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# *A STUDY OF THE POLARIZATION OF Λ HYPERONS PRODUCED IN $\pi^-$p INTERACTIONS AT 7–8 GeV*

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The polarization of Λ hyperons produced in $\pi^-$p interactions at 7–8 GeV was studied. For the asymmetry parameters the following values were obtained: $\alpha\bar{P}_1$ (forward-backward) = +0.04 ± 0.08, $\alpha\bar{P}_2$ (up-down) = +0.01 ± 0.08, and $\alpha\bar{P}_3$ (left-right) = −0.06 ± 0.08. Hence the Λ hyperons produced are unpolarized. The angular distributions of the Λ-hyperon production planes relative to the $K^0$ production planes for cases in which $\Lambda K^0$ pairs are recorded and relative to the plane of $\pi^\pm$ production in two-prong stars were constructed. The results are all in good agreement with parity conservation in strong interactions.

To study the polarization of Λ hyperons we used 60,000 pictures obtained from a 24-liter propane bubble chamber [1] exposed to a beam of 7–8 GeV/c negative pions. The chamber was placed in a constant magnetic field of 13,700 Oe which was homogeneous within ±3% over the fiducial volume of the chamber. The experimental arrangement has been described earlier. [2]

Preliminary results of this polarization study were reported at the Rochester Conference [3] and were published in [4]. The small statistics and incomplete analysis of the unidentified events did not permit an unambiguous conclusion at that time.

The longitudinal polarization and the angular distributions of the Λ-hyperon production planes can give information on parity conservation in strong interactions involving strange particles. [5,6] In the survey article [7] this question was considered mainly on the basis of cosmic-ray experiments. Subsequent studies of the Λ-hyperon polarization were performed with accelerators. [8–22] The available data at the time we began our experiment were contradictory. This was natural, since the study of the Λ-hyperon longitudinal polarization entails a number of experimental difficulties. A final answer to the question of whether or not the Λ-hyperons are polarized requires careful analysis of several important corrections.

## SCANNING OF THE PICTURES AND SELECTION OF INTERACTIONS WITH HYDROGEN

The pictures were scanned on stereo-viewers and partly on reprojectors. The entire material included in the statistics was scanned two to four times.

We selected for measurement those events which satisfied, by visual inspection, the selection criteria for $\pi^-$p interactions [23] and those cases which could not be reliably associated with interactions involving carbon.

The question of whether a given event was the result of a collision between a $\pi^-$ meson and hydrogen was settled only after the measurements and calculations. For $\pi^-$p interactions the following criteria should be satisfied:

1) The event should be coplanar, i.e., the point of production (star center) should lie in the decay plane in the direction of the $V^0$ particle. The identified $V^0$ event should satisfy the kinematics of a Λ or $K^0$ decay.

2) The net charge of all the secondary particles in the star should equal zero.

3) No more than one baryon (Λ, Σ, or p) should be present in the star.

4) The angle of emission of the baryon should not exceed the maximum value allowed by the kinematics of the $\pi^-$p interaction.

An additional analysis of the target mass and of the energy and momentum balance was also made. [24]

After such analysis, the background of Λ and $K^0$ particles from interactions with quasi-free protons among the selected events was 15–20%. The estimate of the quasi-free events in propane ($C_3H_8$) was based on the study of Λ and $K^0$ production on neutrons of carbon under the assumption that at 7–8 GeV the Λ and $K^0$ particles are produced on protons and neutrons with equal probability.

## SCANNING EFFICIENCY

The scanning efficiency plays an important role in the final results. Different types of $V^0$ events are observed in different ways. Some $V^0$'s are readily detected by all scanners, but other $V^0$'s are detected with difficulty. Of the latter type are $V^0$ decays in which one of the particles is of very short range and $V^0$ decays with very large or very small opening angles. The efficiency of a triple scanning was found to be $(94 \pm 3)\%$ under the assumption that the probability of detection for different $V^0$ events is not the same and $\sim 99\%$ under the assumption that the probability of detection is the same for all $V^0$ decays.

In the present experiment the absolute value of the efficiency is not as important as the value of the relative efficiency for different forms of Λ decays of interest to us, namely: 1) decays in which the protons are emitted forward in the rest system of the Λ hyperon relative to the Λ-particle momentum; 2) decays in which the protons are emitted backward; 3) decays in which the $\pi^-$ meson or proton has a very short range in the chamber.

The efficiency for the detection of Λ hyperons in these three groups was estimated after the identification of all $V^0$ events. The results of the triple scanning are shown in Table I. It is seen from this table that the efficiency in the first two groups of events are in good agreement with one another, while the group of Λ decays with a $\pi^-$ meson or proton of short range differs substantially from the first two groups, i.e., there is a danger of overlooking such events. In order to detect $V^0$ decays in which one particle has a small range, we carried out a special scanning of 6000 pictures. In this scanning we found only one $\pi^-$-meson track of length 0.3 cm. The question of the corrections for the loss of such Λ decays will be discussed below.

**Table I**

| Group of Λ hyperons | No. of Λ's | Observed (%) | | |
|---|---|---|---|---|
| | | 3 times | twice | once |
| 1) Protons emitted forward | 98 | 54±6 | 34±4 | 12±2 |
| 2) Protons emitted backward | 119 | 53±5 | 34±4 | 13±2 |
| 3) $\pi^-$ or proton of short range | 45 | 23.3±10 | 33±7 | 23±4 |

## MEASUREMENTS

The effective volume of the chamber was photographed on two films. The optical characteristics of the system and the method of measurement have been described in [23,25,26].

