Measurement of azimuthal asymmetries associated with deeply virtual Compton scattering on an unpolarized deuterium target

The HERMES Collaboration

The HERMES experiment was located at the DESY research centre in Hamburg, Germany. It measured interactions of the 27.5 GeV electron or positron beam of the HERA storage ring with various gaseous targets. The experiment aimed to increase understanding of the internal structure of nucleons (protons or neutrons) inside the target, in particular the spin structure of the nucleon.

Measurements of scattering off deuterium targets can provide information on both nucleons and the deuteron. If the target nucleus is broken up during the process it is known as incoherent, accessing proton and neutron structure information. If the nucleus remains in its ground state it is known as coherent scattering, providing information on the deuteron. Thus comparing results from hydrogen and deuterium may lead to further insights into nucleon structure.

In order to study the spin structure of nucleons either the incident beams and/or the target gasses must be polarized, i.e. their spins must be aligned. The HERA storage ring provided longitudinally polarized electron or positron beams. In this case the deuterium target is unpolarized.

HERMES has measured a variety of scattering processes. In this paper those of interest are the Deeply Virtual Compton Scattering (DVCS) and Bethe-Heitler (BH) processes. In the former process the incoming lepton interacts via a virtual photon with a quark inside the nucleon, which radiates a real photon. By contrast, in the competing BH process the real photon is radiated by the incoming or outgoing lepton. The final states of these processes are experimentally indistinguishable, hence the processes interfere, providing an additional interference term in the process amplitude.

In the HERMES experiment kinematic regime the BH process contribution dominates those of the DVCS and interference terms, which are the contributions of interest. By extracting asymmetries, ratios of count rates, from the data these small contributions can be accessed. The difference in the number events with, e.g., different charge or helicity states enters in the numerator of the asymmetry,

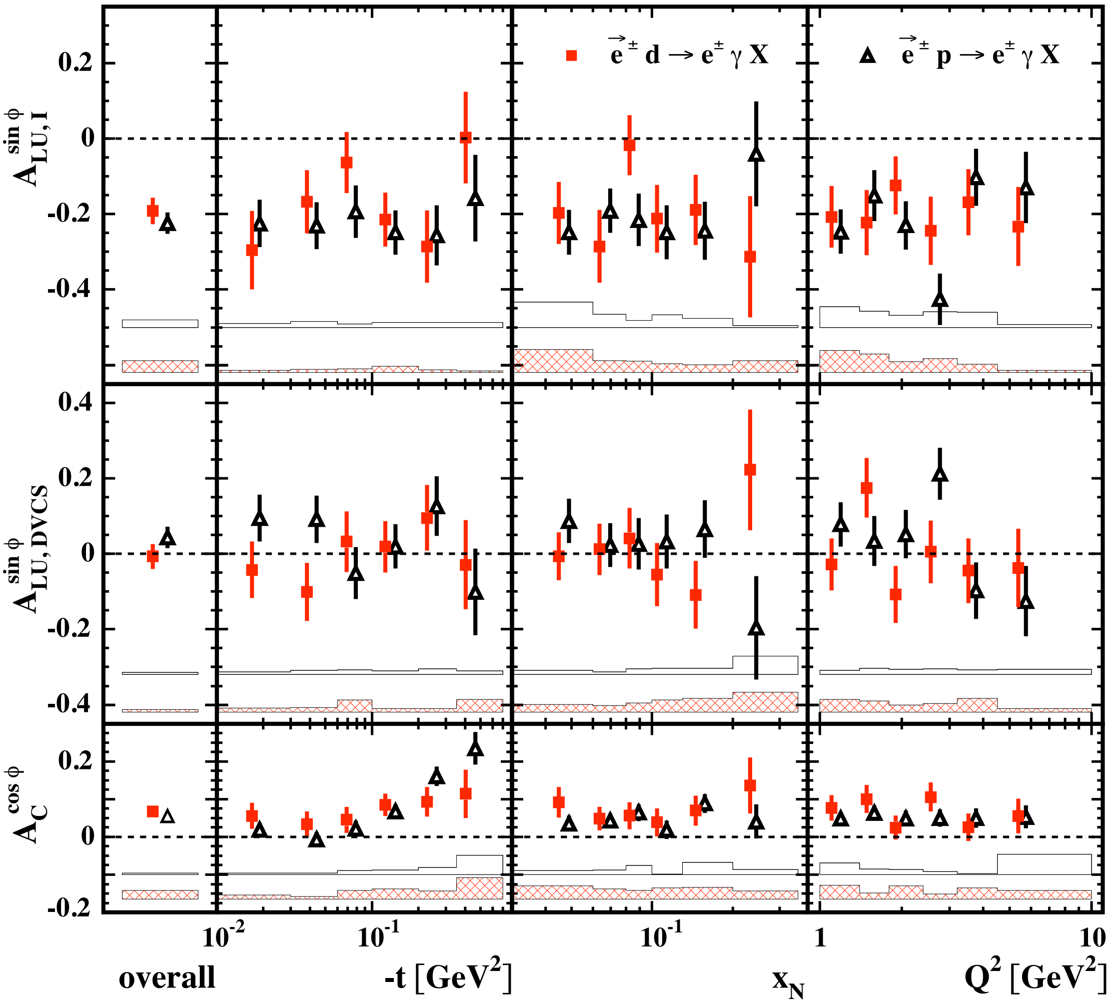

Figure 1: Comparison of different asymmetry amplitudes from hydrogen (black triangles) and deuterium targets (red squares). The first column shows the results integrated over all kinematics, with the remaining columns showing their dependences on the kinematic variables $-t, x_N$ and Q^2. The error bands (bars) depict the statistical (systematic) uncertainties.

with the sum entering in the denominator. This cancels effects from the geometric and kinematic acceptance of the experiment to a certain degree.

Data was taken with both electron and positron beams, each with both helicity states. This gave access to three different asymmetries, of which two are sensitive to the interference term and the other to the squared DVCS amplitude. To extract these asymmetries the experimental results were fitted with a function depending on the azimuthal angle ϕ between the lepton scattering and photon production plane.

Figure 1 shows a comparison of the leading asymmetry amplitudes from hydrogen and deuterium target data. These amplitudes are unsuppressed at HERMES kinematics, and are shown integrated over all kinematics and with their dependences on the variables $-t, x_N$, or Q^2. The first row shows the leading amplitude of the beam helicity asymmetry, with the third row that of the beam charge asymmetry, both sensitive to the interference term. The second row shows the leading amplitude of the beam helicity asymmetry sensitive to the squared DVCS contribution. These amplitudes are found to consistent for hydrogen and deuterium in most kinematic regions, with a possible exception in the last two $-t$ bins of the leading amplitude of the beam charge asymmetry.

Furthermore, information on scattering on the deuteron can be extracted from the measured asymmetry amplitudes at small values of $-t$. These results can be used to indicate favourable model parameters and therefore increase understanding of nucleon and deuteron structure.