Extraction of polarized parton densities from polarized DIS and SIDIS.

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Abstract. We present results on the quark and gluon polarization in the nucleon obtained in a combined next to leading order analysis to the available inclusive and semi-inclusive polarized deep inelastic scattering data.

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INTRODUCTION

For more than fifteen years, polarized inclusive deep inelastic scattering (pDIS) has been the main source of information on how the individual partons in the nucleon are polarized at very short distances. Many alternative experiments have been conceived to improve this situation. The most mature among them are those based on polarized semi-inclusive deep inelastic scattering (pSIDIS).

In the following we present results obtained in a combined next to leading order analysis to the recently updated set of pDIS and pSIDIS data [1]. Specifically, we focused on the extraction of sea quark and gluon densities, analyzing the constraining power of the data on the individual densities. As result, we found not only a complete agreement between pDIS and pSIDIS data, but a very useful complementarity, leading to rather well constrained densities.

Using the Lagrange multiplier approach [2], we explored the profile of the χ^2 function against different degrees of polarization in each parton flavor. In this way we obtained estimates for the uncertainty in the net polarization of each flavor, and in the parameters of the pPDFs. We compared results obtained with the two most recent sets of fragmentation functions. The differences are found to be within conservative estimates for the uncertainties. Nevertheless, there is a clear preference for a given set of FF over the other, shown in a difference of several units in the χ^2 of the respective global fits. In NLO global fits the overall agreement between theory and the full set of data is sensibly higher than in LO case.

GLOBAL FIT

In our analysis [1], we followed the same conventions and definitions for the polarized inclusive asymmetries and parton densities adopted in references [3, 4], however we used more recent inputs, such as unpolarized parton densities [5] and the respective values for

TABLE 1. Inclusive and semi-inclusive data used in the fi t.

Collaboration	Target	Final state	# points	Refs.
EMC	proton	inclusive	10	[8]
SMC	proton, deuteron	inclusive	12, 12	[8]
E-143	proton, deuteron	inclusive	82, 82	[8]
E-155	proton, deuteron	inclusive	24, 24	[8]
Hermes	proton,deuteron,helium	inclusive	9, 9, 9	[8]
E-142	helium	inclusive	8	[8]
E-154	helium	inclusive	17	[8]
Hall A	helium	inclusive	3	[8]
COMPASS	deuteron	inclusive	12	[8]
SMC	proton,deuteron	h^+, h^-	24, 24	[8]
Hermes	proton, deuteron, helium	h^+, h^-, π^+, π^-, K^+, K^-, K^T	36,63,18	[8]
	Total		478	

α_s. Fragmentation functions were taken from either [6] or [7], respectively. We also used the flavor symmetry and flavor separation criteria proposed in [6], at the respective initial scales Q_i^2. The data sets analyzed include only points with $Q^2 > 1$ GeV^2, listed in Table 1, and totaling 478 data points.

In Table 2, we summarize the results of the best NLO and LO global fits to all the data listed in Table 1. We present fits obtained using alternatively fragmentation functions from reference [6], labeled as KRE, and from reference [7], labeled as KKP. Since the fit involves 20 parameters, the number of degrees of freedom for these fits is 478-20=458. Consequently, the χ^2 values obtained are excellent for NLO fits and very good for LO. The better agreement between theory and experiment found at NLO, highlights the importance of the corresponding QCD corrections, for the present level of accuracy achieved by the data.

In NLO fits there seems to be better agreement when using KRE fragmentation functions. The difference between the total χ^2 values between KRE and KKP NLO fits comes mainly from the contributions related to pSIDIS data, while those associated to inclusive data are almost the same, as one should expect in a fully consistent scenario.

