INVESTIGATION OF Λ-HYPERON AND K^0*-MESON PRODUCTION IN* π^-p *INTERACTIONS AT* 7–8 GeV

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The c.m.s. momentum and angular distributions of Λ hyperons and K^0 mesons and of pions involved in the production of Λ and K^0 particles are presented. The experimental distributions are compared with those computed by statistical theory and one-meson graphs. The angular and momentum distributions of particles accompanying the production of $K^0\bar{K}^0$ pairs are compared with those of particles created in π^-p interactions at 7 GeV without strange-particle production. It is concluded that π^-p interactions involving the creation of ΛK^0 and $K^0\bar{K}^0$ pairs are more central than the π^-p interaction with the usual type of multiple pion production. The π^-p interaction with strange particle production can be separated into two groups which we call central and peripheral interactions.

THE production of $\Lambda(\Sigma^0)$ hyperons and K^0 mesons in π^-p interactions at 7–8 GeV has been studied[2)] with the aid of a 24-liter propane bubble chamber with a constant magnetic field of 13,700 Oe. Part of the results of this work have been reported earlier.[1-4] The experimental arrangement has been described in [5]. The Λ and K^0 particles were considered to be produced in π^-p interactions if the following criteria were fulfilled:

1) In the star to which the Λ hyperon or K^0 meson (ΛK^0 or $K^0\bar{K}^0$ pair) belongs no proton evaporation tracks were observed;

2) The net charge of all secondary particles is zero.

3) No more than one baryon (Λ, Σ, p) is observed in the star.

4) The target mass[3)] is smaller or equal to the proton mass.[6]

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[2)]Here we combine the results of two experiments with π^--meson momenta 6.8 and 8 GeV/c.

[3)]The target mass is given by the expression

$$m_t = \sum_{i=1}^{N} E_i - p_i \cos\theta_i,$$

where E_i, p_i, and θ_i are the energy, momentum, and angle of emission for the i-th particle in the l.s.

Table I

Event	n_s 0	2	4	6	Total
Λ	43	155	66	7	271
$\Lambda \sim K^0$	9	59	25	4	97
$\Lambda + K^0$	20	25	9	0	54
$\Lambda \sim K^0 + K^0$	3	12	2	0	17
K^0	56	255	134	15	460
$K^0 + \bar{K}^0$	8	28	4	0	40
Total	139	534	240	26	939

All measurements were made on UIM-21 microscopes. The calculation of the geometrical characteristics of the track and the kinematic analysis of V^0 events and other calculations were performed on electronic computers with a special program.

The results of the selection of events by the foregoing criteria and their analysis are given in Table I for the various multiplicities. A special analysis of the unidentified (Λ or K^0) particles showed[7] that 90% constitute Λ hyperons, and therefore all unidentified cases will hereafter be classified as Λ hyperons. In Table II the experimental distributions of stars with Λ hyperons and K^0 mesons are compared with the statistical theory calculations for the various multiplicities. The number of Λ and K^0 particles in different production channels is shown in Table III.

Table II

n_s	Λ: No. of events	Λ: Percentage of total number of stars, obs.	Λ: Percentage of total number of stars, theory	K^0: No. of events	K^0: Percentage of total number of stars, obs.	K^0: Percentage of total number of stars, theory
0	75	17.1±2	12	87	15±1.6	16
2	251	57.2±3.6	68	320	56±3.1	66
4—6	113	25.7±2.2	20	164	29±2.2	18
$\bar{n}_s$ observed	2.22±0.13			2.32±0.11		
$\bar{n}_s$ theory	2.22 (without isobars)			—		

Table III

Channels	No. of events after correction	No. of strange particles actually observed: Λ	No. of strange particles actually observed: K^0	Correction	Λ-hyperons	K^0-mesons
$\Lambda(\Sigma^0)+K^0$	702±88	287	154	for scanning eff.	1.06	1.06
$\Lambda(\Sigma^0)+K^+$	354±83	145	—	for probability of recording V^0 events in fiduc. region of chamber	1.22	1.27
$K^0+\overline{K^0}$	750±125	—	328	for dependence of recording eff. on azimuthal angle[3]	1.26	1.13
$K^0+K^-(\Sigma^\pm)$; K^0+K^+	538±220	—	118	for neutral decay channels	1.50	3.00

