New Polarized Parton Distributions

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Abstract. This talk summarizes main results of a recent determination of the polarized deeply inelastic parton distributions to NLO from the world data. In the analysis the LO and NLO parton densities and their 1σ statistical errors were derived and parameterized. The strong coupling constant $\alpha_s(M_Z^2)$ is determined: $\alpha_s(M_Z^2) = 0.113 \pm 0.004$ (stat.) $\pm\, 0.004$ (fac.) $+0.008/-0.005$ ren.. Comparisons of the low moments of the parton densities with recent lattice results are performed.

1. Introduction

The polarized parton densities of deep inelastic scattering can be unfolded from measurements of the longitudinal polarization asymmetry. Here the unpolarized denominator–function serves as a normalization and is usually also being determined from data (Arneodo et al. (1995), Withlow et al. (1990)). The present polarized deep inelastic world data have reached a precision which allows to extract the corresponding parton densities and their correlated statistical errors as a function of x and Q^2 as well as the QCD Λ–parameter. Previous analyses (Goto et al. (2000), Glück et al. (2001)) were limited to a determination of the central value of the parton densities. In a recent analysis (Blümlein and Böttcher (2002)) we extended the investigation using the available world data to determine also the correlated errors and the QCD–scale, for which numerical parameterizations are provided as a `FORTRAN` code. In this analysis the QCD scale has been also determined using scheme–invariant evolution equations, which directly describe the evolution of observables as the structure function $g_1(x, Q^2)$ and its slope $\partial g_1(x, Q^2)/\partial \ln(Q^2)$ which was yielding nearly the same value for $\alpha_s(M_Z^2)$. Finally the lower Mellin moments of the present parton distributions were calculated and compared to results obtained in Lattice–QCD. This Note summarizes main results of our analysis.

2. The Parameterizations

The principle shape of the polarized parton densities $x\Delta u_v, x\Delta d_v, x\Delta q_{\rm sea}$ and $x\Delta G$ were chosen as

$$x\Delta q_i(x, Q_0^2) = \eta_i A_i x^{a_i} (1-x)^{b_i} (1 + \gamma_i x + \rho_i x^{1/2}) \;, \tag{1}$$

with A_i the normalization and η_i the first moment. All details of the analysis are found in Blümlein and Böttcher (2002). Some parameters are fixed by sum rules. It turned out that not all parameters can be measured at the same quality and have to

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be set to their value at χ^2_{min}. One typical NLO fit-result is shown in Fig. 1 quoting as well the error of all distributions. Within 1σ we find a positive gluon distribution at NLO.

3. The strong coupling constant

In the analysis $\alpha_s(M_Z^2)$ is measured at NLO. We also include the variations due to a change in the renormalization and factorization scales varying $\mu^2_{R,F}$ by a factor of 2 around Q^2. We obtain

$$\alpha_s(M_Z^2) = 0.113 \pm 0.004(stat) \pm 0.004(fac) + 0.008/-0.005(ren). \qquad (2)$$

4. Comparison with lattice results

The parameterizations may be used to evaluate integer Mellin moments of the respective parton distributions including their errors. These moments correspond to the experimental data, as far as the parameters of the corresponding representations are fixed in the QCD–fit procedure. To evaluate moments the parameterizations have to be partly extrapolated outside the domain of the current measurements. It is now interesting to compare these moments to the results which have been found in recent lattice flavor non–singlet simulations (see Table 1). The comparison shows that the extractions do well agree in all the nine values determined in the lattice measurements ‖. The observation of this agreement, despite the use of pion masses $m_\pi \sim$ 600MeV in the lattice simulations, was surprising to us in early 2002, since parabolic extrapolations were needed to reach agreement between experimental and lattice measurements in the unpolarized case. However, later the year it was found, that the extrapolation to the chiral limit is indeed nearly flat (Detmold et al. (2002), Weise et al. (2002)). The reason for this is a cancellation due to Δ–baryon contributions.

