Jefferson Lab Experiment 97-010

Measurement of Hydrogen and Deuterium Inclusive Resonance Cross Sections at Intermediate $Q^2$ for Parton-Hadron Duality Studies

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This experiment will extend measurements of inclusive nucleon resonance electroproduction cross sections from hydrogen and deuterium targets throughout the resonance region ($1 < W^2 < 4 \text{ GeV}^2$) to span the four-momentum transfer range $0.5 < Q^2 < 7.5 \text{ (GeV/c)}^2$. The cross sections will be used in conjunction with existing deep inelastic, resonance, and elastic data for precision experimental tests of parton-hadron (Bloom-Gilman) duality in the nucleon structure functions.

Three decades ago Bloom and Gilman observed the behavior of elastic scattering and of the electroproduction of nucleon resonances to be closely related to the behavior of deep inelastic electron-nucleon scattering. Precisely, the prominent resonances in inclusive electron-proton scattering do not disappear with increasing $Q^2$ relative to the background under them, but instead fall at roughly the same rate. Also, the smooth scaling limit seen at high $Q^2$ and large missing mass squared ($W^2$) for the structure function $F_2 = \nu W_2(\omega')$ is an average of the resonance enhancements at the same $\omega'$, but lower $Q^2$ and $W^2$. Here, $\omega'$ is an “improved” scaling variable which allows the comparison of data at lower values of $W^2$ and $Q^2$ (the resonance region) to data at higher values (the deep inelastic scaling regime). These observations, now termed parton-hadron, or local, duality, suggest a common origin for both phenomena.

The description of hadrons and their excitations in terms of elementary quark and gluon constituents is one of the fundamental challenges in physics today. Quantum ChromoDynamics (QCD) is the theory of strong interactions that describes particles in terms of these elementary quantities. A QCD-based explanation of why the resonance structure functions average to the $F_2$ scaling curve was offered by De Rujula, Georgi, and Politzer in 1977. While original studies were somewhat qualitative, enormous progress has been made in understanding QCD and recent work has focused once again on Bloom-Gilman duality.

Over the years following the initial duality observations and explanations, a large global data set measuring the structure function $F_2$ in deep inelastic scattering has been accumulated. To now revisit parton-hadron duality quantitatively, what remains to be obtained is precision inclusive nucleon resonance electroproduction data: the goal of experiment E97-010.