Λ HYPERONS

We studied Λ hyperons from the reactions

$$\pi^- + p \rightarrow \Lambda(\Sigma^0) + K^0 + n\pi, \quad (1)$$

$$\pi^- + p \rightarrow \Lambda(\Sigma^0) + K^+ + n\pi \quad (2)$$

(Λ hyperons from Σ^0-hyperon decays were not separated). The Λ-hyperon momentum spectrum in the π^-p c.m.s. is shown in Fig. 1d. The Λ-hyperon c.m.s. momentum distribution curves calculated from the statistical theory are shown in the same figure. It is seen that the experimental momentum distribution has an excess of Λ particles in the region of large momenta p_Λ^* in comparison with the statistical theory distribution. The deviation of the experimental momentum distribution for Λ hyperons from the statistical curves cannot be attributed to the contamination from interactions on carbon.[10] Analysis of events with Λ-hyperon momenta greater than 1.3 GeV/c showed that they are characterized by small values of the 4-momentum Δ:[4]

$$\Delta^2 = \boldsymbol{\Delta}^2 - \Delta_0^2, \qquad \boldsymbol{\Delta} = \mathbf{p}_p - \mathbf{p}_\Lambda, \qquad \Delta_0 = E_p - E_\Lambda$$

(p_p, p_Λ, E_p, E_Λ are the momenta and energy of the protons and Λ hyperons). The momentum distribution of Λ hyperons is well described by statistical theory without isobar formation (Fig. 1d, curve II′) if we disregard cases with $\Delta < 700$ MeV (they constitute ~ 30% of all Λ hyperons). Interactions with $\Delta < 700$ MeV will be called peripheral. The Δ distribution is shown in Fig. 2.

The Λ hyperon c.m.s. angular distribution (Fig. 3) has a sharp peak corresponding to backward emission ($\overrightarrow{n}_\Lambda/\overleftarrow{n}_\Lambda = 0.18 \pm 0.02$). As has been shown earlier,[1,2] most of the Λ hyperons preserve the c.m.s. direction of motion of the proton before the interaction. This has been noted for Λ hyperons produced in hydrogen by π^- mesons at other energies.[11,13]

A change in the characteristics of the momentum distribution for Λ hyperons as a function of the charged-particle multiplicity can be seen from Figs. 1a, b, and c. The shaded region indicates cases with $\Delta < 700$ MeV. With increasing multiplicity n_s, the agreement between the experimental distribution and the statistical curve improves, since the fraction of cases with $\Delta < 700$ MeV decreases. The angular distribution of Λ hyperons and the $p_\perp$ distribution are practically independent of n_s. The mean value of the transverse momentum for Λ hyperons is 383 ± 12 MeV/c, where $\bar{p}_{\Lambda\perp} = 295 \pm 14$ MeV/c for cases with $\Delta < 700$ MeV and $\bar{p}_{\Lambda\perp} = 423 \pm 18$ MeV/c for cases with $\Delta \geq 700$ MeV.

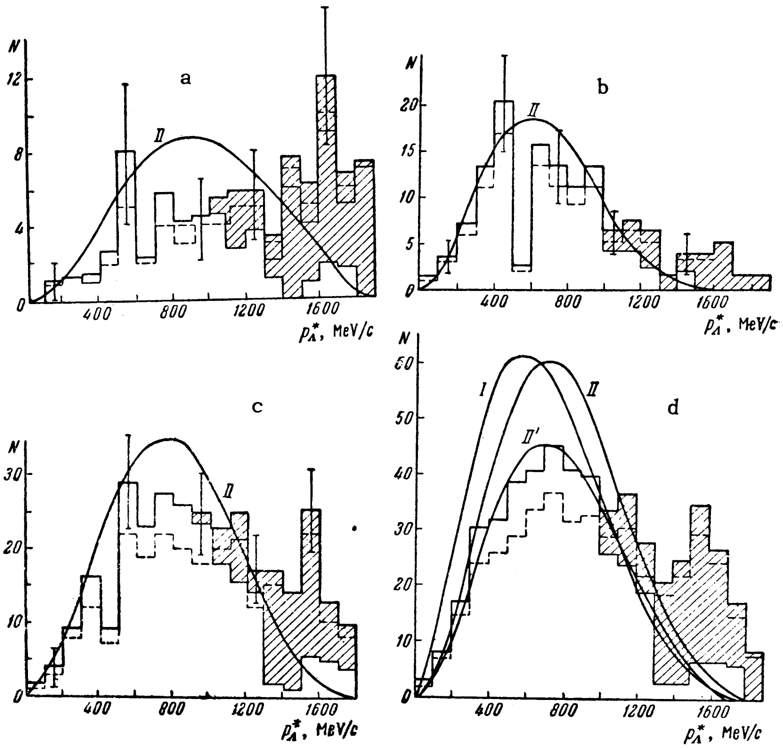


FIG. 1. Λ-hyperon c.m.s. momentum spectra: a – zero-prong stars, b – two-prong stars, c – stars with 4-6 prongs, d – overall spectrum. The shaded region refers to cases with Δ < 700 MeV. The dashed line denotes the spectra without correction for probability of recording Λ hyperons in the fiducial volume of the chamber. The smooth curves are the results of statistical theory calculations: curve I – with isobar production, II and II′ – without the Y* (ref. 8) and K* (ref. 9) isobars. Curves I and II are normalized to the entire area of the histogram, curve II′ is normalized to the area of the histogram without cases with Δ < 700 MeV.

