Measurement of the longitudinal spin transfer to Λ and anti-Λ hyperons

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Abstract

The polarisations of Λ and $\bar{\Lambda}$ hyperons produced in deep inelastic scattering of 160 *GeV* polarised muons off unpolarised deuterons were studied at the COMPASS experiment at CERN. The longitudinal spin transfer was measured for both hyperons, as a function of the Bjorken x and the Feynman x_F variables. The spin transfer to the Λ is small and compatible with zero for both x and x_F. In contrast, the spin transfer to $\bar{\Lambda}$ is positive for both variables, and shows a steep increase for large x_F. Comparison with theoretical predictions indicates that the polarisation of the $\bar{\Lambda}$ hyperon is sensitive to the strange anti-quark distribution in the target nucleon.

Key words: Polarised DIS, Nucleon spin, Hyperon, Spin transfer, Strange quark distribution
PACS: 13.60.Rj, 13.87.Fh, 13.88.+e, 24.85.+p

1. Introduction

Measurements of the polarisation of Λ and $\bar{\Lambda}$ hyperons provide an alternative way of accessing the strange quark content in the nucleon and add information on our understanding of the nucleon spin structure[1]. In the most naive quark model, the u and d valence quarks in the Λ couple to a 0-spin state. The spin properties of the hyperon are then determined by the strange quark only. Since no hyperon targets exist, the Λ must be produced, in e.g. Deep-Inelastic Scattering (DIS), and its polarisation measured through the self-analysing decay $\Lambda \to p\pi^-$ (and $\bar{\Lambda} \to \bar{p}\pi^+$). The Λ polarisation depends not only on the spin of the scattered quark but also on the polarisation of the target remnant [2]. In contrast, the polarisation of the $\bar{\Lambda}$ hyperon is dominated by the spin transferred to it by the $\bar{s}$ quarks. Comparison of the spin transfers to both Λ and $\bar{\Lambda}$ should then give

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Preprint submitted to Elsevier *15 January 2009*

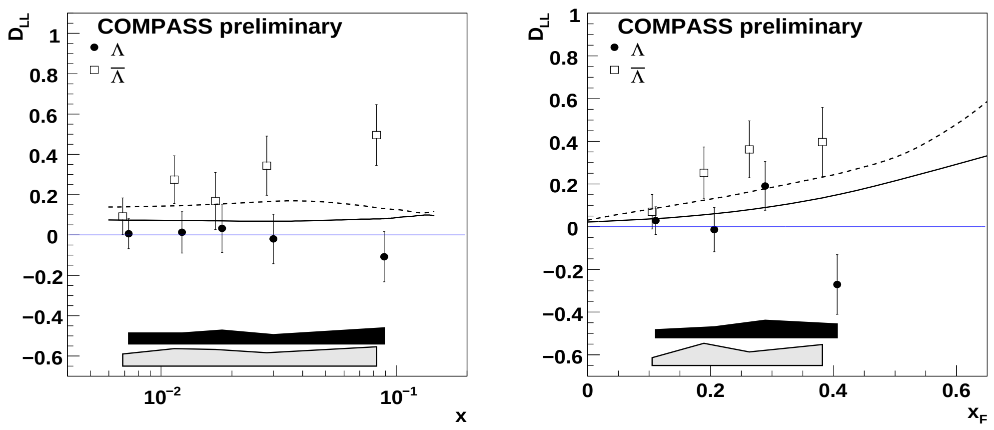

Fig. 1. Longitudinal spin transfer to Λ and $\bar{\Lambda}$, as a function of x (left) and x_F (right). The shaded bands show the size of the corresponding systematic errors. The solid and dashed lines represent the calculation of Ref.[10], for Λ and $\bar{\Lambda}$ spin transfers respectively. The calculation uses the SU(6) model for the hyperon and the CTEQ5L parton distribution functions.

additional insight on the hyperon production mechanism and on the $\bar{s}(x)$ distribution in the nucleon.

In the present paper preliminary measurements of the spin transfer to both Λ and $\bar{\Lambda}$ hyperons are presented. These measurements improve the statistical accuracy previously achieved by nearly an order of magnitude.

