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The study of the Roper resonance in double-polarized pion electroproduction

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Investigations of the structure of the Roper resonance by using coincident electron scattering have been presented at several previous Mini-Workshops, and the most recent result on double-polarized pion electroproduction in the energy region of the Roper has recently been published [1]. This extended abstract is therefore just a reminder of the basic features of this experiment and just lists the highlights of that paper.

Our experimental study of the $p(\boldsymbol{e},e'\mathbf{p})\pi^0$ process was performed at the three spectrometer facility of the A1 Collaboration at the Mainz Microtron (MAMI). The kinematic ranges covered by our experiment were $W \approx (1440 \pm 40)$ MeV for the invariant mass, $\theta_p^* \approx (90 \pm 15)^\circ$ and $\phi_p^* \approx (0 \pm 30)^\circ$ for the CM scattering angles and $Q^2 \approx (0.1 \pm 0.02)(\mathrm{GeV}/c)^2$ for the square of the four-momentum transfer.

We have extracted the two helicity-dependent recoil polarization components, P_x' and P_z', as well as the helicity-independent component P_y, and compared them to the values calculated by the state-of-the-art models MAID [2], DMT [3] and the partial-wave analysis SAID [4]. With the possible exception of P_y at high W which is reproduced by neither of the models, MAID is in very good agreement with the data, while DMT underestimates all three polarization components and even misses the sign of P_x'. The SAID analysis agrees less well with the P_x' data, while it exhibits an opposite trend in P_y and is completely at odds regarding P_z'. This might be a consequence of very different databases used in the analysis and calls for further investigations within these groups.

We were also able to determine the scalar helicity amplitude $S_{1/2}$ in a model-dependent manner. In contrast to its transverse counterpart, $A_{1/2}$, this amplitude is accessible only by electroproduction ($Q^2 \neq 0$) and becomes increasingly difficult to extract at small Q^2. This is a highly relevant kinematic region where many proposed explanations of the structure of the Roper resonance and mechanisms of its excitation give completely different predictions. This is also a region in which large pion-cloud effects are anticipated. In the most relevant region below $Q^2 \approx 0.5\,(\mathrm{GeV}/c)^2$ where quark-core dominance is expected to give way to

manifestations of the pion cloud — and where existing data cease — the predictions deviate dramatically.

Given that the agreement of our new recoil polarization data with the MAID model is quite satisfactory and that the transverse helicity amplitude $A_{1/2}$ is relatively much better known, we have performed a Monte Carlo simulation across the experimental acceptance to vary the relative strength of $S_{1/2}$ with respect to the best MAID value for $A_{1/2}$ and made a χ^2-like analysis with respect to our experimentally extracted P_x', P_y and P_z', of which P_y was the most convenient for the fit. Fixing $A_{1/2}$ to its MAID value and taking $S_{1/2}^{\mathrm{MAID}}$ as the nominal best model value, we have been able to express $S_{1/2}$ from our fit as the fraction of $S_{1/2}^{\mathrm{MAID}}$, yielding

$$S_{1/2} = \left(0.80^{+0.15}_{-0.20}\right) S_{1/2}^{\mathrm{MAID}} = \left(14.1^{+2.6}_{-3.5}\right) \cdot 10^{-3}\mathrm{Ge}^{-1/2} \,.$$

This result is shown in Fig. 3 of Loather Tiator's contribution to these Proceedings.

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