Measurement of Longitudinal Spin Transfer to Λ Hyperons in Deep-Inelastic Lepton Scattering

The HERMES Collaboration

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Spin transfer in deep-inelastic Λ electroproduction has been studied with the HERMES detector using the 27.5 GeV polarized positron beam in the HERA storage ring. For an average fractional energy transfer $z = 0.45$, the measured longitudinal spin transfer from the virtual photon to the Λ is $0.11 \pm 0.17(\text{stat}) \pm 0.03(\text{sys})$. This quantity is expected to be sensitive to the up quark polarization in the Λ hyperon and to the assumption of helicity conservation in the fragmentation process. The experimental result is interpreted in relation to various models of the Λ spin content and found to favor the naive quark parton model. However, the present statistical precision is not yet sufficient to exclude a significant up quark polarization in the Λ.

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Spin-dependent deep-inelastic scattering of charged leptons has provided precise information on the spin structure of the nucleon. Several inclusive experiments on polarized proton and neutron targets [1–6] have confirmed the EMC result [7], from which it was inferred that the quark spins account for only a small fraction of the nucleon spin. Additional information has been obtained from semi-inclusive polarized deep-inelastic scattering experiments, where the correlation between the flavor of the struck quark and the type of hadron observed in the final state allows the separation of the spin contributions of different quark flavors and of valence and sea quarks [8,9]. Those measurements indicate that the contribution of the up and down sea quarks to the nucleon spin is small. However, considerable uncertainties remain in the contributions of strange quarks and gluons.

Recently, it has been proposed that one could obtain additional information on the polarized quark distributions in the baryons of the spin 1/2 octet through the production of Λ hyperons in polarized deep-inelastic lepton scattering [10,11]. Measuring the polarization of the Λ's that are likely to have originated from the struck quark (so-called "current fragmentation"), the longitudinal spin transfer $D_{LL'}^{\Lambda}$, defined as the fraction of the virtual photon polarization transfered to the Λ, can be determined. In the naive quark parton model (QPM), the spin of the Λ is entirely due to the strange quark and the up and down quark spin contributions are zero. On the other hand, assuming SU(3) flavor symmetry, the up, down and strange quark distributions and fragmentation functions for the Λ can be related to those in the proton. If data on hyperon decays and polarized structure functions of the nucleon are interpreted in the framework of SU(3) symmetry, the first moments of the polarized up and down quark distributions in the Λ can be estimated to be about -0.2 [10]. The additional assumption of quark helicity conservation in the fragmentation process results in this same value for the spin transfer in fragmentation from an up or down quark to the Λ.

Longitudinal spin transfer in Λ production has previously been studied at the Z^0 pole at LEP. In the standard model, quarks produced via Z^0 decays have an average polarization of -0.91. Recently, both the ALEPH [12] and the OPAL collaborations [13] have reported a measurement of the Λ polarization of about -0.3 for $z > 0.3$. This value agrees with the assumptions that the Λ spin is entirely due to the spin contribution of the strange quark and that helicity is conserved in the fragmentation process. However, the interpretation of these data is not unique. In ref. [14] the LEP data have been confronted with different models for the Λ spin structure. Three scenarios have been chosen which all describe the results reasonably well: the naive QPM, where only the strange quark carries spin and contributes to polarized Λ production (subsequently referred to as scenario 1), the SU(3) flavor-symmetric model, in which up and down quarks also contribute with a negative sign (scenario 2), and a rather extreme scenario, in which all three light quark flavors contribute equally to the Λ polarization (scenario 3). In contrast to the LEP data, Λ production in deep-inelastic lepton scattering is dominated by scattering on up quarks. Hence such experiments provide a means to distinguish between these models of the Λ spin structure and to further test the assumption of helicity conservation in the fragmentation process.

