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[10]It should be pointed out that, if another narrow resonance were to be discovered in e^+e^- annihilation experiments, it could be accommodated in the present framework by the addition of a T_{11} interaction to Eq. (2). Such a contribution would mix ξ^{*0} with ω, φ, ψ, ψ', and ρ^0. With the quark quantum-number assignments of S. L. Glashow, J. Iliopoulos, and L. Maiani [Phys. Rev. D 2, 1285 (1970)] we have checked that ψ and ψ' can be accommodated by replacing T_{13}' by T_9' in Eq. (2). A third narrow e^+e^- resonance could not be fitted into the 1⊕15 representations in the latter scheme. See D. Boal *et al.*, to be published.

[11]This, of course, depends on the masses of the charmed mesons being large enough so that the decay of ψ into one of them (plus, say, a kaon) is energetically forbidden. The charmed-meson masses in our simple model have this property.

[12]In fact, if one takes the effective Lagrangian for $V' \to V + 2\pi$ to be $gV_\mu' V_\mu \vec{\pi}\cdot\vec{\pi}$ and uses the decay $\rho' \to \rho + 2\pi$ to estimate the size of g, one finds $\Gamma(\psi' \to \psi\pi\pi) \sim 0.02(g^2/4\pi)b^2$ MeV $\gtrsim 20$ keV [b is the strength parameter in Eq. (2)].

[13]This is based on the SU(8) decomposition, $8 \otimes 8^* = 1 \oplus 63$. The 63 contains the 1⊕15 SU(4) representations of vector mesons and a 15 representation of pseudoscalar mesons. (See Ref. 7 for details.)

Polarized-Photon Asymmetries in K^+ Photoproduction at 16 GeV*

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Using a 16-GeV linearly polarized photon beam, we have measured asymmetries in the process $\gamma N \to K^+(\Lambda + \Sigma)$ from hydrogen and deuterium, for square of four-momentum transfer, t, between -0.01 and -0.8 (GeV/c)^2. The data show that for $-t \gtrsim 0.1$ (GeV/c)^2, the cross sections for $\gamma p \to K^+\Lambda$, $\gamma p \to K^+\Sigma^0$, and $\gamma n \to K^+\Sigma^-$ are strongly dominated by natural-parity exchange, as is the case in single-pion photoproduction.

It is generally assumed that pseudoscalar-meson photoproduction at high energies and small momentum transfers proceeds through t-channel exchange mechanisms. The use of a linearly polarized photon beam allows separation of these exchanges into natural- and unnatural-parity sequences, since, to leading order in t/s, $d\sigma_\perp/dt$ ($d\sigma_\parallel/dt$), the cross section for photons polarized perpendicular (parallel) to the reaction plane, is dominated by natural- (unnatural-) parity exchange.[1] Thus the polarized-photon asymmetry

$$\Sigma \equiv \frac{d\sigma_\perp/dt - d\sigma_\parallel/dt}{d\sigma_\perp/dt + d\sigma_\parallel/dt}$$

is a measure of the relative importance of the two parity sequences.

Prior to this experiment, measurements of the differential cross sections for the reactions[2,3] $\gamma p \to K^+\Lambda$, $\gamma p \to K^+\Sigma^0$, and $\gamma n \to K^+\Sigma^-$ and the recoil Λ polarization in $\gamma p \to K^+\Lambda$ have been reported.[4] We present here the first measurements of the polarized-photon asymmetry in these reactions.

The polarized-photon beam used was produced through the selective absorption, by coherent pair production, of one linear polarization state from an unpolarized 16.05-GeV bremsstrahlung beam. This beam, which has been described in detail elsewhere,[5] had an energy spectrum near the end point similar to ordinary bremsstrahlung. The beam polarization was maximized near the end point, and was measured to be 0.255 ± 0.020 between 15 and 16 GeV. The fact that this process polarizes the high-energy end of the bremsstrahlung spectrum was an important factor in making the measurement of the kaon asymmetries possible.

Pions and kaons photoproduced in 1-m-long hydrogen and deuterium targets were detected in the Stanford Linear Accelerator Center 20-GeV/c spectrometer. Particle identification was done with both threshold and differential Cherenkov counters, a lead-Lucite shower counter, and a range telescope, while scintillation-counter hodoscopes measured the particle momentum and both production angles. Details of the particle detection and identification system, the beam monitoring, and the corrections applied to the raw yields, as well as the results for the reactions $\gamma N\rightarrow\pi^{\pm}N$ and $\gamma N\rightarrow\pi^{\pm}\Delta$, have been presented elsewhere.[6,7] Of the corrections applied, only the (small) dead-time corrections can influence the asymmetry; other corrections affect only the overall normalization.

