PHENOMENOLOGICAL ANALYSIS OF DATA ON INCLUSIVE AND SEMI-INCLUSIVE SPIN ASYMMETRIES

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We present a phenomenological analysis of data on both inclusive and semi-inclusive spin asymmetries. We examine the impact of the semi-inclusive results presented by SMC on the determination of polarized parton distributions performing global fits with different sets of observables. We discuss the flavour dependence of the polarized sea inside a nucleon.

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In recent years a number of theoretical attempts [1–10] to determine the polarized quark parton distributions in the nucleon have been performed. The deep inelastic polarized structure functions $g_1^N(x,Q^2)$ or the asymmetries measured in inclusive processes [11–21] are used in phenomenological analyses. Such an analysis of the first moment of the structure function $\Gamma_1^N = \int_0^1 g_1^N(x)dx$ pointed out that quarks carry little of the spin of the nucleon [13,22,23]. The reasonable suggestion is that the sea quarks and/or gluons are polarized. However, inclusive deep inelastic scattering does not provide sufficient information about the flavour separation of the polarized sea. Hence different combination of the polarized parton distributions have to be measured in order to get more information about flavour structure of the polarized sea.

The measurement of the semi–inclusive spin asymmetries for positively and negatively charged hadrons from deep inelastic scattering of polarized muons on polarized protons and deuterons provides additional data on required observables [24]. Presently available semi-inclusive results [25,26] can be used to determine polarized valence and non–strange sea quark distributions, independently from totally inclusive data. The aim of the paper is to combine two kinds of existing data, inclusive and semi–inclusive, to extract polarized parton distributions.

Measurement of the inclusive deep inelastic lepton nucleon scattering gives information about the spin asymmetry [27]:

$$A_1^N(x,Q^2) \simeq \frac{g_1^N(x,Q^2)}{F_1^N(x,Q^2)}, \tag{1}$$

which in leading order QCD parton model is given by:

$$A_1^N(x,Q^2) \simeq \frac{\sum_q e_q^2 \Delta q(x,Q^2)}{\sum_q e_q^2 q(x,Q^2)}, \tag{2}$$

where e_q is the charge of the q–flavoured quark, q and Δq denotes unpolarized and polarized quark distributions respectively, where $q = u, d, s, \bar{u}, \bar{d}, \bar{s}$. This is the consequence of the fact that in LO QCD $2g_1 = \sum_q e_q^2 \Delta q$, $\frac{1}{x}F_2 = \sum_q e_q^2 q$ and of the Callan–Gross relation $F_2 = 2xF_1$. First attempt to improve such a model is to use $R^N(x,Q^2) = (F_2^N - 2xF_1^N)/2xF_1^N \neq 0$, which is the ratio of the absorption cross–sections for virtual longitudinal and transverse photons ($R = \sigma_L/\sigma_T$) [28]. In calculations, we use the parametrization of R described in Ref. [29], which is analogous to the one given in Ref. [30], but fitted to the enlarged set of data on R with new experimental values [31–34]. This correction leads to the expression:

$$A_1^N(x,Q^2) \simeq \frac{\sum_q e_q^2 \Delta q(x,Q^2)}{\sum_q e_q^2 q(x,Q^2)}(1 + R^N(x,Q^2)), \tag{3}$$

for proton and neutron target ($N = p, n$). The parton distributions are those of the proton whereas for neutron are obtained by the isospin interchange $u \leftrightarrow d$. For deuteron target case one has to multiply above expression by additional factor $1 - 3/2p_D$ where p_D is a probability of D-state in deuteron wave function ($p_D = 0.05 \pm 0.01$) [35].

Analogously, for the semi-inclusive asymmetries, the expression in the same order can be written as:

$$A_1^{N\,h}(x,Q^2)\Big|_Z \simeq \frac{\int\limits_Z dz\, g_1^{N\,h}(x,z,Q^2)}{\int\limits_Z dz\, F_1^{N\,h}(x,z,Q^2)}, \tag{4}$$

where h denotes the hadron detected in the final state and the variable z is given by $E_h/E_N(1-x)$ with energies given in $\gamma^* p$ CM frame. The region Z is determined by kinematical cuts in measurement of the asymmetries. Summing over positively charged hadrons, *i.e.* π^+, K^+ and p, and negatively charged (π^-, K^-, $\bar{p}$) respectively, we get:

$$A_1^{N+(-)}(x,Q^2) \simeq \frac{\sum_{q,h^{+(-)}} e_q^2 \Delta q(x,Q^2) D_q^h(Q^2)}{\sum_{q,h^{+(-)}} e_q^2 q(x,Q^2) D_q^h(Q^2)} (1+R^N(x,Q^2)). \qquad (5)$$