2. Data analysis

The data presented below were collected during the years 2003 and 2004 at the COMPASS experimental set-up[3] at CERN. The longitudinally polarised muon beam was scattered off two, 60 cm long, oppositely polarised target cells, filled with a ^{6}LiD material. The data from the two target orientations were averaged in the present analysis. DIS events were selected using momentum transfer ($Q^2 > 1(Gev/c)^2$) and virtual photon fractional energy cuts. The Λ hyperons were identified after suppressing background events with secondary vertex location and co-linearity between the primary and secondary vertex cuts. A transverse momentum cut rejects the numerous e^+e^- pairs. The current fragmentation region was selected by requiring that $x_F > 0.05$. Nearly 70000 Λ and 42000 $\bar{\Lambda}$ events remain for the final analysis after all selection cuts have been applied.

The polarisation of the $\Lambda(\bar{\Lambda})$ is determined via the angular distribution of the decay protons(anti-protons), in the hyperon rest frame. An acceptance correction, calculated using a Monte-Carlo simulation, was also applied. Note that this correction is quite smooth and changes by 20-30 % only, in the angular range of the data. The Λ and $\bar{\Lambda}$ polarisations P_L are then obtained from a linear fit to the corresponding angular distributions. Fig.1 shows the resulting spin transfer $D_{LL} = P_L/(D(y)P_\mu)$, where $D(y)$ is the virtual photon polarisation and P_μ the polarisation of the muon beam. The spin transfer to Λ is small and compatible with zero. However, the spin transfer to $\bar{\Lambda}$ is

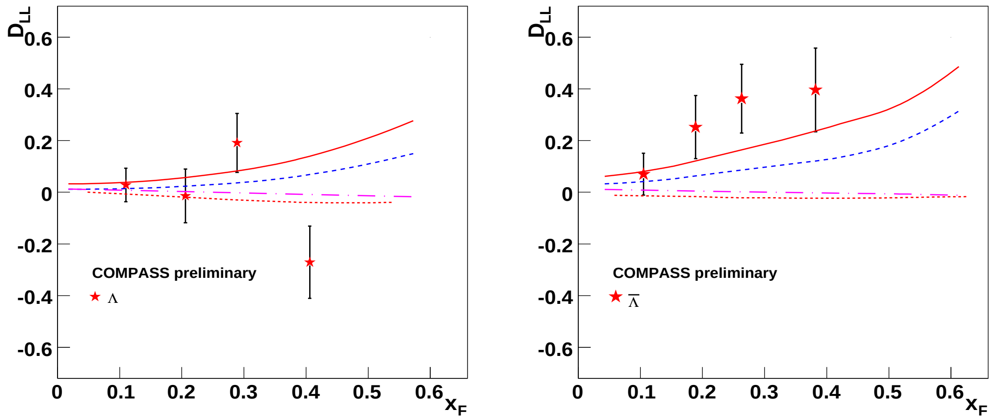

Fig. 2. Longitudinal spin transfer to Λ (left) and $\bar{\Lambda}$ (right). The data are compared to the calculation of Ref.[10] with GRV98LO(dashed) or the CTEQ5L(solid) pdfs, assuming a SU(6) model for the hyperons. The prediction with CTEQ5L, but without the contribution from the $s(\bar{s})$ quark, is displayed for the SU(6)(dash-dotted) and BJ hyperon models[1](dotted).

strictly positive and increases with x_F. The COMPASS data are in good agreement with all previous DIS experiments[4–9].

3. Discussion

The D_{LL} data are compared to the calculation of Ref.[10] in Fig.2. This calculation, performed for the COMPASS kinematic conditions, considers two different sets of parton distributions functions (pdf), CTEQ5L[11] and GRV98LO[12]. The data for the Λ can not discriminate between the two predictions. In contrast, the prediction using CTEQ5L for the $\bar{\Lambda}$ hyperon is nearly two times larger than the one made with GRV98LO. This behaviour reflects the difference in magnitude between the corresponding $\bar{s}(x)$ distributions in the nucleon. The strong sensitivity to the $\bar{s}(x)$ distribution is further illustrated if the contribution of the $s(\bar{s})$ quarks is switched off: the spin transfer to the hyperon then essentially vanishes, not only for the SU(6) hyperon model, but also for the BJ model[1].

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