$K^0(\bar{K}^0)$ MESONS

We studied $K^0(\bar{K}^0)$ mesons from the reactions

$$\pi^- + p \to \begin{cases} K^0 + \Lambda(\Sigma^0) + n\pi, & (1) \\ K^0 + \bar{K}^0 + N + n\pi, & (3) \\ K^0 + K^- + N + \pi n, & (4) \\ \bar{K}^0 + K^+ + N + n\pi, & (5) \\ K^0 + \Sigma^\pm + n\pi. & (6) \end{cases}$$

The overall momentum spectrum for $K^0(\bar{K}^0)$ mesons from reactions (1), (3)—(6) in the c.m.s. is shown in Fig. 4. Curves giving the $p^*_{K^0}$ distribution calculated from statistical theory are shown in the same figure. The experimental spectrum of the K^0 mesons is softer than the theoretical, in contrast to the Λ-hyperon spectrum. In the 200—400 MeV/c interval there is a surplus of events in comparison with the statistical distribution.

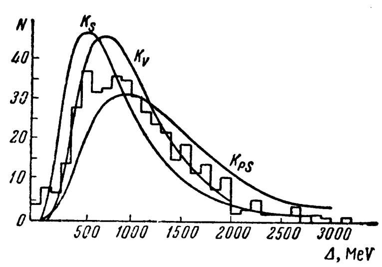


FIG. 2. Distribution of the momentum transfer Δ. The curves K_{PS}, K_S, K'_V are the results of calculations by the one-meson graphs with the exchange of pseudoscalar and scalar K mesons and a vector K′ meson, respectively.

The K^0 meson angular distribution is shown in Fig. 5d. Apart from the isotropic part, there is a peak corresponding to forward emission ($\vec{n}_{K^0}/\overleftarrow{n}_{K^0}$ = 1.61 ± 0.15). It can be seen from Figs. 5a, b and c that the angular distributions for K^0 mesons change with the multiplicity of the charged particles. For zero-prong and two-prong stars the K^0 angular distribution has a distinct peak corresponding to forward emission: the ratio of the num-

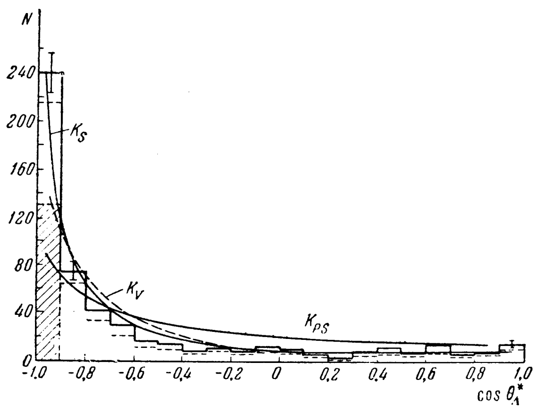


FIG. 3. C.m.s. angular distribution of Λ hyperons. The shaded region denotes cases with Δ < 700 MeV. The dashed line denotes the distribution without correction for the probability of recording Λ hyperons in the fiducial volume of the chamber. The curves K_{PS}, K_S, K'_V are the results of the calculations with the one-meson graphs with the exchange of pseudoscalar and scalar K mesons and a vector K′ meson, respectively.

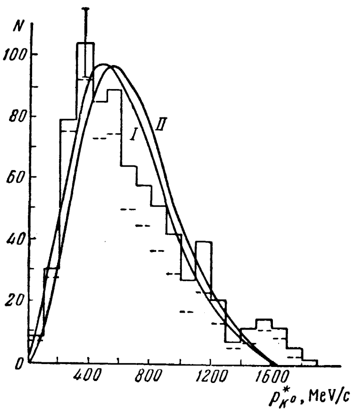


FIG. 4. C.m.s. momentum spectrum of K^0 mesons. The dashed line denotes the spectrum without correction for the probability of recording K^0 mesons in the fiducial volume of the chamber. The smooth curves are the results of statistical theory calculations: I – with isobar production, II – without Y*, N*, and K* isobars.

ber of K^0 mesons emitted forward to the number emitted backward is $\vec{n}_{K^0}/\overleftarrow{n}_{K^0} = 2.6 \pm 0.52$ for $n_s = 0$ and $\vec{n}_{K^0}/\overleftarrow{n}_{K^0} = 1.70 \pm 0.17$ for $n_s = 2$. For n_s equal to 4 and 6 we find $\vec{n}_{K^0}/\overleftarrow{n}_{K^0} = 1.05 \pm 0.15$, i.e., the distribution is isotropic. The character of the $p_{K^0\perp}$ distribution varies little as a function of n_s. For the mean value we obtain $\bar{p}_{K^0\perp} = 384 \pm 11$ MeV/c.