Here $D_q^h(Q^2) = \int_{0.2}^1 dz D_q^h(z,Q^2)$ and $D_q^h(z,Q^2)$ is the fragmentation function which represents the probability that a struck quark with a flavour q fragments into a hadron h. To reduce the number of independent fragmentation functions one can use charge invariance and isospin rotation symmetry as well as assumption for the unfavoured and favoured fragmentation [24–26]. Further assumption concerning the strange quark fragmentation function (*e.g.* $D_s^{K+} + D_s^{K-} = 2D_u^{K+}$) reduces the number of independent fragmentation functions to 6. Finally the set of different weights in Eq. (5) is:

$$\begin{aligned}
\sum_{h^+} D_u^h &= \sum_{h^-} D_{\bar{u}}^h = D_u^{\pi^+} + D_u^{K^+} + D_u^p\,, \quad \sum_{h^-} D_u^h = \sum_{h^+} D_{\bar{u}}^h = D_u^{\pi^-} + D_u^{K^-} + D_u^{\bar{p}}\,,\\
\sum_{h^+} D_d^h &= \sum_{h^-} D_{\bar{d}}^h = D_u^{\pi^-} + D_u^{K^-} + D_u^p\,, \quad \sum_{h^-} D_d^h = \sum_{h^+} D_{\bar{d}}^h = D_u^{\pi^+} + D_u^{K^-} + D_u^{\bar{p}}\,,\\
\sum_{h^+} D_s^h &+ \sum_{h^+} D_{\bar{s}}^h = 2(D_u^{\pi^+} + D_u^{K^+} + D_u^p)\,. \qquad (6)
\end{aligned}$$

The presence of different $\sum_h D_q^h$ in Eq. (5) enables to examine combination of the polarized parton distributions different than in the inclusive case.

To compare theoretical predictions of Eq. (3) and Eq. (5) with experimental results we have to construct or choose the set of unpolarized and polarized quark parton distribution functions. These functions are combinations of the elementary ones, *i.e.* density of quarks with spin parallel to the nucleon spin $q^+(x,Q^2)$ and density of quarks with spin anti-parallel to the nucleon spin $q^-(x,Q^2)$. In details: $q(x,Q^2) = q^+(x,Q^2) + q^-(x,Q^2)$ and $\Delta q(x,Q^2) = q^+(x,Q^2) - q^-(x,Q^2)$. Our assumption is that distributions q^+ and q^- have the same functional behaviour, so there is the only difference in the numerical coefficients [6]. It is not necessarily true for q and Δq because the appropriate coefficients in q^+ and q^- could be equal (or have the same absolute value but opposite sign) and in this case equivalent coefficients in q Δq (q) vanish. The idea is to use formulas for the unpolarized quark parton distributions as an input, then to extract from them formulas for q^+ and q^- distributions just by splitting the numerical constants.

Previously this idea was explored in Ref. [6][1], where the latest version of the MRS [36] parametrization was used. To test the dependence of final results on the input parametrization we have chosen the latest version of GRV parametrization for unpolarized parton distributions [37].This parametrization gives for the valence quarks at $Q^2 = 4$ GeV^2:

$$\begin{aligned} u_v(x) &= 3.221x^{-0.436}(1-x)^{3.726}(1-0.689x^{0.2}+2.254x+1.261x^{\frac{3}{2}}), \\ d_v(x) &= 0.507x^{-0.624}(1-x)^{4.476}(1+1.615x^{0.553}+3.651x+1.3x^{\frac{3}{2}}), \quad (7) \end{aligned}$$

whereas for the sea anti-quarks:

$$\begin{aligned} &\bar{s}(x) = 0.0034x^{-1}(1-x)^{6.166}(1-2.392\sqrt{x}+7.094x)e^{2.592\sqrt{\ln\frac{1}{x}}}\left(\ln\frac{1}{x}\right)^{-1.15}, \\ &S(x) = x^{-1}(1-x)^{6.356}\Bigg[0.00285e^{2.003\sqrt{\ln\frac{1}{x}}} \\ &\qquad +x^{0.158}(0.738-0.981x+1.063x^2)\left(\ln\frac{1}{x}\right)^{0.037}\Bigg], \\ &\delta(x) = 0.107x^{-0.596}(1-x)^{8.621}(1+0.441x^{0.876}+18.721x), \qquad (8) \end{aligned}$$

where $S(x)=\bar{d}(x)+\bar{u}(x)$ is the non-strange singlet contribution to the sea and $\delta(x)=\bar{d}(x)-\bar{u}(x)$ is the isovector non-strange part of the quark sea. For the unpolarized gluon distribution we get:

$$\begin{aligned} G(x) &= x^{-1}(1-x)^{5.566}\Bigg[0.0527e^{2.141\sqrt{\ln\frac{1}{x}}} \\ &\qquad +x^{0.731}(5.11-1.204x-1.911x^2)\left(\ln\frac{1}{x}\right)^{-0.472}\Bigg]. \qquad (9) \end{aligned}$$

Generally the unpolarized parton distribution for the valence quarks and the isovector non-strange part of the sea can be written in the form $q(x) = x^{\alpha_q}(1-x)^{\beta_q}W(x)$. In other cases there is a similar part $(1-x)^{\beta_q}$, which describes asymptotic behaviour for x tending to 1 but terms responsible for behaviour for x tending to 0 are more complicated.

