[7]For the detailed structure of meson and baryon fields, see Sakita and Wali, reference 5.

[8]Because the definition of Φ includes a γ_5 matrix,[7] $\bar{\Psi}\Psi\Phi$ is a parity-conserving interaction.

[9]"Observable terms" is used to denote those terms that engender observable decays within the octet of $J=\frac{1}{2}^+$ baryons.

[10]$[X]_{\lambda\mu}{}^{\alpha\beta}$ is constructed from its symmetry properties with respect to $\alpha\beta$, and to $\lambda\mu$, but no normalization is imposed, e.g. $[\underline{27}]_{\lambda\mu}{}^{\alpha\beta}=\bar{B}_\lambda{}^\alpha B_\mu{}^\beta+\bar{B}_\mu{}^\alpha B_\lambda{}^\beta+\bar{B}_\lambda{}^\beta B_\mu{}^\alpha+\bar{B}_\mu{}^\beta B_\lambda{}^\alpha-$trace terms. For the symmetries of $[\underline{10}]$ and $[\underline{10}^*]$, see S. Okubo, Progr. Theoret. Phys. (Kyoto) 28, 24 (1962). Notice also that $F_\beta{}^\alpha=\frac{1}{2}[(B\bar{B})_\beta{}^\alpha-(\bar{B}B)_\beta{}^\alpha]$, $D_\beta{}^\alpha=\frac{1}{2}[(B\bar{B})_\beta{}^\alpha+(\bar{B}B)_\beta{}^\alpha-$trace term].

[11]The combined effect of pre- and post-multiplying Φ by γ_5 is to change the sign of the mass of the pseudoscalar meson; see reference 7.

[12]To understand why other choices of A, B, E do not contribute to the S-wave amplitudes, we note that γ_5 links the "large" components of one Dirac spinor to the "small" components of another. Thus any term with A or B equal to γ_5 is smaller by a factor v/c than the corresponding term with A and B both equal to the unit matrix. By setting $E\equiv\gamma_5$, however, we merely cancel out a γ_5 appearing in the definition of Φ (see reference 7).

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[19]We use H_i(RP), $i=1,2$, to denote the SU(6) couplings of Rosen and Pakvasa.[2]

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EXISTENCE OF PIONS WITH SPIN

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It has recently been proposed[1] that one of the secondaries from $K_2{}^0\to\pi^++\pi^-$ decay, first observed by Christenson et al.,[2] and later by others,[3,4] is not a normal pion but a pion with spin (spion). The existence of such a spion could explain a long-standing asymmetry[5,6] in the $\pi\to\mu$ decay angular distribution for the lower part of the π^+ spectrum in τ decay. An admixture of at least 5% of spions in τ decay would be required. Several other consequences follow from this assumption, as pointed out in reference 1:

(a) The ratio of the decay rates for electronic and muonic modes should be comparable for the charged spion.

(b) If the spin of the spion is 1 and neutral spions exist, the preferred decay mode would be into an electron-positron pair plus a photon. Assuming a very short lifetime ($\lesssim 10^{-12}$ sec), one expects to observe in a bubble chamber an anomalous number of Dalitz pairs in K^+ decays.

We have checked hypothesis (a) in τ and τ' decay and hypothesis (b) in τ', in $K_{\mu3}$, and in all K^+ decays involving a π^0. We have not found any evidence of the above effects, all the results being compatible with a completely normal behavior of the pions from K^+ decays.

