Measurement of double-spin asymmetries associated with deeply virtual Compton scattering on a transversely polarized hydrogen target

(The HERMES Collaboration)

The HERMES experiment was located at the DESY research center in Hamburg, Germany. It measured interactions of the 27.6 GeV electron or positron beam from the HERA storage ring with various gaseous targets. The experiment aims to increase understanding of the internal structure of nucleons (protons or neutrons), in particular the spin structure of the proton.

Generalized Parton Distributions (GPDs) provide a framework for describing the multidimensional structure of the nucleon. They encompass information on the correlated transverse spatial and longitudinal momentum distributions of partons in the nucleon. Furthermore, access to the parton total angular momentum contribution to the nucleon spin may be provided by GPDs through the so-called Ji relation.

Hard exclusive leptoproduction of a meson or photon, leaving only an intact nucleon in the final state, can be described in terms of GPDs. GPDs depend on four kinematic variables: the Mandelstam variable t, the variables x and ξ which are related to the longitudinal momentum of the struck parton as a fraction of the target momentum, and the evolution scale parameter Q^2, which is the virtuality of the exchanged photon given by the squared difference between the four-momenta of the incident and scattered leptons. The skewness ξ can be related to the Bjorken scaling variable $x_{\mathrm{B}} \equiv Q^2/(2p \cdot q)$ (p is the initial momentum of the target nucleon and q is the difference between the momentum of the incident and scattered leptons), through $\xi \simeq x_{\mathrm{B}}/(2 - x_{\mathrm{B}})$ in the generalized Bjorken limit.

GPDs can be constrained through measurements of cross sections asymmetries in exclusive processes. This paper reports the first measurement of azimuthal asymmetries (in two angles ϕ and ϕ_S, shown in Fig. 1) with respect to target polarization combined with beam helicity and beam charge,

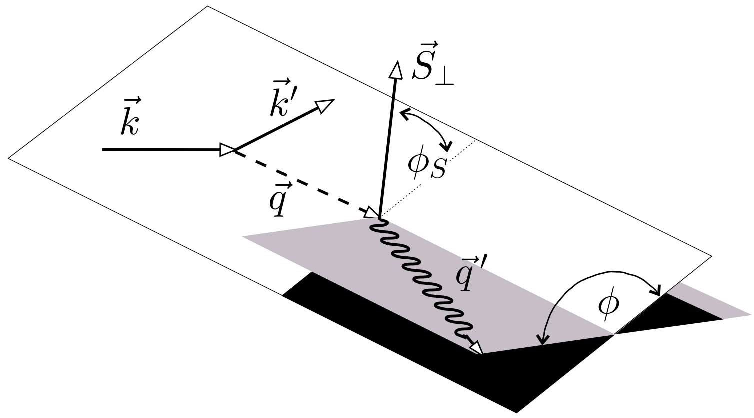

Fig. 1. Momenta and azimuthal angles for exclusive real-photon electroproduction in the target rest frame. The quantity ϕ denotes the angle between the lepton scattering plane containing the three-momenta $\vec{k}$ and $\vec{k}'$ of the incoming and outgoing lepton and the photon production plane correspondingly defined by the vector $\vec{q} = \vec{k} - \vec{k}'$ and the momentum $\vec{q}'$ of the real photon. The symbol ϕ_S denotes the angle between the lepton scattering plane and $\vec{S}_\perp$, the component of the target polarization vector that is orthogonal to $\vec{q}$.

and with respect to target polarization combined with beam helicity alone, for exclusive electroproduction of real photons from a transversely polarized hydrogen target. This measurement adds up to already earlier published HERMES data on the more prominant asymmetries, as e.g. beam-charge, beam-helicity or target-spin asymmetries on the proton. The asymmetries arise from the Deeply Virtual Compton Scattering (DVCS) process, i.e., the hard exclusive leptoproduction of a real photon, where the photon is radiated by the struck quark, and its interference with the Bethe–Heitler (BH) process, where the photon is radiated by the initial- or final-state lepton. The double-spin asymmetries reported here are related to the real part of the same combination of GPDs as that determining the transverse target single-spin asymmetries through the imaginary part. The most interesting harmonics are those which are sensitive to the GPD E. Therefore, together with the GPD H, derived from the measurements of other DVCS observables at HERMES and other experiments, the measurement of the target-spin asymmetry can provide information about the total angular momentum J_u of u-quarks inside the proton.

The results for the leading Fourier amplitudes of the *beam-charge-difference* double-spin asymmetries is presented in Fig. 2.

The results for various harmonics of the charge-difference and charge-averaged double-spin asymmetries were found to be compatible with zero within the total experimental uncertainties. Nevertheless, they may serve as additional constraints in global fits to extract GPDs from measurements. The measured asymmetry amplitudes are not incompatible with the predictions of an available GPD-based calculation.

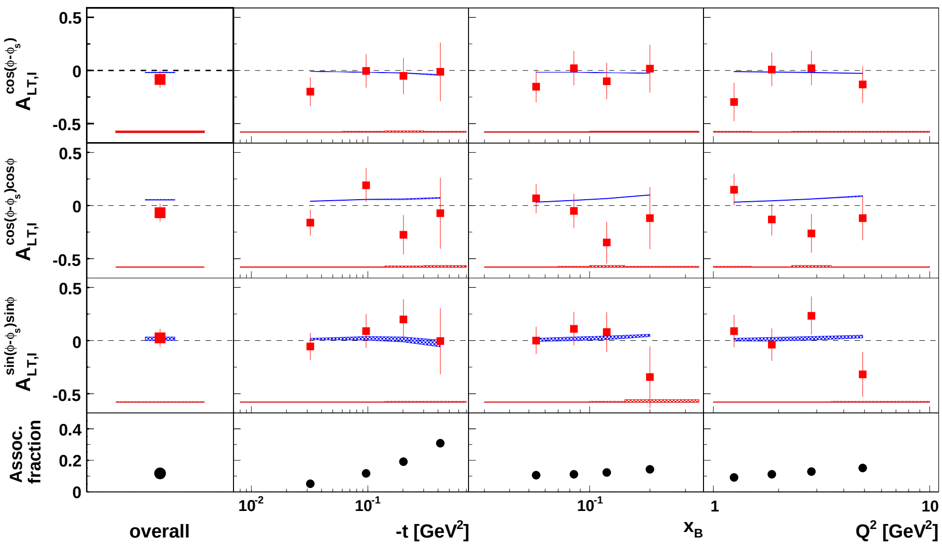

Fig. 2. Charge-difference double-spin asymmetry amplitudes describing the dependence of the interference term on transverse target polarization in combination with beam helicity and beam charge extracted from hydrogen target data. The error bars (bands at the bottom of the panels) represent the statistical (systematic) uncertainties. There is an additional overall 8.6% scale uncertainty arising from the uncertainties in the measurements of the beam and target polarizations. The curves show the results of theoretical calculations using the VGG double-distribution model with a Regge ansatz for modeling the t dependence of GPDs. The width of the curves represent the effect of varying the total angular momentum J_u of u-quarks between 0.2 and 0.6, with $J_d = 0$. The bottom row shows the fractional contribution of associated BH production as obtained from a MC simulation.