The coordinates of corresponding points of the track were measured on UIM-21 microscopes. We measured 8 to 20 points, depending on the length of track; the points of production and decay were always measured. Possible errors of measurement were due to the following causes: 1) the error in the optical system and the motion of the liquid; 2) Coulomb scattering of the particles in propane; 3) bubble noise along the track; 4) setting and reading errors; 5) use of approximate formulas [24] for analysis of the measurements; 6) nonuniformity and uncertainty of the value of the magnetic field; 7) energy losses of particles traveling through the propane and the error in the range-energy curve.

It is very difficult to take each of these factors into account. For practical purposes, however, it is quite sufficient to take into account only their combined effect. An analysis showed that our chamber, its optical system, and the methods of measurement and calculation introduce no systematic distortion. The rms error in the measurements of the coordinates of the points was 0.06 mm in the X direction, 0.17 mm in the Y direction, and 0.40 in the Z direction (in the space of the chamber).

The accuracy of the angular measurements depends on the track length, and for lengths greater than 5 cm the rms measurement error was 34′. The accuracy of the momentum measurements depend on the track length, the value of the momentum, the value of the magnetic field, and on multiple Coulomb scattering. Multiple Coulomb scattering makes the main contribution to the error; the error in the momentum measurements was, on average, equal to 10%. [26]

## CALCULATIONS

The space coordinates, angles, momenta, and other characteristics necessary to identify $V^0$ events and also to identify Λ and $K^0$ particles and to calculate the cosines of the angles of the positive particles, i.e., p or $\pi^+$ mesons ($\cos\theta_+^*$, $\cos\nu$, and $\cos\kappa$ in Fig. 8), were calculated on electronic computers at the computing center of the Joint Institute of Nuclear Research.

All events were measured and calculated twice. In the analysis we used only those results which gave two-fold agreement. In the case of discrepan-

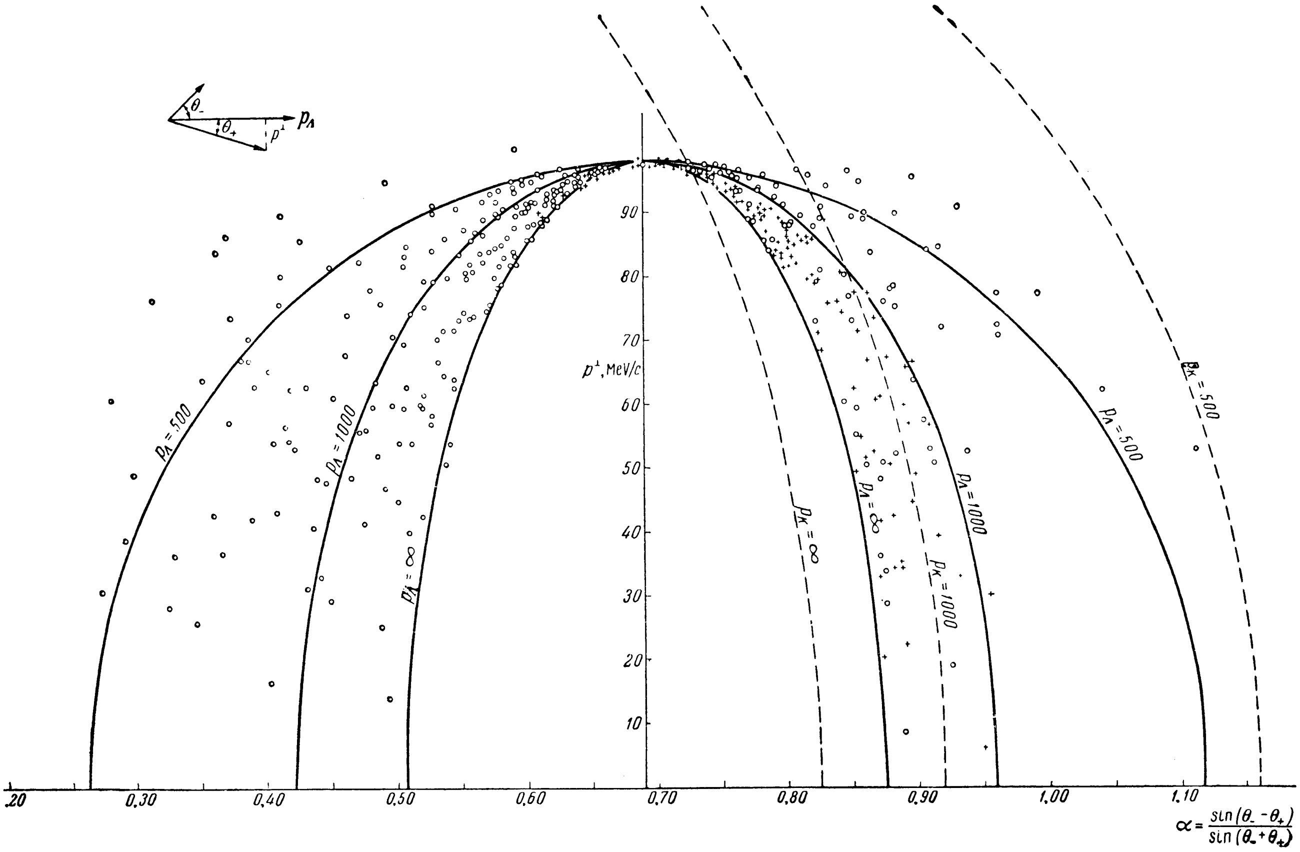

FIG. 1. Distribution of Λ hyperons in the $\alpha, p$ plane. The circles denote the identified Λ hyperons, the crosses denote the unidentified events (Λ or $K^0$). The solid and dashed curves represent the kinematic curves for Λ and $K^0$ decay, respectively, for fixed l.s. momenta.

cies in the results of the measurements or calculations, the event was remeasured or recalculated. If the results of the measurements and calculations agreed within the limits of error, but the noncoplanarity angle $\eta$ was one and a half to two times the allowable measurement error[1] $\Delta\eta$ or if the transverse momenta of the $V^0$ decay products did not balance, the event was discarded.