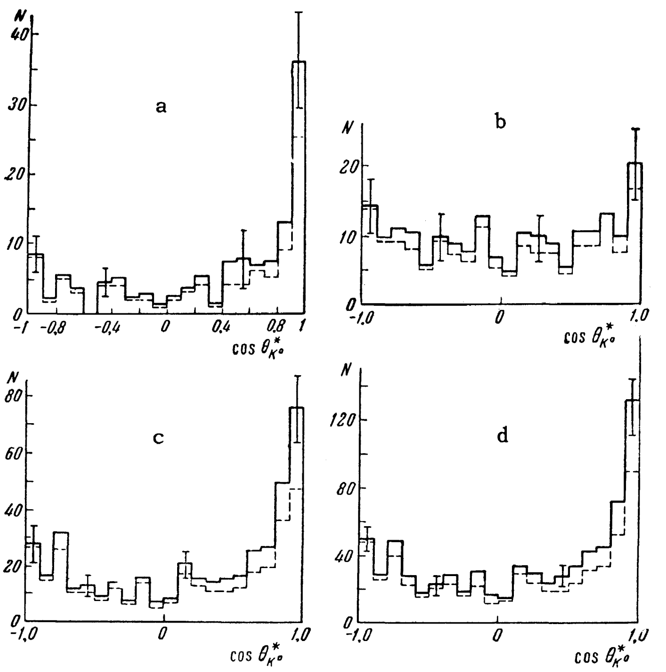


FIG. 5. C.m.s. angular distributions of K^0 mesons for stars of various multiplicity: a – for $n_s = 0$, b – for $n_s = 2$, c – for $n_s = 4$ and 6, d – for all stars. The dashed line denotes the distribution without correction for the probability of recording K^0 mesons in the fiducial volume of the chamber.

π MESONS FROM π^-p INTERACTIONS WITH THE PRODUCTION OF Λ HYPERONS

The c.m.s. momentum distributions for π^- and π^+ mesons for stars in which a Λ hyperon is produced are shown in Fig. 6. Also shown there for comparison are the curves calculated from the statistical theory without Y* and K* isobar production. It can be seen that these curves well describe part of the spectrum with $p^*_\pi \geq 400$ MeV/c. In the region with $p^*_\pi < 400$ MeV/c the experimental distribution rises above the theoretical.

The π^+- and π^--meson angular distributions are given in Fig. 7. They can be characterized by the ratios ($n_s = 2, 4, 6$)

$$\vec{n}_{\pi^+}/\overleftarrow{n}_{\pi^+} = 1.10 \pm 0.12, \qquad \vec{n}_{\pi^-}/\overleftarrow{n}_{\pi^-} = 1.40 \pm 0.13.$$

In the identification of charged particles accompanying the production of Λ hyperons in reactions (1) and (2), it was kept in mind that the negative particles could be only π^- mesons, while the positive particles could be only π^+ mesons or K^+ mesons. Only a small part of K^+ mesons, with l.s. momentum to 500 MeV/c, were separated on the basis of the ionization. The remaining positive particles were transformed to the c.m.s. under the assumption that they were pions; their momentum and angular distributions are shown in Figs. 6 and 7 by the dashed lines. These distributions were then checked for the K^+ contamination (which was estimated from the data of Table III on the basis of the momentum and angular distributions of K^0 mesons[4)] transformed to the c.m.s. under the same assumptions).

In the investigation of π^-p interactions with the production of Λ hyperons we also studied γ rays from π^0-meson decays. The mean number of π^0 mesons per π^-p interaction with the production of a Λ hyperon[5)] was found to be 1.23 ± 0.14.

CHARGED PARTICLES FROM π^-p INTERACTIONS WITH THE PRODUCTION OF $K^0(\bar{K}^0)$ MESONS

The analysis of charged particles accompanying the production of $K^0(\bar{K}^0)$ mesons in reactions (3) –(5) is made difficult by the impossibility of distinguishing π^+, K^+ mesons, and protons as well

[4)]It was assumed that the momentum spectrum and the angular distribution of the K^+ mesons from ΛK^+ pairs were identical to the K^0-meson distributions from ΛK^0 pairs.

[5)]A detailed account on the production of π^0 mesons in stars with Λ hyperons and K^0 mesons will be published later.