The data were obtained from two exposures of the 81-cm Saclay CERN bubble chamber to beams of stopping K^+ mesons. The liquid in the chamber was H_2 for the first and D_2 for the second exposure. To check hypothesis (a) in τ decay, we studied the decays of the stopped positive secondaries. At least 3% of these should decay directly into positrons of 70-MeV energy to explain the observed magnitude of the $\pi\to\mu$ decay asymmetry. In the scan we examined all the positive secondaries of τ^+ for apparently direct decays into a positron. We found 78 events out of 14 806 τ^+'s. The range of the secondary and the momentum of the positron were measured for these events. A large background is expected among these events due to $\pi \to \mu + \nu$ decays with a very small angle between the π and the μ track, followed by $\mu \to e + \nu + \bar{\nu}$ decay. However, the momentum resolution (the average measurement error on the positron momentum is 8%) should allow us to separate out the $\pi^+ \to e^+ + \nu$ decays. The momentum distribution of the positrons is shown in Fig. 1. For comparison, the theoretical distribution for $\mu \to e + \nu + \bar{\nu}$ decay ($\rho = \frac{3}{4}$), with an average 8% measurement error folded in, is shown. The agreement is good (70% chi-squared probability). No example of $\pi^+ \to e^+ + \nu$ decay was found. This is still compatible with the theoretical $(\pi^+ \to e^+ + \nu)/(n^+ \to \mu^+ + \nu)$ branching ratio of 1.2×10^{-4} since, from the above-quoted τ count, taking into account the average probability that a π^+ stops in the chamber and the scan efficiency, we expected 0.7 ± 0.2 $\pi^+ \to e^+ + \nu$ decays. If one believes in the spion hypothesis, our result sets an upper limit to the product of the spion percentage (P_+) among pions times the branching ratio $R_+ = (\text{spion} \to e^+ + \nu)/(\text{all spion decays})$: $R_+P_+ \leq 4 \times 10^{-4}$ with 95% confidence. This is about two orders of magnitude below the value proposed by Cvijanovich, Jeannet, and Sudarshan.[1] It is to be noted that the positive secondaries from τ decay that we examined are predominantly from the lower part of the energy spectrum, where the asymmetries observed[5,6] were most significant. The presence of depolarizing effects in this experiment should not affect hypothesis (a).

A similar analysis was applied to τ' decays. In this case the background is due both to the above-mentioned collinearity between π and μ tracks and to the $K_{\mu 3}$ decay. To study the $K_{\mu 3}$ muon spectrum and longitudinal polarization we have measured all apparent $K_{\mu 3}$ decays in the first exposure,[7] and are now continuing in the second. As well, all apparent τ' decays in the first exposure were measured.[8] The spions, if present in τ' decay, would constitute a background to the $K_{\mu 3}$ measurements. Figure 2 shows the momentum distribution of the positrons resulting from 1744 apparent $K_{\mu 3}$ decays which correspond to approximately 4700 τ' decays in the given chamber geometry. One event consistent with $\pi^+ \to e^+ + \nu$ decay was found. The resulting upper limit for the product is $R_+P_+ \leq 1.1 \times 10^{-3}$.

An indicative test of hypothesis (b) is provided by the Dalitz-pair frequency in K^+ decay. In

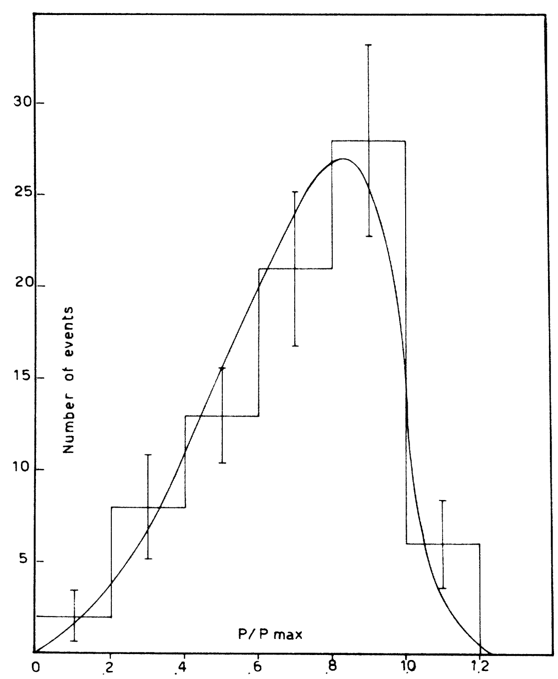

FIG. 1. Spectrum of the positrons apparently emerging directly from the stopped positive secondaries in τ decay (78 events). The smooth curve is the positron spectrum from muon decay with 8% measurement error folded in.

