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A new evaluation of polarized parton densities in the nucleon

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Abstract. We present a new leading and next-to-leading 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.

1 Introduction

Deep inelastic scattering (DIS) of leptons on nucleons has remained the prime source of our understanding of the internal partonic structure of the nucleon and one of the key areas for the testing of perturbative QCD. Decades of experiments on unpolarized targets have led to a rather precise determination of the unpolarized parton densities. Spurred on by the famous EMC experiment [1] at CERN in 1988, there has been a huge growth of interest in *polarized* DIS experiments which yield more refined information about the partonic structure of the nucleon, *i.e.*, how the nucleon spin is divided up among its constituents, quarks and gluons. Many experiments have been carried out at SLAC, CERN and DESY.

In this paper we present an updated version of our NLO polarized parton densities in both the $\overline{\mathrm{MS}}$ and the JET (or so-called chirally invariant) [2] factorization schemes as well as the LO ones determined from the world data [1,3,4] on inclusive polarized DIS. Comparing to our previous analysis [5]:

i) For the axial charges a_3 and a_8 their updated values are used [6,7]:

$$a_3 = g_A = \mathrm{F} + \mathrm{D} = 1.2670 \ \pm\ 0.0035, \\ a_8 = 3\mathrm{F} - \mathrm{D} = 0.585 \ \pm\ 0.025\ . \qquad (1)$$

ii) In our ansatz for the input polarized parton densities

$$\Delta f_i(x, Q_0^2) = \rho_i(x)\ f_i^{\mathrm{MRST}}(x, Q_0^2) \qquad (2)$$

we now utilize the MRST'99 set [8] of unpolarized parton densities $f_i(x, Q_0^2)$ instead of the MRST'98 one.

iii) The recent SLAC/E155 proton data [4] are incorporated in the analysis.

iv) The positivity constraints on the polarized parton densities are discussed.

2 Method of Analysis

The nucleon spin-dependent structure function of interest, $g_1^N(x, Q^2)$, is a linear combination of the asymmetries $A_\parallel^N$ 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 subdominant contributions, $A_1^N(x, Q^2)$ can be expressed via the polarized structure function $g_1^N(x, Q^2)$ as

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

or

$$A_1^N(x, Q^2) \cong \frac{g_1^N(x, Q^2)}{F_2^N(x, Q^2)} 2x[1 + R^N(x, Q^2)] \qquad (4)$$

using the relation between the unpolarized structure function $F_1(x, Q^2)$ and the usually extracted from unpolarized DIS experiments $F_2(x, Q^2)$ and $R(x, Q^2)$

$$2xF_1^N = F_2^N(1 + \gamma^2)/(1 + R^N) \quad (N = p, n, d). \qquad (5)$$

In (3) the kinematic factor γ^2 is given by

$$\gamma^2 = \frac{4M_N^2 x^2}{Q^2}\ . \qquad (6)$$

In (6) $\mathrm{M_N}$ is the nucleon mass. It should be noted that in the SLAC and HERMES kinematic region γ cannot be neglected.

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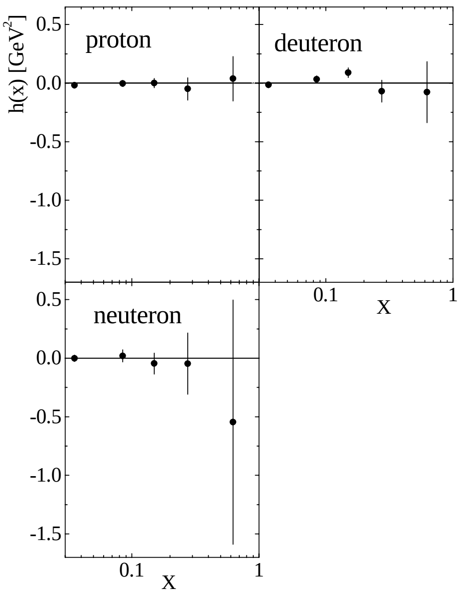