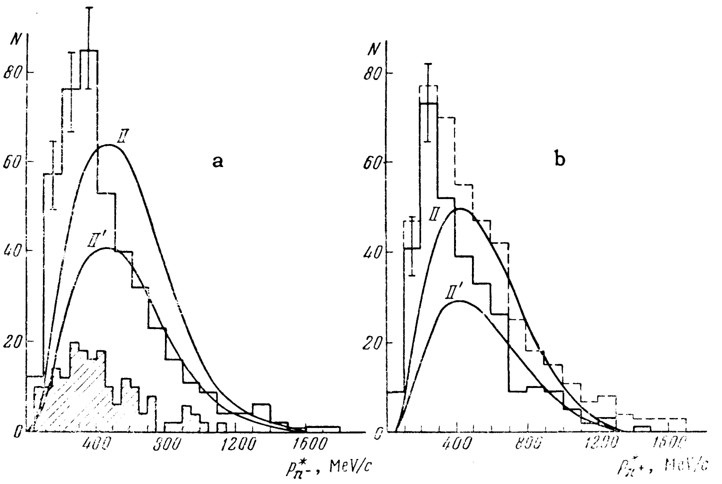


FIG. 6. C.m.s. momentum distribution from stars with Λ-hyperon production: a – π^- mesons, b – π^+ mesons. The shaded region denotes cases with $\Delta < 700$ MeV. The dashed line represents the distribution of all positive particles accompanying the production of Λ hyperons transformed to the c.m.s. as pions. The smooth curves represent the results of the statistical theory calculations without the Y*, and K* isobars. Curves II are normalized to the total area of the histogram, curves II′ are normalized to the area with $p_{\pi^\pm} > 400$ MeV/c.

as π^- and K^- mesons at large momenta (when the ionization of these particles is close to minimum).

The momentum and angular distributions of the π^- mesons is shown in Figs. 8 and 9 (solid line). The correction for the K^- contamination was made similarly to the correction for the K^+ contamination in the case of positive particles produced together with Λ hyperons. The distributions of all negative particles transformed to the c.m.s. as pions are shown by dashed lines. For the angular distribution of π^- mesons from stars with K^0 mesons, we found $\overrightarrow{n}_{\pi^-}/\overleftarrow{n}_{\pi^-} = 1.10 \pm 0.10$.

The positive particles which could not be identified were transformed to the c.m.s. of the π^-p system as pions and as protons. Figure 10 shows the momentum spectrum of all positive particles transformed to the c.m.s. as pions. Shown separately are the distribution of unidentified positive particles (π^+, K^+, p) and the distribution of unidentified mesons (π^+ or K^+) transformed to the c.m.s. as pions. The remaining part of the spectrum consists of identified π^+ mesons and positive particles from ΛK^0 pairs which were considered as π^+ mesons, since cases of production of more than two strange particles are very rare at our energies. The positive particles in the shaded region of Fig. 10a were transformed to the c.m.s. also as protons (Fig. 10b). The spectrum of the identified protons is shown in Fig. 10c.

The corresponding angular distributions of positive particles for the same stars are shown in Fig. 11. It is seen that π^+ mesons have a tendency to be emitted preferentially backward in the c.m.s.

DISCUSSION OF RESULTS

The mean number of charged particles produced together with Λ hyperons $\bar{n}_s = 2.22 \pm 0.13$ agrees well with the value $\bar{n}_s = 2.20$ calculated from statistical theory without the Y* and K* isobars, and is smaller than the value $\bar{n}_s = 3.2 \pm 0.2$ obtained

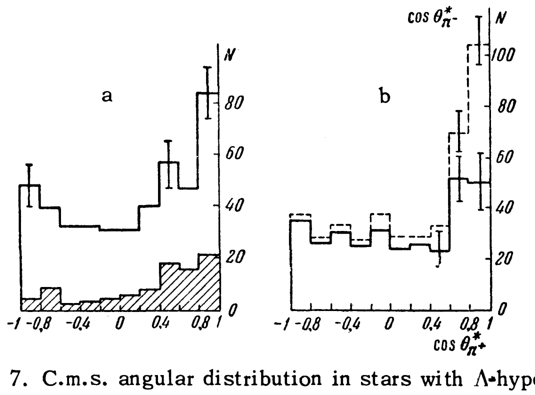


FIG. 7. C.m.s. angular distribution in stars with Λ-hyperon production: a – π^- mesons, b – π^+ mesons. The dashed line represents the distribution of all positive particles transformed into the c.m.s. under the assumption that the particles have the mass of pions. The shaded region represents the cases with $\Delta < 700$ MeV.

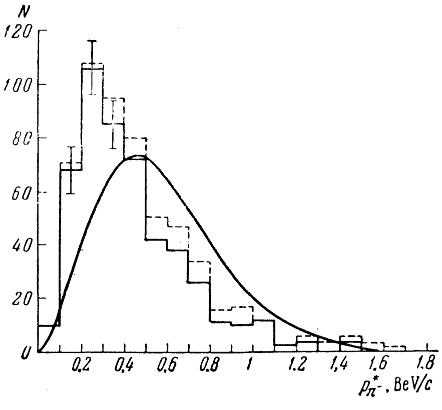


FIG. 8. C.m.s. momentum distribution of π^- mesons from stars with K^0 mesons. The dashed line represents the distribution of all negative particles transformed to the c.m.s. under the assumption that the particles are pions. The smooth curve represents the results of the statistical theory calculation without isobar production.

