ΔG FROM COMPASS

KRZYSZTOF KUREK *
On behalf of COMPASS Collaboration
Andrzej Sołtan Institute for Nuclear Studies, Hoża 69, 00-681 Warsaw, Poland
E-mail: kurek@fuw.edu.pl

Measurements of the gluon polarization $\frac{\Delta G}{G}$ via the open charm channel and based on the helicity asymmetry of large transverse-momentum hadrons in the final state are presented. The data have been collected in the years 2002-2004 by the COMPASS experiment at CERN. The new result for $\frac{\Delta G}{G}$ from the charm channel is $-0.57 \pm 0.41(stat.)$ at $x_G \simeq 0.15$ and scale $\mu^2 \simeq 13$ (GeV/c)^2.
The gluon polarization from high-p_T hadron pairs is $\frac{\Delta G}{G} = 0.016 \pm 0.058(stat.) \pm 0.055(syst.)$ at $x_G \simeq 0.085^{+0.07}_{-0.035}$ ($Q^2 < 1$ (GeV/c)^2 and $\mu^2 \simeq 3$ (GeV/c)^2)

1. Introduction

The EMC spin asymmetry measurement [1] and the naive interpretation of the results following of Ellis-Jaffe sum rule [2] have introduced the so-called "spin crisis": quarks carry very small fraction of the nucleon's helicity. The next experiments at CERN, DESY and SLAC confirmed that quarks are only responsible for 1/3 of nucleon's helicity. The quark helicity distributions $\Delta q_i(x, Q^2)$ are related to vector-axial quark current which is not conserved due to the Adler-Bell-Jackiw anomaly. This fact allows to explain the spin crisis by changing the interpretation of the measurement: instead of quark spin contents $\Delta\Sigma = \int_0^1 \sum_{i=1}^{n_f} q_i(x, Q^2)dx$ the combination $\Delta\Sigma - \frac{3\alpha_s}{2\pi}\Delta G$ is measured, where ΔG is a gluon polarization inside the nucleon. The spin crisis and the violation of the Ellis-Jaffe sum rule can be then avoided if ΔG is large enough. To complete the picture, beside the quark's helicity $\Delta\Sigma$, and the gluon polarization ΔG also an orbital angular momentum of quarks and gluons can build the nucleon spin structure. This interpretation was a "driving force" in preparation a series of new polarized DIS type experiments related to direct measurement of ΔG:

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HERMES in DESY, SMC and COMPASS at CERN, STAR and PHOENIX at RHIC. //In this paper I will present new results for a direct measurement of gluon polarization $\frac{\Delta G}{G}$ obtained by COMPASS collaboration after analyzing the data sets collected in years 2002-2004. The experiment is using a 160 GeV/c polarized muon beam from SPS at CERN scattered off polarized ^{6}LiD target (for more details see F.Kunne [3]). In the LO QCD approximation the only subprocess which probes gluons inside nucleon is Photon-Gluon Fusion (PGF). There are two ways allowing direct access to gluon polarization via the PGF subprocess available in the COMPASS experiment: the open charm channel where the events with reconstructed D^0 mesons are used and the production of two hadrons with relatively high-p_T in the final state. The open charm channel guarantees no physical background because the PGF subprocess is the only possible mechanism for charm quarks pair production in LO QCD approximation. Therefore the estimation of the gluon polarization in this case is much less Monte-Carlo (MC) dependent than in the two high-p_T hadrons method, where the complicated background requires very good MC description of the data. On the other hand the statistical precision in high-p_T hadrons method is much higher than in the open charm channel.

2. $\frac{\Delta G}{G}$ from open charm channel

For events with charm quarks production a helicity asymmetry has been measured. Charm quarks were tagged by measuring D mesons in one of the two channels: the D^0 meson decaying into the "golden" channel i.e. to a kaon and a pion, and D^* decaying into soft pion and a D^0 with subsequent decay (so-called D^*-tagged events). For particle identification the RICH detector was used. The gluon polarization $\frac{\Delta G}{G}$ is related to the measured helicity asymmetry as follows:

$$A_{LL} = \frac{S}{S+B} a_{LL} \frac{\Delta G}{G}, \tag{1}$$

where S and B denote signal and combinatorial background, respectively, and a_{LL} is the analyzing power - the ratio of spin-dependent and spin-independent cross sections in the PGF process and is given as a function of photon as well as gluon kinematics. The photon kinematics can be fully reconstructed based on the incoming and scattered muons but the gluon part cannot be reconstructed because only one charmed meson is measured. From MC studies it was shown that the knowledge of the kinematics of only one charmed meson can be used to reconstruct the analyzing power approximately. The parametrization of a_{LL} was found by a neural network trained using MC sample generated by the AROMA generator and reconstructed as for real data. Combining data from 2002-2004 we obtained the following preliminary COMPASS result for the gluon polarization from the open charm channels: $\frac{\Delta G}{G} = -0.57 \pm 0.41(stat.)$ at $x_G \simeq 0.15$ and with the scale $\mu^2 \simeq 13$ (GeV/c)^2. We expect the systematical uncertainty of the result to be smaller than statistical error.

