A NEW EVALUATION OF POLARIZED PARTON DENSITIES IN THE NUCLEON* **

Elliot Leader

Imperial College, University of London
London WC1E 7HX, England

Aleksander V. Sidorov

Bogoliubov Theoretical Laboratory, Joint Institute for Nuclear Research
141980 Dubna, Russia

and D.B. Stamenov

Institute for Nuclear Research and Nuclear Energy
Sofia 1784, Bulgaria

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We present a new Next-to-Leading Order (NLO) QCD analysis of the world data on inclusive polarized deep inelastic scattering. A new set of polarized parton densities is extracted from the data and the sensitivity of the results to the newly incorporated SLAC/E155 proton data is discussed.

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1. Introduction

In this talk we present an updated version of our NLO polarized Parton Densities (PD) determined from the world data [1, 2] on inclusive polarized DIS. Comparing to our previous analysis [3]:

(i) For the axial charges a_3 and a_8 their updated values are used:

$$\begin{aligned} a_3 &= g_A = F + D = 1.2670 \pm 0.0035\,, \\ a_8 &= 3F - D = 0.585 \pm 0.025\,. \end{aligned} \tag{1}$$

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(ii) In our Ansatz for the input polarized PD

$$\Delta f_i(x,Q_0^2) = A_i\ x^{\alpha_i}\ f_i^{\mathrm{MRST}}(x,Q_0^2) \tag{2}$$

we now utilize the MRST'99 set [4] of unpolarized parton densities $f_i(x,Q_0^2)$ instead of the MRST'98 one. In (2) A_i, α_i are free parameters (6 parameters in our fit after using the sum rules (1) for the quark polarizations).

(iii) The recent SLAC/E155p data [2] are incorporated in the analysis.

2. Method of analysis

The spin-dependent structure function of interest, $g_1^N(x,Q^2)$, is a linear combination of the asymmetries $A_{\|}^N$ and $A_{\perp}^N$ (or the related virtual photon-nucleon asymmetries $A_{1,2}^N$) measured with the target polarized longitudinally or perpendicular to the lepton beam, respectively. Neglecting as usual the sub-dominant contributions, $A_1^N(x,Q^2)$ can be expressed via the polarized structure function $g_1^N(x,Q^2)$ as

$$A_1^N(x,Q^2) \cong (1+\gamma^2)\frac{g_1^N(x,Q^2)}{F_1^N(x,Q^2)}\,, \qquad N=p,n,d\,, \tag{3}$$

where F_1^N is the unpolarized structure function and γ^2 is a kinematic factor.

All details of our approach to the fit of the data are given in [5]. Here we would like to emphasize that according to this approach the NLO QCD predictions have been confronted with the data on the spin asymmetry $A_1^N(x,Q^2)$, rather than on the $g_1^N(x,Q^2)$. The choice of A_1^N appears to minimize the higher twist (HT) contributions to g_1^N which are expected to partly cancel with those of F_1^N in the ratio (3), allowing use of data at lower Q^2 (in polarized DIS most of the small x experimental data points are at low Q^2). Indeed, we have found [6] that if for g_1 and F_1 Leading-Twist (LT) QCD expressions are used, the higher twist corrections $h(x)$ to $A_1(x,Q^2) = A_1(x,Q^2)_{\mathrm{LT}} + h(x)/Q^2$ are negligible and consistent with zero (see Fig. 1). On the other hand, it was shown [7] that if F_2 and R (F_1 in (3) can be expressed via usually measured F_2 and R) are taken from experiment (as has been done in some of the analyses) the HT corrections to A_1 are sizeable and important. So, in order to extract the polarized parton densities from g_1 data the HT contribution to g_1 (unknown at present) has to be included in the data fit. Note that a QCD fit to the g_1 data, keeping in $g_1(x,Q^2)_{\mathrm{QCD}}$ only the leading-twist expression, leads to some "effective", parton densities which involve in themselves the HT effects and, therefore, are not quite correct. These results suggest that in order to determine polarized parton densities less sensitive to higher twist effects, it is preferable at present to analyze A_1 data directly using for g_1 and F_1 their leading twist expressions.