An example of fully corrected and fitted yields of pions and kaons, as a function of spectrometer momentum, obtained at a single angle setting of the spectrometer, is given in Fig. 1. In obtaining these data, the spectrometer momentum was scanned over a limited momentum range, as described elsewhere.[7] Since the incident beam has a continuous energy spectrum, a continuous momentum spectrum is obtained for the detected particles. For two-body reaction, the rapid cutoff of the incident beam at the end-point energy causes "steps" in the detected-particle momentum spectrum at momenta determined by the mass of the undetected recoil particle. The pion-yield data of Fig. 1 clearly show the step due to the process $\gamma p\rightarrow\pi^+n$, followed, at lower momenta, by the onset of the broad quasi-two-body process $\gamma p\rightarrow\pi^+\Delta^0$.

The K^+ yield curve of Fig. 1 shows that the overall resolution of the experiment is inadequate to separate cleanly the yields from the processes $\gamma p\rightarrow K^+\Lambda$ and $\gamma p\rightarrow K^+\Sigma^0$. At 16 GeV, the kaon momenta for the two reactions differ by less than 0.6%, compared to our normal rms resolution of 0.25%. This resolution is effectively broadened further by the finite slope of the bremsstrahlung spectrum at the end point. In an attempt to improve the overall experimental resolution, data were obtained at three angles from the hydrogen

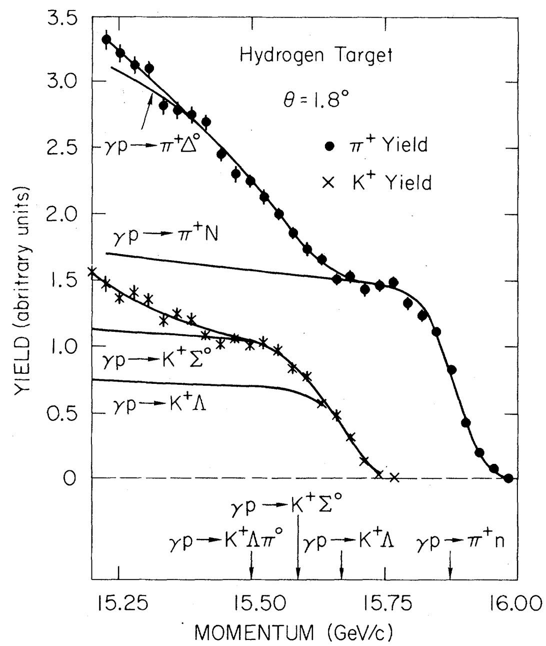

FIG. 1. Corrected π^+ and K^+ yields as a function of spectrometer momentum. The curves are the results of fits to the data (see text). The arrows show the thresholds for the indicated reactions at 16 GeV. The curve labeled $\gamma p\rightarrow K^+\Lambda$ is the fitted yield due to this process alone, while that labeled $\gamma p\rightarrow K^+\Sigma^0$ is the fitted yield for both processes. The unlabeled curve rising at lower momenta includes a polynomial beginning at the $\gamma p\rightarrow K^+\Lambda\pi^0$ threshold. The contributions to the π^+ yields are similarly labeled.

target with both narrowed energy-defining slits in the electron beam and a reduced photon-beam vertical size at the target (since momentum analysis in the spectrometer was done by vertical bending). These changes, which improved the rms resolution to 0.20%, were obtained at the expense of beam intensity. The data obtained with improved resolution were consistent with those taken with normal resolution, and are included in the results presented here. The yields of Fig. 1 were obtained with normal resolution.

To obtain cross sections and asymmetries, the measured photon-beam energy spectrum[5] was used to fit the meson momentum spectra, as described in Ref. 7. A simultaneous fit was made to the average yield from the two polarizations, to obtain the unpolarized cross sections, and to the difference of the yields, to obtain the asymmetry. In fitting the kaon yields, the cross sections and asymmetries for the reactions $\gamma p\rightarrow K^+\Lambda$ and $\gamma N\rightarrow K^+\Sigma^{-,0}$ and a single-parameter polynomial background term beginning at the $\Lambda\pi^0$ threshold were allowed to vary. The effective experimental resolution, and an energy shift (to accommodate slight differences between the spectrometer and beam momentum calibrations), were obtained from fits to the pion yields, which had both better statistics and a single clean step in the yield curve. When fitting deuterium data, smearing of the momentum spectra due to the Fermi motion was included.

Since the background term cannot kinematically be present over most of the K^+ momentum region in which the Λ and Σ cross sections rise, our results for the sum of these cross sections are quite insensitive to the background parametrization chosen. However, since the Λ and Σ "steps" are not cleanly resolved, there are highly correlated erros in the cross sections for the separate reactions. Errors in the asymmetries for the two reactions are further magnified by the small beam polarization, and we therefore present asymmetries only for the sum of the processes $\gamma p \to K^+\Lambda$ and $\gamma N \to K^+\Sigma^{0,-}$.