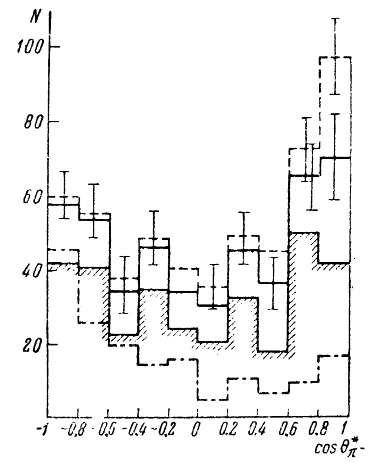


FIG. 9. C.m.s. angular distribution of π^- mesons from stars with K^0 mesons. The dashed line represents the distribution of of all negative particles accompanying the production of K^0 mesons transformed to the c.m.s. under the assumption that the particles are pions. The histogram with the shaded edge represents the angular distribution of π^- mesons from π^-p interactions with $K\overline{K}$-pair production. The dash-dotted lines represent the angular distribution of identified π^- mesons.

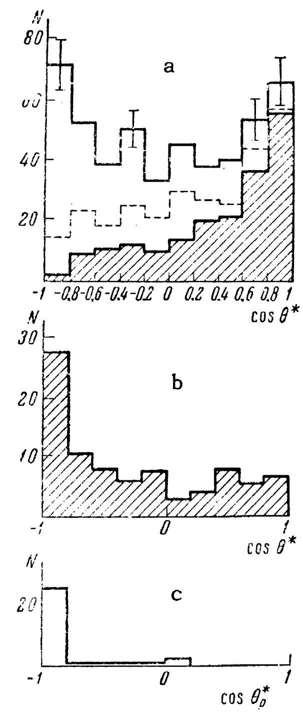


FIG. 11. C.m.s. angular distribution of positive particles from stars with K^0 mesons: a – for all positive particles under the assumption that they are pions; the shaded region represents the unidentified particles (π^+, K^+, p); the dashed line denotes the spectrum of π^+ or K^+ mesons; b – for unidentified particles under the assumption that they are protons; c – for identified protons.

for ordinary multiple production of pions in π^-p interactions at 7 GeV.[14] Table II shows that the experimental distributions of n_s for cases with Λ hyperons and K^0 mesons display the main features expected from the statistical-theory calculations. Most of the Λ and K^0 particles are produced in two-prong stars.

According to our calculations, within the limits of experimental error, we can write the following equation (see Table III) for the number of produced pairs:

$$N_{\Lambda(\Sigma^0)K^0} = 2N_{\Lambda K^+},$$
$$N_{K^0\overline{K}^0} = N_{K^0K^-} + N_{\overline{K}^0K^+}.$$

The $K^0\Sigma^\pm$-pair contamination is less than 20% of

FIG. 10. Momentum spectra of positive particles from stars with K^0 mesons: a – spectrum of positive particles transformed to the c.m.s. as pions; shaded region – spectrum of unidentified particles (π^+, K^+, p); dashed line – spectrum of unidentified particles (π^+, K^+); smooth curves – π^+-meson spectra calculated from statistical theory with (I) and without (II) Y*, N*, and K* isobar production; b – spectrum of unidentified particles transformed to the c.m.s. as protons; c – spectrum of identified protons.

