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RECENT RESULTS FROM THE COMPASS EXPERIMENT AT CERN

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Abstract

Recent data from the COMPASS experiment at CERN, including inclusive and semi-inclusive double-spin asymmetries are presented. The gluon and the valence quarks spin distributions are determined from the data.

1 Introduction

Understanding the nucleon spin structure is one of the main objectives of the COMPASS experiment [1] at CERN. In the years 2002-2006, COMPASS collected a large amount of data on inclusive, semi-inclusive, and transverse spin asymmetries. In this talk two of our new results are presented: the shape of the gluon spin distribution, as inferred from a Next-to-Leading order QCD fit to the inclusive asymmetries, and the valence quarks spin distribution, as determined from the semi-inclusive data.

2 The polarized gluon distribution

Deep-inelastic scattering cross section asymmetries were measured [2] for values of the Bjorken variable x ranging from 0.004 to 0.7 and for four-momenta Q^2 between 1 and 100 $(GeV/c)^2$. The deuteron spin structure function $g_1^d(x)$ is determined from the experimental asymmetries, by taking into account the beam and the target polarizations, the target dilution factor, the ratio of the longitudinal to transverse cross sections and the $F_2(x)$ unpolarized structure function. The data are in good agreement with previous results on $g_1^d(x)$ from SMC [3]. The statistical accuracy is significantly improved, particularly in the lowest x region, where $g_1^d(x)$ is found to be compatible with zero.

[1] On behalf of the COMPASS collaboration.

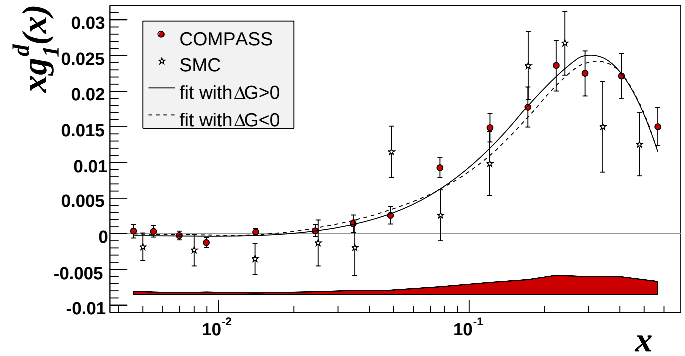

Figure 1: The deuteron g_1^d structure function, as measured by COMPASS and by SMC [3]. The solid and the dashed curves are the QCD fits to the data for the solution with $\Delta G > 0$ and $\Delta G < 0$ respectively.

A Next-to-Leading Order QCD fit of the world proton, deuteron and ^{3}He data available (see Ref. [2] and references therein) was carried out, based on two different approaches: in the (x, Q^2) space and in the space of moments. Both approaches use the QCD evolution equations, in which the Q^2 dependence of the nucleon polarized structure function is described in terms of singlet $\Delta\Sigma(x)$, non-singlet $\Delta q_3(x)$ and $\Delta q_8(x)$, and gluon $\Delta G(x)$ distributions. The fits are performed in the $\overline{MS}$ renormalization and factorization scheme at the reference Q_0^2 value of 3 $(GeV/c)^2$. In total, 230 data points were used, out of which 43 are from COMPASS.

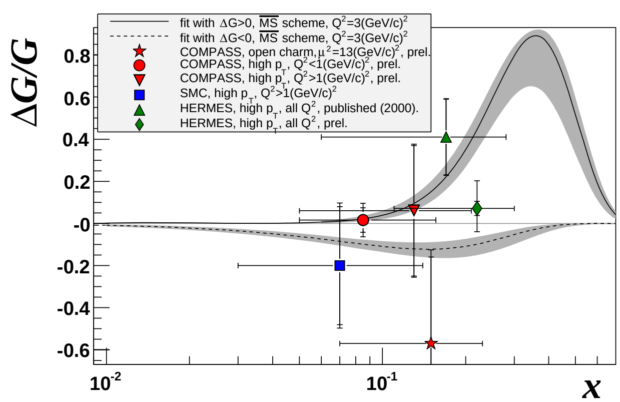

Figure 2: QCD fit results for the gluon distribution, together with the available $\Delta G/G$ measurements from COMPASS, SMC, and HERMES [5].