Fig. 1. Higher twist contribution $h^N(x)$ to the spin asymmetry $A_1^N(x,Q^2)$ extracted from the data

In the NLO QCD approximation the quark-parton decomposition of the proton structure function $g_1^p(x,Q^2)$ has the following form (a similar formula holds for g_1^n):

$$g_1^p(x,Q^2) = \frac{1}{2}\sum_q^{N_f} e_q^2 \left[(\Delta q + \Delta\bar{q}) \otimes \left(1 + \frac{\alpha_s(Q^2)}{2\pi}\delta C_q\right) + \frac{\alpha_s(Q^2)}{2\pi}\Delta G \otimes \frac{\delta C_G}{N_f} \right], \tag{7}$$

where $\Delta q(x,Q^2), \Delta\bar{q}(x,Q^2)$ and $\Delta G(x,Q^2)$ are quark, anti-quark and gluon polarized densities in the proton which evolve in Q^2 according to the spin-dependent NLO DGLAP equations. $\delta C_{q,G}$ are the NLO terms in the spin-dependent Wilson coefficient functions and the symbol $\otimes$ denotes the usual convolution in Bjorken x space. $\mathrm{N_f}$ is the number of flavours.

It is well known that at NLO and beyond, the parton densities as well as the Wilson coefficient functions become dependent on the renormalization (or factorization) scheme employed[1]. Both the NLO polarized coefficient functions [9] and the NLO polarized splitting functions (anomalous dimensions) [10] needed for the calculation of $g_1(x,Q^2)$ in the $\overline{\mathrm{MS}}$ scheme are well known at present. The corresponding expressions for these quantities in the JET scheme can be found in [11].

All details of our approach to the fit of the data are given in [12]. Here we would like to emphasize only that according to this approach first used in [13], the NLO QCD predictions have been confronted to 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 [14] that if for g_1 and F_1 *leading-twist* (LT) QCD expressions are used in (3), the HT corrections $h(x)$ to $A_1(x,Q^2) = A_1(x,Q^2)_{\mathrm{LT}} + h(x)/Q^2$, extracted from the data, are negligible and consistent with zero within the errors (see Fig. 1). (Note that the polarized parton densities in QCD are related to the leading-twist expression of g_1.) On other hand, it was shown [15] that if F_2 and R in (4) are taken from experiment (as has been done in some of the analyses) the higher twist 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 into data fit. Note that a QCD fit to the g_1 data keeping in $g_1(x,Q^2)_{QCD}$ 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 structure functions their leading twist expressions. Bearing in mind this discussion one must be careful when comparing the polarized parton densities determined from the inclusive DIS data with those extracted from semi-inclusive DIS data [16]. The results will depend, especially in a LO QCD analysis, upon whether the higher twist terms are or are not taken into account.

Following the procedure of our previous analyses we have extracted the NLO (as well as LO) polarized parton densities from the fit to the world data on $A_1^N(x,Q^2)$ using for the flavour non-singlet combinations of their first moments

$$a_3 = (\Delta u + \Delta\bar{u})(Q^2) - (\Delta d + \Delta\bar{d})(Q^2)\ , \tag{8}$$

$$a_8 = (\Delta u + \Delta\bar{u})(Q^2) + (\Delta d + \Delta\bar{d})(Q^2) - 2(\Delta s + \Delta\bar{s})(Q^2)\ , \tag{9}$$

the sum rule values (1). The sensitivity of the polarized parton densities to the deviation of a_8 from its SU(3) flavour symmetric value (0.58) has been studied and the results are given in [17]. Here we will present only the polarized parton densities corresponding to the SU(3) symmetric value of a_8 in (1).