Table 2 includes also the first moment of each flavor distribution at $Q^2 = 10$ GeV^2, and that for the singlet distribution $\delta\Sigma$, as reference. Most noticeably, while the KRE NLO fit favors the idea of a SU(3) symmetric sea, KKP NLO finds $\bar{u}$ polarized opposite to $\bar{d}$ and to $\bar{s}$. Gluon and strange sea quark polarization are similar in both fits and the total polarization carried by quarks is found to be around 30%.

TABLE 2. χ^2 values and fi rst moments for distributions at $Q^2 = 10$ GeV^2

set		χ^2	χ^2_{DIS}	χ^2_{SIDIS}	$\delta\bar{u}$	$\delta\bar{d}$	$\delta\bar{s}$	δg	$\delta\Sigma$
NLO	KRE	430.91	206.01	224.90	-0.0487	-0.0545	-0.0508	0.680	0.284
	KKP	436.17	205.66	230.51	0.0866	-0.107	-0.0454	0.574	0.311
LO	KRE	457.54	213.48	244.06	-0.0136	-0.0432	-0.0415	0.121	0.252
	KKP	448.71	219.72	228.99	0.0497	-0.0608	-0.0365	0.187	0.271

UNCERTAINTIES

Many strategies have been implemented in order to assess the uncertainties in PDFs and their propagation to observables, specially those associated with experimental errors in the data. The Lagrange multiplier method [2] probes the uncertainty in any observable or quantity of interest relating the range of variation of one or more physical observables dependent upon PDFs to the variation in the χ^2 used to judge the goodness of the fit to data. In Figure 1 we show the outcome of varying the χ^2 of the NLO fits to data against

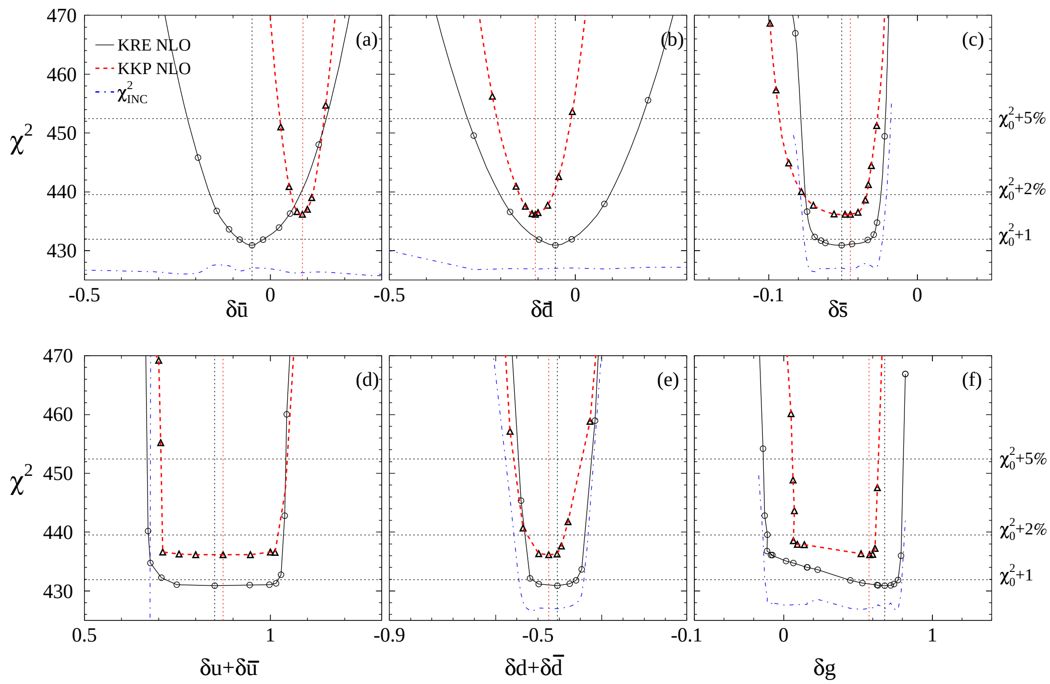

FIGURE 1. χ^2 profiles for NLO fits obtained using Lagrange multipliers at $Q^2 = 10$ GeV^2.