Now we split the above distribution functions between q^+ and q^- in order to get polarized parton distributions as $\Delta q(x) = q^+(x) - q^-(x)$. The asymptotic behaviour for $x \to 1$ (*i.e.* the value of β_q) is the same for all distributions like in the unpolarized case and for $x \to 0$ (the value of α_q) it

[1] It is not the first paper on this subject (see references therein) but the data on semi–inclusive asymmetries was included into the fit for the first time.

remains unchanged for valence quarks and the isovector part of quark sea. We must be more careful in treating the strange sea and the isoscalar part. Assuming that the polarized structure function g_1 have to be integrable one has to split appropriate numerical constants in such a manner that non-integrable terms of unpolarized parton distributions disappear in polarized parton distributions (*i.e.* one has to split these coefficients equally between q^+ and q^-). This procedure, of course, changes asymptotic behaviour but functions remain integrable despite singular behaviour at $x \to 0$. Our expressions for $\Delta q(x)$ are:

$$\begin{aligned}
\Delta u_v(x) &= x^{-0.436}(1-x)^{3.726}(A_u + B_u\, x^{0.2} + C_u\, x + D_u\, x^{\frac{3}{2}})\,, \\
\Delta d_v(x) &= x^{-0.624}(1-x)^{4.476}(A_d + B_d\, x^{0.553} + C_d\, x + D_d\, x^{\frac{3}{2}})\,, \\
\Delta \bar{s}(x) &= x^{-0.5}(1-x)^{6.166}(A_s + B_s\sqrt{x})e^{2.592\sqrt{\ln\frac{1}{x}}}(\ln\frac{1}{x})^{-1.15}\,, \\
\Delta S(x) &= x^{-0.842}(1-x)^{6.356}(A_S + B_S\, x + C_S\, x^2)(\ln\frac{1}{x})^{0.037}\,, \\
\Delta \delta(x) &= x^{-0.596}(1-x)^{8.621}(A_\delta + B_\delta x^{0.876})\,,
\end{aligned} \tag{10}$$

where we have introduced 15 new parameters.

The polarized parton distribution functions must satisfy positivity constraint,

$$\left|\Delta q(x,Q^2)\right| \leq q(x,Q^2)\,, \tag{11}$$

which leads to several constraints on coefficients in each distribution. Furthermore we fix the normalization of the non-singlet distributions using the experimental value of the axial charge:

$$\Delta q_8 = 3F - D\,, \tag{12}$$

where F and D are the antisymmetric and symmetric SU(3) coupling constants of hyperon beta decays [38,39]. Δq denotes the first moment, *i.e.* the total polarization of each quark (or combination of quarks), which is defined as:

$$\Delta q = \int_0^1 dx \Delta q(x). \tag{13}$$

The $\mathrm{SU(3)_{flavour}}$ non-singlet combinations are defined by:

$$\begin{aligned}
\Delta q_8 &= (\Delta u + \Delta\bar{u}) + (\Delta d + \Delta\bar{d}) - 2(\Delta s + \Delta\bar{s})\,, \\
\Delta q_3 &= (\Delta u + \Delta\bar{u}) - (\Delta d + \Delta\bar{d})\,.
\end{aligned} \tag{14}$$

Assuming that the sea contribution for quarks and anti-quarks are equal, first moments of above non-singlet combinations become:

$$\begin{aligned}\Delta q_8 &= \Delta u_v + \Delta d_v + 2\Delta S - 4\Delta \bar{s}\,,\\ \Delta q_3 &= \Delta u_v - \Delta d_v - 2\Delta \delta\,.\end{aligned} \tag{15}$$

As we do not fix the first moment Δq_3 we are able to test the Bjorken sum rule [40]

$$\Delta q_3 = F + D\,. \tag{16}$$

We do not put $\Delta\delta(x,Q^2) = 0$ (we distinguish $\Delta\bar{u}$ and $\Delta\bar{d}$), thus we are able to test $\mathrm{SU}(2)_{\mathrm{isospin}}$ breaking effects. Other first moments that can be calculated using the obtained integrated quark polarizations are:

$$\begin{aligned}\Delta\Sigma &= \Delta u_v + \Delta d_v + 2\Delta\bar{s} + 2\Delta S\,,\\ \Gamma_1^p &= \frac{2}{9}\Delta u_v + \frac{1}{18}\Delta d_v + \frac{1}{9}\Delta\bar{s} + \frac{5}{18}\Delta S - \frac{1}{6}\Delta\delta\,,\\ \Gamma_1^n &= \frac{1}{18}\Delta u_v + \frac{2}{9}\Delta d_v + \frac{1}{9}\Delta\bar{s} + \frac{5}{18}\Delta S + \frac{1}{6}\Delta\delta\,,\end{aligned} \tag{17}$$

