Photoproduction of ϕ Mesons with Linearly Polarized Photons

Understanding the processes involved in the photoproduction of vector mesons is an important part of the CEBAF program, touching physics issues of vector meson dominance (VMD), the strangeness content of the nucleon, and t-channel meson exchange (including π, η, and η') processes [1]. The presently existing data are of poor statistical accuracy and only the VMD or diffractive signature is clearly visible. [2] In the CEBAF experiments, the goals are to go well beyond this single issue and measurements involving polarization will be a key part of the advance. We will measure the photoproduction of ϕ mesons from the proton by using a linearly polarized beam of photons together with the complete $\phi \to K^+K^-$ decay distribution.

Although diffractive scattering is expected to dominate at low 4-momentum transfer squared (t) and high energies, this mechanism alone will be insufficient for a complete description of ϕ meson production near threshold. For c.m. energies near ϕ-photoproduction threshold, π and η meson exchange are expected to contribute significantly to the cross section, as well as processes which violate the Okubo-Zweig-Iizuka (OZI) rule. Whereas diffractive scattering is intrinsically a *natural* parity exchange, pseudo-scalar meson exchange possesses the quantum numbers of the *unnatural* parity process. Knowledge of the direction of polarization of the beam of linearly polarized photons will serve as a parity filter to distinguish between natural and unnatural parity exchange [3].

There is considerable theoretical interest in the strangeness content of the proton and the nature of OZI violating processes [1]. Deep inelastic scattering [4] and the 'sigma term' from π-nucleon scattering [5] have provided evidence that $s\bar{s}$ pairs in the nucleon contribute to observable quantities. Near the ϕ meson production threshold, direct knockout of a pre-existing $s\bar{s}$ pair in the proton [6, 7] and π+η-meson exchange are predicted to have cross sections comparable with the diffractive process [8, 9].

The quantities to be measured in this experiment are the spin density matrix elements of the photoproduced ϕ meson. These observables, three from unpolarized photoproduction experiments and six additional ones with a linearly polarized beam of photons [10], are extracted in the rest frame of the ϕ meson by measuring the polar and azimuthal angular distributions of the decay kaons. Measuring the nine density matrix elements as a function of four-momentum transfer squared near the ϕ meson production threshold will provide the opportunity for disentangling the competing parity exchange mechanisms. Of these nine quantities, all but two will be identically equal to zero if the photoproduction of the ϕ meson is mediated by either pomeron or pseudo-scalar exchange. Of the other seven spin density matrix elements, a significant departure from zero will signal contributions from previously unmeasured production mechanisms.

In this experiment we will study the reaction $\gamma + p \to p + \phi$ $(\phi \to K^+K^-)$ by detecting the proton and the decay K^+ in CLAS and measuring the angular distributions of the K^+ as a function of t. A tightly collimated beam of tagged photons with energies in the range of $1.9 < E_\gamma < 2.2$ GeV and average polarization of 65% (80%) will be produced by coherently scattering a 4 GeV (6 GeV) electron beam directed upon a thin diamond crystal radiator. This photon beam will strike the 14 cm long Saclay liquid hydrogen target. With the measurement of the tagged photon, recoil proton, and the decay K^+ meson with CLAS, the reaction will be kinematically overdetermined; from the reconstruction of the missing 4-momentum of the decay K^-, we will determine the 4-momentum of the ϕ meson, as well as the angular distributions of the K^+ meson as a function of t.

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