Each of the two analyses of $g_1^d(x)$ provide us with two different solutions, one with $\Delta G < 0$ and the other with $\Delta G > 0$. The two solutions (Fig. 1) yield comparable $\Delta\Sigma(x)$, $\Delta q_3(x)$, and $\Delta q_8(x)$ distributions with nearly identical χ^2 probabilities. In spite of the sign difference, the two fits to $g_1^d(x)$ are hardly distinguishable all over the measured range in x. They start to differ only for the very low values of x and have different behavior when x tends to zero.

The first moments η_G for each of the two gluon distributions are small for both solutions and nearly equal in absolute values, i.e. $|\eta_G| \approx 0.2 - 0.3$. The available measurements [5] of $\Delta G/G$, all obtained via the Photon-Gluon Fusion (PGF) process, are compard to the fits results in Fig. 2. Within the present statistical errors, the PGF measurements are compatible with either of the two solutions.

From the difference between $\Delta\Sigma(x)$ and $\Delta q_8(x)$ we also determine the strange quark distribution. It is negative, peaks at high x, and contributes to the nucleon spin for $\Delta s + \Delta\overline{s} = -0.10 \pm 0.01(stat.) \pm 0.01(evol.)$.

3 Polarized valence quark distribution

Additional insight into the nucleon spin structure is obtained through the correlation between the flavor of the struck quark, and the outgoing hadron detected in coincidence with the scattered lepton. In the period 2002-2004, COMPASS has measured [6] semi-inclusive asymmetries for both positive and negative hadrons. The asymmetries are in good agreement with previous data from SMC [3] and HERMES [4] experiments, and show improved statistics, particularly in the region of low x ($x < 0.04$).

From the positive and negative hadron spin asymmetries we define the difference asymmetry. At leading order the difference asymmetry is not sensitive to the fragmentation functions, which cancel out in the cross-section ratio. Since for a deuteron target both pion and kaon difference asymmetries are related to the valence quark polarization $\Delta u_v + \Delta d_v$, no particle identification is required.

The valence quark spin distribution is determined from the difference asymmetries by using the unpolarized valence distribution from Ref. [7] and correcting for the deuteron D-state. The results are shown in Fig. 3. For values of $x > 0.3$ inclusive data points are also displayed. Since in this region the contribution of the unpolarized sea quarks becomes negligible, all the polarization is due to the valence quarks. The inclusive results agree with the semi-inclusive data, and have better statistical errors.

The first moment of the valence quark spin distribution has the value

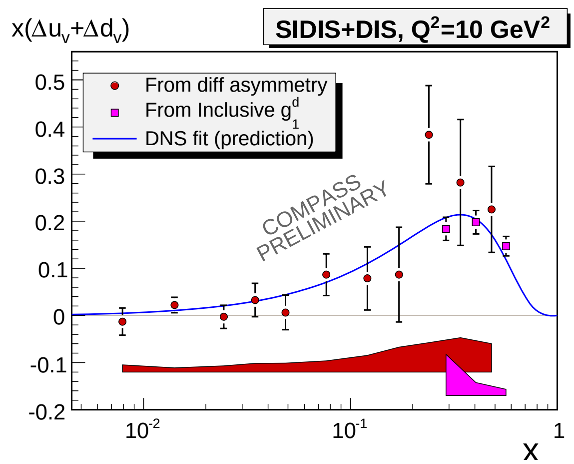

Figure 3: Valence quark spin distribution, evolved to $Q^2 = 10\ \ (GeV/c)^2$ The square points at $x > 0.3$ are obtained from the inclusive measurements on g_1^d. The line is a fit result prediction from Ref. [8].

$0.41 \pm 0.07(stat.) \pm 0.05(syst.)$. The contribution of the unmeasured regions to this value was found to be negligible. Combining the valence quarks first moment with the first moment of $g_1(x)$, for which both valence and sea quarks contribute, we derive the light quark polarized sea contribution. The result $(0.0 \pm 0.04(stat.) \pm 0.03(syst.))$ indicates that if $\Delta\overline{u}(x)$ and $\Delta\overline{d}(x)$ are different from zero, they should have an opposite sign. The polarized sea should be then flavor asymmetric: $\Delta\overline{u}(x) = -\Delta\overline{d}(x)$, at the two σ level.

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