The remaining 16 coefficients of Eqs. (10) are determined by fitting the available data on the inclusive spin asymmetries for proton, neutron and deuteron targets and on the semi-inclusive spin asymmetries for the proton and deuteron target. The fit is performed assuming that the spin asymmetries do not depend on Q^2. Although the latter assumption is not consistent with theoretical predictions (Q^2-evolution of the numerator of Eqs. (1), (4)) differs from Q^2-evolution of the denominator due to different polarized and unpolarized splitting functions), it is consistent with experimental observation [11–19].

The results for the parameters in Eq. (10) derived from the fit to data on inclusive and semi-inclusive spin asymmetries are presented below:

$$\begin{array}{llll} A_u = 0.175\ , & B_u = 0.301\ , & C_u = 2.010\ , & D_u = 6.752\ ,\\ A_d = -0.381\ , & B_d = 0.083\ , & C_d = 0.046\ , & D_d = -2.944\ ,\\ A_s = -0.00052\ , & B_s = -0.007\ , & & \\ A_S = 0.026\ , & B_S = 0.574\ , & C_S = -1.863\ , & \\ A_\delta = 0.002\ , & B_\delta = -0.289\ , & & \end{array} \tag{18}$$

For the fit we get $\chi^2 = 147$ for 157 d.o.f. (we use 123 data points from totally inclusive experiments and 48 data points from semi-inclusive experiment), hence $\chi^2/N_{\mathrm{d.o.f.}} = 0.94$. Results for the inclusive asymmetries for the proton, neutron and deuteron target are compared to the experimental data in Fig. 1. The comparison of the *fitted* semi-inclusive spin asymmetries for production of positively and negatively charged hadrons from the proton

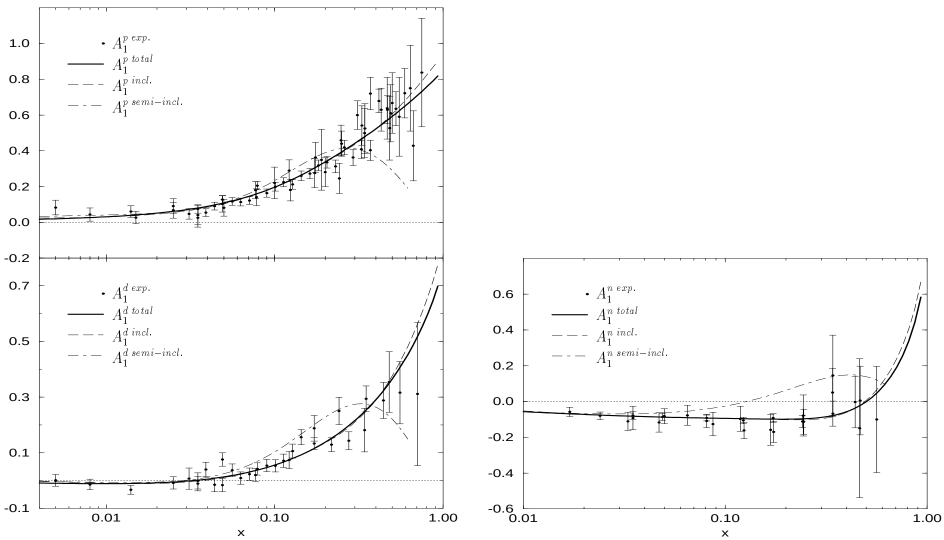

Fig. 1. The inclusive spin asymmetries $A_1^{N\ \mathrm{total}}$ obtained from the total fit to the inclusive and semi–inclusive data, compared to all existing inclusive data points. $A_1^{N\ \mathrm{incl.}}$ and $A_1^{N\ \mathrm{semi-incl.}}$ are predictions which come out from the fit to data on inclusive and semi-inclusive spin asymmetries, correspondingly.

and deuteron target to experimental points is given in Fig. 2. Polarized quark distributions are presented in Fig. 3.

