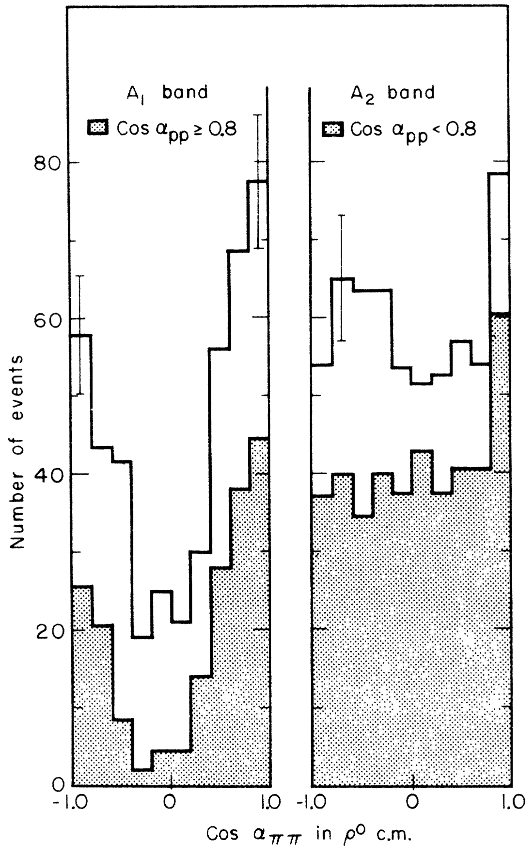

FIG. 4. The distribution of $\cos\alpha_{\pi\pi}$, the $\pi\pi$ scattering angle in the ρ c.m. The data shown are selected with $\pi^{\pm}\rho^0$ mass in the A_1 and A_2 bands, respectively, and for $(\pi^{\pm}p)_{\text{out}}$ masses above the $N^*(1238)$ band.

John L. Brown and George H. Trilling in various stages of this work.

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K^+n CHARGE-EXCHANGE SCATTERING AT 2.3 BeV/c*

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We present here the differential cross section for the reaction $K^+ + n \rightarrow K^0 + p$ at 2.3 BeV/c. On comparing the differential scattering cross section in the forward direction with the value derived from the optical theorem, we find the experimental value to be considerably larger than the optical-theorem point. This indicates that the charge-exchange amplitude is predominantly real.

This study is based on an analysis of 297 events of the type

$$K^+ + d \rightarrow K^0 + p + p, \tag{1}$$

with a visible K^0 decay. The events were obtained in 100 000 photographs taken with the Brookhaven National Laboratory 20-in. bubble chamber filled with deuterium and exposed to a K^+ beam at the AGS.[1] In this sample we find 53% of the events with two visible protons and 47% with only one visible proton. For the latter we fitted the events as one-constraint fits to Reaction (1).

In Reaction (1) the choice as to which of the two protons is the recoil proton and which the spectator has been made on the basis of their respective momenta. If the slower proton is chosen as the supposed spectator, it is found to have a momentum distribution which agrees well with that expected from the Hulthén wave function, provided that its momentum does not exceed 300 MeV/c. With the same momentum limitation, the angular distribution of the spectator in the laboratory is isotropic. We find that in 14% of the events, both protons have momenta greater than 300 MeV/c, whereas the expected number consistent with the Hulthén wave function is 1 to 2%. We attribute this discrepancy to double scattering in the deuteron. In the subsequent analysis we have included only events with spectator momenta below 300 MeV/c. There are 257 such events. All events were weighted according to the probability that a K^0 of the observed momentum decays within the chosen fiducial volume. Cross sections have been corrected to allow for K_2^0 and neutral K_1^0 decays. By this procedure we find the cross section for charge exchange to be 1.50 ± 0.15 mb.

Figure 1 shows the observed angular distribution of the K^0 from Reaction (1) in the laboratory system. Figure 2 shows (solid bars) the observed values of $d\sigma/d\Omega$ as a function of the K scattering angle Θ^* in the Kn center-of-mass system (or $\partial\sigma/\partial t$ as a function of momentum transfer, t).

If the charge-exchange scattering amplitude on a free neutron is given by $f = a + b(\hat{\sigma}\cdot\hat{n})$, where $\hat{n}$ is the unit vector perpendicular to the scattering plane, then the differential cross section for a neutron bound in a deuteron is given by

$$d\sigma/d\Omega = [\,|a|^2 + (\tfrac{2}{3})|b|^2][1-H(q)] + \tfrac{1}{3}|b|^2[1+H(q)]. \qquad (2)$$

Here the cross section is given in the K^+n center-of-mass system, $H = \int \Psi^*(\vec{r})\exp(-i\vec{q}\cdot\vec{r}) \times \Psi(\vec{r})d\vec{r}$ is a real and positive quantity, Ψ is the deuteron spatial wave function, and $\vec{q}$ is the difference between the initial and final K momenta in the laboratory system. Final-state interaction and double-scattering effects are ignored in this expression.[2]

Equation (2) may be rewritten as

$$d\sigma/d\Omega = [1-H(q)](d\sigma/d\Omega)_{nf} + [1-\tfrac{1}{3}H(q)](d\sigma/d\Omega)_f, \qquad (3)$$

where $(d\sigma/d\Omega)_{nf}$ and $(d\sigma/d\Omega)_f$ are the free-neutron cross sections for spin nonflip and spin flip, respectively.