## IDENTIFICATION OF Λ AND $K^0$ PARTICLES

In the identification of the particles by means of the $\chi^2$ test [25] we used the following five parameters in most cases: $p_+$, $p_-$, $\theta_+$, $\theta_-$, and $\theta$, where $p_+$ and $p_-$ are the momenta of the positive and negative decay products, $\theta$ is the angle between the positive and negative particles, while $\theta_+$ and $\theta_-$ are the angles of emission of the positive and negative particles relative to the direction of the momentum of the decaying particle (Λ or $K^0$). In cases in which one or two parameters of the five could not be reliably measured, we used for the calculations approximate values corresponding to $V^0$ decays with an error of 100% or more.[2]

When the kinematics did not permit separation of Λ and $K^0$ particles, we resorted to other methods, for example, ionization measurements, [26,27] measurements of the momenta of δ electrons, produced by charged particles from the decay, analysis of secondary interactions of the positive particles. However, even use of the additional methods did not allow us to identify 127 $V^0$ events (12% of all $V^0$ decays). To obtain an idea of the momentum intervals for which it is difficult to distinguish a Λ from a $K^0$ particle, all events were plotted on the $\alpha$, $p^\perp$ plane (Figs. 1 and 2), where

$$\alpha=\sin(\theta_- - \theta_+)/\sin(\theta_- + \theta_+)=(p_+^{\parallel}-p_-^{\parallel})/(p_+^{\parallel}+p_-^{\parallel}),$$

$p^\perp$ and $p^{\parallel}$ are the transverse and longitudinal momenta of the $V^0$-particle decay products.

It is seen from Figs. 1 and 2 that the unidentified $V^0$ events all have values of $p^\perp \lesssim 100$ MeV/c

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[1] $\Delta\eta \approx 1.5\Delta\theta$, where $\Delta\theta$ is the error in the determination of the space angle $\theta$.

[2] These parameters do not play an important role in the identification of the particles, but decrease the number of degrees of freedom (for five parameters the number of degrees of freedom is three).

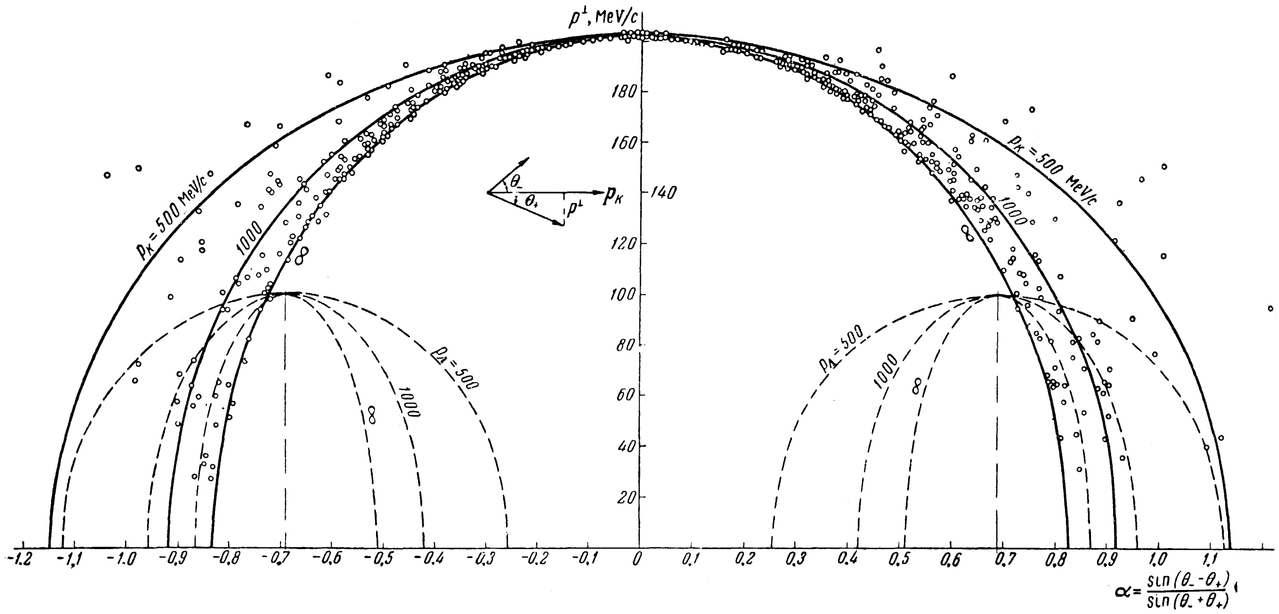


FIG. 2. Distribution of K⁰ mesons in the α, p plane. The circles denote the identified K⁰ mesons. The solid curves represent the kinematic curves for K⁰ for fixed l.s. momenta. The dashed curves are the corresponding curves for Λ (right) and $\bar{\Lambda}$ (left) decay.

and $\alpha \gtrsim 0.7$. We estimated the probability that a K⁰ meson falls in the region of uncertain identification and found that only 6.3% of all K⁰ mesons can lie there. Among this group of V⁰ particles we could separate part of the Λ and K⁰ particles on the basis of the kinematics and ionization in the case of V⁰ particles of small momenta when the tracks can be measured with sufficient accuracy. In this way we found that the kinematics of only 2–3% of the K⁰ particles corresponded to the kinematics of Λ hyperons, which corresponds to ~ 15 K⁰ particles out of 127 Λ or K⁰.

