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Electroproduction of Light Quark Mesons (CEBAF EXPERIMENT 93-012)

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CEBAF experiment 93-012 addresses fundamental questions regarding the nature of two-quark systems (mesons). Mesons consist of a quark and an antiquark bound together by the color field of gluons. The color field is similar to the Coulomb field ($V_1 \propto \frac{1}{r}$) at short distances and increases linearly ($V_2 \propto r$) at large distances. The colored quarks are confined in hadrons because of this infinitely increasing potential. Understanding quark confinement is one of the most fundamental problems facing particle physics today.

To investigate the interaction of quarks at large distances one should measure highly excited states of the $q\bar{q}$ system. Protons and neutrons are surrounded by a field of pions, which binds the protons and neutrons in nuclei. If one uses a proton as a target then virtual pions can also be used as a target. The interaction with the pion cloud can be separated from the interactions with the proton three-quark system if interactions with small momentum transfer to the nucleon are selected. In these separated collisions the electron transfers its energy and momentum not to the nucleon but to the virtual pion and thereby excites the two-quark system. The probability for the excitation from the pion level to the excited meson level is known as the transition form-factor. This quantity will be measured in this experiment.

Two-quark systems are easier to calculate than three-quark systems and therefore the meson transition form-factors, which are very sensitive to the meson structure, allow testing of various quark models. For example, in the framework of the non-relativistic quark model, the form-factors provide constraints for the $q\bar{q}$ wave functions. The high intensity of the CEBAF accelerator allows investigation of the transition form-factors at large Q^2, where the cross section of the reaction drops rapidly. It can be shown that at large Q^2 high excitations start to dominate. This helps to disentangle highly excited mesons and may even lead to the discovery of new mesons which have not yet been found experimentally.

The experiment is based on the CEBAF Large Acceptance Spectrometer (CLAS). The large acceptance allows investigation of the electroproduction of light quark mesons for different decay modes which could even include one neutral particle. The neutral particle can be reconstructed using missing mass technique and can also be measured directly. The experimental information can be obtained during the approved run time for the CLAS detector: 1200 hours with a H_2 target and 800 hour with a D_2 target. The tremendous data set that will be gathered by this experiment will allow us to investigate such properties of meson electroproduction as the $\rho\omega$ mixing effect and the polarization of secondary mesons. Improved understanding of the excitation of the $q\bar{q}$ system will help theorists move beyond the nonrelativistic first-order models of hadrons.