The polarization of Λ hyperons can be measured via the parity-violating weak decay channel $\Lambda \rightarrow \mathrm{p}\pi^-$ through the angular correlation of the final state:

$$\frac{dN_{\mathrm{p}}}{d\Omega} \propto 1 + \alpha P_{\Lambda} \cos\Theta, \qquad (1)$$

where $\alpha = 0.642 \pm 0.013$ is the asymmetry parameter of the parity-violating weak decay, P_{Λ} is the polarization of the Λ, and Θ is the angle between the proton momentum and the Λ polarization direction in the rest frame of the Λ. For a longitudinally polarized lepton beam and an unpolarized target, the Λ polarization along its momentum axis is given in the quark parton model by [11,15]

$$P_{\Lambda} = P_B D(y) \frac{\sum_f e_f^2 q_f^N(x,Q^2) G_f^{\Lambda}(z,Q^2)}{\sum_f e_f^2 q_f^N(x,Q^2) D_f^{\Lambda}(z,Q^2)}, \qquad (2)$$

where P_B is the polarization of the charged lepton beam, $-Q^2$ is the squared four-momentum transfer of the virtual photon with energy ν, and $x = Q^2/2M\nu$ is the Bjørken scaling variable, M being the proton mass. The fractional energy transfered to the nucleon is $y = \nu/E$ where E is the lepton beam energy, $z = E_{\Lambda}/\nu$ is the energy fraction of the Λ, and $D(y) \approx y(2-y)/(1+(1-y)^2)$ is the virtual photon depolarization factor. In this expression $q_f^N(x,Q^2)$ is the quark distribution for flavor f in the nucleon, $D_f^{\Lambda}(z,Q^2)$ is the fragmentation function for Λ production from quark flavor f, $G_f^{\Lambda}(z,Q^2)$ is the corresponding longitudinal spin-dependent fragmentation function, and e_f is the quark charge in units of the elementary charge e.

Following ref. [11] the longitudinal spin transfer to the Λ is defined as

$$D_{LL'}^{\Lambda} \equiv \frac{P_{\Lambda}}{P_B D(y)} = \frac{\sum_f e_f^2 q_f^N(x,Q^2) G_f^{\Lambda}(z,Q^2)}{\sum_f e_f^2 q_f^N(x,Q^2) D_f^{\Lambda}(z,Q^2)}, \qquad (3)$$

where the subscripts L and L' denote the fact that the spin is transfered from a polarized photon to a polarized Λ and that the two longitudinal spin quantization axes are different. Due to the charge factor for the up quark, the spin transfer in Λ electroproduction is dominated by the spin transfer from the up quark to the Λ. Moreover, due to isospin symmetry the up and down quark spin transfer to the Λ are expected to be equal. Thus Eq. (3) can be approximated by:

$$D_{LL'}^{\Lambda} \simeq \frac{G_{\rm u}^{\Lambda}(z,Q^2)}{D_{\rm u}^{\Lambda}(z,Q^2)}. \quad (4)$$

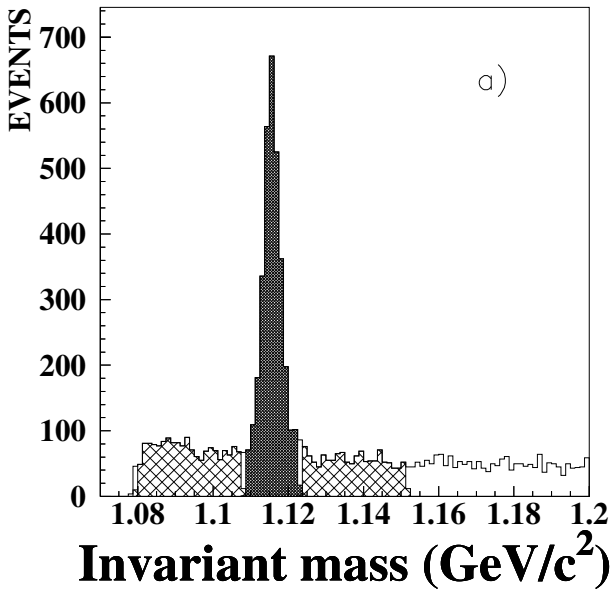
Consequently, Λ electroproduction in the current fragmentation region is most sensitive to the ratio $G_{\rm u}^{\Lambda}/D_{\rm u}^{\Lambda}$ $\sim G_{\rm d}^{\Lambda}/D_{\rm d}^{\Lambda}$. Since the Q^2 range of the measurement reported here is small, it is assumed that $D_{LL'}^{\Lambda}$ depends on only the energy fraction z.

