Resonant contributions to DIS/SIDIS from the CLAS exclusive meson electroproduction data

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The studies of exclusive meson electroproduction off protons with the CLAS detector at Jefferson Lab [1–4] provided the first and only available worldwide results on transition helicity amplitudes from the proton ground state to its excited states, or the so-called $\gamma_v pN^*$ electrocouplings, for many excited nucleon states. $\gamma_v pN^*$ electrocouplings were obtained for all well established N^* states in the mass range up to 1.8 GeV and at photon virtualities Q^2 up to 5.0 GeV^2 from a comprehensive analysis of JLab-CLAS data on differential cross sections, longitudinally polarized beam asymmetries, and longitudinal target and beam-target asymmetries measured with almost complete coverage of the final hadron state phase space provided by the CLAS detector. The measured observables are stored in the CLAS Physics Data Base [5].

Table I summarizes the results on $\gamma_v pN^*$ electrocouplings as of May 2016. Consistent results on $\gamma_v pN^*$ electrocouplings of $N(1440)1/2^+$ and $N(1520)3/2^-$ resonances obtained from independent analyses of two major exclusive meson electroproduction channels $N\pi$ and $\pi^+\pi^- p$ with different non-resonant contributions carried out within the framework of different reaction models offer a strong and almost model independent evidence for reliable extraction of these fundamental quantities [6]. Reliable extraction of $\gamma_v pN^*$ electrocouplings from the CLAS meson electroproduction data is also supported by consistent results on electrocouplings of $\Delta(1620)1/2^-$, $\Delta(1700)3/2^-$, $N(1720)3/2^+$ resonances and $N'(1720)3/2^+$ candidate state [7] obtained in independent analyses of $\pi^+\pi^- p$ electroproduction off protons in different intervals of the invariant masses of the final hadron system W [4, 8], as well as by consistent results on $N(1535)1/2^-$ electrocouplings from independent analyses of $N\pi$ and ηp exclusive electroproduction channels [1].

The CLAS results on $\gamma_v pN^*$ electrocouplings are stored in the web-page [9]. The FORTRAN code was developed capable of evaluating $\gamma_v pN^*$ electrocouplings of all four-star nucleon resonances in the mass range up to 1.8 GeV and $Q^2 < 5.0$ GeV^2 by employing polynomial interpolation/extrapolation of the CLAS results on $\gamma_v pN^*$ electrocouplings [9] over Q^2. The FORTRAN code and the plots which demonstrate the achieved quality of $\gamma_v pN^*$ electrocoupling interpolation/extrapolation are available in the web-page [10]. In the near term future the information on the $\gamma_v pN^*$ electrocouplings will be extended by the new results from the independent analyses of $N\pi$ and $\pi^+\pi^- p$ exclusive electroproduction off protons, providing the $\gamma_v pN^*$ electrocouplings of most excited nucleon states in mass range up to 2.0 GeV and at photon virtualities from 0.3 GeV^2 to 5.0 GeV^2 [12].

Detailed information on Q^2-evolution of $\gamma_v pN^*$ electrocouplings extracted from the experimental data on exclusive meson electroproduction off protons is of interest for several areas in DIS/SIDIS, as well as for the development of new precision radiative correction methods for inclusive, semi-inclusive and exclusive processes.

The experimental results on $\gamma_v pN^*$ electrocouplings, being employed in the AJM approach [11], will allow us for the first time to evaluate the inclusive structure functions in the resonance region accounting for the contributions of all relevant excited nucleon states seen in the exclusive meson electroproduction data. In general, the experimental results on $\gamma_v pN^*$ electrocouplings and, eventually, the fit to the data exclusive electroproduction amplitudes in the resonance excitation region are of particular importance for credible evaluation of the hadronic tensors of all relevant meson electroproduction channels. Reliable knowledge of the exclusive electroproduction hadronic tensors is needed for the development of the next generation precision radiative correction procedures for exclusive, semi-inclusive and inclusive electroproduction processes.