The fraction of K⁰ mesons among the unidentified Λ or K⁰ particles can also be estimated with the aid of the angular distributions of positive (or negative) particles from K⁰-decays in the K⁰ rest system relative to the direction of the K⁰ momentum. Since K⁰ particles have zero spin, the distribution should be isotropic. The distribution of $\pi^+$ mesons from K⁰ decays is shown in Fig. 3. The dashed line includes the unidentified events. It is seen from the figure that the unidentified events are not consistent with isotropy and only 7 ± 7 of the 127 Λ or K⁰ particles can be ascribed to K⁰ mesons. The remaining cases were considered to be Λ hyperons. The first and second estimates are in good agreement.

## CORRECTIONS

The corrections for the geometry of the chamber are needed for the determination of the cross section and have been considered earlier.[23] Analysis showed that the chamber geometry had no influence on the angular distributions of particles from the Λ decays in the rest system of the Λ relative to the Λ momentum. To consider this question, the hyperons in the fiducial region

Table II

| $\alpha\bar{P}$ | Direction of motion of Λ hyperon | | | |
|---|---|---|---|---|
| | up | down | left | right |
| $\alpha\bar{P}_1$ | —0.02±0.11 | +0,07±0.12 | —0,04±0,12 | +0,08±0,11 |
| $\alpha\bar{P}_2$ | +0,19±0,11 | —0,25±0,12 | —0,03±0,12 | +0,02±0,11 |
| $\alpha\bar{P}_3$ | —0,06±0.11 | —0,13±0,12 | —0,06±0,12 | —0,12±0.11 |

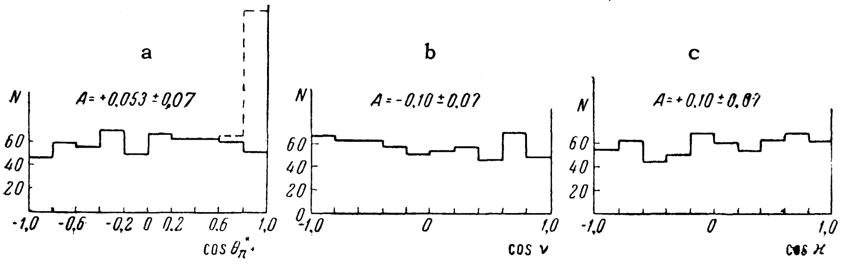


FIG. 3. C.m.s. angular distributions of $\pi^+$ mesons from K⁰ decays relative to the direction of the K⁰ meson (see Fig. 8): a – forward-backward distribution ($\cos\theta_+^*$), b – up-down distribution ($\cos\nu$), c – left-right distribution ($\cos\varkappa$). A denotes the asymmetry coefficient in the distribution of the form $1 + A\cos\theta_+^*$ etc.

of the chamber were classified into four groups depending on the direction of emission: up, down, left and right relative to the direction of motion of each of the interacting particles. The values of the asymmetry coefficients[3] $\alpha\bar{P}_i$ for these four groups are listed in Table II.

The scanning loss for "anomalous" decays, i.e., decays in which the $\pi^-$ meson or proton has a very short range, turns out to have a large effect on the angular distributions. Shown in Fig. 4 is the dependence of the proton emission angle on the $\Lambda$ momentum for different ranges of $\pi^-$ mesons and protons from $\Lambda$-particle decays. It is seen that the loss of events in which the protons are of short range makes an almost uniform contribution to the angular distribution, while the loss of events in which the $\pi^-$ mesons are of short range can lead to a strong distortion of the angular distribution (to a forward-backward asymmetry).

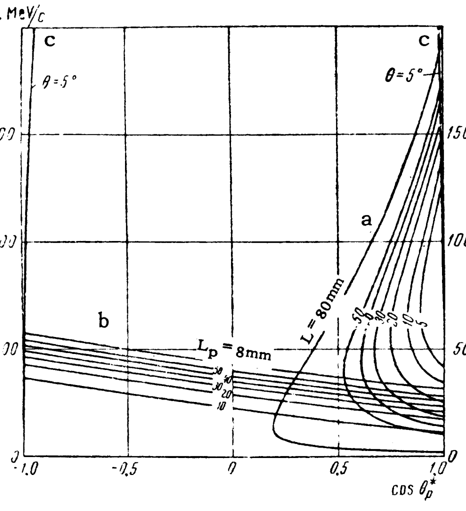
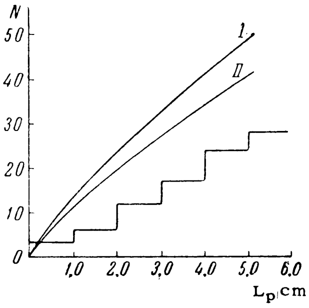


FIG. 4. Angle of emission of the protons from $\Lambda$ decays in the $\Lambda$ rest system relative to the direction of the $\Lambda$ momentum as functions of $p_\Lambda$ ($\Lambda$ hyperon l.s. momentum – curves a) and $L_p$ (proton range – curves b) and as functions of $p_\Lambda$ and the angle $\theta$ between the proton and meson (curves c). The numbers on curves a and b denote the range of the $\pi^-$ mesons and protons in propane.