3. $\frac{\Delta G}{G}$ from two high-p_T hadrons

Two parallel high-p_T hadrons analyzes are going on: the so-called quasi-real photoproduction ($Q^2 < 1(\mathrm{GeV/c})^2$) of high-$p_T$ hadron pairs and the high-p_T hadrons analysis with high Q^2 ($Q^2 > 1(\mathrm{GeV/c})^2$). The reason for performing the analysis in the two kinematical regions separately is that in the two cases different background processes are contributing. Corrections for this background have to be taken from MC simulations and therefore very good agreement between data and MC is required. The helicity asymmetry for two high-p_T hadrons is expressed as follows:

$$A_{LL} = R_{PGF} a_{LL} \frac{\Delta G}{G} + A_{Bkg.}, \tag{2}$$

where again a_{LL} is the analyzing power for PGF subprocess, R_{PGF} is a fraction of PGF processes (taken from MC) and A_{Bkg} denotes the asymmetry from different background processes which contribute to the observed two hadron final state. In the low Q^2 sample the complicated background, including resolved photon contribution was simulated with the PYTHIA MC generator. An important contribution to the systematic error is related to unknown polarized distribution functions in the photon (two scenarios: plus or minus maximal polarization were taken into account).The detailed procedure, data/MC comparison and results for $\frac{\Delta G}{G}$ obtained for 2002-2003 data have been recently published [4]. The preliminary result - including the 2004 data is: $\frac{\Delta G}{G} = 0.016 \pm 0.058(stat.) \pm 0.055(syst.)$ at $x_G \simeq 0.085^{+0.07}_{-0.035}$ and scale $\mu^2 \simeq 3$ (GeV/c)^2. The comparison of all COMPASS $\frac{\Delta G}{G}$ results and the results from SMC [5] and HERMES [6] experiments is presented in Figure 1. A new result for the high Q^2 - including the 2004 data set is expected soon. In contrast to low Q^2 the physical background is dominated by the leading and the QCD-Compton process. The LEPTO MC generator is used in this analysis. Due to the fact that large Q^2 guarantees a perturbative scale the p_T cuts can be released increasing statistics. The neural network approach similar to the one used in the SMC analysis [5]

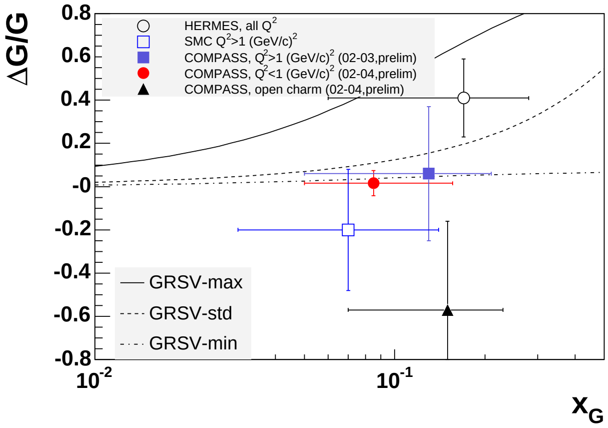

Figure 1. Comparison of the $\frac{\Delta G}{G}$ measurement from COMPASS, SMC and HERMES.

is now tested. At the end it is worth to note that NLO corrections are partially taken into account by using parton showers in MC generators and string type fragmentation functions. Although model (MC) dependent - the obtained result for low Q^2 is the most precise estimation of the $\frac{\Delta G}{G}$ from directly measured helicity asymmetry.

4. Conclusions

The new measurements of the gluon polarization obtained from the COMPASS experiment have been presented. The model-independent direct measurement based on the open charm channel and the most precise but model (MC) dependent result from two high-p_T hadron pairs analysis indicate that a small ΔG is preferred. The Ellis-Jaffe sum rule seems to be violated if a large ΔG is excluded. The small ΔG indicates the important role of angular orbital momentum in nucleon spin decomposition in the frame of parton model and perturbative QCD.

References

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