the first moment of the respective polarized parton densities δq at $Q^2 = 10$ GeV^2, one at a time. This is, to minimize

$$\Phi(\lambda_q, a_j) = \chi^2(a_j) + \lambda_q\, \delta q(a_j) \qquad q = u, \overline{u}, d, \overline{d}, s, g. \tag{1}$$

In order to see the effect of the variation in χ^2 on the parton distributions themselves, in Figure 2, we show KRE best fit densities together with the uncertainty bands corresponding to $\Delta\chi^2 = 1$ (darker band) and $\Delta\chi^2 = 2\%$ (light shaded band). As expected, the relative uncertainties in the total quark densities and those strange quarks are rather small. For gluon densities the $\Delta\chi^2 = 1$ band is also small, but the most conservative $\Delta\chi^2 = 2\%$ estimate is much more significative. For light sea quarks the $\Delta\chi^2 = 1$ bands are moderate but the $\Delta\chi^2 = 2\%$ are much more larger.

Two programmed experiments, the one based on the PHENIX detector already running at RHIC [9], and the E04-113 experiment at JLab [10] will be able to reduce dra-

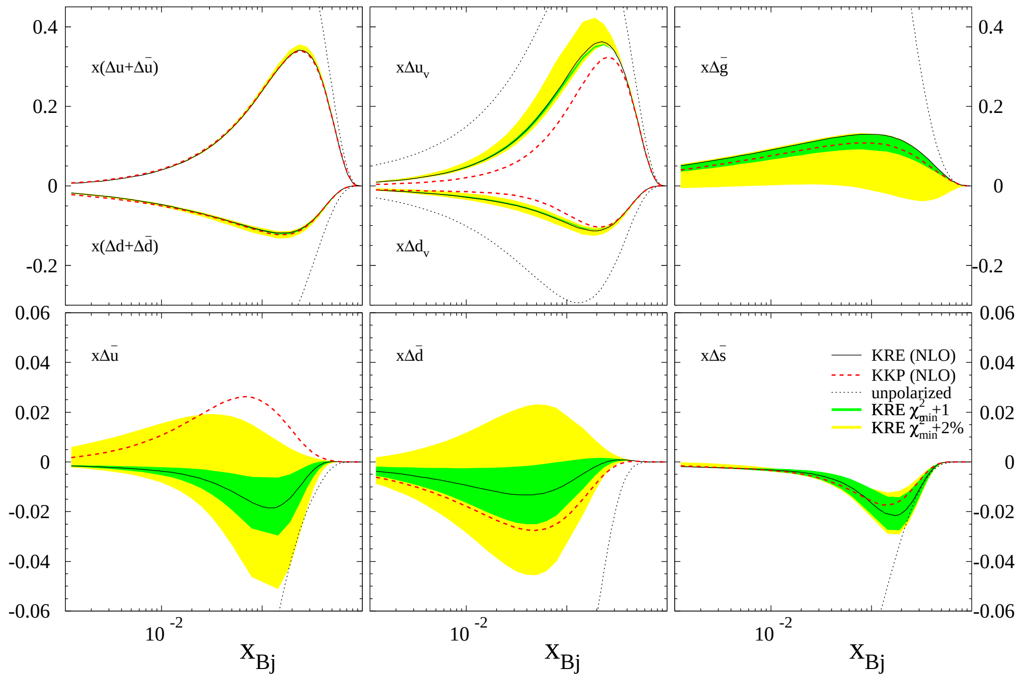

FIGURE 2. Parton densities at $Q^2 = 10\ \mathrm{GeV}^2$, and the uncertainty bands corresponding to $\Delta\chi^2 = 1$ and $\Delta\chi^2 = 2\%$

matically the uncertainty in both the gluon and the light sea quark densities respectively, the latter providing also an even more stringent test on fragmentation functions.

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