POLARIZED PARTON DENSITIES IN THE NUCLEON

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We present a new NLO QCD analysis of the world data on inclusive polarized deep inelastic scattering. Comparing to our previous analysis: i) the values of $g_A$ and $a_8 = 3F - D$ are updated ii) the MRST’99 instead of the MRST’98 parametrization for the input unpolarized parton densities is used and iii) the recent SLAC E155 proton data on the spin asymmetry $A_1$ are included in the analysis. A new set of polarized parton densities is extracted from the data and the sensitivity of the results to different positivity constraints 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 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. Many experiments have been carried out at SLAC, CERN and DESY. In this talk we present an updated version of our NLO polarized parton densities (PD) determined from the world data on inclusive polarized DIS. Comparing to our previous analysis:

i) For the axial charges $g_A$ and $a_8$ their updated values are used:

$$g_A = F + D = 1.2670 \pm 0.0035,$$

$$a_8 = 3F - D = 0.585 \pm 0.025.$$  \hspace{1cm} (1)

ii) In our ansatz for the input polarized PD

$$\Delta f_i(x, Q_0^2) = A_i \, x^{\alpha_i} \, f_i^{MRST}(x, Q_0^2)$$  \hspace{1cm} (2)

we now utilize the MRST’99 set of unpolarized parton densities $f_i(x, Q_0^2)$ instead of the MRST’98 one. In (2) $A_i, \alpha_i$ are free parameters (6 parameters in our fit after using the sum rules for the quark polarizations).
iii) The recent SLAC/E155 proton data are incorporated in the analysis.
iv) The positivity constraints on the polarized PD are discussed.

2 Method of Analysis

The spin-dependent structure function of interest, \( g_1^N(x, Q^2) \), is a linear combination of the asymmetries \( A_{1N}^\parallel \) and \( A_{1N}^\perp \) (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

\[
A_1^N(x, Q^2) \approx (1 + \gamma^2) \frac{g_1^N(x, Q^2)}{F_1^N(x, Q^2)},
\]

(3)

where \( F_1^N \) is the unpolarized structure function and \( \gamma^2 \) is a kinematic factor.

All details of our approach to the fit of the data are given in [6]. Here we would like to emphasize only that in our approach 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 \( A_1^N \) should minimize the higher twist contributions which are expected to partly cancel 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 [7] that if for \( g_1 \) and \( F_1 \) leading-twist QCD expressions are used, the HT corrections \( h(x) \) to \( A_1(x, Q^2) = A_1^{QCD}(x, Q^2) + h(x)/Q^2 \) are negligible and consistent with zero (see Fig. 1(a)). On other hand, it was shown [8] that if \( F_2 \) and \( R \) (instead of \( F_1 \) in Eq. (3)) are taken from experiment (as has been done in many analyses) the higher twist corrections to \( A_1 \) are sizeable and important.

3 Results

The results of analysis are presented in the JET scheme [9]. A remarkable property of the JET [and Adler-Bardeen (AB)] schemes is that \( \Delta \Sigma(Q^2) \), as well as \( \Delta s(Q^2) \), 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 \( Q^2 \).

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. However, if for the polarized PD the Set2 (see below) is used the values of $A_1$ at large $x$ increase, in a better agreement with the large $x$ E155/p data.

We have determined from the data two sets of polarized PD: i) Set1 - without any constraints on the polarized PD during the fit, ii) Set2 - fit to the data with imposition of LO positivity constraints determined by the MRST unpolarized densities. All polarized PD of Set1, with the exception of the strange sea density $\Delta_s(x)$, are compatible with the LO positivity bounds imposed by the MRST unpolarized PD. 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. [4]), the Set1 $\Delta_s(x)$ lies in the allowed region. It is important to mention that $s(x)_{BPZ}$ is determined with a higher accuracy compared to other global fits. The Set1 PD are found to be within the error bands of the old PD, while the changes of the Set2 $(\Delta s + \Delta \bar{s})(x)$ and $\Delta G(x)$ are larger, especially for the strange sea quarks (see Fig. 1(b) and Fig. 1(c)).

Finally, let us sumarize the changes in the quark and gluon polarizations at $Q^2 = 1 \text{ GeV}^2$ which arise from the new analysis:

- $(\Delta u + \Delta \bar{u})$ and $(\Delta d + \Delta \bar{d})$ practically do not change.
- the magnitude of the $n = 1$ moment, $|\Delta s + \Delta \bar{s}|$, has increased a little: $0.06 \pm 0.01 \text{ (old)} \rightarrow 0.07 \pm 0.01 \text{ (Set1)} \rightarrow 0.09 \pm 0.02 \text{ (Set2)}$
- The central value of $\Delta \Sigma$ has decreased:
  - $0.40 \pm 0.04 \text{ (old)} \rightarrow 0.37 \pm 0.04 \text{ (Set1)} \rightarrow 0.32 \pm 0.05 \text{ (Set2)}$
• The axial charge $a_0(Q^2) = \Delta \Sigma_{MS}(Q^2)$ is also decreasing:
  $0.26 \pm 0.05 \text{ (old)} \rightarrow 0.21 \pm 0.06 \text{ (Set 1, 2)}$

• For the gluon polarization $\Delta G$ we have found that the positive values of $\Delta G$ lie in the wide range $[0, 1.5]$ if one takes into account the correlations and the sensitivity to the SU(3) flavour symmetry breaking. A negative $\Delta G$ is still not excluded from the present DIS inclusive data.

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