Photoproduction of the ρ Meson from the Proton with Linearly Polarized Photons: Jefferson Lab Experiment 94-109

We will measure the photoproduction of ρ mesons by using a beam of linearly polarized photons in the search for baryon resonances that decay through the ρN mode. The beam of linearly polarized photons will be produced by the Coherent Bremsstrahlung Facility.

Semi-relativistic symmetric SU(6) $\otimes$ O(3) quark models, such as the Koniuk-Isgur model [1], successfully describe the low-mass baryon spectrum, particularly those resonances that decay via the πN channel. Moreover, they predict the existence of a fairly large number of resonances that couple to the $\pi\pi N$ channel. Although some these resonances have been identified, far more are predicted than heretofore have been empirically determined. It is expected that several of these 'missing baryons' will decay via the ρN channel, especially above $\sqrt{s}$ = 1.7 GeV, where the N* (Δ^*) $\rightarrow \pi\pi N$ channel dominates. On the other hand, diquark models, which restrict the internal degrees of freedom by demanding that two quarks be bound in a diquark pair and thereby will lower the level density of baryon resonances, do not predict any additional resonances than have been seen. In this experiment, we will measure the reactions $\vec{\gamma}p \rightarrow \rho^\circ p \rightarrow \pi^+\pi^- p$ and $\vec{\gamma}p \rightarrow \rho^+ n \rightarrow \pi^+\pi^\circ n$. We note that in the case of the $\rho^+ n$ channel that there are three neutral particles in the final state. Measurement of such a channel represents a major undertaking, made possible only through such a facility as the CLAS. Our $\rho^+ n$ photoproduction measurement will be the first such measurement using a beam of linearly polarized photons.

We will identify the ρ° and ρ^+ channels by separating the ρ meson from background events without unduly sacrificing the acceptance of the signal. The quantities to be determined in this experiment are the spin density matrix elements [2] of the ρ meson. These observables, three from unpolarized photoproduction experiments and six additional ones with a linearly polarized photon beam, are extracted in the rest frame of the ρ by measuring the polar and azimuthal angular distributions (i.e., the differential cross section) of the decay π^+ referenced with respect to the orientation of the photon spin. Data to be obtained over the full $\theta_{\rm lab}$ range and over a large incident photon energy range will allow us to extract the spin density matrix elements as functions both of the square of the four-momentum transfer t and of the c.m. energy $\sqrt{s}$. These six polarization related spin density matrix elements will place stringent constraints on the bilinear combinations of the parity-conserving helicity amplitudes. Their behavior as a function of s and t will thereby provide information on the spin-parity state of the underlying baryon resonance.

A major challange is cleanly separating resonance events from those arising from nonresonant mechanisms. For example, in the Vector Dominance Model the incident photon couples directly to a vector meson, which then diffractively scatters from the target proton. In general, these background processes tend to smear out the resonant contributions, especially at low and high t, making it difficult to extract information on a particular scattering amplitude. The problem is particularly acute in the kinematical regime where many broad overlapping resonances are expected to contribute to the total cross section. Our tool of employing the additional degree of freedom afforded by the polarization variable, i.e., the beam of linearly polarized photons, is crucial in disentangling resonant from nonresonant production.

The experiment will probe the lower energy region ($0.9 < \mathrm{E}_\gamma < 1.5$ GeV) with an average 60% photon polarization using a 4 GeV electron beam, and 11 days of beamtime. A second run of 9 days with a 6 GeV electron beam will permit measurements in the energy regime $1.5 < \mathrm{E}_\gamma < 2.15$ GeV with an average 70% photon polarization. We plan to take data within two years after the commissioning of the CLAS. We anticipate obtaining over three million events in the central $\theta_{\rm cm}$ bins, where the resonance differential cross section is most enhanced. (The world's data for the reaction $\vec{\gamma}p \rightarrow \rho N$ currently consists of several thousand events [3].) We will bin the final-state pions finely in c.m. polar angle and energy. The variation of the spin-density matrix elements as a function of s and t will provide information on the spin-parity of the underlying resonances. By the absence or presence of these predicted 'missing' excited baryon states that decay via the ρN channel, we intend to delineate the internal symmetries and dynamics of these assemblies of three nonstrange quarks in considerable detail.

[1] R. Koniuk and N. Isgur, Phys. Rev. D 21, 1868 (1980).

[2] K. Schilling, P. Seyboth, and G. Wolf, Nucl. Phys. B 15, 397 (1970).

[3] J. Ballam *et al.*, Phys. Rev. Lett. 24, 960 (1970),
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