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

$$(\Delta u + \Delta\bar{u})(x,Q^2),\quad (\Delta d + \Delta\bar{d})(x,Q^2),\quad (\Delta s + \Delta\bar{s})(x,Q^2) \tag{10}$$

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 $\Delta d_v(x,Q^2)$:

$$\Delta u_v \equiv \Delta u - \Delta\bar{u},\quad \Delta d_v \equiv \Delta d - \Delta\bar{d} \tag{11}$$

cannot be determined without additional assumptions about the flavour decomposition of the sea. Nonetheless

[1] Of course, physical quantities such as the virtual photon-nucleon asymmetry $A_1(x,Q^2)$ and the polarized structure function $g_1(x,Q^2)$ are independent of choice of the factorization convention

(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 (10) 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

$$\Delta u_{sea} = \Delta\bar{u} = \Delta d_{sea} = \Delta\bar{d} = \Delta s = \Delta\bar{s}. \quad (12)$$

For the input LO and NLO polarized parton densities at $Q_0^2 = 1\ GeV^2$ we have adopted a very simple parametrization

$$\begin{aligned} x\Delta u_v(x,Q_0^2) &= \eta_u A_u x^{a_u} x u_v(x,Q_0^2),\\ x\Delta d_v(x,Q_0^2) &= \eta_d A_d x^{a_d} x d_v(x,Q_0^2),\\ x\Delta s(x,Q_0^2) &= \eta_s A_s x^{a_s} x s(x,Q_0^2),\\ x\Delta G(x,Q_0^2) &= \eta_g A_g x^{a_g} x G(x,Q_0^2), \end{aligned} \quad (13)$$

where on RHS of (13) we have used the MRST98 (central gluon) [18] and MRST99 (central gluon) [8] parametrizations for the LO and NLO($\overline{\rm MS}$) unpolarized densities, respectively. The normalization factors A_f in (13) are fixed such that η_f are the first moments of the polarized densities. The first moments of the valence quark densities η_u and η_d are constrained by the sum rules (1). The rest of the free parameters in (13),

$$\{a_u,\ a_d,\ \eta_s,\ a_s,\ \eta_g,\ a_g\}, \quad (14)$$

have been determined from the best fit to the data.

The guiding arguments to choose for the input polarized parton densities the ansatz (13) are simplicity (not too many free parameters) and the expectation that polarized and unpolarized densities have similar behaviour at large x. Also, such an ansatz allows easy control of the positivity condition, which in LO QCD implies:

$$|\Delta f_i(x,Q_0^2)| \le f_i(x,Q_0^2), \quad |\Delta\bar{f}_i(x,Q_0^2)| \le \bar{f}_i(x,Q_0^2). \quad (15)$$

The constraints (15) are consequence of a probabilistic interpretation of the parton densities in the naive parton model, which is still correct in LO QCD. Beyond LO the parton densities are not physical quantities and the positivity constraints on the polarized parton densities are more complicated. They follow from the positivity condition for the polarized lepton-hadron cross-sections $\Delta\sigma_i$ with the unpolarized ones ($|\Delta\sigma_i| \le \sigma_i$) and include also the Wilson coefficient functions. It was shown [20], however, that for all practical purposes it is enough at the present stage to consider LO positivity bounds, since NLO corrections are only relevant at the level of accuracy of a few percent.

3 Results

In this section we present the numerical results of our fits to the world data on $A_1(x,Q^2)$. The data used (185 experimental points) cover the following kinematic region:

$$0.005 \le x \le 0.75, \quad 1 < Q^2 \le 58\ GeV^2\ . \quad (16)$$

The total (statistical and systematic) errors are taken into account. The systematic errors are added quadratically.

We prefer to discuss the NLO results of analysis in the JET scheme. To compare our NLO polarized parton densities with those extracted by other groups, we present them also in the usually used $\overline{\rm MS}$ scheme using the renormalization group transformation rules for the parton densities.