In several experiments it was assumed that no $V^0$ particles with $\pi^-$-meson ranges less than some value $L_{\pi^-}$ are observed. The choice of the value of $L_{\pi^-}$, however, was made quite arbitrarily. This usually leads to an underestimation of the number of overlooked events. With increasing $L_{\pi^-}$ the number of events with a $\pi^-$-meson range less than $L_{\pi^-}$ increases rapidly (Fig. 5), but at the same time the probability of overlooking these events in the scanning decreases. The curves in Fig. 5 were calculated on the basis of the kinematics of the $\Lambda$-decay and the experimental momentum spectrum under the assumption that the protons from the $\Lambda$ decays are distributed either isotropically (i.e., $\alpha\bar{P} = 0$) or anisotropically with a value $\alpha\bar{P} = -0.2$. The experimental histogram was constructed on the basis of the observed $\Lambda$ decays in which the $\pi^-$ stopped in the fiducial volume of the chamber. Comparison of these curves with the experimental distribution has meaning only up to $L_{\pi^-} \lesssim 5$ cm, since for $L_{\pi^-} > 5$ cm most of the $\pi^-$ mesons escape from the chamber. It is seen from Fig. 5 that the scanning efficiency reaches the usual value when $L_{\pi^-} \approx (3-4)$ cm. The difference in ordinates between the experimental and theoretical curves corresponds to the loss of $\Lambda$ hyperons ($N = 24 \pm 8$ with $\alpha\bar{P} = 0$). It is seen that events are missed even if $\alpha\bar{P} = -0.2$ ($N = 16 \pm 7$).

FIG. 5. Number of $\Lambda$ hyperons with $\pi^-$ mesons of short range (integral distribution). Curves I and II were calculated under the assumptions that $\alpha\bar{P}_1 = 0$ and $-0.2$, respectively.



A correction for the missing of $V^0$ events as a result of the small opening angles between the decay products was introduced for angles up to $\theta = 5°$, since for larger angles a $V^0$ event is easily distinguished from a $\gamma$ quantum. The correction for small opening angles is very small when the momentum is low and amounts to ~ 2% for a $\Lambda$ momentum of 2 BeV/c.

We calculated the lifetimes of the $\Lambda$ hyperons from the first and second groups in Table I. The results are shown in Table III.

The difference obtained for the lifetimes cannot be accounted for by events which should be added to the first and second groups if the foregoing corrections are taken into account. The difference in

**Table III**

| $V^0$ particle group | $\tau_\Lambda$, $10^{-10}$ sec | $\tau_{K_1^0}$ $10^{-10}$ sec |
|---|---|---|
| 1) Protons ($\pi^+$) from $\Lambda$ ($K^0$) decay emitted forward | $2.35^{+0.46}_{-0.33}$ | $1.04^{+0.16}_{-0.12}$ |
| 2) Protons ($\pi^+$) emitted backward | $3.18^{+0.66}_{-0.48}$ | $0.95^{+0.14}_{-0.11}$ |
| 3) Total | $2.78^{+0.38}_{-0.30}$ | $0.99^{+0.10}_{-0.08}$ |

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[3] See [11] for a detailed discussion on $\alpha\bar{P}$.

the lifetimes is rather surprising (if it is not due to statistical fluctuations). For comparison, the lifetimes of the two groups of $K^0$ mesons are shown in Table III.

## SOME CHARACTERISTICS OF THE Λ AND $K^0$ PRODUCTION PROCESS

In this article we shall discuss only certain characteristics of the Λ and $K^0$ production process in hydrogen without their detailed analysis.[4] We will need them for the study of the dependence of the Λ polarization on the conditions of production. Of 1050 $V^0$ events we identified 327 Λ hyperons and 596 $K^0$ mesons on the basis of the kinematics, ionization, interactions of positive particles, and δ electrons, while 127 cases were unidentifiable (Λ or $K^0$ particles). Since Λ hyperons constitute 90% of the unidentified cases, we hereafter include them in the Λ hyperon statistics. The momentum and angular distributions of the Λ and $K^0$ particles are shown in Figs. 6 and 7.

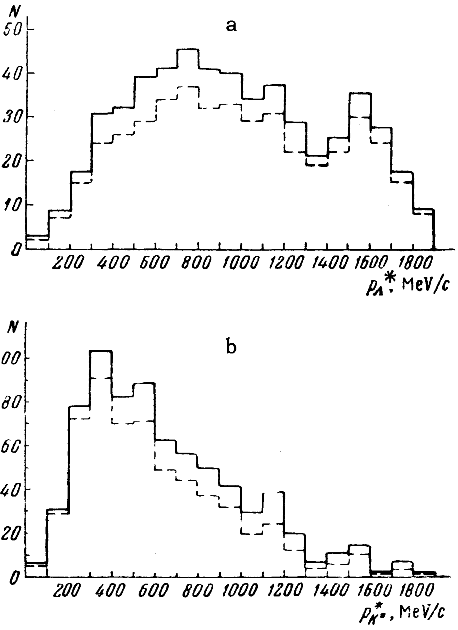

FIG. 6. C.m.s. momentum distribution of Λ hyperons (a) and $K^0$ mesons (b). The dashed line represents the distribution without correction for scanning loss of $V^0$ particles; the solid line represents the corrected distribution.