The values of the first moments of parton distributions are as follows:

$$\begin{aligned} &\Delta u_v = 0.60 \pm 0.01\ , &&\Delta\bar{u} = 0.08 \pm 0.02\ , \\ &\Delta d_v = -0.56 \pm 0.01\ , &&\Delta\bar{d} = 0.07 \pm 0.02\ , \\ &\Delta\bar{s} = -0.042 \pm 0.004\ . && \end{aligned} \tag{19}$$

From these numbers one can evaluate the values of the first moments of the structure functions and other combinations of the polarized quark parton distributions:

$$\begin{aligned} &\Delta u = 0.68 \pm 0.02\ , &&\Delta d = -0.49 \pm 0.02\ , \\ &\Gamma_1^p = 0.142 \pm 0.002\ , &&\Gamma_1^n = -0.057 \pm 0.005\ , \\ &\Delta\Sigma = 0.26 \pm 0.01\ , &&\Delta q_3 = 1.19 \pm 0.07\ , \\ &\Delta q_{\mathrm{sea}} = 2(\Delta\bar{u} + \Delta\bar{d} + \Delta\bar{s}) = 0.22 \pm 0.04\ . && \end{aligned} \tag{20}$$

In our model quark contribution to the spin of the proton is dominated by the sea polarization. The contribution of each valence quark is almost the same but has the opposite sign, hence valence quarks carry little of the spin of the proton. However all distributions are fitted to the data points from

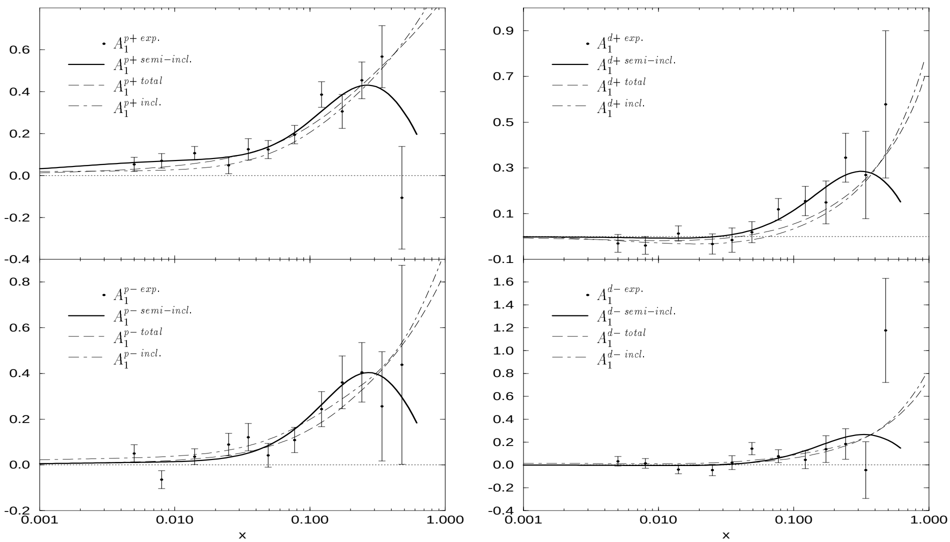

Fig. 2. The semi-inclusive spin asymmetries obtained from the fit to the data on semi-inclusive spin asymmetries, compared to recent results presented by SMC [26]. $A_1^{N\pm\ \mathrm{total}}$ denotes semi-inclusive asymmetries obtained from the total fit to inclusive and semi-inclusive data. Predictions for semi-inclusive asymmetries calculated using distributions which come out from the fit to inclusive data are also presented ($A_1^{N\pm\ \mathrm{incl.}}$). Note the last data point for A_1^{p+}, which gives the largest contribution to χ^2, even for the semi-inclusive fit.

the measured region, *i.e.* for $x > 0.003$, and contributions beyond the measured region ($\int_0^{0.003} dx\, f(x)$) are questionable. Moreover the low x behaviour of the polarized quark parton distributions is determined by the unpolarized ones, therefore it is not consistent with the Regge theory prediction. Though application of Regge theory is incompatible with the pQCD [41,42] it is interesting to compare predictions of the Regge type behaviour for low x to the predictions of our model, especially as some of the considered quantities change rapidly for $x < 0.003$. For example $\int_0^{0.003} dx\, \Delta d_v(x) = -0.113$ while $\int_{0.003}^1 dx\, \Delta d_v(x) = -0.451$. It is the consequence of the power-like behaviour of the type $x^{-0.624}$. More dramatical change can be observed for the non-strange sea quark distribution. The contribution of the low x region is $\int_0^{0.003} dx\, \Delta S(x) = 0.072$ while for $x > 0.003$ we get $\int_{0.003}^1 dx\, \Delta S(x) = 0.079$. This is due to the fact, that $\Delta S(x)$ is more singular for x tending to 0 than any valence quark distribution. Multiplication of the term $x^{-0.842}$ by the term $(\ln \frac{1}{x})^{0.037}$ enlarges the value of integral over the range from $x = 0$ to $x = 0.003$, but not significantly. The strange quark distribution behaviour for low x is the most complex one. The term $x^{-0.5}$ is suppressed with the