It is useful to recall the transformation rules relating the first moments of the singlet quark density, $\Delta\Sigma(Q^2)$, and the strange sea, $(\Delta s+\Delta\bar{s})(Q^2)$, in the JET and $\overline{\rm MS}$ schemes:

$$\Delta\Sigma_{\rm JET} = \Delta\Sigma_{\overline{\rm MS}}(Q^2) + N_f\frac{\alpha_s(Q^2)}{2\pi}\Delta G(Q^2), \quad (17)$$

$$\begin{aligned}(\Delta s+\Delta\bar{s})_{\rm JET} &= (\Delta s+\Delta\bar{s})_{\overline{\rm MS}}(Q^2)\\ &\quad +\frac{\alpha_s(Q^2)}{2\pi}\Delta G(Q^2),\end{aligned} \quad (18)$$

where $\Delta G(Q^2)$ is the first moment of the polarized gluon density $\Delta G(x,Q^2)$ (note that ΔG is the same in the factorization schemes under consideration).

A remarkable property of the JET (and so-called Adler-Bardeen (AB) [19]) schemes is that the singlet $\Delta\Sigma$ (Q^2), as well as the strange sea polarization $(\Delta s+\Delta\bar{s})(Q^2)$, 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* if ΔG in (18) is positive and large. 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 ($\Delta G = 0.68$):

$$\begin{aligned}(\Delta s+\Delta\bar{s})_{\overline{\rm MS}} &= -0.13 \pm 0.04\\ (\Delta s+\Delta\bar{s})_{\rm JET} &= -0.07 \pm 0.02.\end{aligned} \quad (19)$$

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 ($Q^2 \approx 0$).

The numerical results of our fits to the data are summarized in Table 1. The best LO and NLO(JET) fits correspond to χ^2 per degree of freedom of $\chi^2_{\rm DF,LO} = 0.921$ and to $\chi^2_{\rm DF,NLO} = 0.871$. In LO QCD $\Delta G(x,Q^2)$ does not contribute directly in g_1 and the gluons cannot be determined from DIS data alone. For that reason the LO fit to the data was performed using for the input polarized gluon density $\Delta G(x,Q_0^2)$ that one extracted by the NLO fit to the data:

$$\Delta G(x,Q_0^2)_{\rm LO} = \Delta G(x,Q_0^2)_{\rm NLO(JET)}\ . \quad (20)$$

We consider that such a procedure leads to non-realistic errors of the rest of parameters and therefore, we present only their central values in Table 1. It is important to

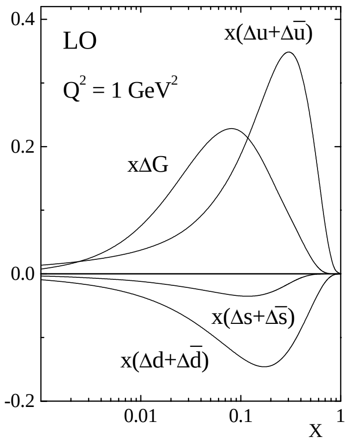

Fig. 2. Leading order polarized parton densities at Q^2=1 GeV^2

Table 1. Results of the LO and NLO fits to the world A_1^N data ($Q_0^2 = 1\ GeV^2$). The errors shown are total (statistical and systematic). The parameters marked by (*) are fixed

Fit	LO	NLO(JET)
DF	185 - 4	185 - 6
χ^2	166.7	155.9
χ^2/DF	0.921	0.871
η_u	0.926*	0.926*
a_u	0.121	0.253 ± 0.027
η_d	- 0.341*	−0.341*
a_d	0.102	0.000 ± 0.054
η_s	- 0.055	- 0.036 ± 0.007
a_s	0.754	1.613 ± 0.429
η_g	0.681*	0.681 ± 0.141
a_g	0.149*	0.149 ± 0.741

