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Gluon polarisation in the nucleon and longitudinal double spin asymmetries from open charm muoproduction

COMPASS Collaboration

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ABSTRACT

The gluon polarisation in the nucleon has been determined by detecting charm production via D^0 meson decay to charged K and π in polarised muon scattering off a longitudinally polarised deuteron target. The data were taken by the COMPASS Collaboration at CERN between 2002 and 2006 and correspond to an integrated luminosity of 2.8 fb^{-1}. The dominant underlying process of charm production is the photon–gluon fusion to a $c\bar{c}$ pair. A leading order QCD approach gives an average gluon polarisation of $\langle \Delta g/g \rangle_x = -0.49 \pm 0.27(\text{stat}) \pm 0.11(\text{syst})$ at a scale $\mu^2 \approx 13$ (GeV/c)^2 and at an average gluon momentum fraction $\langle x \rangle \approx 0.11$. The longitudinal cross-section asymmetry for D^0 production is presented in bins of the transverse momentum and the energy of the D^0 meson.

1. Introduction

Pioneering experiments on the spin structure of the nucleon performed in the seventies at SLAC [1] were followed by the EMC experiment at CERN which obtained a surprisingly small quark contribution to the proton spin [2], in contrast to the naive expectation that the spin of the nucleon is built mainly from valence quark spins [3]. This result triggered extensive studies of the spin structure of the nucleon in polarised lepton nucleon scattering experiments at CERN by the SMC [4] and COMPASS [5], at SLAC [6], at DESY [7] and at JLAB [8] as well as in polarised proton–proton collisions at RHIC [9,10]. As a result, the parton helicity distributions in the nucleon were extracted using perturbative QCD analyses. The contribution of the quark spins to the nucleon spin is now confirmed to be around 30%, smaller than 60%, the value expected from the Ellis–Jaffe sum rule [11]. The reduction from the naive expectation of 100% can be explained by the relativistic nature of quarks (e.g. in the MIT bag model) [12]. However, due to the limited range in the four-momentum transfer squared, Q^2, covered by the experiments, the QCD analyses (e.g. [5]) show limited sensitivity to the gluon helicity distribution as a function of the gluon momentum fraction x, $\Delta g(x)$, and to its first moment, ΔG. (The perturbative scale, μ^2, in these QCD analyses is set to Q^2.) The determination of $\Delta g(x)$ from QCD evolution has therefore to be complemented by direct measurements in dedicated experiments.

The average gluon polarisation in a limited range of x, $\langle \Delta g/g \rangle_x$, has been determined in a model-dependent way from the photon–gluon fusion (PGF) process by HERMES [13], SMC [14] and COMPASS [15]. These analyses used events containing hadron pairs with high transverse momenta, p_T, (typically 1 to 2 GeV/c) with respect to the virtual photon direction. PYTHIA [16] was used by HERMES and by COMPASS for the analysis of small Q^2 events, while LEPTO [17] was used in SMC and the ongoing COMPASS analysis for $Q^2 > 1$ (GeV/c)^2 events. This method provides good statisti-

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