The measurement was carried out by the HERMES experiment at DESY using the 27.5 GeV polarized positron beam of the HERA storage ring. At HERA, the positrons become transversely polarized by the emission of synchrotron radiation [16]. Longitudinal polarization of the positron beam at the interaction point is achieved with spin rotators [17] situated upstream and downstream of the HERMES experiment. Equilibrium polarization values in the range of 0.40 to 0.65 are reached with a rise time of about 30 minutes. The beam polarization is continuously measured using Compton back-scattering of circularly polarized laser light. The statistical accuracy of this measurement is typically 1% in 60 seconds; its systematic uncertainty is 3.4%, dominated by the normalization uncertainty determined from the rise-time calibration [18]. The beam helicity was reversed between the two years of data aquisition. The data for this analysis are combined from two three-week running periods, one in each of 1996 and 1997, which were dedicated to measurements with unpolarized targets of hydrogen, deuterium, ^{3}He and nitrogen with a typical target density of around $1 \cdot 10^{15}$ nucleons/cm^2.

A detailed description of the HERMES spectrometer is provided in ref. [19]. The trajectories of the particles are determined in the region in front of the spectrometer magnet by a set of two drift chambers, and the momenta are determined by matching these to tracks in two sets of drift chambers in the back region behind the magnet. In addition there are three proportional chambers inside the magnet to track low momentum particles that do not reach the rear section of the spectrometer. Particle identification is accomplished using a lead glass calorimeter, a scintillator hodoscope preceded by two radiation lengths of lead, a transition radiation detector, and a C_4F_{10}/N_2 (30:70) gas threshold Cerenkov counter. Combining the responses of these detectors in a likelihood method leads to an average positron identification efficiency of 99%, with a hadron contamination of less than 1%. In addition, the Cerenkov counter is used to distinguish pions from heavier hadrons for momenta between 4.5 and 13.5 GeV.

Semi-inclusive Λ events were selected by the requirement of at least three reconstructed tracks: a positron track in coincidence with two hadron candidate tracks of opposite charge. Both the track of the scattered positron and that of the positive hadron candidate are always reconstructed using all drift chambers and all particle identification detectors. The negative hadron candidate is allowed to have only partial track information. These partial tracks are reconstructed by the drift chambers in the front region and by the wire chambers located in the magnet region. In this way it is possible to get momentum and charge information from these tracks, though no information from the particle identification and drift chambers in the back portion of the detector exists. As almost all negative particles are pions, particle identification is not essential for these tracks. In this analysis, the track resolution at HERMES is dominated by the resolution of the drift chambers in front of the magnet. Thus the resolution of the partial tracks does not differ significantly from that of the full tracks. An invariant mass is reconstructed assuming that the positive hadron is a proton and the negative hadron is a pion. If more than one positive or negative hadron exists in one event, all possible pairings of positive and negative hadrons are used.

Several requirements were imposed to ensure that the events are in the deep-inelastic scattering region and to reduce the background in the semi-inclusive Λ sample : $Q^2 > 1$ GeV^2, $W > 2$ GeV, and $y < 0.85$, the latter to avoid a region where radiative corrections might be significant. Here W is defined as the invariant mass of the photon-nucleon system. The calorimeter energy deposited by the scattered positron was required to be greater than 4 GeV, well above the trigger threshold of 3.5 GeV. To ensure that the event occurred in the target gas, the longitudinal vertex position of the positron track was constrained to be within the total length of the target cell ($\pm$20 cm from the center of the target). The positron interaction vertex and the Λ decay vertex were required to be separated by more than 10 cm to eliminate background events originating from the primary vertex. Additionally, the distance of closest approach between the two hadron tracks was required to be less than 1.5 cm. The collinearity, defined as the cosine of the angle between the Λ momentum (computed from the proton and pion momenta) and the Λ direction of motion (computed from the vector displacement between the positron vertex and the Λ decay vertex), was required to be above 0.998. To reduce the large pion contribution to the positive hadron sample, the positive hadron was required to have no Cerenkov signal. Finally, to ensure that the Λ hyperons are primarily from the current fragmentation region, a positive value of $x_F \approx 2p_L/W$ was required. Here p_L is the momentum component of the Λ that is longitudinal with respect to the virtual photon in the photon-nucleon center-of-mass frame. After all these criteria have been implemented, a clean Λ signal is observed in the invariant mass distribution (see Fig. 1a). Lambda events have been selected by a cut on the invariant mass distribution: 1.109 GeV $< M_{\rm p\pi} <$ 1.123 GeV, resulting in a total number of 2237 Λ events (after background subtraction).



