Separation of contributions from deeply virtual Compton scattering and its interference with the Bethe-Heitler process in measurements on a hydrogen target

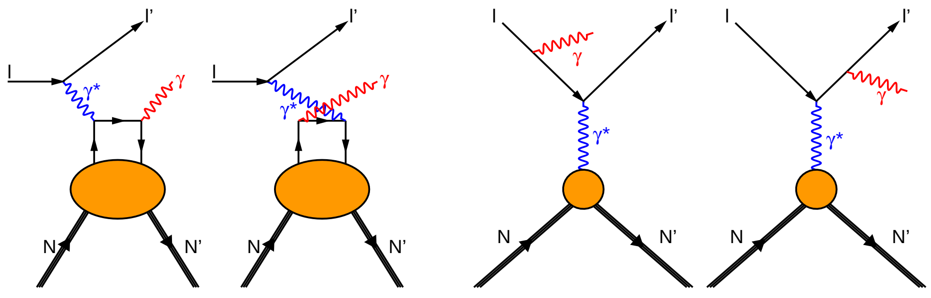
(The Hermes collaboration)

The Hermes experiment was located at the Hera storage ring at the research center Desy in Hamburg, Germany. It used a 27.5 GeV lepton beam that scattered off various gaseous targets. The result presented here is obtained with data taken on an unpolarized hydrogen target. The aim of the experiment is to learn about the inner structure of the nucleons (protons and neutrons) inside the target, with a special focus on the spin structure of the nucleon.

The momentum of the point-like leptons needs to be large in order to probe deep inside the nucleons. Typical resolutions achieved at Hermes were on the order of 1 fm, which is known to be approximately the size of a nucleon. The spin structure of the nucleons can be studied by polarizing, i.e., aligning the spin of, either the incident beam or the target particle. In the present case longitudinally polarized electron and positron beams were used.

A variety of scattering processes can be examined at Hermes. A rather simple process is known to be the Deeply Virtual Compton Scattering (DVCS) process, depicted in figure 1(a), in which the nucleon remains intact after the scattering process. The incoming lepton interacts via a virtual photon with a quark inside the nucleon, which radiates a real photon. A competing process is the Bethe-Heitler (BH) process (see figure 1(b)), in which the real photon in the final state is emitted by the incoming or outgoing lepton. The two processes are experimentally indistinguishable and therefore interfere, leading to an additional interference term in the process amplitude.

At Hermes energies the contribution from BH dominates the ones from



(a) (b)

Figure 1: The left two diagrams show the leading contributions to the DVCS process and the right two diagrams those to the BH process. In the figure l (N) and l′ (N′) label a lepton (nucleon) in the initial and final state, respectively. The virtual and real photons are denoted with $\gamma^\star$ and γ, respectively.

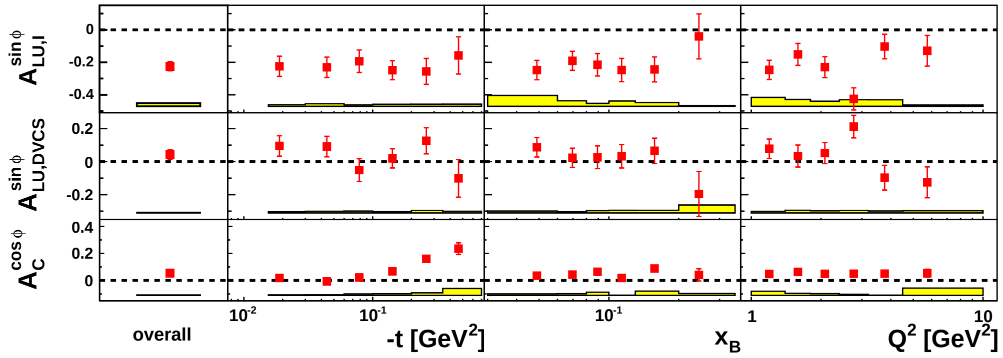


Figure 2: The three rows show different asymmetry amplitudes. In the first column the integrated values are displayed, followed by the dependences on the three kinematic variables $-t$, x_{B} and Q^2. The error bars (bands) display the statistical (systematic) uncertainties.

DVCS and interference, which are those of interest. In order to gain access to these small contributions, asymmetries can be extracted from data, which are ratios of count rates. The difference of the number of events with, e.g., different helicity or charge state, enters in the numerator and its sum in the denominator. In this way effects from the geometric and kinematic acceptance cancel to a certain degree.

Due to the fact that Hermes took data with electron and positron beams with both helicity states for each beam, three different asymmetries could be accessed. Two of them are sensitive to the interference term and one to the squared DVCS amplitude. The results are fitted with a function depending on the azimuthal angle ϕ between the lepton scattering and the photon production plane.

The leading asymmetry amplitudes, which are unsuppressed in Hermes kinematics, are displayed in the three rows of figure 2. The two asymmetry amplitudes sensitive to the interference term are displayed in the first and third row. Both show a significant non–zero value. In contrast, the amplitude shown in the second row, sensitive to the squared DVCS amplitude, is found to be compatible with zero. The results are shown in an integrated form in the left column, and as a function of the kinematic variables $-t$, x_{B} and Q^2. While t is the negative squared momentum transfer to the nucleon, x_{B} and Q^2 only depend on the kinematics of the incoming and scattered lepton. The binning in different variables allows for a better comparison to model calculations. Within these models the present result can be combined with measurements of other asymmetry amplitudes or various other observables to access the total angular momentum of quarks inside the target nucleon, to better understand the spin structure of the nucleon.