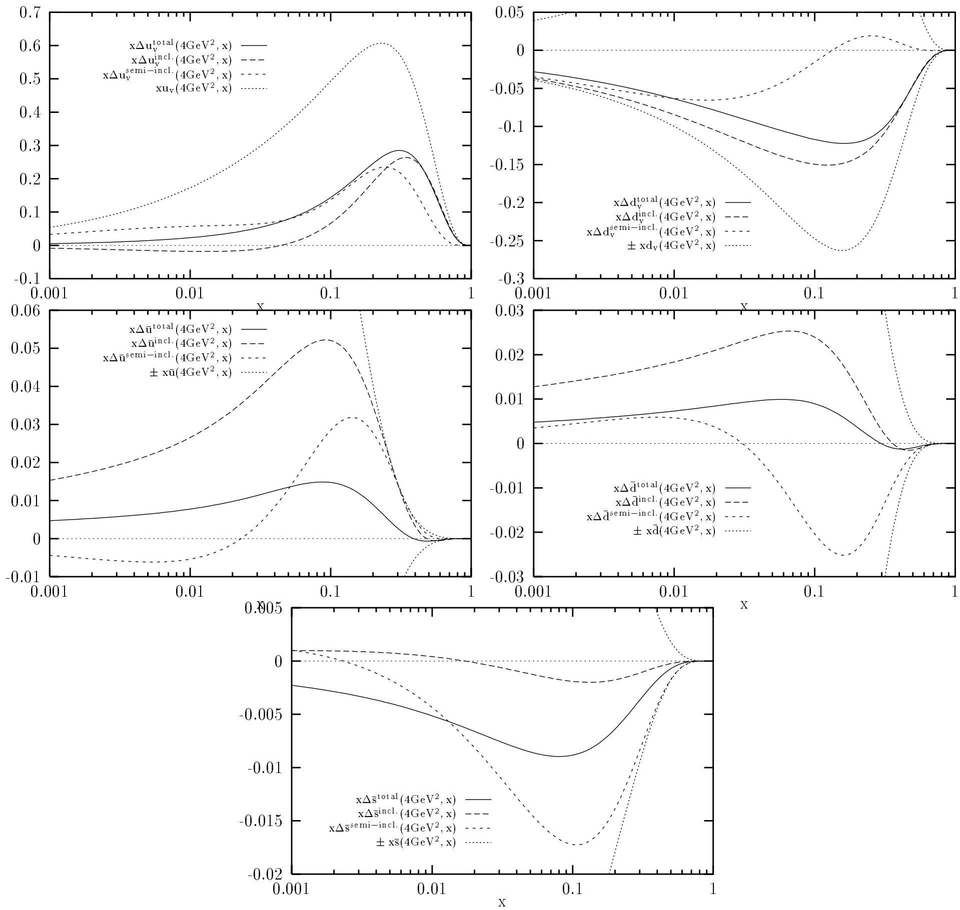

Fig. 3. The distributions derived from the total fit and from fits to the data on inclusive and semi-inclusive spin asymmetries separately.

$(\ln \frac{1}{x})^{-1.15}$ term but the multiplying term $e^{2.592\sqrt{\ln \frac{1}{x}}}$ increases the contribution to the integral of the low x region very fast. Finally an integration over x below 0.003 gives -0.012 to the total polarization of the quark $\bar{s}$ which is -0.043.

Now we can compare our results to the more stable Regge theory prediction. The quantities integrated over region from $x = 0.003$ to $x = 1$ (integration over the region covered by the experimental data plus extrapolation for higher x) extrapolated to $x = 0$, postulating the Regge type behaviour for all quark parton distributions of a type $x^{-0.5}$, give:

$$\begin{array}{lllll} \Delta u_v=0.61\,, & \Delta d_v=-0.54\,, & \Delta\bar{u}=0.06\,, & \Delta\bar{d}=0.05\,, & \Delta\bar{s}=-0.04\,, \\ \Gamma_1^p=0.132\,, & \Gamma_1^n=-0.063\,, & \Delta\Sigma=0.20\,, & \Delta q_3=1.17\,, & \Delta q_{\rm sea}=0.13\,. \end{array} \quad (21)$$