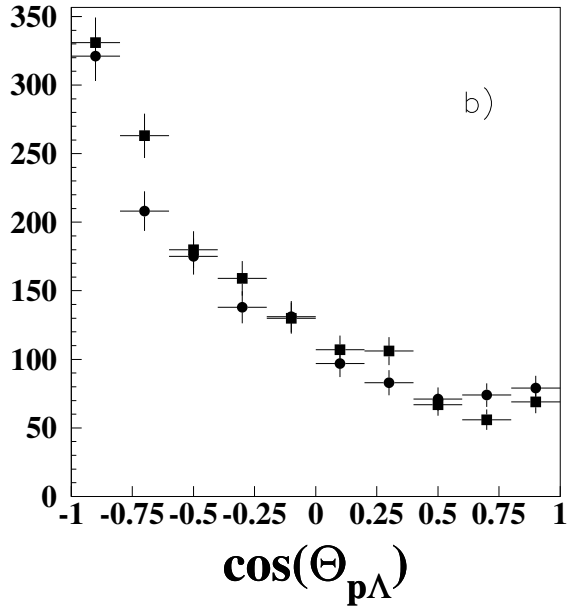


FIG. 1. (a) Invariant mass spectrum from the reconstruction of candidate Λ events. The filled and hatched areas respectively indicate the signal and background regions used in the analysis. (b) Spectrum of $\cos\Theta_{p\Lambda}$ for the two beam helicities (circles and squares). The asymmetric appearance of these spectra is almost entirely due to the acceptance of the HERMES spectrometer for reconstructing Λ decays.

As the HERMES detector is a forward detector, its acceptance for the reconstruction of Λ hyperons is limited and strongly depends on $\cos\Theta_{p\Lambda}$ (see Fig. 1b). Here $\Theta_{p\Lambda}$ is the angle between the proton momentum and the Λ spin quantization axis in the rest frame of the Λ. This spin quantization axis has been taken parallel to the direction of motion of the Λ hyperon, calculated in the laboratory frame. To minimize acceptance effects, the spin transfer to the Λ has been determined combining the two data sets measured with opposite beam helicities in such a way that the luminosity–weighted average beam polarization for the selected data sample is zero. Using this data sample and assuming that the detector acceptance did not change between the two beam helicity states, the spin transfer to the Λ is determined from the forward-backward asymmetry in the angular distributions in Λ electroproduction [20,21]:

$$D_{LL'}^{\Lambda} = \frac{1}{\alpha < P_B^2 >} \cdot \frac{\sum_{i=1}^{N_\Lambda} P_{B,i} \cos\Theta_{p\Lambda}^i}{\sum_{i=1}^{N_\Lambda} D(y_i) \cos^2\Theta_{p\Lambda}^i} \qquad (5)$$

where the sum is over the Λ events and $< P_B^2 >$ is the luminosity–weighted average square of the beam polarization. Here the spin quantization axis has been taken parallel to the direction of motion of the Λ hyperon. In addition, the derivation of Eq. (5) requires that there is no correlation among the kinematic variables, *i.e.* between y and $\cos\Theta_{p\Lambda}$. This has been verified for this data set.

