Brief Reports

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Further studies of Fermi-motion effects in lepton scattering from nuclear targets

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(Received 9 March 1981)

We have calculated the ratio of deep-inelastic structure functions of nuclear targets to the sum of free-neutron and -proton structure functions. The calculations incorporate structure-function fits which are based on quantum-chromodynamic considerations. This paper is an addendum to an earlier publication in which we calculated the Fermi-motion corrections using other fits to the nucleon structure functions.

The effects of nuclear binding in the case of deep-inelastic scattering from the deuteron have been discussed in detail by Atwood and West.[1] We have extended that method to the case of a general nucleus in a recent publication.[2] In that publication we presented numerical results using input structure functions from fits[3] to deep-inelastic electron-scattering data. These fits parametrized the scaling violations in terms of a modified scaling variable[4] and also described the resonance region in detail using forms suggested by Atwood and Stein.[5] Although these structure functions fit the data well in the region $Q^2 = 0.2$ to 20 $(\text{GeV}/c)^2$, they are of a form such that the scaling violations are attributed to low-Q^2 phenomena ("higher-twist effects") and therefore vanish at very large values of Q^2. We have repeated our calculations using other fits to the same data which are based on quantum-chromodynamics (QCD) considerations. Those fits (due to Buras and Gaemers[6]) are compared to the fits used in our earlier publication in Fig. 1, and in Figs. 2, 3, and 4. Both fits yield similar values in the low-Q^2 region, but diverge when extrapolated to the high-Q^2 region. However, the QCD fits do not describe the resonance region in detail. The notation and definitions used in this addendum are identical to those of our earlier publication.[2]

The Buras-Gaemers fits[6] assume that all the scaling violations observed at low Q^2 are due to QCD effects. The other fits (by Bodek *et al.*[3]), as mentioned earlier, assume that all the scaling violations are due to low-Q^2 effects. In general, it is expected that both low-Q^2 and logarithmic high-Q^2 terms exist. Since the calculation of the Fermi-motion corrections to the structure functions requires the knowledge of the free-nucleon structure functions, it involves an iterative procedure that must be undertaken by the experimenters. We present the calculation of the Fermi-motion corrections using the Buras-Gaemers structure functions in order to provide information about the sensitivity of the corrections to the input structure functions.

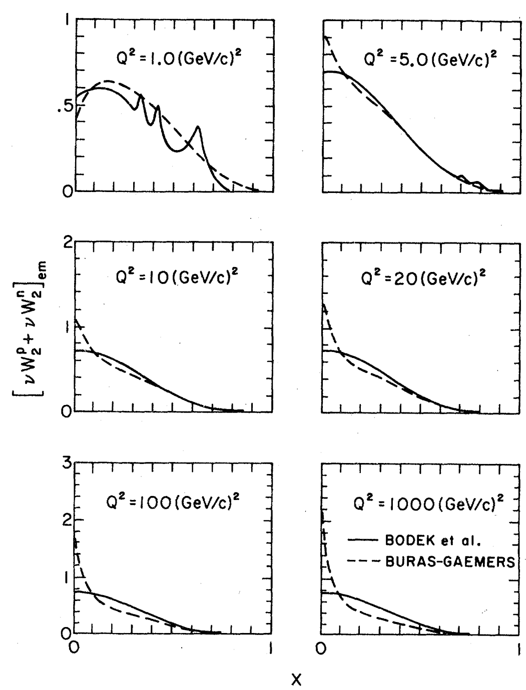

FIG. 1. A comparison of the two fits to the SLAC electroproduction data, and the results they yield when extrapolated to very high values of Q^2. The solid line is the fit from Bodek *et al.* (Ref. 3) and the dashed line is from Buras and Gaemers (Ref. 6). The structure functions are shown as a function of x for fixed values of Q^2.

