect for the spin-independent nuclear structure functions can be successfully described in terms of the self consistent scalar and vector fields which couple to the quarks inside the nucleons. The individual nucleons in this approach are described as bound states of a quark and a diquark, where both the scalar and axial vector diquark channels are taken into account[2)]. Predictions for the spin-dependent counterpart of the EMC effect have also been made in this model.

The calculations of Ref.[1)] have been carried out in nuclear matter, and in this work we present results for finite nuclei. First studies of the polarized EMC effect should concentrate on light to medium heavy nuclei with valence proton particles or holes carrying the nuclear spin. Examples are ^{11}B and ^{15}N, which have a relatively simple structure so that one can investigate the effects of the medium on the quark substructure without too many complications caused by the nuclear many body problem.

We report on the results for ^{11}B in this work. It is assumed that the nucleons move in average scalar and vector fields, for which we take Woods-Saxon forms for simplicity. From the wave functions we obtain the spin dependent light cone momentum distributions of the nucleons[3)]. To get the quark distributions in the nucleons, we use the quark-diquark model of Ref.[2)], where the mean nuclear fields are incorporated into the constituent quark and diquark propagators. The convolution formalism is then applied to calculate the quark light cone momentum distributions in the nucleus.

The results for the polarized up and down quark distributions for the $p_{3/2}$ proton hole state are shown in Fig.1 for the low energy scale $Q_0 = 0.4$ GeV. The dotted line shows the distribution in a free proton, the dashed line shows the result including the effective mean scalar field which applies to the $p_{3/2}$ state, the dotted-dashed line shows the result including the Fermi motion, and the solid line also includes the effective mean vector field. Figure 2 shows the resulting polarized EMC ratio for the nucleus ^{11}B (dashed line) in comparison to the unpolarized one (solid line) and the experimental data for the ^{12}C nucleus. For the unpolarized case, where all nucleons contribute, this ratio is defined as usual by $\overline{F}_{2A}/F_{2N}$, where $\overline{F}_{2A}$ is the nuclear structure function per nucleon and F_{2N} is the average of the free proton and neutron structure functions. For the polarized case, the ratio is defined as $\frac{g_{1A}}{g_{1p}}/P$, where we divide out the nuclear polarization factor (P) so that the ratio becomes 1 for the case of no medium modifications. The comparison of these two ratios shows that the medium modifications are more important for the case of the spin-dependent structure function than for the spin-independent one.

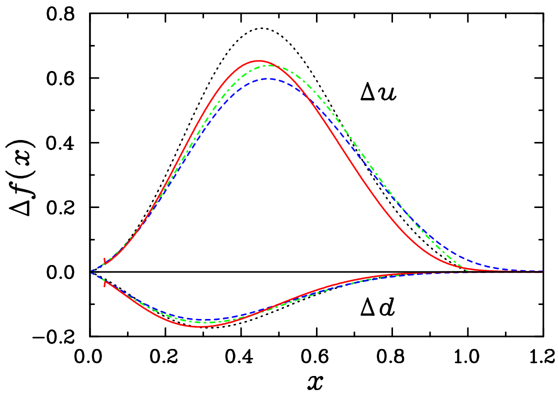

Fig. 1. The polarized up and down quark distribution for the $p_{3/2}$ proton state.

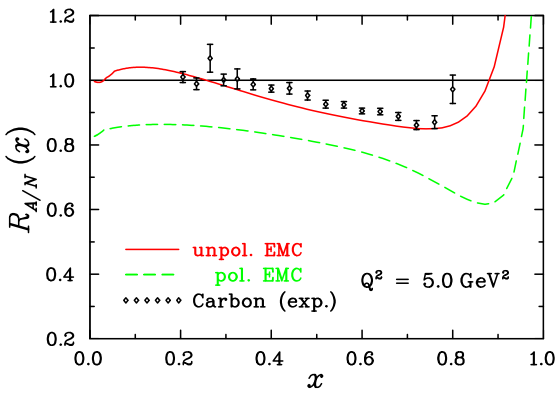

Fig. 2. Polarized (dashed line) and unpolarized (solid line) EMC ratios for ^{11}B. The experimental data of the unpolarized ratio for ^{12}C are shown for comparison.

References

1) I.C. Cloet, W. Bentz and A.W. Thomas, Phys. Rev. Lett. **95** (2005) 052302.
2) I.C. Cloet, W. Bentz and A.W. Thomas, Phys. Lett. **B 621** (2005) 246.
3) R.L. Jaffe and A. Manohar, Nucl. Phys. **B 321** (1989) 343.

† Condensed from an article by I.C. Cloet, W. Bentz, and A.W. Thomas, to be published.

*1 Jefferson Laboratories, Newport News, VA, U.S.A.
*2 Department of Physics, Tokai University, Kanagawa, Japan