## ANGULAR DISTRIBUTIONS OF PROTONS FROM Λ DECAYS

Longitudinal polarization of Λ hyperons in production would indicate the violation of parity conservation in strong interactions involving strange particles. A longitudinal polarization of Λ hyperons would be manifested in the angular distribution of the protons from the Λ decays. It should be kept in mind, however, that in the experimental study of the angular distribution of the Λ-hyperon decay products, the factors enumerated above (scanning efficiency for different types of decay, missing of Λ particles with $\pi^-$ mesons of short range, $K^0$ background, etc.) generally act in one direction and distort the true angular distribution. A reliable estimate of the necessary corrections can therefore be made only with a sufficient number of analyzed events.

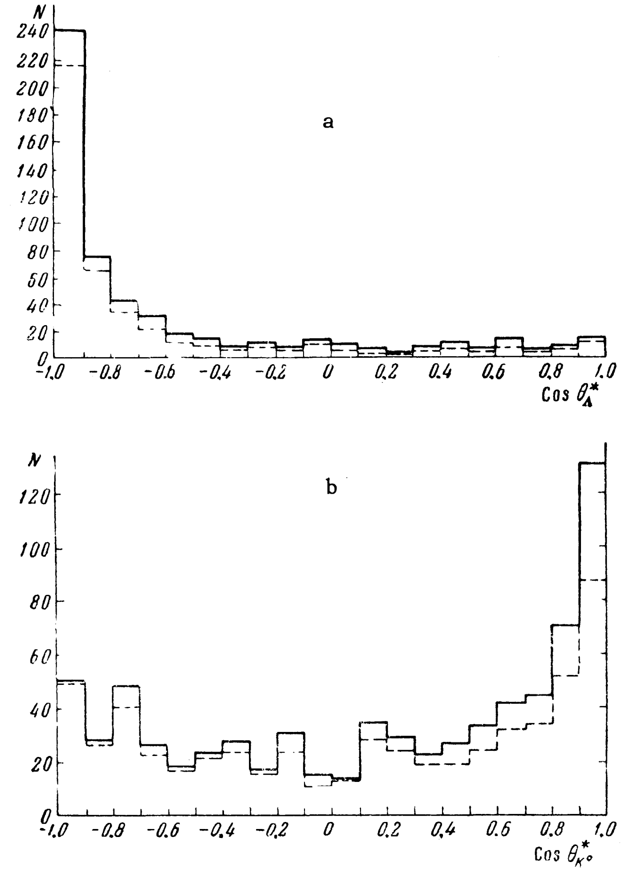

FIG. 7. C.m.s. angular distributions of Λ hyperons (a) and $K^0$ mesons (b). The notation is the same as in Fig. 6.

The coordinate system in which the angular distribution of the protons from the Λ decays is studied is shown in Fig. 8 (the distribution of $\pi^+$

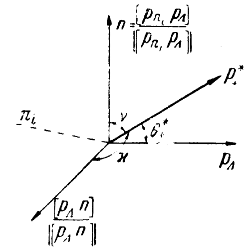

FIG. 8. Coordinate system for the study of the angular distribution of protons and $\pi^+$ mesons from Λ and $K^0$ decays.

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[4] For a detailed discussion of Λ and $K^0$ production in hydrogen see [24].

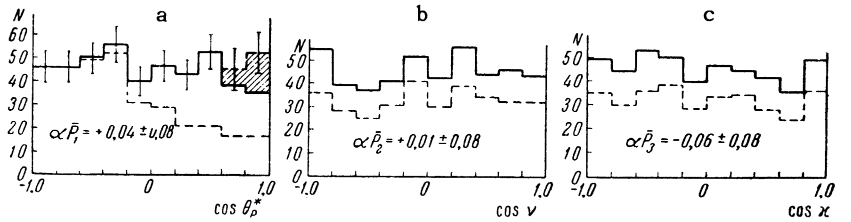

FIG. 9. Angular distribution of protons from Λ-hyperon decays (in the Λ rest system): a – forward-backward ($\cos\theta_p^*$), b – up-down ($\cos\nu$), and c – left-right ($\cos\varkappa$).

mesons from $K^0$ decays is considered in the same coordinate system).

The angular distribution of protons from the decay of Λ hyperons can be written analytically in the form $(1 + \alpha\bar{P}\xi)$ and is shown in Fig. 9. In the $\cos\theta_p^*$ (forward-backward) distribution corrections have been made for the unidentified cases (the region above the dashed line) and for the loss of Λ hyperons with $\pi^-$ mesons of short range (shaded region). Only the unidentified events are taken into account in the $\cos\nu$ and $\cos\kappa$ distributions. No correction was made for the loss of Λ hyperons with $\pi^-$ mesons of short range, since their effect on these distributions is negligible.

The quantity $\alpha\bar{P}$ was calculated from the well-known formulas

$$\alpha\bar{P} = 2(N_+ - N_-)/N \pm \sqrt{3/N}, \tag{1}$$

where $N_+$ is the number of events with $\xi > 0$; $N_-$ is the number of events with $\xi < 0$; $N = N_+ + N_-$; $\xi = (\cos\theta^*_-, \cos\nu, \cos\kappa)$;

$$\alpha\bar{P} = 3\bar{\xi} \pm \sqrt{3/N}, \tag{2}$$

where N is the number of events over the entire interval of $\xi$, and $\bar{\xi} = \sum_{i=1}^{N} \xi_i/N$.