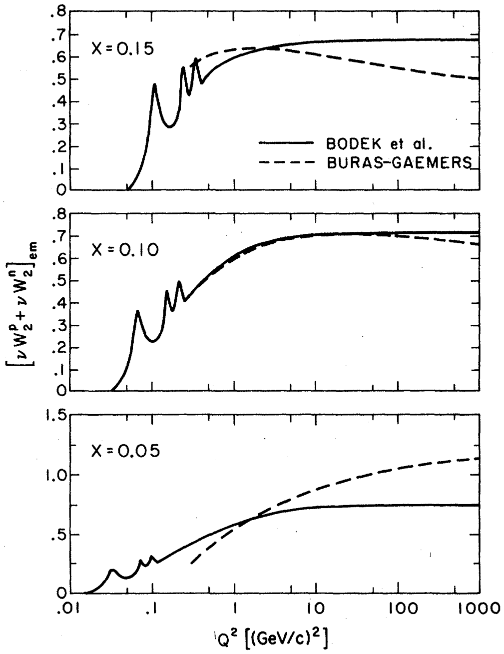

FIG. 2. Extrapolations of the Bodek *et al.* fit and the Buras-Gaemers fits of the structure functions to high values of Q^2 for values of $x=0.05$, $x=0.10$, and $x=0.15$.

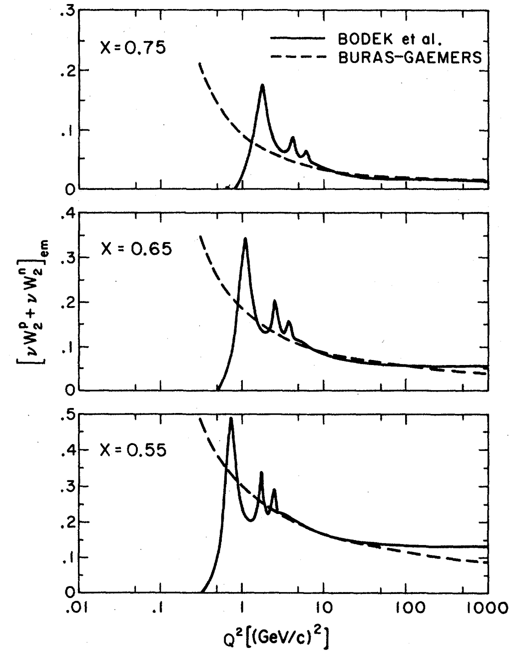

FIG. 4. Extrapolations of the Bodek *et al.* fit and the Buras-Gaemers fits of the structure functions to high values of Q^2 for values of $x=0.55$, $x=0.65$, and $x=0.75$.

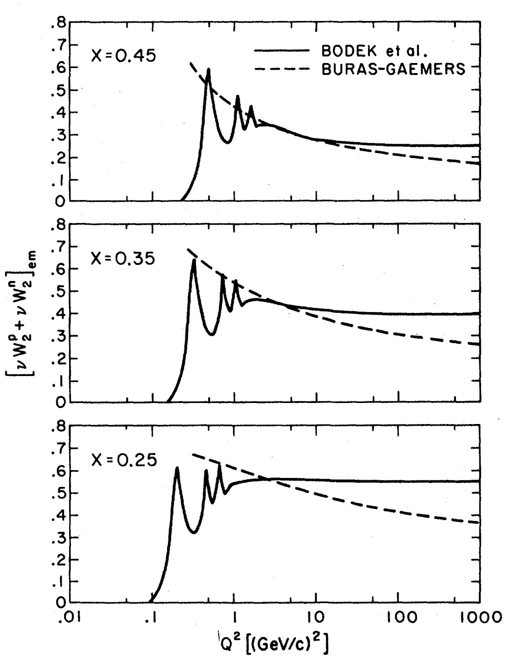

FIG. 3. Extrapolations of the Bodek *et al.* fit and the Buras-Gaemers fits of the structure functions to high values of Q^2 for values of $x=0.25$, $x=0.35$, and $x=0.45$.