Our results on first moments of the proton and neutron structure functions are in agreement with experimental results given in Ref. [18]. Other estimations in Ref. [14, 15, 20, 21] are slightly smaller but our results are still consistent within two standard deviations. For the first moment of the deuteron structure function $g_1^d = \frac{1}{2}(g_1^p + g_1^n)(1 - 1.5p_D)$ we get $\Gamma_1^d = 0.039 \pm 0.004$ (or $\Gamma_1^d = 0.032$ if the Regge behaviour for low x is assumed) what is in excellent agreement with results in Ref. [16, 19]. For the purely non-singlet combination of the structure functions $(g_1^p - g_1^n)$, which in our model is $\Gamma_1^{p-n} = \frac{1}{6}\Delta q_3$, we obtain $\Gamma_1^{p-n} = 0.198$ (0.195 assuming Regge behaviour). This value is in good agreement with the $O(\alpha_s^3)$ [43] prediction 0.188 ($\alpha_s(M_Z^2) = 0.109$). The non-singlet combination is expected to be less sensitive to the low x shape than its singlet counterpart [44]. Similarly, we observe that the value of Δq_3 varies between 1.19 and 1.17 while $\Delta u + \Delta d = \Delta u_v + \Delta d_v + 2\Delta S$ changes from 0.34 in our model to 0.28 for Regge-type behaviour. We obtain a quite large and positive non-strange sea polarization and the whole sea polarization alike ($2\Delta\bar{s} = -0.08$ seems to be reasonable). Finally, $\Delta\Sigma = 0.26\,(0.20)$ is consistent with existing determinations.

Performing fits to the inclusive and semi-inclusive data separately we can test the impact of each type of data on the total fit. When we use our model to make a fit to the data on inclusive spin asymmetries solely, we get $\chi^2 = 95$, nearly equal to 96.6, which is the contribution of the inclusive data points to the $\chi^2 = 147$ of the total fit ($\chi^2/N_{\rm d.o.f.} = 0.87$ is better then in the total case $\chi^2/N_{\rm d.o.f.} = 0.94$). It can be observed in Fig.1, that inclusive spin asymmetries derived from both types of fits do not differ much from each other in our model. Moreover results on the integrals over $0.003 < x < 1$ of the structure functions and singlet or non-singlet combinations of quark distributions are very close to those obtained in the total fit. In details: $\Delta\Sigma = 0.27$, $\Gamma_1^p = 0.126$, $\Gamma_1^n = -0.050$, $\Delta q_3 = 1.05$. Although the total polarization of quarks of a certain flavour (*i.e.* $\Delta u(d,s) = \Delta u(d)_v + 2\Delta\bar{u}(\bar{d},\bar{s})$) does not vary much, the division between valence and sea quarks differs from the total fit considerably. For example, in $0.003 < x < 1$ region, we get $\Delta u_v = 0.336$, $\Delta d_v = -0.565$. The reason is, that the valence and sea quark distributions of the same flavour have the same weight (electric charge squared) in the inclusive spin asymmetry (Eq. (12)). Hence the asymmetry is sensitive only to the whole Δq distributions but not to valence and sea quark distributions separately. The distributions Δu and Δd derived from the total fit and the fit to inclusive data have the same shape, which can be seen in Fig. 4, whereas splits between valence and sea quark distributions are different in both cases (compare Fig. 1).

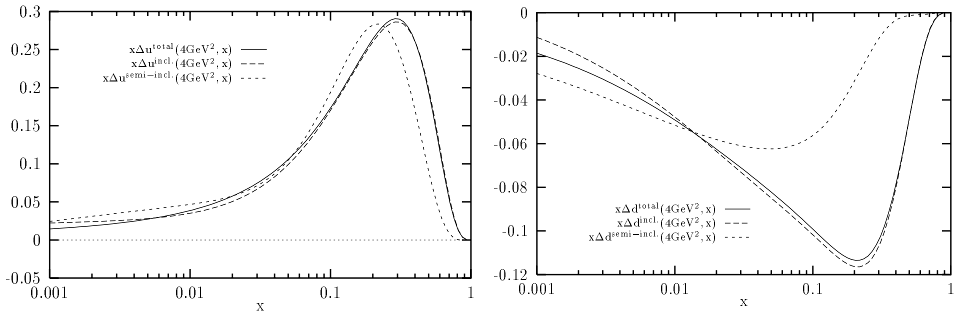

Fig. 4. The whole Δd and Δu distributions derived from the total fit and from fits to the data on inclusive and semi-inclusive spin asymmetries separately.

The comparison to the similar analysis (performed in Ref. [6]), which uses the MRS parametrization as an input shows us the influence of choice of input parametrization on distributions and first moments. There is almost no difference between first moments of distributions for quarks of a certain flavour obtained in Ref. [6] and in this analysis. Corresponding results are: $\Delta u = 0.76$ (0.70 assuming Regge behaviour), $\Delta d = -0.52$ (-0.37), $\Delta s = -0.07$(-0.07). There is a significant difference in division between valence and sea quarks. What is most important, the total polarization of the sea quarks changes its sign. In Ref. [6] $\Delta q_{\rm sea} = -0.18$(-0.22) whereas we have obtained $\Delta q_{\rm sea} = 0.22(0.13)$.