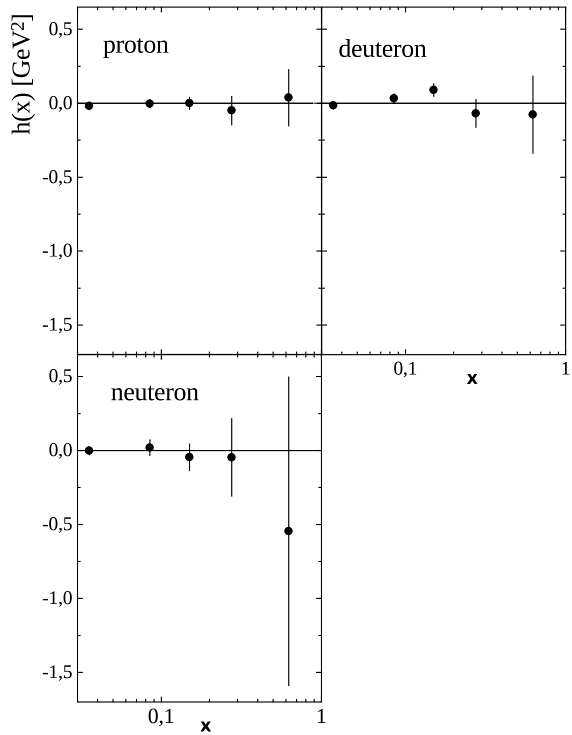

Fig. 1. Higher twist contribution $h^N(x)$ to the spin asymmetry $A_1^N(x, Q^2)$ extracted from the data.

What we can deduce from inclusive DIS in the absence of charged current neutrino data is the sum of the polarized quark and anti-quark densities

$$(\Delta u + \Delta \bar{u})(x, Q^2)\,, \quad (\Delta d + \Delta \bar{d})(x, Q^2)\,, \quad (\Delta s + \Delta \bar{s})(x, Q^2) \tag{4}$$

and the polarized gluon density $\Delta G(x, Q^2)$. The non-strange polarized sea-quark densities $\Delta \bar{u}(x, Q^2)$ and $\Delta \bar{d}(x, Q^2)$, as well as the valence quark densities $\Delta u_v(x, Q^2)$ and $\Delta d_v(x, Q^2)$:

$$\Delta u_v \equiv \Delta u - \Delta \bar{u},\ \Delta d_v \equiv \Delta d - \Delta \bar{d} \tag{5}$$

cannot be determined without additional assumptions about the flavour decomposition of the sea. Nonetheless (because of the universality of the parton densities) they are of interest for predicting the behaviour of other processes, like polarized *pp* reactions, *etc.* That is why, we extract from the data not only the quark densities (4) and $\Delta G(x, Q^2)$, but also the valence parts $\Delta u_v(x, Q^2)$, $\Delta d_v(x, Q^2)$ and anti-quark densities using the assumption on the flavour symmetric sea: $\Delta u_{\rm sea} = \Delta \bar{u} = \Delta d_{\rm sea} = \Delta \bar{d} = \Delta s = \Delta \bar{s}$.

3. Results

The results of analysis [8] are presented in both the JET [9] and $\overline{\rm MS}$ factorization schemes. A remarkable property of the JET [and Adler–Bardeen (AB)] schemes is that the singlet $\Delta\Sigma(Q^2)$, as well as the strange sea polarization $\Delta s(Q^2)$, are Q^2 *independent* quantities. Then, in these schemes it is meaningful to directly interpret $\Delta\Sigma$ as the contribution of the quark spins to the nucleon spin and to compare its value obtained from DIS region with the predictions of the different (constituent, chiral, *etc.*) quark models at low Q^2. It is important to mention that the difference between the values of the strange sea polarization, obtained in the $\overline{\rm MS}$ and JET schemes could be *large* due to the axial anomaly. To illustrate how large it can be, we present the values of $(\Delta s + \Delta \bar{s})$ at $Q^2 = 1$ GeV^2 obtained in our analysis of the world DIS data in the $\overline{\rm MS}$ and JET schemes ($\Delta G = 0.68$):

$$(\Delta s + \Delta \bar{s})_{\overline{\rm MS}} = -0.13 \pm 0.04, \quad (\Delta s + \Delta \bar{s})_{\rm JET} = -0.07 \pm 0.02. \qquad (6)$$