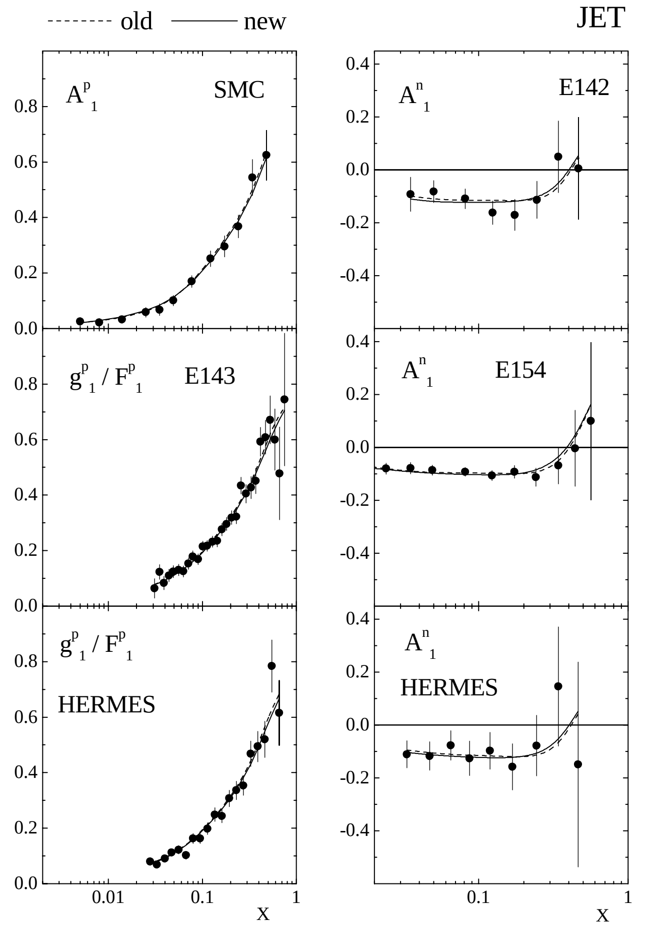

Fig. 3. Comparison of our NLO results in JET scheme for $A_1^N(x, Q^2)$ with the experimental data at the measured x and Q^2 values. Errors bars represent the total (statistical and systematic) error. Our old NLO results [5] are shown for comparison

note that in the polarized case the LO approximation has some peculiarities compared to the unpolarized one. As has been already mentioned above, as a consequence of the axial anomaly, the difference between NLO anti-quark polarizations $\Delta\bar{q}_i$ in different factorization schemes could be quite large, in order of magnitude of $\Delta\bar{q}_i$ themselves. In this case the leading order will be a bad approximation, at least for the polarized sea-quark densities extracted. Also, bearing in mind that in polarized DIS most of the data points are at low Q^2, lower than the usual cuts in the analyses of unpolarized data ($Q^2 \geq 4 - 5\ GeV^2$), the NLO corrections to all polarized parton densities are large in this region and it is better to take them into account. Nevertheless, the LO polarized parton densities may be useful for many practical purposes: For preliminary estimations of the cross sections in future polarized experiments, etc. For that reason we present them in this paper, at $Q^2 = 1\ GeV^2$ (see Fig. 2 and Appendix) and for any Q^2 in the region: $1 \leq Q^2 \leq 6.10^5$ (the FORTRAN code is available[2]). Further, we will discuss mainly the NLO QCD results.

As in our previous analysis [5] a very good description of the world data on A_1^N and g_1^N is achieved. The new NLO theoretical curves for A_1 corresponding to the best fit practically coincide with the old ones (see Fig. 3). The agreement with the SLAC/E155p data involved in this analysis is also very good. This is illustrated in Fig. 4. The NLO QCD theoretical predictions for A_1 corresponding to our previous analysis of the data are also shown. They are in a good agreement with the SLAC/E155 data not available at the time our previous analysis was performed. In Fig. 5 we compare the new NLO g_1 curves with the SMC and SLAC/E143 proton data. The extrapolations for g_1^p in the yet unmeasured small x region at different Q^2 are also shown. As seen from Fig. 5, the proton spin dependent structure function g_1^p changes sign at x smaller than 10^{-3} and becomes negative if the gluon polarization is positive. One of the challenges to future polarized DIS experiments is to confirm or reject this behaviour, quite different from the usual Regge type behaviour.