For events produced with $\cos\Theta^* < 0.92$, we obtain $H(q) \le 0.1$, and effects due to the deuteron are thus negligible. For the remaining events the value of $H(q)$ becomes significant, and corrections implied by Eq. (3) must be included. To apply these corrections, one must know the relative size of spin-flip and spin-nonflip contributions. The relative importance of these two terms is not known. However, since all

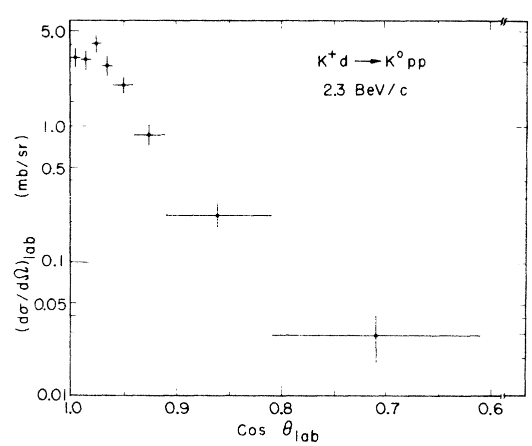

FIG. 1. Observed laboratory differential cross section for the reaction $K^+ + d \to K^0 + p + p$ as a function of the K^0 production angle.

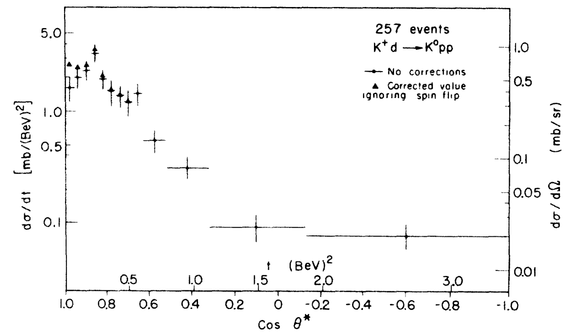

FIG. 2. Differential cross section for the reaction $K^+ + d \to K^0 + p + p$ as a function of the K^0 production angle in the K^+n center-of-mass system (or momentum transfer t). Solid bars show experimental data; triangles show the conversion from K^+d scattering to K^+n scattering if spin-flip contributions to the scattering are ignored.

corrections apply primarily to forward-scattering angles we have neglected the spin-flip term. The triangles in Fig. 2 show the result of correction where only the spin-nonflip term has been included.

We now compare the forward-scattering cross section with that derived from the optical theorem. In terms of isotopic-spin amplitudes, the amplitudes for K^+p scattering, K^+n scattering, and K^+n charge exchange (ce) are given, respectively, by

$$f(K^+ + p \to K^+ + p) = f_1, \quad f(K^+ + n \to K^+ + n) = \tfrac{1}{2}(f_1 + f_0),$$
$$\text{and } f_{\text{ce}} = \tfrac{1}{2}(f_1 - f_0);$$

hence

$$f_{\text{ce}} = f(K^+ + p \to K^+ + p) - f(K^+ + n \to K^+ + n).$$

From the optical theorem we thus obtain

$$(\text{Im} f_{\text{ce}})_{t=0} = k/4\pi[\sigma_t(K^+p) - \sigma_t(K^+n)], \qquad (4)$$

which yields the inequality

$$(d\sigma_{\text{ce}}/d\Omega)_{t=0} \geq \{k/4\pi[\sigma_t(K^+p) - \sigma_t(K^+n)]\}^2. \qquad (5)$$

From the uncorrected data in Fig. 2, which is a lower limit to the K^+n charge-exchange cross section, we would predict a difference of ~5 mb between the K^+p and K^+n cross sections if Eq. (5) is taken to be an equality. The measured cross-section difference $\sigma_t(K^+p) - \sigma_t(K^+n)$ at this energy was given by Cook et al. as -0.6 ± 1.0 mb.[3] These two results are clearly incompatible, which implies that Eq. (5) must be considered as an inequality. Thus the real part of the forward K^+n charge-exchange amplitude, f_{ce}, must be considerably greater than the imaginary part. It is noteworthy that this is in contrast with high-energy K^-p charge exchange, which has a predominantly imaginary amplitude.[4] On the basis of a Regge-pole model of KN scattering invoking only ρ and A_2 trajectories, Phillips and Rarita have predicted that K^+n charge exchange should have a predominantly real amplitude and K^-p charge exchange a predominantly imaginary amplitude.[5] The possible validity of such a Regge approach at an energy as low as 2.3 BeV/c is supported by the fact that K^+n scattering is free of resonances in the direct channel, and that the only other trajectory that might have to be considered would be an $I, J^P = 1, 0^+$ exchange.

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