Δf	n	QCD results NLO moments at $Q^2 = 4$ GeV^2	lattice results QCDSF	LHPC/ SESAM
Δu_v	−1	0.926 ± 0.071	0.889(29)	0.860(69)
	0	0.163 ± 0.014	0.198(8)	0.242(22)
	1	0.055 ± 0.006	0.041(9)	0.116(42)
Δd_v	−1	-0.341 ± 0.123	-0.236(27)	-0.171(43)
	0	-0.047 ± 0.021	-0.048(3)	-0.029(13)
	1	-0.015 ± 0.009	-0.028(2)	0.001(25)
Δu–Δd	−1	1.267 ± 0.142	1.14(3)	1.031(81)
	0	0.210 ± 0.025	0.246(9)	0.271(25)
	1	0.070 ± 0.011	0.069(9)	0.115(49)

Table 1. Moments of the NLO parton densities (for ISET =3, see Blümlein and Böttcher (2002)) at $Q^2 = 4$ GeV^2 and from recent lattice simulations at the scale $\mu^2 = 1/a^2 \sim 4$ GeV^2. (Göckeler et al. (1996, 1997, 2001), Capitani et al. (1999), Güsken et al. (1999), Dolgov et al. (2002))

‖ The value of g_A, the first moment of $\Delta u_v - \Delta d_v$ moved by $\sim +10\%$ in a very recent lattice measurement (Panic'02).

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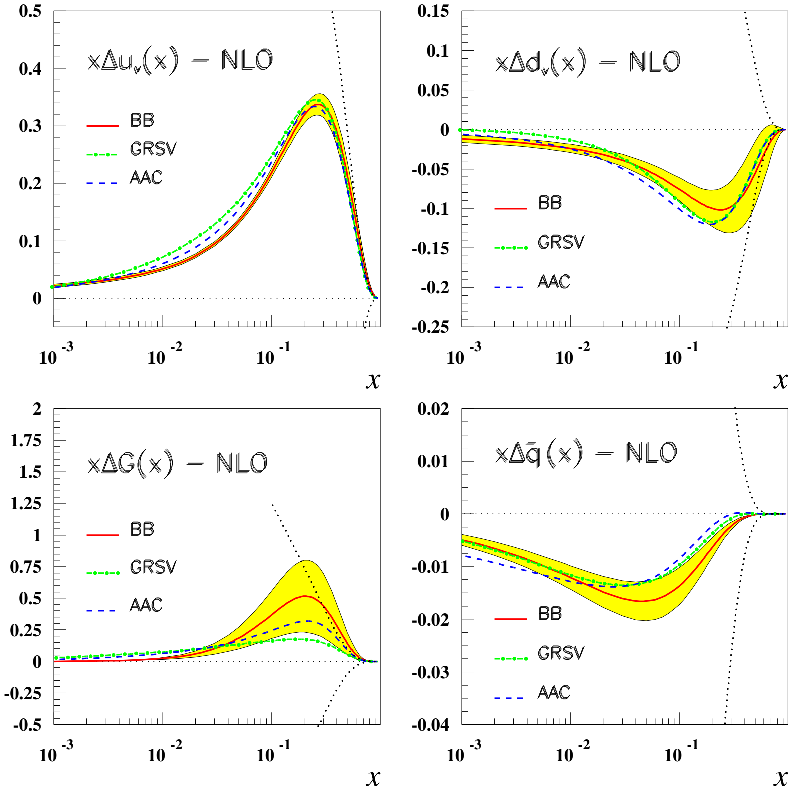

Figure 1. Polarized parton distributions at the input scale $Q_0^2 = 4.0$ GeV^2 (solid line, Blümlein and Böttcher (2002)) compared to results obtained by Glück et al. (2001) (dashed–dotted line), Goto et al. (2000) (dashed line). The shaded areas represent the fully correlated 1σ error bands calculated by Gaussian error propagation. The dark dotted lines correspond to the positivity bounds given by the unpolarized densities.