A NEW PARAMETRIZATION OF POLARIZED PARTON DISTRIBUTION FUNCTIONS

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Requiring the positivity and counting rule, we propose a new parametrization of the polarized parton distribution which reproduce the data well. We found that the NLO analysis is absolutely necessary to extract the correct information on the polarized gluon distributions. The calculated results of $x\Delta d_v(x)$ and $\Delta d_v(x)/d_v(x)$ seem to be consistent with the SMC data at Q^2 =10GeV^2.

Recently there has been renewed interest on polarized parton distributions in the nucleon, largely stimulated by the development of the next-to leading order(NLO) QCD calculations of polarized parton distribution functions[1] and acquisition of high-precision polarized data on various targets[2].

In this work, requiring reasonable physical conditions, (1)the positivity condition and (2) the counting rule for the helicity dependent parton distribution functions, we propose a new parametrization[3] of the polarized parton distribution function which is more reliable and fits better to the data than other parametrizations proposed so far.

Based on the positivity condition and counting rule for helicity dependent distributions, we propose the following functional form of the polarized parton distributions at an initial scale Q_0^2,

$$\Delta f_i(x,Q_0^2) = A_i \; x^{\alpha_i} \; (1+\gamma_i \; x^{\lambda_i}) \; f_i(x,Q_0^2) \; , \tag{1}$$

where $\Delta f_i(x,Q_0^2)$ and $f_i(x,Q_0^2)$ are polarized and unpolarized distributions with $i = u_v$, d_v, $\bar{q}$ and g. α_i, γ_i and λ_i are free parameters and A_i is the normarization factor. Further constraints are obtained,

$$A_i = \frac{1}{1+\gamma_i} \; , \quad \alpha_i \geq 0 \; , \quad \gamma_i \neq -1 \; , \quad \lambda_i > -\alpha_i \; , \tag{2}$$

from the condition, $f_i^+(x,Q_0^2) \gg f_i^-(x,Q_0^2)$ for $x \to 1$, derived from the counting rule assumption[4] and a reasonable assumption that the first moment of each polarized parton distributions should not become infinite at Q_0^2. The remaining 3 parameters(α_i, γ_i and λ_i) for each i are determined from χ^2–fitting to the data.

In this analysis, we assume the SU(3)$_f$ symmetry and take $\Delta\bar{u}(x) = \Delta\bar{d}(x) = \Delta\bar{s}(x)$ at an initial Q_0^2, for simplicity. Then the first moments of Δu_v and Δd_v, which are written as η_{u_v} and η_{d_v}, respectively, can be described in terms of weak hyperon decay constants F and D as follows, $\eta_{u_v} - \eta_{d_v} = F + D$, $\eta_{u_v} + \eta_{d_v} = 3F - D$. Using updated values of the β–decay data of np, Λp, $\Xi\Lambda$ and Σn, F and D are calculated as $F = 0.463 \pm 0.008$, $D = 0.804 \pm 0.008$ which lead to $\eta_{u_v} = 0.926$ and $\eta_{d_v} = -0.341$. Then, for $i = u_v$ and d_v, we can reduce the number of free parameters from 3 to 2 by using those fixed first moments. Thus, we are to have 10 parameters, $\alpha_{u_v}, \gamma_{u_v}, \alpha_{d_v}, \gamma_{d_v}, \alpha_{\bar{q}}, \gamma_{\bar{q}}, \lambda_{\bar{q}}, \alpha_g, \gamma_g, \lambda_g$, which can be determined by the χ^2–analysis to the experimental data, $A_1(x, Q^2)$, of the pol–DIS on the proton, neutron and deuteron.

Using the GRV parametrization for unpolarized parton distribution functions at the LO and NLO[5] and the R_{1990} values[6] for $R(x, Q^2)$, we have carried out the χ^2–analysis to the data by minimizing $\chi^2 = \sum (A_1^{data} - A_1^{calc})^2/(\sigma_{A_1}^{data})^2$ with the help of the CERN subroutine MINUIT, where $\sigma_{A_1}^{data}$ is the experimental error including both systematic and statistical errors. The QCD parameter Λ_{QCD} in the DGLAP equations is taken as $\Lambda_{LO}^{(3,4,5)} = 232, 200, 153$MeV for the LO and $\Lambda_{NLO,\overline{MS}}^{(3,4,5)} = 248, 200, 131$MeV for the NLO with $N_f = 3$. The results of χ^2–analysis are substantially better for the NLO(χ^2/d.o.f=304.25/339) than for the LO(χ^2/d.o.f=368.84/339). The obtained parameters reproduce well the experimental data and thus the model of our parametrization seems promising. Since the difference between the NLO ($\overline{\text{MS}}$–scheme) and LO is due to if the polarized gluon contributes to the structure function g_1 via Willson coefficient, the result that the fitting at the NLO is better than at the LO implies that the polarized gluon has a nonzero contribution to the nucleon spin, *i.e.* $\Delta g \neq 0$ at Q_0^2. In this analysis, we have also found that the fitting at the NLO is more sensitive to the polarized gluon distribution than that at the LO. Therefore we can say that the NLO analysis is absolutely necessary to extract informations on the polarized gluon distribution. Details will be given in our forthcoming paper[3].

As an additional test of the present parametrization, we have presented our calculations of $x\Delta d_v(x)$ and $\Delta d_v(x)/d_v(x)$ and compared with the SMC data[7] at Q^2 =10GeV^2 in fig.1. It is interesting to see that the results seems to be consistent to the data, though the error bars of the data are large.

In this analysis, we have not taken into account the SU(3) flavor symmetry breaking effect of the polarized parton distributions which needs further investigation.

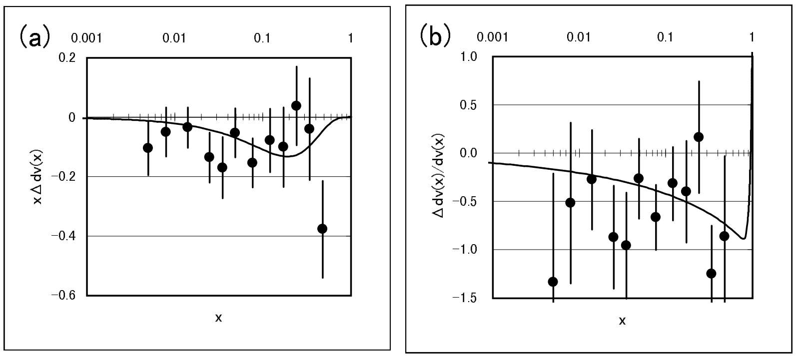

Figure 1: Calculated distributions of $x\Delta d_v(x)$ and $\Delta d_v(x)/d_v(x)$ at Q^2 =10GeV^2. Data are from Ref.[7].

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