The differential cross sections measured in this experiment show a t dependence in good agreement with the results of Boyarski *et al.*[2] Within the normalization uncertainties of the two experiments, the sum of our cross sections for $\gamma p \to K^+\Lambda$ and $\gamma p \to K^+\Sigma^0$ also agrees with the results of Ref. 2, while our measurements[6] of the single pion-photoproduction cross sections are systematically greater than those of Boyarski *et al.*[8] Our ratios of Σ to Λ production from both hydrogen and deuterium targets[7] are somewhat different from those of Boyarski *et al.*[2,3] This is likely due to the considerable difficulty in separating the yields from the two reactions at high energy. We do not believe that these overall normalization and/or t-independent systematic difences influence our asymmetries for the sum of the two kaon-photoproduction processes in any meaningful way.

Figure 2(a) shows the polarized-photon asymmetries for the sum of the reactions $\gamma p \to K^+\Lambda$ and $\gamma p \to K^+\Sigma^0$, and Fig. 2(b) gives the asymmetries for the sum of the reactions $\gamma d \to K^+\Lambda n_s$, $\gamma d \to K^+\Sigma^0 n_s$, and $\gamma d \to K^+\Sigma^- p_s$ from a deuterium target, where the subscript s indicates a spectator nucleon. The error bars in these figures do not include the 8% normalization uncertainty in the asymmetry due to the uncertainty in the beam polarization. For $-t$ greater than 0.1 $(\text{GeV}/c)^2$, the data are consistent with an asymmetry of unity. Since the cross sections for the individual

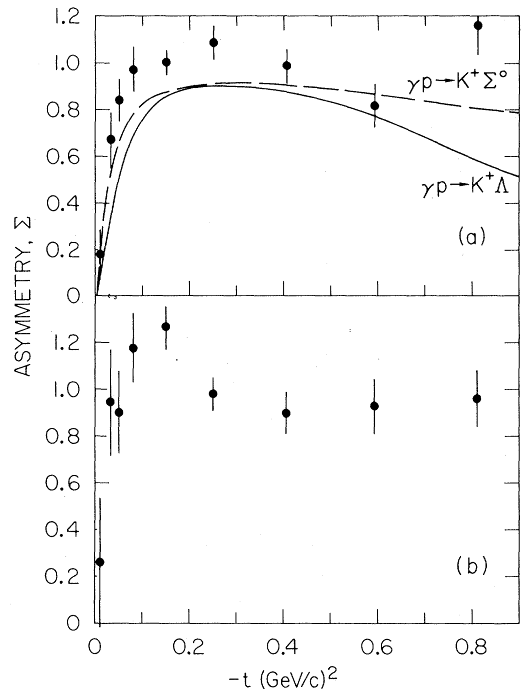

FIG. 2. (a) The polarized-photon asymmetry for the sum of the reactions $\gamma p \to K^+\Lambda$ and $\gamma p \to K^+\Sigma^0$ as a function of t. The curves are the predictions of Ref. 14, calculated at 16 GeV. (b) The polarized-photon asymmetry for the sum of the reactions $\gamma d \to K^+\Lambda n_s$, $\gamma d \to K^+\Sigma^0 n_s$, and $\gamma d \to K^+\Sigma^- p_s$, as a function of t.

processes are comparable, the asymmetry in each individual process must also be near unity. For $-t$ less than 0.1 $(\text{GeV}/c)^2$ the data of Fig. 2(b), which are more heavily dominated by $\gamma N \to K^+\Sigma^{-,0}$, lie slightly above the data of Fig. 2(a), which are more heavily dominated by $\gamma p \to K^+\Lambda$. This is consistent with Kim's prediction[9] that unnatural-parity K exchange is stronger in $K^+\Lambda$ than in $K^+\Sigma^0$ photoproduction. Recent data from electroproduction experiments[10] support this prediction.

Our data show that the cross sections for the three reactions $\gamma p \to K^+\Lambda$, $\gamma p \to K^+\Sigma^0$, and $\gamma n \to K^+\Sigma^-$ are dominated by natural-parity exchanges for $-t$ greater than 0.1 $(\text{GeV}/c)^2$. Natural-parity dominance at larger values of $-t$ has been observed in all pseudoscalar-meson photoproduction reactions for which asymmetries have been measured.[6,7,11]

Several predictions have been made for the asymmetries in kaon photoproduction. Our results are clearly inconsistent with those models which predict structure or significantly less than unity asymmetry[12,13] over our t range. Two recent models have predicted large, relatively featureless asymmetries in our t region.[14,15] The predictions of Goldstein *et al.*[14] are shown with the data of Fig. 2(a) as an example.

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