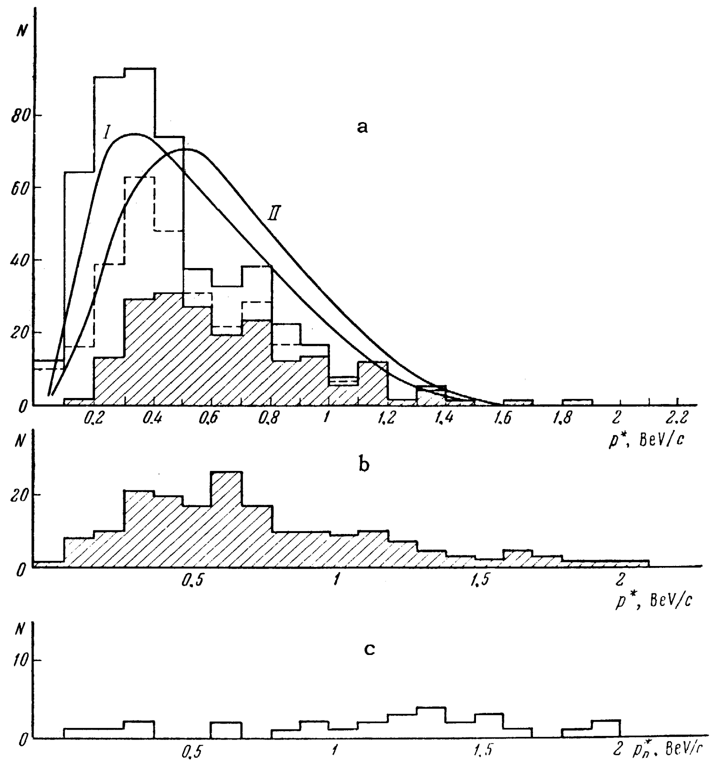


Table IV

	$\Delta < 700$ MeV	$\Delta \geqslant 700$ MeV		$\Delta < 700$ MeV	$\Delta \geqslant 700$ MeV
$\bar{p}^*_\Lambda$	1550 ± 76	772 ± 20	$\cos\theta^*_\Lambda$	-0.9680	-0.5114
$p_{\Lambda\perp}$	295 ± 14	423 ± 18	$\bar{p}^*_{\pi^-}$	436 ± 28	469 ± 18
$\bar{n}_s$	1.71 ± 0.24	2.46 ± 0.20	$\bar{p}_{\pi^-\perp}$	288 ± 23	322 ± 12

the number of $K^0K^- + \bar{K}^0K^+$ pairs. Comparison of the Λ-hyperon momentum distribution with the curve calculated from the statistical theory allows the separation of all cases involving the production of Λ hyperons into two groups, whose characteristics are shown in Table IV. The π^-p interactions involving the production of Λ hyperons in the group with $\Delta < 700$ MeV are called peripheral and those in the group with $\Delta \geq 700$ MeV are called central. The angular distribution of Λ hyperons from the second group is not, however, isotropic (see Fig. 3 without the shaded region) as follows from statistical theory. Moreover, most of the Λ hyperons (85%) in the isotropic part of the angular distribution of Fig. 3 have c.m.s. momenta up to 700 MeV/c, which does not agree with statistical theory.

In view of the fact that we were not able to separate part of the events for which the angular and momentum distributions would be described by statistical theory, we assumed that the basic contribution to the process of production of ΛK pairs for both groups comes from the one-meson Feynman graphs shown in Fig. 12. Since at the present time it is not possible to calculate these graphs accurately, we resort to a rather crude approximation, and therefore we should not expect more than a qualitative explanation of the observed phenomena from the calculations of the graphs. The graphs of Fig. 12 involve poorly known functions (for example the πK and ππ cross sections) of two independent relativistic-invariant variables Δ^2 and w (w is the total c.m.s. energy in the πK or ππ c.m.s.).

As a first approximation we calculated the p^*_Λ, $\cos\theta^*_\Lambda$, and Δ distributions with the use of the graph 1 and under the assumption that the functions change little over the range of the variables of interest to us; we therefore replaced them by constants. The calculated curves for the K-pseudoscalar (K_{PS}), K-scalar (K_S), and K′-vector (K'_V) theories are shown in Figs. 13, 2, and 3. The curves for the K_{PS} and K_S theories in Fig. 13 coincide. It can be seen that none of the theories describes the Λ hyperon c.m.s. momentum distribution satisfactorily. The agreement between the experimental data and the K_{PS} curve in the high-energy region of the Λ-hyperon spectrum (Fig. 13) can be obtained most simply within the framework of the one-meson approximations if the Kπ resonance [9] is taken into account in the energy dependence of the πK cross section in the 700—1000 MeV interval. Allowance for the energy dependence of the πK cross section at the upper vertex of graph I in this energy interval made it possible to obtain curve A of Fig. 13. Here, agreement with the experimental data is obtained with $\sigma_{\pi K\,res}/\sigma_{\pi K} \approx 5-7$.

Allowance for the dependence of the πK cross section on the energy in the 700—1000 MeV interval at the upper vertex of graph I in the K_{PS} theory gives the greatest contributions in the region of large negative values (from −0.9 to −1) of $\cos\theta^*_\Lambda$ in the angular distribution and in the region of $\Delta \approx 500$ MeV in the momentum transfer distribution for Λ hyperons, which are in qualitative agreement with the experimental data.

For graph III we calculated the p^*_Λ distribution under the assumption that the Λ and K particles are produced in a resonant state with a total energy 1.7—1.9 GeV. The corresponding curve is shown in Fig. 13—curve B.

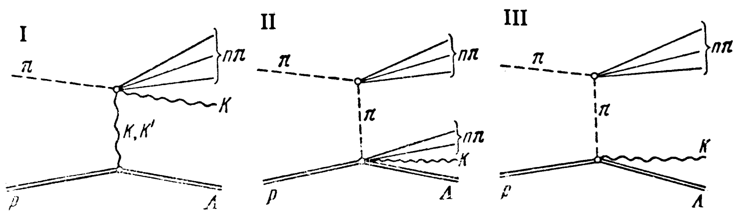


FIG. 12. One-meson graphs.