The extracted NLO(JET) polarized parton densities at $Q^2 = 1\ GeV^2$ are shown in Fig. 6a,b. (The explicit expressions are given in the Appendix.) The new parton

[2] http://durpdg.dur.ac.uk/HEPDATA/PDF

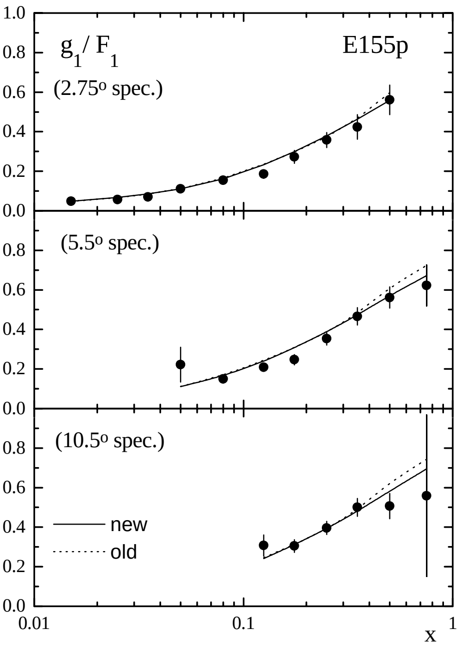

Fig. 4. Comparison of our NLO(JET) result for A_1^p with SLAC/E155p experimental data. Error bars represent the total errors. The predictions for A_1^p (dot curves) from our old analysis [5] are also shown

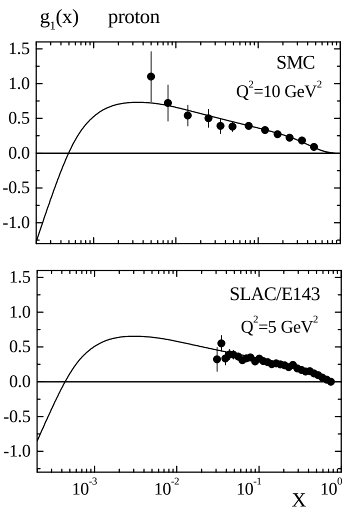

Fig. 5. Comparison of our NLO(JET) results for g_1^p with SMC and SLAC/E143 proton data. The extrapolations at small x are also shown

densities are found to be within the error bands of the old ones. The positivity constraints have not been imposed during the fit. Except for the strange sea density $\Delta s(x)$, the polarized parton densities determined from the data are compatible with the LO positivity bounds (15) imposed by the MRST99 unpolarized parton densities. However, if one uses the *more accurate* LO positivity bounds on $\Delta s(x)$ obtained by using the unpolarized strange sea density $s(x)_{BPZ}$ (Barone et al. [21]), $\Delta s(x)$ also lies in the allowed region. It is important to mention that $s(x)_{BPZ}$

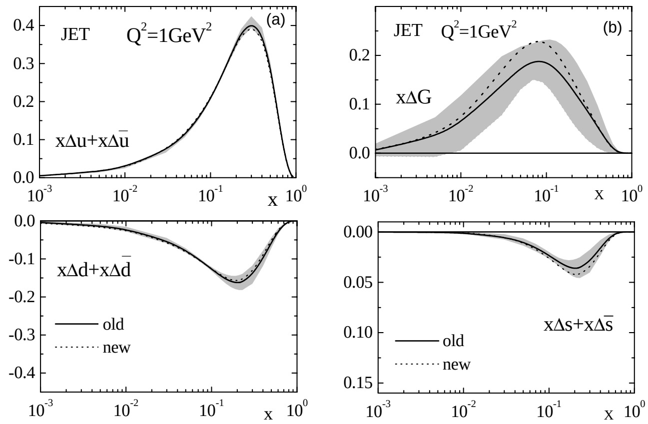

Fig. 6a,b. NLO(JET) polarized parton densities $x(\Delta u + \Delta\bar{u})$ and $x(\Delta d + \Delta\bar{d})$ **a**, and strange sea $x(\Delta s + \Delta\bar{s})$ and gluon polarized parton densities **b** at $Q^2 = 1$ GeV^2. The old parton densities together with their error bands are presented for comparison