After applying all the requirements described above, the spin transfer to the Λ is extracted using Eq. (5). As no nuclear effects were observed within the limited statistics of this measurement, the data collected on the various targets (^{1}H, ^{2}H, ^{3}He and ^{14}N) have been added. To minimize possible acceptance-induced false asymmetries, the data have been corrected by the difference in tracking efficiencies between the two years by normalising the number of Λ events to ther number of all events where two hadrons and a scattered positron were reconstructed. The spin transfer $D_{LL'}^{\Lambda}$ due to background events in the selected invariant mass region has been determined from the events below and above the Λ invariant mass region (indicated by the hatched areas in Fig. 1a). It was found to be consistent with zero and has been taken into account as a dilution. At an average z value of 0.45 the spin transfer to the Λ is found to be $D_{LL'}^{\Lambda} = 0.11 \pm 0.17(\text{stat}) \pm 0.03(\text{sys})$, using the Λ momentum as the spin quantization axis. (If instead the virtual photon momentum is chosen as quantization axis the result changes to $0.03 \pm 0.17(\text{stat}) \pm 0.03(\text{sys})$.) The data cover a z range of $0.2 < z < 0.7$ with x values of $0.02 < x < 0.4$ and Q^2 varying between 1 and 10 GeV^2. The systematic error of the measurement is dominated by the uncertainties in detector efficiency differences between the two data sets. Possible efficiency differences due to the different kinematic distributions of the Λ decay products and of two reconstructed hadrons in any event have been explored and found to be negligible. Additionally, by considering all events with two hadrons, treated as Λ decays, the effect on $D_{LL'}^{\Lambda}$ of changes in the detec-

tor performance between the two years was constrained to be less than 0.05. Finally, the known changes in the detector operation have been estimated by a Monte Carlo simulation and were found to have negligible influence.

Eq. (3) is based on the assumption that the Λ hyperons originate from the current fragmentation region. Contributions from the target fragmentation region are suppressed by the requirement of $x_F > 0$ and have been estimated by a Monte Carlo simulation to be smaller than 1%. A more significant complication arises from the fact that Λ hyperons may originate from decays of heavier hyperons, in particular from the decay $\Sigma^0 \to \Lambda + \gamma$. At HERMES, Λ particles from this decay can not be distinguished from those produced directly in the fragmentation process. The contribution of Σ^0 decays to the observed Λ sample has been estimated by a Monte Carlo simulation and was found to be about 20%. The LUND fragmentation parameters used in this simulation have been adjusted to fit the HERMES semi-inclusive hadron multiplicities, especially the K^0 multiplicity. However, a significant uncertainty remains, as the simulation underestimates the Λ yield by about a factor of two. The effect of the Σ^0 decay on the Λ polarization additionally depends on the model for the Σ^0 spin. Using the naive quark parton model, the effect of the Σ^0 on the Λ spin transfer is expected to be about -0.04 [21]. Such a small but model-dependent correction should be taken into account when comparing to models of the Λ spin structure.

The same three models for the Λ spin structure that were mentioned earlier in comparison to the LEP data have been used to predict the z dependence of the spin transfer in Λ electroproduction. Fig. 2 shows a comparison of the present measurement with these predictions, which effectively account for the contributions of heavier hyperons. Following ref. [14] the data are not given at $z = E_\Lambda/\nu$ but at $z' \equiv E_\Lambda/(E_N(1-x))$, a variable which accounts for the small contamination by target fragmentation. Here E_N is the energy of the nucleon in the photon-nucleon center of mass system. In contrast to the LEP data, the HERMES measurement is dominated by scattering on up quarks and thus can impose different constraints on the various models of the Λ spin structure. Assuming helicity conservation in the fragmentation process as supported by the LEP data, the HERMES measurement of the spin transfer to the Λ favors the naive QPM of the Λ spin structure. However, the present statistical precision is not yet sufficient to exclude the other models, in particular a significant up quark polarization in the Λ hyperon.

