SPIN PHYSICS RESULTS FROM HERMES

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ON BEHALF OF HERMES COLLABORATION

A selection of HERMES spin physics results for 95-97 data taking period is presented. Inclusive and semi-inclusive asymmetries provided measurements of nucleon spin structure functions and a flavour decomposition of the nucleon spin. The first measurement of the gluon polarisation was performed through high analysis of high p_T hadron pairs of opposite charge. HERMES also performed the first measurement of single spin asymmetries for semi-inclusive pion produced in deep inelastic scattering, showing its sensitivity to the still unmeasured quark transverse polarisation distributions.

1 Quark polarisation from inclusive and semi-inclusive asymmetries.

Inclusive and semi-inclusive double spin asymmetries have been measured by scattering of positron from 27.5 GeV HERA polarised positron beam off ^{3}He and ^{1}H internal polarised gas target. The results are summarised in Fig. 1. On the left side of Fig. 1, HERMES inclusive asymmetries are compared to SLAC (E143, E154) and CERN (SMC) data, which mean Q^2 is much higher than for HERMES. No Q^2 dependence of A_1 can be seen within the measured range and statistical accuracy. Nucleon spin structure functions g_1 as well as deep inelastic contribution to the generalised Gerasimov-Drell-Hearn integral for the proton and neutron were extracted from these inclusive measurements [1 2 3].

One of the main feature of HERMES experiment is its unique ability to separate hadrons from scattered lepton with marginal contamination ($< 1\%$). Appropriate kinematic cuts can select hadrons from the current fragmentation region to tag the flavour of the struck quark and therefore provide a flavour decomposition of the quark contribution to the nucleon spin. Semi-inclusive asymmetries $A_1^{\mathrm{h}}(x,Q^2)$ are related to quark polarisations ($\frac{\Delta q(x)}{q(x)}$) by

$$A_1^{\mathrm{h}}(x,Q^2) = \sum_q \frac{e_q^2 q(x) D_q^{\mathrm{h}}(z)}{\sum_{q'} e_{q'}^2 q'(x) D_{q'}^{\mathrm{h}}(z)} \frac{\Delta q(x)}{q(x)} \tag{1}$$

where the fragmentation functions $D_q^{\mathrm{h}}(z)$ are related to the probability that a struck quark of flavour f fragments into a hadron of type h. Fig. 2 shows

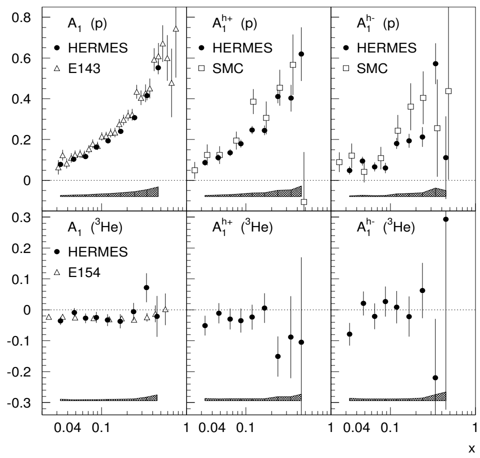

Figure 1. Inclusive (left) and semi-inclusive double spin asymmetries for positively (center) and negatively (right) charged hadrons on proton (top) and ^{3}He (bottom). The data points are given for the measured mean Q^2 at each value of x, which is different for each experiment. The bands represent the systematic uncertainties.

the flavour decomposition of polarised quark distributions [4]. The flavour decomposition arise from a global fit of HERMES inclusive and semi-inclusive asymmetries shown in Fig. 1. The factors relating the measured asymmetries to the quark polarisation in equation 1 were computed from unpolarised quark distributions parameterisation and from Monte Carlo simulation based on LUND string fragmentation model [5]. The results show that u quarks polarisation is clearly positive while d quarks polarisation is negative over the whole x range covered by the experiment. The sea polarisation was found to be compatible with zero.

Since the present asymmetries have low sensitivity to the sea polarisation because of u quark dominance, the analysis assumed flavour independent sea polarisation, namely $\frac{\Delta u_s(x)}{u_s(x)} = \frac{\Delta d_s(x)}{d_s(x)} = \frac{\Delta s(x)}{s(x)} = \frac{\Delta \overline{u}(x)}{\overline{u}(x)} = \frac{\Delta \overline{d}(x)}{\overline{d}(x)} = \frac{\Delta \overline{s}(x)}{\overline{s}(x)}$. The new HERMES Dual-Radiator Ring Imaging Čerenkov Detector (RICH) [6] will provide a direct measurement of the sea polarisation in near future, through unambiguous identification of all hadrons (pions, protons and kaons) over the whole kinematic range.