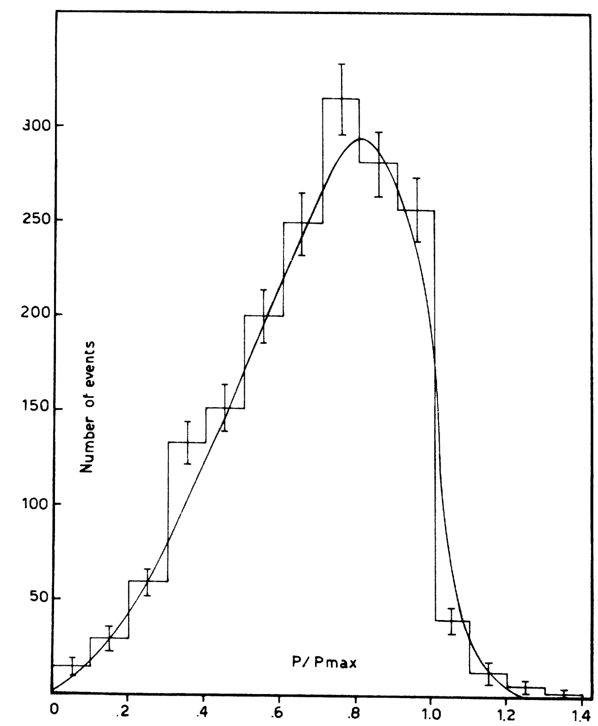

FIG. 2. Spectrum of the positrons resulting from apparent $K_{\mu 3}$ decays (1744 events). The smooth curve is the positron spectrum from muon decay with 8% measurement error folded in.

a recent determination of the τ branching ratio[9] we found a Dalitz-pair frequency of $(0.41 \pm 0.07)\%$ of all K^+ decays, based on 36 Dalitz pairs found. This is to be compared with $(0.39 \pm 0.01)\%$ expected from recently published K^+ branching ratios[10] and the Dalitz-pair probability observed for π^0's produced in strong interactions.[11] The resulting product R_0P_0 is $(2.0^{+7.0}_{-2.0}) \times 10^{-4}$, where P_0 is the neutral spion frequency, and R_0 is the Dalitz-pair frequency in the neutral spion decay. We applied the same test separately to τ' and $K_{\mu 3}$ decays. In the first exposure we found 61 Dalitz pairs (56 expected) among 2393 τ' decays and 10 (12.4 expected) among 1062 apparent $K_{\mu 3}$ decays. In the second exposure we have not yet determined the Dalitz pair efficiency. The resulting products R_0P_0 are $(2.0^{+3.0}_{-2.0}) \times 10^{-4}$ for τ' decay, and $(0^{+0.7}_{-0}) \times 10^{-4}$ for $K_{\mu 3}$ decay.

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SMALL-ANGLE CHARGE EXCHANGE OF π^- MESONS BETWEEN 6 AND 18 GeV/c

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Charge-exchange processes in the region of the highest available accelerator energies have gained considerable attention during the past year.[1-5]

These reactions provide critical tests of the currently popular exchange models of high-energy strong-interaction physics. For models investigating one-particle intermediate states in the crossed channels, there are stringent limitations: Only nonstrange mesons with isotopic spin 1 can be exchanged for low momentum transfers. For K-nucleon and π-nucleon charge exchange there is the further condition that the spin and parity of the intermediate state must be of the series 0^+, 1^-, 2^+, etc. Finally, for π-nucleon charge exchange the additional limitation on G parity excludes all but the ρ from the list of particles with known quantum numbers. Cross sections for $\pi^- + p \to \pi^0 + n$ have been calculated using Regge-pole theory[6,7] and one-particle exchange with absorption.[8-10]

Supposing the exchange of one meson only, Regge-pole theory requires a shrinking of the forward peak. Non-Reggeized exchange models investigated so far predict purely real forward scattering amplitudes, and energy-independent cross sections for vector-meson exchange.

The cross section at 0° can be calculated using an unsubtracted dispersion relation and the