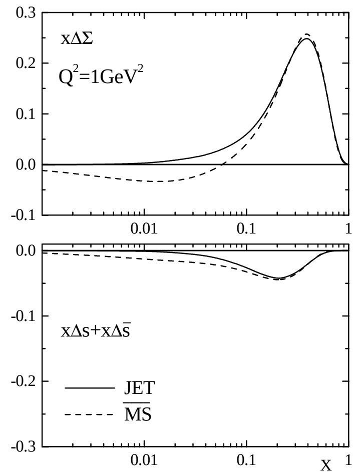

Fig. 7. Comparison between NLO polarized singlet and strange sea parton densities at $Q^2 = 1$ GeV^2 in the JET and $\overline{\text{MS}}$ schemes

is determined with a higher accuracy compared to other global fits.

In Fig. 7 we illustrate the difference between the singlet quark density $\Delta\Sigma(x, Q^2)$ and the strange sea density $(\Delta s + \Delta\bar{s})(x, Q^2)$ determined in the JET and $\overline{\text{MS}}$ schemes at $Q^2 = 1\ GeV^2$. They differ essentially in the small x region and this difference increases with ΔG increasing. In Fig. 8a,b we compare our NLO($\overline{\text{MS}}$) polarized parton densities with those obtained by AAC [7] and GRSV [15] using almost the same set of data. This comparison is a good illustration of the present situation in polarized DIS. While the quality and the kinematic range of the data are sufficient to determine the valence polarized densities $\Delta u_v(x, Q^2)$ and $\Delta u_v(x, Q^2)$ with a good accuracy (if an SU(3) symmetry of the flavour decomposition of the sea is assumed), the polarized strange quark density $\Delta s(x, Q^2)$ as well as the polarized gluon density $\Delta G(x, Q^2)$ are still weakly constrained, especially ΔG.

Table 2. First moments (polarizations) of polarized parton densities at $Q^2 = 1\ GeV^2$

Fit	$\Delta u + \Delta\bar{u}$	$\Delta d + \Delta\bar{d}$	$\Delta s + \Delta\bar{s}$	ΔG	$\Delta\Sigma$	a_0
old/JET	0.86±0.03	-0.40±0.05	-0.06±0.02	0.57±0.31	0.40±0.06	0.26±0.10
new/JET	0.85±0.03	-0.41±0.05	-0.07±0.02	0.68±0.32	0.37±0.07	0.21±0.10
new/$\overline{\mathrm{MS}}$	0.80	-0.47	-0.13	0.68	0.21	0.21
LO	0.82	-0.45	-0.11	0.68	0.25	0.25

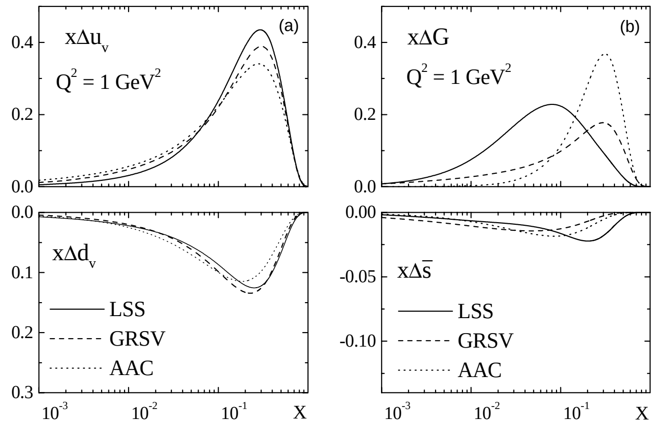

Fig. 8a,b. Comparison between our NLO($\overline{\mathrm{MS}}$) polarized valence quark densities **a** and polarized strange quark and gluon densities **b** at $Q^2 = 1$ GeV^2 with those obtained by AAC (NLO-2 set) [7] and GRSV ('standard' scenario) [15]

Finally, let us turn to the quark and gluon polarizations (the first moments of the polarized parton densities). The results of the new as well as of the old analysis are presented in Table 2 ($Q^2 = 1$ GeV^2). The corresponding values in the $\overline{\mathrm{MS}}$ scheme are also given. The changes of the central values of the parton polarizations (JET scheme) 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 $\Delta\Sigma(Q^2)_{\overline{\mathrm{MS}}}$ in $\overline{\mathrm{MS}}$ scheme) we obtain now somewhat smaller value: $a_0(1\ \mathrm{GeV}^2) = 0.21 \pm 0.10$ than the old one: $a_0 = 0.26 \pm 0.10$. The values of the LO parton polarizations are between those of the JET and $\overline{\mathrm{MS}}$ schemes.