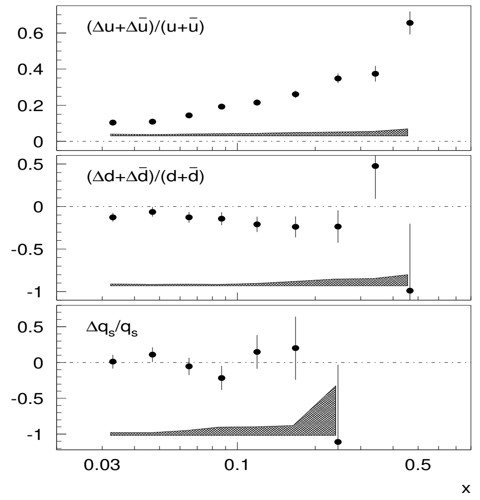

Figure 2. Flavor decomposition of the quark polarisation as function of x. The bands represent the systematic uncertainties.

2 Gluon polarisation from high p_T hadron pairs

The quarks contribution to nucleon spin is only $\sim 30\%$. The deficit can be explained by a large positive gluon polarisation $\Delta G/G$. No measurement of gluon polarisation have been performed up to now. The gluon polarisation can be indirectly probed through scaling violation of polarised structure function. However, in contrast to the unpolarised case, the $x - Q^2$ range of world polarised DIS data is too limited to constrain ΔG. The first measurement of the gluon polarisation have been performed by HERMES by measuring spin asymmetries in photon gluon fusion (PGF) process. The PGF process signature is characterised by two hadrons of opposite charge and high transverse momentum (p_T). In order to maximize the contribution of photon gluon process in the data sample and to include the low Q^2 region which dominates the cross section, the scattered e^+ was not required by the trigger. The semi-inclusive longitudinal cross section asymmetry $A_{\parallel}(p_T^{h^+}, p_T^{h^-})$ for $h^{\pm}$ pair production measured is close to zero when averaged over the whole p_T range. For the highest p_T accessible, a negative asymmetry is measured [10] (see Fig. 3). Averaging over the bins where $p_T^{h1} > 1.5$ GeV^2 and $p_T^{h2} > 1.0$ GeV^2 gives $A_{\parallel} = -0.28 \pm 0.12(\text{stat.}) \pm 0.02(\text{syst.})$. This negative asymmetry

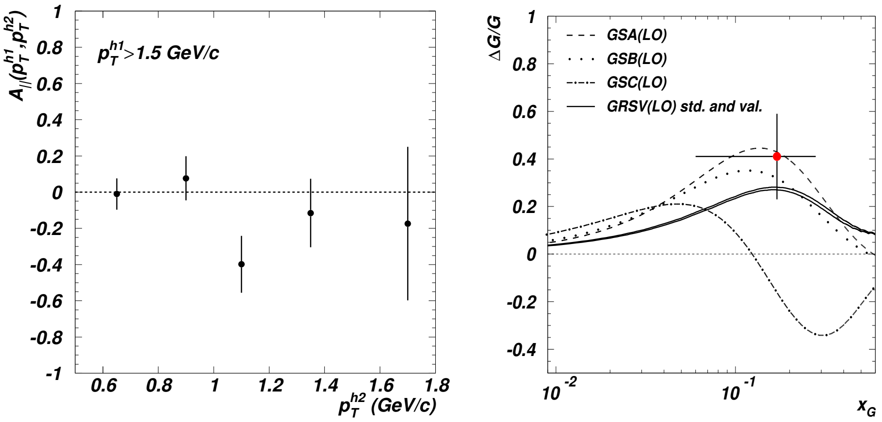

Figure 3. Longitudinal cross section asymmetry $A_{\|}(p_T^{h^+}, p_T^{h^-})$ for $h^{\pm}$ pair production (left) and the corresponding extracted value of $< \Delta G/G >$ compared with several QCD fits [7] [8] (right). The error bars represent the statistical uncertainty only.

is in contrast to the positive asymmetry measured in DIS from proton. This asymmetry is interpreted considering contributions from four different processes: deep inelastic scattering (DIS), vector meson dominance (VMD), LO QCD Compton and PGF. Monte Carlo studies based on PYTHIA [9] model clearly showed that PGF dominates over all other considered processes in the phase space where the negative asymmetry is observed. The asymmetry of QCD Compton process is calculated to be positive whereas the asymmetries of VMD process is assumed to be zero. Within this model, the extracted value for the gluon polarisation is $< \Delta G/G >= +0.41 \pm 0.18(\text{stat.}) \pm 0.03(\text{syst.})$ at $< x_G >= 0.17$. This result is compared at Fig. 3 to several LO QCD fits to world data. The systematic error does not include any model uncertainties from neglected contributions. It is important to stress that any ignored process with zero asymmetry will contribute only as a dilution factor, leading to an increase of value $< \Delta G/G >$ extracted but the significance of its deviation from zero will remain the same.

