POLARIZED PARTON DISTRIBUTIONS FOR SPIN ASYMMETRIES

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We have used QCD and polarized deep-inelastic scattering data to construct x-dependent polarized parton distributions. These flavor dependent distributions evolve under the NLO DGLAP equations, satisfy positivity constraints and agree well with the data. We perform all of the analysis in x-space, avoiding difficulties with moments, and use these distributions to predict spin observables. The small-x behavior is sensitive to the model for the polarized gluon distribution.

Polarized x-dependent parton distributions can be used to predict spin observables, such as hard scattering cross sections and asymmetries for polarized processes.[1] We have created flavor dependent distributions at $Q_0^2 = 1$ GeV^2, motivated by physical constraints and data, then evolved them to arbitrary Q^2 to predict polarized observables. The polarized distributions are generated from the unpolarized ones and theoretical assumptions.

The distributions are constructed subject to the following:
(1) the integration over x should reproduce the values extracted from PDIS data,[2] so that the fraction of spin carried by each constituent is contained implicitly in the flavor-dependent distributions
(2) they should reproduce the x-dependent polarized structure functions, g_1^i, i=p,n and d at the average Q^2 values of the data
(3) the small-x behavior of $g_1(x)$ should fall between a Regge-like power of x and a gluon-dominated logarithmic behavior
(4) the Q^2 behavior is generated by the NLO evolution equations,
(5) the positivity constraints are satisfied for all of the flavors.

The first two constraints build in compatibility with the PDIS data. The third and fourth satisfy the appropriate x and Q^2 kinematical dependence. The last constraint is fundamental to our physical interpretation of polarization.

The polarized valence distributions are determined from the unpolarized distributions by imposing a modified SU(6) model,[3,4] which satisfies the Bjorken Sum Rule (BSR) with QCD corrections.

For the sea, we use a broken SU(3) model, to account for mass effects in polarizing strange quarks. We include charm via the evolution equations (N_f), at the appropriate Q^2 of charm production. The entire NLO analysis is done in x-space. A basic sea model, [4] and data motivate the following form used for each sea flavor: $\Delta q_f(x) \equiv \eta_f(x)\, x\, q_f(x)$, where $q_f(x)$ is the unpolarized distribution for flavor f.[5] Then, $\eta_f(x)$ is chosen to satisfy the normalization:

$$\langle \Delta q_f \rangle = \int_0^1 \eta_f(x)\, x\, q_f(x)\, dx \equiv \langle \eta x q_f \rangle = \eta_{av} \, \langle x q_f \rangle \, , \tag{1}$$

where η_{av} is extracted from data for each flavor. [3] Physically, $\eta(x)$ may be interpreted as a modification of Δq due to effects of soft physics at low x.

The gauge- (or $\overline{MS}$) and chiral-invariant (or AB) schemes representing the polarized sea are related by: [6] $\Delta q(x)_{GI} = \Delta q(x)_{CI} - (N_f \alpha_s / 2\pi) \Delta G(x)$, where the GI and CI refer to the gauge- and chiral-invariant schemes, respectively. Since there exists no empirical evidence that ΔG is very large at the relatively small Q^2 values of the data, [7] we assume three different moderate ΔG models. The first model assumes a positively polarized glue: $\Delta G(x) = xG(x)$. In the second model, we set $\Delta G = 0$, which is equivalent to the gauge-invariant scheme, since the anomaly term vanishes. The third model is motivated by an instanton-induced ΔG, which is negatively polarized at small-x. [8]

The overall parametrization for each of the polarized sea flavors, including all gluon models is given in reference 1. We have used these to calculate the structure functions, $g_1^{p,n,D}(x)$. These all agree with data at the average Q^2 value for each set.[1,2] The plot for g_1^p is shown in Fig. 1.

The polarized sea distributions exhibit Regge-like behavior at small-x and become slightly positive at moderate x. With the positive gluon model, we find that $g_1^p \sim x^{-0.19}$ at small x. It does not have the steep rise characteristic of the logarithmic behavior due to gluon exchange,[9] but is compatible with Regge behavior. The distributions are consistent with data at small-x and are compatible with the appropriate counting rules at large-x. [10]

It may be possible to narrow down the models with more precise PDIS experiments at small-x, which are planned at SLAC (E155) and DESY (HERMES). However, there are other experiments which would provide a better indication of the size and shape of ΔG, including: (1) jet production in $e-p$ and $p-p$ collisions, (2) prompt photon production, (3) charm production and (4) meson production. Groups at RHIC, CERN and DESY are planning these experiments. For details, see reference 11. We are presently calculating jet and direct photon production asymmetries using these distributions.[12]

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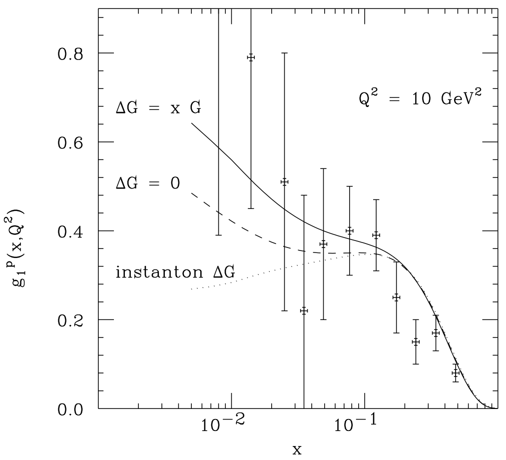

Figure 1: $g_1^p(x)$ for three models of ΔG compared to SMC data.

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