The unitarized Breit Wigner ansatz developed and successfully employed in extraction of the $\gamma_v pN^*$ electrocouplings from the exclusive meson electroproduction data [6] will allow us to evaluate the resonant parts of the amplitudes of all exclusive meson electroproduction channels contributing to the inclusive electroproduction off protons. The resonant amplitudes obtained in this way from exclusive meson electroproduction data are fully consistent with the restrictions imposed by a general unitarity condition. Knowledge of the resonant amplitudes makes it possible to evaluate the resonant contributions to unpolarized cross sections and polarization asymmetries of all exclusive meson electroproduction channels as well as to evaluate the resonant parts of semi-inclusive, inclusive unpolarized/polarized structure functions. The representative example of the evaluated resonance contributions to nine one-fold differential $\pi^+\pi^- p$ electroproduction cross sections is shown in Fig 1.

Reliable evaluation of the N^* contributions to inclusive and semi-inclusive structure functions will allow us to extend the knowledge on the ground nucleon state partonic structure functions towards closer to unity x_B in the resonance region. Full information on the resonant contributions to exclusive electroproduction channels will further facilitate the studies of Bloom-Gilman quark-hadron duality [14] making it possible to replace the model expectation on the resonance contributions by the experimental results on resonance electroexcitation

Exclusive meson electroproduction channels	Nucleon resonances	Q^2-ranges for extracted $\gamma_v p N^*$ electrocouplings, GeV^2
$\pi^0 p$, $\pi^+ n$	$\Delta(1232)3/2^+$,	0.16-6.0
	$N(1440)1/2^+$, $N(1520)3/2^-$, $N(1535)1/2^-$	0.30-4.16
$\pi^+ n$	$N(1675)5/2^-$, $N(1675)5/2^-$	1.6-4.5
	$N(1710)1/2^+$	
ηp	$N(1535)1/2^-$	0.2-2.9
$\pi^+\pi^- p$	$N(1440)1/2^+$, $N(1520)3/2^-$	0.25-1.5
	$\Delta(1620)1/2^-$, $N(1650)1/2^-$, $N(1680)5/2^+$	0.5-1.5
	$\Delta(1700)3/2^-$, $N(1720)3/2^+$, $N'(1720)3/2^+$	0.5-1.5

TABLE I: Summary of the available results on the nucleon resonance electrocouplings from analyses of the CLAS exclusive meson electroproduction data off protons as of May 2016 [1–4, 6, 8].

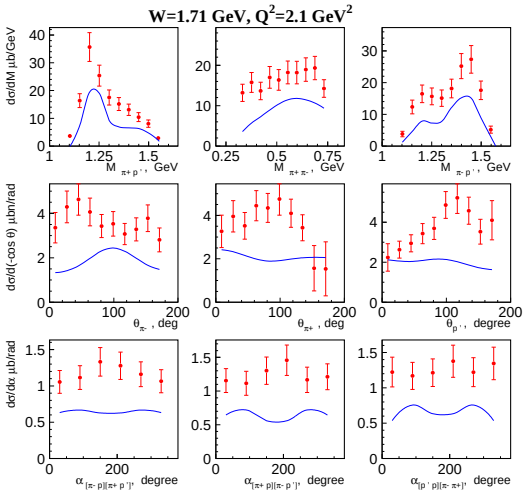

FIG. 1: (Color Online) The resonant contributions (blue solid lines) to the preliminary CLAS data on nine one-fold differential $\pi^+\pi^- p$ electroproduction cross sections at W=1.71 GeV and Q^2=2.1 GeV^2 [13] obtained within the framework of unitarized Breit-Wigner ansatz [6] with resonance electrocouplings and hadronic decay widths determined from the CLAS data.

[1–4] for the first time.

Therefore, the evaluation of the resonant amplitudes from the experimental data on exclusive meson electroproduction in the resonant region represent the import synergistic effort between the DIS/SIDIS and the N^* physics communities.

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