Search for Evidence of Parity Nonconservation in K-He Interactions*

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Parity conservation in strong strange-particle producing interactions is not yet experimentally settled. We describe below a search for evidence of parity nonconservation in K-He interactions. To search for such evidence we measure the expectation value of the pseudoscalar $\mathbf{P}_\Lambda \cdot \boldsymbol{\sigma}_\Lambda$. This quantity is directly obtained from the decay-pion angular distribution in the Λ rest frame. The observed angular distribution is symmetric. An analysis of 485 Λ° producing interactions gives $\alpha\langle \mathbf{P}_\Lambda \cdot \boldsymbol{\sigma}_\Lambda \rangle = +0.04 \pm 0.08$. Thus, we find no evidence for parity nonconservation in K-He[4] reactions.

THIS report is part of a continuing study of K^- interactions in helium,[1,2] obtained in an exposure of the Duke University helium chamber to a low-energy K^- beam at Berkeley.[3] We describe below a search for evidence of parity nonconservation in K-He interactions.

Parity conservation in strong, strange-particle producing interactions is a subject of much theoretical interest,[4] which is not yet experimentally settled, except in the case of "direct" Λ production, i.e., in $\pi^- + p \rightarrow \Lambda^0 + K^0$. In fact, a compilation of cloud chamber results[5] shows evidence of a strong forward-backward asymmetry in the Λ-decay angular distribution, in contrast to the forward-backward symmetry present in the decay distribution of Λ's made in hydrogen.[6] However, the cloud chamber sample consists of both direct Λ's and those made by Σ conversion, i.e., the two-step process in which a Σ is made in a primary interaction and subsequently interacts with a nucleon inside the nucleus to produce a Λ. It has been speculated,[5] therefore, that the Σ-conversion process might be responsible for the apparent longitudinal polarization.

Since the Σ-conversion process is responsible for the majority of Λ's produced in He,[2] we have a large statistical sample ($\sim$500 events) for our study. We find no evidence of parity nonconservation.

In order to detect parity nonconservation in any reaction it is necessary to observe a nonzero expectation value of a psuedoscalar observable. In this experiment we measure the expectation value of the psuedoscalar $\mathbf{P}_\Lambda \cdot \boldsymbol{\sigma}_\Lambda$, where $\mathbf{P}_\Lambda$, $\boldsymbol{\sigma}_\Lambda$ are the Λ momentum and spin, respectively. This quantity is directly obtained from a measurement of $f(\theta)$, the decay-pion angular distribution in the Λ rest frame. Since the spin of the Λ is $\frac{1}{2}$, $f(\theta)$ can be written in the form[7]

$$f(\theta) = (1 + \alpha \bar{P}_\Lambda \cos\theta) d\Omega, \qquad (1)$$

where α is the well-known asymmetry parameter,[8] and $\bar{P}_\Lambda$ is the component of the polarization (averaged over the range of dynamical variables describing the Λ) along the axis from which θ is measured. Since the magnitude of α is[7] greater than 0.7, if the axis of quantization is chosen to be the Λ momentum direction, any observed asymmetry in $f(\theta)$ would be indicative of a longitudinal polarization which could only result from parity nonconservation in the Λ-production process.

The sample chosen for analysis in this experiment contains about 1750 K^--He interactions of which about

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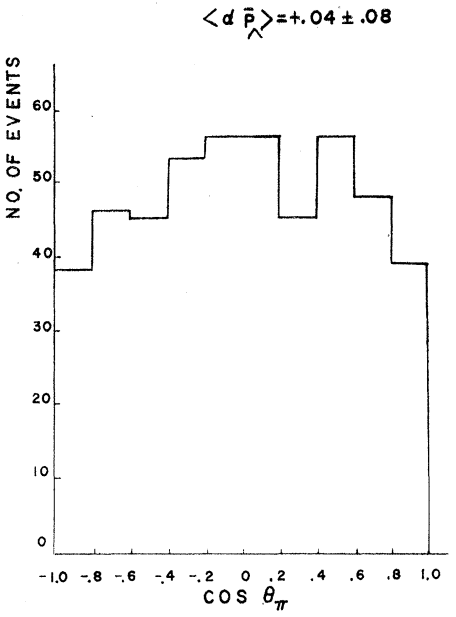

FIG. 1. The decay angular distribution of neutral hyperon events from all K^- interactions (482 events).