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] [17]. A negative ΔG is still *not* excluded from the present DIS inclusive data.

4 Conclusion

We have re-analyzed the world data on inclusive polarized deep inelastic lepton-nucleon scattering in leading and next-to-leading order of QCD adding to the old set of data the SLAC/E155 proton data. Compared to our previous analysis: i) the updated values for the non-singlet axial charges g_A and a_8 and ii) in the ansatz for the input polarized parton densities the MRST99 set of unpolarized parton densities instead of the MRST98 one have been used. It was demonstrated that the polarized DIS data are in an excellent agreement with the pQCD predictions for $A_1^N(x, Q^2)$ and $g_1^N(x, Q^2)$ and that the new theoretical curves practically coincide with the old ones. A new set of NLO polarized parton densities in the JET and $\overline{\mathrm{MS}}$ factorization schemes as well as LO polarized patron densities have been extracted from the data. We note that one must be careful when using LO polarized densities. The LO QCD approximation could be a bad one, at least for the polarized sea-quark densities, if it will turn out that the gluon polarization is positive and large (the first direct measurement of ΔG [22] as well as the QCD analyses support such a possibility). We have found that the new NLO(JET) polarized parton densities do not change essentially and lie within the error bands of the old parton densities.

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.

A FORTRAN package containing our NLO polarized parton densities in both the JET and $\overline{\mathrm{MS}}$ factorization schemes as well as LO parton densities can be found at http://durpdg.dur.ac.uk/HEPDATA/PDF or obtained by electronic mail:

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Appendix

For practical purposes we present here explicitly our LO and NLO(JET) polarized parton densities at Q^2=1 GeV^2. The polarized valence quark densities correspond to SU(3) flavour symmetric sea.

LSS - LO:

$$\begin{aligned} x\Delta u_v(x) &= \ 0.3112\ x^{0.4222}\ (1-x)^{3.177} \\ &\quad \times(1-0.4085\ x^{1/2}+17.60\ x)\ , \\ x\Delta d_v(x) &= -0.01563\ x^{0.2560}\ (1-x)^{3.398} \\ &\quad \times(1+37.25\ x^{1/2}+31.14\ x)\ , \\ x\Delta s(x) &= -0.08548\ x^{0.5645}\ (1-x)^{8.653} \\ &\quad \times(1-0.9052\ x^{1/2}+11.53\ x)\ , \\ x\Delta G(x) &= \ 19.14\ x^{1.118}\ (1-x)^{6.879} \\ &\quad \times(1-3.147\ x^{1/2}+3.148\ x)\ . \end{aligned} \tag{A.1}$$

LSS - NLO(JET):

$$\begin{aligned} x\Delta u_v(x) &= \ 0.5052\ x^{0.6700}\ (1-x)^{3.428} \\ &\quad \times(1+2.179\ x^{1/2}+14.57\ x)\ , \\ x\Delta d_v(x) &= -0.01852\ x^{0.2704}\ (1-x)^{3.864} \\ &\quad \times(1+35.47\ x^{1/2}+28.97\ x)\ , \\ x\Delta s(x) &= -0.1525\ x^{1.332}\ (1-x)^{7.649} \\ &\quad \times(1+3.656\ x^{1/2}+19.50\ x)\ , \\ x\Delta G(x) &= \ 19.14\ x^{1.118}\ (1-x)^{6.879} \\ &\quad \times(1-3.147\ x^{1/2}+3.148\ x)\ . \end{aligned} \tag{A.2}$$

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