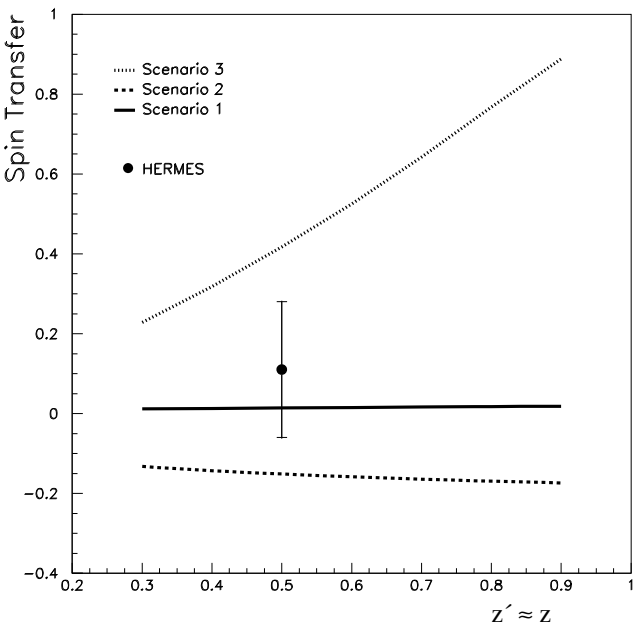


FIG. 2. Spin transfer $D^\Lambda_{LL'}$ as a function of $z' = \frac{E_\Lambda}{E_N(1-x)}$. The curves correspond to various models for the Λ spin structure: the naive QPM (scenario 1), the SU(3) flavor-symmetric model (scenario 2) and a model with equal contributions of all light quark flavors to the Λ polarization (scenario 3) and are explained in the text.

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[1] E142 Collaboration, P.L. Anthony *et al.*, Phys. Rev. D54 (1996) 6620.

[2] E143 Collaboration, K. Abe *et al.*, Phys. Rev. Lett. 74 (1995) 346; Phys. Lett. B364 (1995) 61; Phys. Rev. D58 (1998) 112003.
[3] SMC Collaboration, D. Adams *et al.*, Phys. Lett. B329 (1994) 399; Phys. Rev. D56 (1997) 5330; B. Adewa *et al.*, Phys. Lett. B412 (1997) 414; Phys. Rev. D58 (1998) 112001.
[4] E154 Collaboration, K. Abe *et al.*, Phys. Rev. Lett. 79 (1997) 26.
[5] HERMES Collaboration, K. Ackerstaff *et al.*, Phys. Lett. B404 (1997) 383.
[6] HERMES Collaboration, A. Airapetian *et al.*, Phys. Lett. B442 (1998) 484.
[7] EMC Collaboration, J. Ashman *et al.*, Nucl. Phys. B328 (1989) 1.
[8] SMC Collaboration, D. Adams *et al.*, Phys. Lett. B420 (1998) 180.
[9] HERMES Collaboration, K. Ackerstaff *et al.*, Phys. Lett. B464 (1999) 123.
[10] M. Burkardt and R. L. Jaffe, Phys. Rev. Lett. 70 (1993) 2537.
[11] R. L. Jaffe, Phys. Rev. D54 (1996) R6581; and references therein.
[12] ALEPH Collaboration, D. Buskulic *et al.*, Phys. Lett. B374 (1996) 319.
[13] OPAL Collaboration, K. Ackerstaff *et al.*, Eur. Phys. J. C2 (1998) 49.
[14] D. de Florian, M. Stratman and W. Vogelsang, Phys. Rev. D57 (1997) R5811.
[15] P. J. Mulders and R. D. Tangerman, Nuclear Physics B461 (1996) 197; and references therein.
[16] A.A. Sokolov and I.M. Ternov, Sov. Phys. Doklady 8 (1964) 1203.
[17] D. P. Barber *et al.*, Phys. Lett. B343 (1995) 436.
[18] D.P. Barber *et al.*, Nucl. Inst. and Meth. A (1993) 79.
[19] HERMES Collaboration, K. Ackerstaff *et al.*, Nucl. Inst. and Meth. A417 (1998) 230.
[20] S. Belostotski, HERMES internal report 98-091.
[21] G. Schnell, Ph.D. Thesis, New Mexico State University, May 1999 (unpublished).