Note that if ΔG is larger than 0.68, $(\Delta s + \Delta \bar{s})_{\rm JET}$ could *vanish* in agreement with what is intuitively expected in quark models at low-Q^2 region ($Q^2 \approx 0$). As in our previous analysis a very good description of the world data on A_1^N and g_1^N is achieved (for the best fit $\chi^2 = 155.9$ for 179 DOF). The new theoretical curves for A_1 and g_1 corresponding to the best fit practically coincide with the old ones. The agreement with the SLAC/E155p data is also very good. This is illustrated in Fig. 2. The extracted NLO(JET) polarized parton densities at $Q^2 = 1$ GeV^2 are shown in Fig. 3. The new parton densities are found to be within the error bands of the old ones. The changes of the central values of the parton polarizations (the first moments of the polarized parton densities) are negligible and within the errors of the quantities. Note that for the central value of the axial charge $a_0(Q^2)$ (equal to $\Delta\Sigma(Q^2)_{\overline{\rm MS}}$ in $\overline{\rm MS}$ scheme) we obtain now somewhat smaller value: $a_0(1~{\rm GeV}^2) = 0.21 \pm 0.10$ than the old one: $a_0 = 0.26 \pm 0.10$. For the gluon polarization ΔG corresponding to the best NLO(JET) fit we have found $\Delta G = 0.68 \pm 0.32$ at $Q^2 = 1$ GeV^2. However, if one takes into account the sensitivity of ΔG to variation of the non-singlet axial charge a_8 from its SU(3) symmetric value of $3F - D$, the positive values of ΔG could lie in the wider range [0, 1.5] [10]. A negative ΔG is still *not* excluded from the present DIS inclusive data.

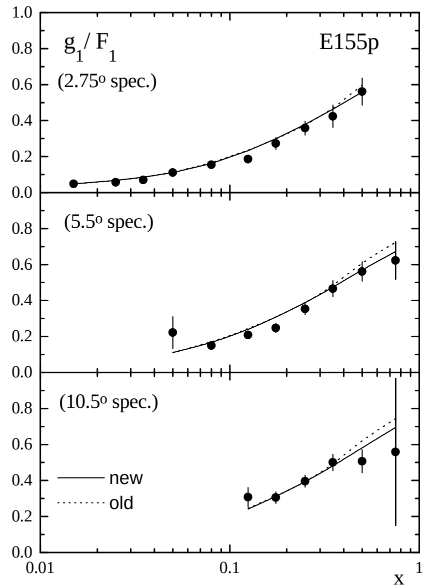

Fig. 2. Comparison of our NLO(JET) result for A_1^p with SLAC/E155p experimental data. Error bars represent the total errors. The predictions for A_1^p (dot curves) from our old analysis [3] are also shown.

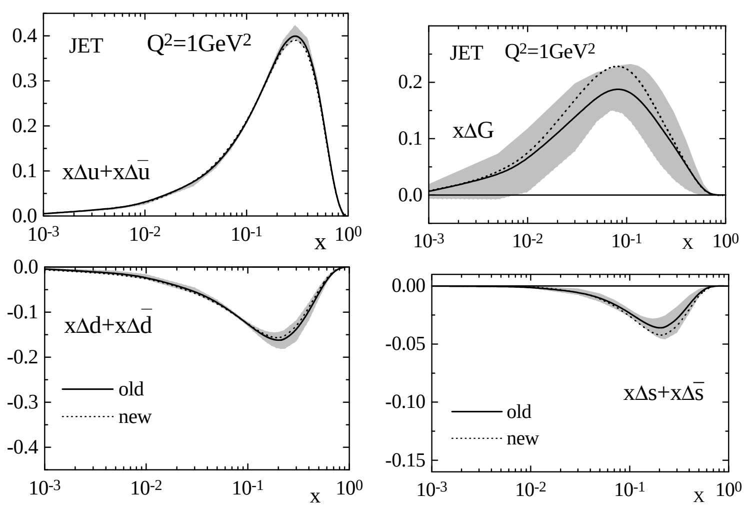

Fig. 3. NLO(JET) polarized parton densities at $Q^2 = 1$ GeV^2. The old parton densities together with their error bands are presented for comparison.

4. Conclusion

What follows from our analysis is that the limited kinematic range and the precision of the present generation of inclusive DIS experiments are enough to determine with a good accuracy only the polarized parton densities $(\Delta u + \Delta\bar{u})(x,Q^2)$ and $(\Delta d + \Delta\bar{d})(x,Q^2)$. The polarized strange sea density $(\Delta s + \Delta\bar{s})(x,Q^2)$ as well as the polarized gluon density $\Delta G(x,Q^2)$ are still weakly constrained, especially ΔG. The non-strange polarized sea-quark densities $\Delta\bar{u}$ and $\Delta\bar{d}$ cannot be determined, in principle, from the inclusive DIS experiments alone without additional assumptions. The further study of flavour decomposition of the sea as well as a more accurate determination of the gluon polarization are important next steps in our understanding of the partonic structure of the nucleon and this will be done in the forthcoming and future polarized lepton-hadron and hadron–hadron experiments.

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