1150 are due to K^- absorptions at rest. These events consist of about 25% charged Σ's and 75% neutral hyperons (of which about 50% decay by the visible π^-+p mode). It is not possible in all cases to distinguish Λ production events from Σ^0 production events on the basis of kinematics; the sample reported on here contains secondary Λ's from Σ^0 decay along with direct and converted Λ's. However, the fraction of $\Sigma^0 \rightarrow \Lambda+\gamma$ events which emerge from all K^- interactions can be obtained from the charge independence relation: $f_{\Sigma^0}=\frac{1}{2}(f_{\Sigma^+}+f_{\Sigma^-}) \simeq 13\%$. Since 75% of all K interactions produce a neutral hyperon (Y^0), the fraction of Σ^0's present in the group of all neutral hyperons is only $\sim 17\%$.

The decay-pion angular distribution of all Y^0 events, from *all* K interactions, is shown in Fig. 1.[9] The spectrum shows no evidence of asymmetry.[10] A maximum likelihood fit of Eq. (1) to the data gives

$$\alpha \bar{P}_\Lambda = \frac{3}{N} \sum_{i=1}^{N} \cos\theta_i \pm \left(\frac{3}{N}\right)^{\frac{1}{2}} = +0.04 \pm 0.08.$$

For the sake of comparison we have separated Y^0's which are made in K^- absorptions from rest. The Λ-decay angular distribution for these events is shown in Fig. 2. The best-fit asymmetry parameter is $\alpha \bar{P}_\Lambda$ (K at rest) $= +0.03 \pm 0.09$. Thus the angular distributions of Λ's emerging from K^--He^4 interactions, both at rest and in flight, show no asymmetry.

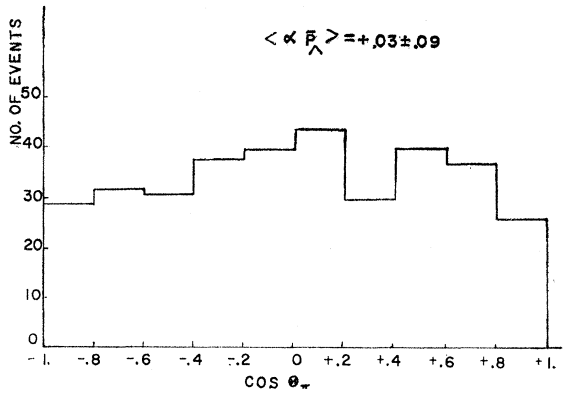

FIG. 2. The Λ-decay angular distribution of neutral hyperons from K^- absorptions at rest (347 events).

The Λ's studied here are made in various types of fundamental K-nucleon and K-two-nucleon interactions, both of the direct and Σ-conversion variety. An estimate of the relative importance of these reactions has been given previously.[2] A detailed analysis of all K absorptions at rest will be presented in a forthcoming publication. The preliminary results of this analysis show that about 50% of all Y^0's emerging from K absorptions at rest are due to the Σ-conversion process.

Because this number is so large, if we assume that the direct Λ's have a symmetric angular distribution, we must conclude that the symmetry present in the total data is the result of symmetry in the Σ-conversion reaction. Ignoring the insignificant effect[11] of the Σ^0's, we can estimate the asymmetry parameter due to the Σ-conversion events alone:

$$\alpha \bar{P}_\Lambda(\Sigma\text{-conversion}) \cong (1/0.5)[\alpha \bar{P}_\Lambda(\text{total})] = 0.08 \pm 0.15.$$

Thus we find no evidence of parity nonconservation in K^--He interactions,[12] and in particular, in the Σ-conversion process.

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[9] The number of events appearing in Figs. 1 and 2 are less than what one would expect from the above production figures because certain selection criteria have been applied to the raw data in order to reduce biases of various kinds.

[10] The distribution of Fig. 1 is slightly inconsistent with isotropy, indicating a bias against extremely forward or backward pions. These biases are understood. No corrections have been made to the raw data of Fig. 1, since these biases cannot contribute to any *asymmetry* in $\cos\theta$.

[11] Furthermore, it has been shown by R. Gatto (private communication) that the magnitude of the polarization of secondary Λ's from $\Sigma^0 \rightarrow \Lambda+\gamma$ decay, averaged over the Λ^0 decay angle, is only $\frac{1}{3}$ of the original Σ^0 polarization. Thus, no matter what $\alpha \bar{P}$ is contributed by the Σ^0's included in the total spectrum, it will be completely dominated by that due to the Λ's.

[12] *Note added in proof.*—We wish to point out that the Λ's emitted from K-He interactions have an average momentum of the order of 300 Mev/c. Our result, therefore, does not preclude the possibility of the existence of pronounced asymmetries at higher energies, owing to an unusual energy dependence of $\alpha \bar{P}_\Lambda$. Such asymmetries (for Λ's up to $\sim$1 Bev/c) have been recently reported by Soleviev et al., at the 1960 Rochester Conference.