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ANGULAR DISTRIBUTIONS IN Σ^+ DECAY

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Abstract

Angular distributions in Σ^+ decay are analyzed for information on Σ spin and parity conservation in Σ production. No evidence for a Σ spin $>1/2$ or parity nonconservation in Σ production is found.

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I. Introduction

A sample of 145 decays of Σ^+ hyperons produced by K^- capture in hydrogen¹ has been analyzed.

The folded angular distribution for all Σ^+ decays is of interest because any anisotropy would be an indication of a Σ spin $> 1/2$. No significant anisotropy was found.

The c.m. angular distributions of 82 " Σ_0^+ " events (i.e., $\Sigma^+ \rightarrow \pi^0 + p$) and 63 " Σ_+^+ " events (i.e., $\Sigma^+ \rightarrow \pi^+ + n$) with respect to the Σ^+ direction are also of interest because any fore-aft asymmetry would indicate some degree of parity nonconservation in Σ^+ production. Again no asymmetry was found.

II. The Angular Distribution of All Σ^+ Decays

The pion angular distribution of all Σ^+ decays is shown in Fig. 1. There is no statistically significant anisotropy; thus no evidence exists for spin $> 1/2$.^{1,2} For the sake of completeness we have analyzed the data by the method of Lee and Yang.³ The results are listed below, in the form of experimentally averaged test functions,³ T_{JM} , which must satisfy the inequalities $|T_{JM}| \leq 1$, for $M=J \dots -J$ for an assumed spin J . These test inequalities are easily satisfied for any isotropic angular distribution, and thus yield no further information on the spin.

* On leave from Syracuse University

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Fig. 1. Folded angular distribution of all Σ^+ decays (145 events).

T_{JM} Test Function Inequalities

$\langle T_{1/2, 1/2} \rangle$	$= 0.02 \pm .14$
$\langle T_{3/2, 3/2} \rangle$	$= 0.12 \pm .37$
$\langle T_{3/2, -3/2} \rangle$	$= 0.25 \pm .29$
$\langle T_{3/2, 1/2} \rangle$	$= 0.06 \pm .43$
$\langle T_{3/2, -1/2} \rangle$	$= 0.43 \pm .30$
$\langle T_{5/2, 5/2} \rangle$	$= 0.43 \pm .68$
$\langle T_{5/2, -5/2} \rangle$	$= 0.19 \pm .80$
$\langle T_{5/2, 3/2} \rangle$	$= 1.35 \pm .62$
$\langle T_{5/2, -3/2} \rangle$	$= 0.39 \pm .44$
$\langle T_{5/2, 1/2} \rangle$	$= 0.59 \pm .30$
$\langle T_{5/2, -1/2} \rangle$	$= 0.01 \pm .38$

III. Parity Conservation in Strong Interactions Involving Strange Particles

Parity conservation in strong, strange-particle-producing reactions has been firmly established only for the reaction $\pi + p \rightarrow \Lambda + K^0$, observed in the associated-production experiments of Crawford et al.⁴ The question of parity conservation in other strong strange-particle interactions is still unsettled and is a subject of much theoretical interest.⁵

We describe a search for evidence of parity nonconservation in the reaction

$$K + p \rightarrow \Sigma^+ \pi^-, \quad (1)$$

using the $\Sigma^+ \rightarrow \pi^0 p$ decay mode as an analyzer, in the following.

The sample chosen for analysis consisted of 82 Σ_0^+ events, 95% of which came from K^- absorption at rest. These were obtained by selecting events in which the Σ and primary π^- looked collinear. In order to eliminate biases it was important that every event be identified as one, and only one, of the many possible hyperon-production modes. However, if all Σ were chosen for analysis the scanner would be unable to distinguish between a "zero-length" Σ_0^+ (i.e., a Σ^+ which goes less than 1 mm before decaying into $\pi^0 p$), and a zero-length Λ . Since most of these events have not as yet been fully analyzed, separation could not be made on kinematic grounds. We therefore required that the Σ have a length ≥ 0.9 mm. This length criterion was adopted on the basis of experience, in order to keep as much of the data as possible, while reducing the possibility of event-type confusion to a minimum.

There is a further difficulty in identification which is due to the inability of the scanner to distinguish ionization density for short tracks. It is possible to confuse a Σ_0^+ with a Σ_+^+ if the decay track is short; the scanner classifies these events as Σ_0^+ . Each of these was submitted to a full kinematic analysis before positive identification was made.

This experiment is designed, as are all experiments to detect parity nonconservation, to detect a pseudoscalar variable, namely, the component of the Σ spin in the direction of the Σ momentum. Assuming that the Σ spin is $1/2$, the angular distribution of the Σ^+ decay products in the Σ^+ rest frame can be written in the form

$$1 + a P_{\Sigma} \cos \theta,$$

where a is an asymmetry parameter and P_{Σ} is the component of polarization along the axis from which θ is measured.

The analyzing properties of the Σ_0^+ mode have been demonstrated by Cool et al.⁶ They find $a_0 \geq 0.7 \pm .3$. It follows, then, that if our Σ^+ were $(100 P_{\Sigma} \%)$ polarized we should observe an asymmetry $\geq (0.7 \pm .3) P_{\Sigma}$ in the π^0 angular distribution. This in turn would indicate some degree of parity nonconservation in reaction a.

The experimental angular distribution is shown in Fig. 2. There is no statistically significant asymmetry. A maximum-likelihood estimate of the asymmetry,

$$\langle a_{\pi^0 P_{\Sigma}} \rangle = \frac{3}{N} \sum_{i=1}^N \cos \theta_i \pm \sqrt{\frac{3}{N}},$$

gives $\langle a_{\pi^0 P_{\Sigma}} \rangle = 0.02 \pm .10$. Hence we find no evidence for parity nonconservation in π^0/Σ^+ production.

We can check our procedure by noting that Cool et al. find no asymmetry for the Σ_+^+ decay mode. Thus if we analyze our Σ_+^+ events in the same way as we have treated the Σ_0^+ , we should find $\langle a P_{\Sigma} \rangle$ close to zero. We have done this and find $\langle a P \rangle = -0.03 \pm .22$, which is indeed isotropic, and constitutes indirect evidence against hidden biases.

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Fig. 2. Angular distribution of protons from $\Sigma^+ \rightarrow p + \pi^0$ (83 events).

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