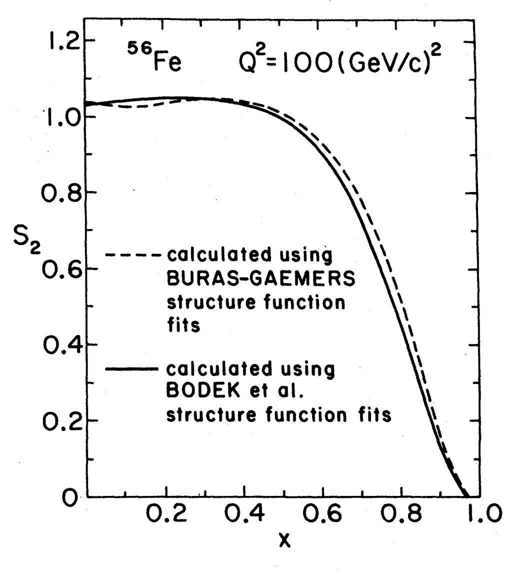

FIG. 5. The ratio of the sum of free-nucleon structure functions to the structure function νW_2 calculated for steel (^{56}Fe) using the Buras-Gaemers structure functions (dashed line) and using the Bodek *et al.* structure functions (solid line). This figure indicates the sensitivity of the Fermi-motion corrections to the input structure functions. The results are shown as a function of x for $Q^2=100$ (GeV/c)^2.

The Fermi-motion corrections to the structure function νW_2 for a steel (^{56}Fe) target are shown in Fig. 5 as a function of x for $Q^2 = 100$ (GeV/c)^2. The dashed line shows the correction calculated using the Buras-Gaemers QCD structure functions and the solid line shows the correction calculated using the Bodek *et al.* structure-function fits. The quantity that is shown is S_2 which is defined to be the ratio of the sum of free-nucleon structure functions to the structure function for the nucleus ^{56}Fe. As can be seen from the figure, the correction calculated using the different structure functions agree to within 1% for x values which are less than 0.5. The corrections for larger values of x differ by 2–16%.

The Buras-Gaemers structure functions do not describe the resonance region in detail, but provide a smooth curve that averages the structure functions through the resonance region (see Figs. 1–4). We may use these structure functions to provide an average Fermi-motion correction in the resonance region. Figure 6 illustrates the effect of the nuclear Fermi motion at two different values of Q^2. Shown are the free-nucleon structure functions as compared to the structure function for the nucleus ^{56}Fe. As expected, the Fermi-motion corrections deplete the low-x region and enhance the structure function at large values of x.

Tables which give various quantities related to the Fermi-motion corrections for the three structure functions W_1, W_2, and W_3, calculated using the Buras-Gaemers structure-function fits can be found in Refs. 7 and 8. These tables are similar to the tables in our earlier publication,[2] but in addition give the corrections in the resonance region ($W < 2$ GeV/c^2).

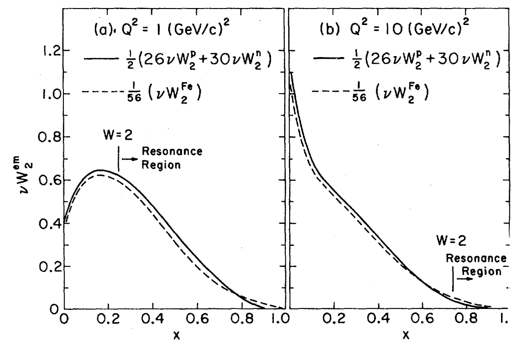

FIG. 6. The sum of free-nucleon structure functions calculated using the Buras-Gaemers fits as compared to the calculated structure functions for steel (^{56}Fe). The fits do not describe the resonance region in detail but provide an idea as to the average behavior in the resonance region. (a) $Q^2 = 1.0$ (GeV/c)^2. (b) $Q^2 = 10.0$ (GeV/c)^2.

This work was supported in part by the U. S. Department of Energy under Contract No. DE-AC02-76ER13065. One of us (A.B.) thanks the Alfred P. Sloan Foundation for support.

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[8]See AIP document no. PAPS-PRVDA-24-1400 for 11 pages of detailed tables of Fermi-motion corrections in lepton scattering from nuclear targets calculated using Buras-Gaemers structure functions. Order by PAPS number and journal reference from American Institute of Physics, Physics Auxiliary Publication Service, 335 East 45th Street, New York, N. Y. 10017. The price is $1.50 for a microfiche, or $5.00 for a photocopy.