3 Single Spin Azimuthal Asymmetries.

The complete twist-2 description of the nucleon requires three sets of structure functions: the unpolarised structure functions, the longitudinal spin distribution functions and the still unmeasured transverse spin distribution functions. A classification of the complete set of distribution functions at the twist-2 and twist-3 levels can be found in [11]. Transversity distributions are still unmeasured because of their particular chiral-odd nature which implies that they are not directly observable in inclusive lepton scattering experiments. However, transversity distributions are predicted to be measurable in semi-inclusive measurements where only the lepton beam *or* the target are polarised [12]. In the case of semi-inclusive pion production from a longitudinally polarised target, the combination of chiral odd quark spin distribution functions and a fragmentation of the same structure (the Collins chiral-odd time-odd fragmentation function) leads to an asymmetry in the distribution of the azimuthal angle ϕ of the pion around the virtual photon momentum, with respect to the lepton scattering plane [11 13].

The first measurement of single spin asymmetries for semi-inclusive pion production in DIS as recently been performed by HERMES. The $\sin\phi$ moments of the distribution have been extracted according to

$$\mathcal{A}_{UL}^{\sin\phi} = \frac{\frac{L^+}{L_P^+}\int_0^{2\pi}\sin\phi\ \mathrm{d}N_+ \ - \ \frac{L^-}{L_P^-}\int_0^{2\pi}\sin\phi\ \mathrm{d}N_-}{\frac{1}{2}[\int_0^{2\pi}\mathrm{d}N_+ \ + \ \int_0^{2\pi}\mathrm{d}N_-]}$$

where $\pm$ refer to the target spin state, $L^\pm$ are the dead-time corrected luminosities, and $L_P^\pm$ luminosities weighted by the target polarization. The measured asymmetries for π^+ and π^- are shown on Fig. 4 as function of inclusive variable x and as function of the transverse momentum of pions $P_\perp$ [14]. The asymmetries averaged over x and $P_\perp$ are

$$\begin{aligned} \pi^+ \quad \mathcal{A}_{UL}^{sin\phi} &= \ \ 0.022 \pm 0.005(stat) \pm 0.003(syst) \\ \pi^- \quad \mathcal{A}_{UL}^{sin\phi} &= -0.005 \pm 0.008(stat) \pm 0.004(syst). \end{aligned}$$

The difference between π^+ and π^- can be interpreted in term of favoured and unfavoured Collins fragmentation function [15]. The apparent increase of the effect with x suggests that the effect is associated with valence quark contributions [16]. The increase of $\mathcal{A}_{UL}^{\sin\phi}$ for π^+ as $P_\perp$ increase up to ~ 0.8 GeV can be related to the dominant role of intrinsic quark transverse momentum when $P_\perp$ remain below typical hadronic mass scale [17].

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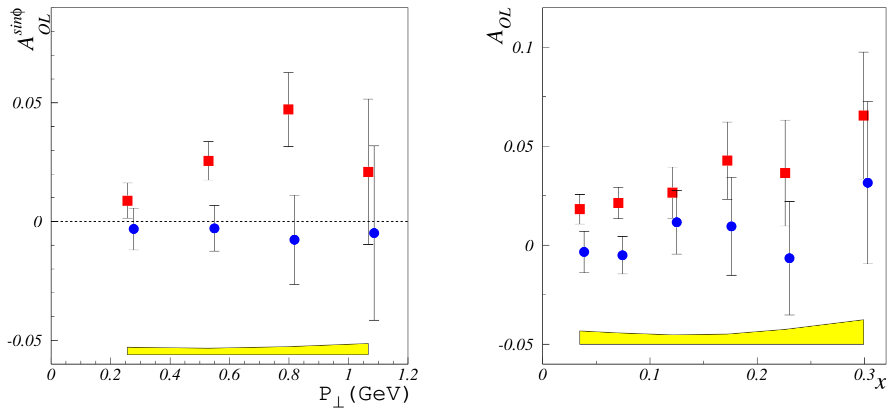

Figure 4. $\mathcal{A}_{UL}^{\sin\phi}$ for π^+ (squares) and for π^- (circles) as function of pion transverse momentum (left) and as function of Bjorken x (right). The bands represents the systematic uncertainties.

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