CEBAF EXPERIMENT 89-037

Electroproduction of the P33(1232) Resonance

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This experiment, in conjunction with Experiment 89-042 is aimed at a precise study of the electromagnetic transition between the ground state nucleon and the lowest isospin 3/2 Δ state. The $P_{33}(1232)$ is the lowest mass I =3/2 state, and also the dominant state at low momentum transfers. The radiative transition from the ground state nucleon to the $P_{33}(1232)$ is usually described using the electromagnetic mutipoles M_{1+}, E_{1+}, S_{1+}. Quark models based on SU (6)x0(3) symmetry describe this transition as a spin flip in the $L_{3Q} = 0$ ground state, corresponding to a pure magnetic dipole transition, and thus $R_{EM} = E_{1+}/M_{1+} \equiv 0$ and $R_{SM} = S_{1+}/M_{1+} \equiv 0$. The explanation of a dominant magnetic $\gamma N\Delta$ transition was one of the early successes of the constituent quark model. Non-zero values for R_{EM} and R_{SM} may arise from a tensor force term, such as the one-gluon exchange contribution. In the static limit, this is interpreted as related to a quadrupole deformation of the $P_{33}(1232)$ state. Quark models, which take into account the color magnetic hyperfine interaction, predict the size of R_{EM} and R_{SM} to be small, but finite for low and modestly high Q^2. Precise measurements are needed to determine whether the small color magnetic contribution is indeed present. Measurement of the Q^2 dependence of R_{EM} and R_{SM} will allow to discriminate between the various models used to model the internal structure of light-quark systems such as the nucleon and Δ.

On the other hand, there are model-independent predictions from perturbative QCD that R_{EM} should approach unity at asymptotic values of Q^2. Experimentally, R_{EM} and R_{SM} were found to be small, in qualitative agreement with the theoretical models. Unfortunately, the data are not sufficiently accurate to discriminate against any of the dynamical models. A qualitative improvement in the data quality and completeness of kinematical coverage are needed. The improvement expected from the proposed experiments is very significant and should result in a much improved determination of R_{EM} and R_{SM} in a large Q^2 range.

The experimental program includes differential cross section measurements in different isospin channels such as: ^{2}H $p(e,e'p)H^0, p(e,e'\pi^+)n,$ and $(e,e'\pi^- p)p_s$ where the subscript s denotes the spectator nucleon. Processes where a charged pion, like in $\gamma_v p \rightarrow n\pi^+$ has to be detected, are particularly difficult to measure with two spectrometer setups as were used in previous experiments, because the pion is emitted over the full 4π solid angle. This experiment will be the first measurements with nearly complete angular coverage, and vastly improved over previous experiments for all channels with expected statistical accuracy.