The value of $\alpha\bar{P}$ can also be calculated by the maximum likelihood method for the entire interval of values of $\xi$ as well as for part of the interval contained within some limits a and b. In the latter case the maximum likelihood function is written in the following form:

$$f(\alpha\bar{P}) = \frac{W(\alpha\bar{P})}{W(\alpha\bar{P} = 0)} = \prod_{i=1}^{N} \frac{1 + \alpha\bar{P}\xi_i}{1 + \alpha\bar{P}(a + b)/2},$$

where N is the number of events in the interval a, b. The values of $\alpha\bar{P}$ calculated from formulas (1) and (2) and the maximum likelihood method for different intervals a, b (see Fig. 10) are shown in Table IV. The results obtained for all Λ hyperons are in agreement with the value zero for the quantities $\alpha\bar{P}_1$, $\alpha\bar{P}_2$, and $\alpha\bar{P}_3$.

The angular distributions for different conditions of Λ-hyperon production were also studied in [28-30].

1) Investigation of the dependence of the quantity $\alpha\bar{P}_1$ on the Λ-hyperon l.s. momentum. For Λ hyperons whose momentum falls in the interval $400 \le P_\Lambda \le 1200$ MeV/c, the value $\alpha\bar{P}_1 = -0.07 \pm 0.12$ was obtained.

2) Two groups of Λ hyperons are noted in the Λ-hyperon c.m.s. momentum distribution (Fig. 6).[31] One group with momentum up to 1300 MeV/c is well described by a curve calculated from statistical theory; a second group, with momentum greater than 1300 MeV/c, deviates from this curve.

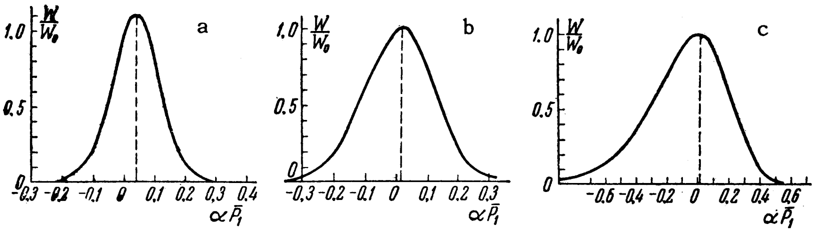

FIG. 10. Probability function for the quantity $\alpha\bar{P}_1$ in the intervals: a) $-1 \le \cos\theta_p^* \le +1$, b) $-1 \le \cos\theta_p^* \le +0.6$, and c) $-1 \le \cos\theta_p^* \le 0$.

Table IV

| | Eq. (1) | Eq. (2) | Maximum likelihood method | | |
|---|---|---|---|---|---|
| | | | $a = -1$<br>$b = +1$ | $a = -1$ :<br>$b = +0.6$ | $a = -1$<br>$b = 0$ |
| $\alpha\bar{P}_1$ | $+0.02 \pm 0.08$<br>(477) | $+0.04 \pm 0.08$<br>(477) | $+0.04 \pm 0.07$<br>(477) | $+0.02 \pm 0.11$<br>(379) | $+0.01 \pm 0.24$<br>(237) |
| $\alpha\bar{P}_2$ | $-0.01 \pm 1.08$<br>(453) | $+0.01 \pm 0.08$<br>(453) | — | — | — |
| $\alpha\bar{P}_3$ | $-0.09 \pm 0.08$<br>(453) | $-0.06 \pm 0.08$<br>(453) | — | — | — |

Note: The number of investigated cases is shown in parentheses.

The calculated values of $\alpha\bar{P}_1$ for these groups differ somewhat.

$$\alpha\bar{P}_1 = +0.14 \pm 0.09 \text{ for } p^*_\Lambda \leqslant 1300 \text{ MeV}/c,$$
$$\alpha\bar{P}_1 = -0.19 \pm 0.15 \text{ for } p^*_\Lambda > 1300 \text{ MeV}/c.$$

3) It can be seen from the angular distribution characterizing the production of Λ hyperons (Fig. 7) that most of the Λ hyperons (~ 80%) are emitted backward in the c.m.s.

For the two groups of Λ hyperons we found

$$\alpha\bar{P}_1 = -0.09 \pm 0.13 \text{ for } -1.0 \leqslant \cos\theta^*_\Lambda \leqslant -0.9,$$
$$\alpha\bar{P}_1 = +0.06 \pm 0.17 \text{ for } -0.5 \leqslant \cos\theta^*_\Lambda \leqslant +1.0.$$

The calculated values of $\alpha\bar{P}_1$ for different angular intervals do not differ from zero within the limits of statistical error.

The dependence of the quantity $\alpha\bar{P}_1$ on the maximum Λ-hyperon l.s. momentum and on the minimum production angle in the c.m.s. is shown in Fig. 11.