Parameterizations obtained using inclusive and semi-inclusive data give a good description of the semi-inclusive asymmetries, as can be seen in Fig. 4 (the contribution of 48 semi-inclusive data points to $\chi^2 = 147$ of the total fit amounts 50.4, where the data point for A_1^{p+} at $x = 0.48$ gives the biggest part). Still, fit performed using only semi-inclusive data leads to different set of coefficients of distribution functions and other integrated results, as is seen in Figs. 1, 4. This is mainly caused by the data point for A_1^{p+} at $x = 0.48$, which makes that semi-inclusive asymmetries go below the total and inclusive predictions (Fig. 2). Absence of this point would improve the result of comparison to the experiment and change high x behaviour of the fitted semi-inclusive asymmetries.

We get for the fit with semi-inclusive data points only $\chi^2 = 39.3$ ($\chi^2/N_{\rm d.o.f.} = 1.2$). The integrated quantities are:

$$\begin{array}{lll}
\Delta u_v = 0.68 \pm 0.01\ , & \Delta\bar{u} = 0.02 \pm 0.05\ , & \Delta u = 0.70 \pm 0.05\ , \\
\Delta d_v = -0.32 \pm 0.05\ , & \Delta\bar{d} = -0.02 \pm 0.07\ , & \Delta d = -0.34 \pm 0.09\ , \\
\Delta\bar{s} = -0.035 \pm 0.004\ , & & \\
\Gamma_1^p = 0.137 \pm 0.003\ , & \Gamma_1^n = -0.042 \pm 0.018\ , & \Gamma_1^d = 0.044 \pm 0.010\ , \\
\Delta\Sigma = 0.30 \pm 0.04\ , & \Delta q_3 = 1.08 \pm 0.21\ , & \Delta q_{\rm sea} = -0.06 \pm 0.17\ .
\end{array} \tag{22}$$

There is no important difference between above first moments and integrals obtained assuming Regge behaviour for low x. These results are in a good agreement with experimental estimations [26]. The presence of various weights in the semi-inclusive spin asymmetries (Eq. (12)) induces that division of Δu and Δd between valence and sea parts is no longer strongly model dependent. Also differences among sea quarks of different flavours are emphasized. In Fig. 1, one sees that the parametrizations obtained using only semi-inclusive data points give inclusive asymmetries too far from experimental data points. If we compute χ^2 for all data points of both types with the obtained distributions we get 505 what is an unacceptable value. The substantial part comes from the E154 data for the neutron target, mainly due to the differences in the whole Δd distribution obtained from semi-inclusive and total fits, as can be seen in Fig. 4.

We have performed an analysis of the world data on polarized deep inelastic scattering, inclusive and semi-inclusive, assuming that $\Delta\bar{u} \neq \Delta\bar{d}$, *i.e.* $\Delta\delta \neq 0$. But in the inclusive case only whole quark distributions of a certain flavour are distinguished, *i.e.* have different weights in the asymmetry. As $\Delta u(d) = \Delta u(d)_v + \Delta S \mp \Delta\delta$, putting $\Delta\delta \neq 0$ gives two additional coefficients, very weakly constrained. We have performed also a fit to the inclusive data only, putting $\Delta\delta = 0$ and we have got almost the same value of χ^2 as before. Although it is possible to obtain the information about difference between $\Delta\bar{u}$ and $\Delta\bar{d}$ without taking into account semi-inclusive data, the results are very poorly constrained by the data.

The situation is better in the semi-inclusive case where all of the distributions (valence and sea separately) appear in the semi-inclusive spin asymmetry with different weights. Hence, up till now, there are 24 data points[2] constraining the coefficients of the $\Delta\delta$ distribution. Performing a fit to the semi-inclusive data with $\Delta\delta = 0$ we have got a slightly worse value of χ^2 then in the case with $\Delta\delta \neq 0$.

The inclusion of available semi-inclusive data to the analysis of the inclusive events gives more stable results. Using data on semi-inclusive spin

[2] For the deuteron target $\Delta\delta$ does not appear in the formula for the semi-inclusive spin asymmetry.

asymmetries we can distinguish valence and sea quarks distributions of the same flavour as well as $\Delta\bar{u}$ and $\Delta\bar{d}$. However parametrization obtained as the best fit to the semi-inclusive data gives the unacceptable description of the inclusive ones, mainly due to the differences in the Δd distribution. Hence, we have got no perfect consistence of inclusive and semi-inclusive results in our model. Additional data from semi-inclusive experiments using ^{3}He target can reverse the situation. The next step in the analysis, *i.e.* addition of the Q^2-dependence of distribution functions can also improve an agreement of our model with an experiment.

Our analysis shows that the result which gives the polarization of the sea quarks depends strongly on used parametrization of the polarized parton distributions.

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