4) We calculated the values of $\alpha\bar{P}_1$ for groups of Λ hyperons produced in stars with different numbers of charged particles ($n_s$):

$$\alpha\bar{P}_1 = +0.15 \pm 0.10 \text{ for } n_s = 0;\ 2,$$
$$\alpha\bar{P}_1 = -0.25 \pm 0.15 \text{ for } n_s = 4;\ 6.$$

## ANGULAR DISTRIBUTIONS OF THE Λ-HYPERON PRODUCTION PLANES

The angular distributions of the Λ-hyperon production planes relative to the production plane of any definite particle can provide evidence of the conservation or nonconservation of parity in strong interactions.[5-32]

1) The angular distribution of the Λ-hyperon production planes relative to $K^0$-meson production planes from interactions in which a Λ and $K^0$ pair are recorded in the fiducial region of the chamber is shown in Fig. 12. The ratio of the number of Λ hyperons emitted upward to the number emitted downward is

$$37/30 = 1.23 \pm 0.30 \quad \text{(uncorrected)}$$
$$120/140 = 1.15 \pm 0.24 \quad \text{(corrected)}$$

Monte-Carlo calculations gave complete isotropy. The hypothesis that the $\omega_{\Lambda K^0}$ distribution (see Fig. 12) is isotropic was checked against the experimental distribution by the $\chi^2$ test. It was found that

$$\chi^2 = 5.37, \quad p(\chi^2 > 5.37) = 36\% \quad \text{(uncorrected)}$$
$$\chi^2 = 5.25, \quad p(\chi^2 > 5.25) = 38\% \quad \text{(corrected)}$$

(for five degrees of freedom).

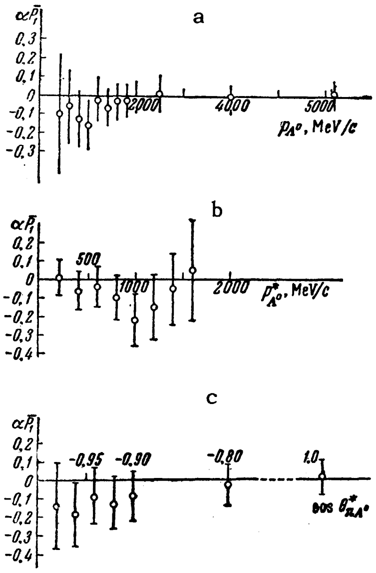

FIG. 11. Dependence of the asymmetry coefficient $\alpha\bar{P}_1$ (forward-backward) on: a) maximum l.s. momentum of the Λ hyperons, b) minimum c.m.s. momentum of the Λ hyperons, and c) maximum value of cos $\theta^*_\Lambda$.

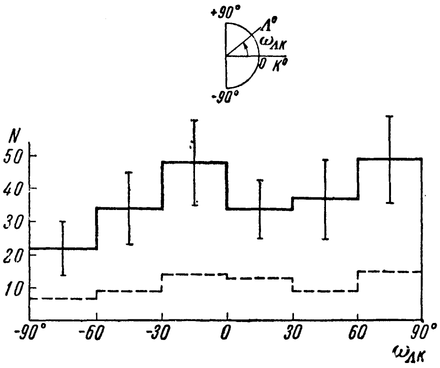

FIG. 12. Angular distribution of the Λ-hyperon production planes relative to the $K^0$-production planes. The dashed line represents the distribution without corrections for the scanning loss and the geometry of the chamber; the solid line is the corrected distribution.

2) The angular distribution of the Λ-hyperon production planes relative to the $\pi^-$-meson production planes from two-prong stars is shown in Fig. 13a.

The ratio of the number of Λ hyperons emitted upward to the number emitted downward relative to the $\pi^-$-meson production plane is 1.28 ± 0.18. If it is assumed that the $\omega_{\Lambda\pi^-}$ distribution is isotropic, then $\chi^2 = 7.80$ (for five degrees of freedom), i.e., $p(\chi^2 > 7.8) = 17\%$.

The distribution of the production planes of positive particles is given in Fig. 13b. This distribution is not entirely unambiguous, since the production plane of positive particles can include both $\pi^+$ and $K^+$ mesons (in most cases the $\pi^+$ and $K^+$ cannot be identified).

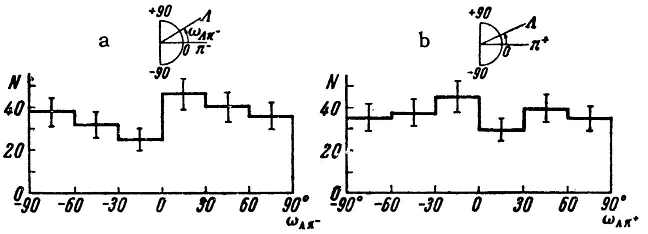

FIG. 13. Angular distribution of the Λ-hyperon production planes relative to the $\pi^-$-meson production planes (a) and $\pi^+$ ($K^+$)-production planes (b).

## CONCLUSIONS

1. No asymmetry is observed in the angular distributions of protons from Λ decay in the Λ rest system relative to the Λ-hyperon momentum. The values of $\alpha\bar{P}_1$, $\alpha\bar{P}_2$, and $\alpha\bar{P}_3$ are equal to zero, which indicates the absence of polarization of Λ hyperons in production. No dependence of the values of $\alpha\bar{P}_1$ on the l.s. momentum and c.m.s. production angle was found. No definite conclusion can be made regarding the existence of a dependence of $\alpha\bar{P}_1$ on the Λ-hyperon momentum in the c.m.s. of the initially interacting particles ($\pi^-p$) and on the multiplicity $n_s$; for this, increased statistics are necessary.

2. The angular distributions of the Λ-hyperon production planes relative to the production planes of definite particles are close to isotropic.

For our sample of Λ particles, no deviation from parity conservation in strong interactions involving strange particles was observed.

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