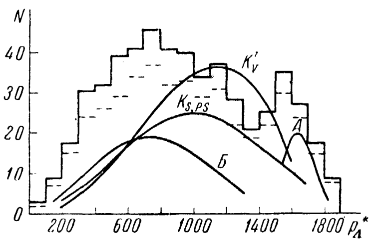


FIG. 13. C.m.s. momentum spectra of Λ hyperons. The smooth curves K_{PS}, K_S, K_V', A and B represent the results of calculations for the one-meson graphs I and III of Fig. 12. The dashes represent the Λ-hyperon spectrum without correction for the probability of recording events in the fiducial region of the chamber.

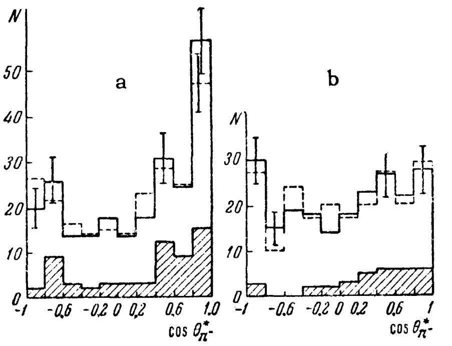


FIG. 14. C.m.s. angular distribution of π^- mesons from stars with Λ hyperons as a function of the multiplicity: a – for $n_s = 2$, b – for $n_s = 4$ and 6. The dashed line represents the angular distribution of π^- mesons from ordinary multiple production[14]: a – for $n_s = 4$, b – for $n_s = 6$ and 8. The shaded region represents cases with $\Lambda < 700$ MeV.

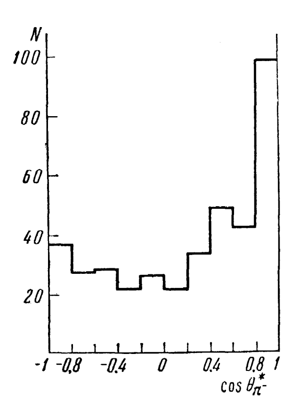
The π^-- and π^+-meson momentum distributions from π^-p interactions in which Λ hyperons are produced are consistent with each other with a probability of 68%:[6)]

$$\bar{p}_{\pi^+}^* = 425 \pm 16\text{MeV}/c, \qquad \bar{p}_{\pi^-}^* = 444 \pm 15\text{MeV}/c.$$

The π^+- and π^--meson angular distributions coincide with a probability of 35%. Hence the π^- mesons do not differ from the π^+ mesons as in the case of ordinary multiple production of pions in π^-p interactions at 7 GeV.[14]

Comparison of the π^--meson c.m.s. momentum spectra from π^-p interactions involving the production of Λ hyperons (Fig. 6a) and without the production of strange particles (Fig. 4 in [14]) shows that they differ in the region > 1100 MeV/c The π^--meson spectrum from stars with Λ hyperons in this region does not differ from the statistical curve II′, while in the spectrum p_π^*- spectrum from π^-p interactions without strange particles 10% of the cases extend beyond the corresponding statistical curve.[7)]

FIG. 15. C.m.s. angular distribution of π^- mesons from π^-p interactions with multiple production of pions at 7 GeV according to the data of [14].



In the comparison of the angular distributions of π^- mesons from π^-p interactions with the production of Λ hyperons (see Fig. 14) and ordinary multiple production, we can see that the angular distributions of π^- mesons from two-prong stars with Λ hyperons and from four-prong stars without the production of strange particles[8)] are in agreement and also that the angular distributions of π^- mesons from four- and six-prong stars with Λ hyperons and from six- and eight-prong stars without strange particles are also in agreement.[9)] The probability that the angular distributions of π^- mesons from two-prong stars for both types of π^-p interactions are the same is 0.03%.

Hence on the basis of the foregoing comparisons we can say that the processes involving the production of ΛK pairs are "more central" than processes of multiple production of pions at the same primary π^--meson energies.

A similar comparison of the c.m.s. angular distribution of π^- mesons accompanying the production of $K\bar{K}$ pairs (Fig. 9, shaded region) with the angular distribution of π^- mesons from ordinary multiple production (Fig. 15) leads to the conclusion that the $K\bar{K}$-pair production process is more central than the pion multiple production process. In favor of this conclusion is also the tendency for the preferential emission of π^+ mesons in the backward direction (Fig. 11) and the fact that the $K\bar{K}$ pairs are produced mostly together with fast ($p_p > 600$ MeV/c in the l.s.) nucleons.

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6)Estimated from the Kolmogorov-Smirnov test.[15]

7)The probability that 10% of the cases extend beyond the statistical curve by chance is equal to 0.09% according to the Kolmogorov-Smirnov test.

8)The possibility of agreement is 68% according to the Kolmogorov-Smirnov test.

9)The probability of agreement is 96% according to the Kolmogorov-Smirnov test.

In the l.s. proton spectrum from the reactions (3)—(5) up to 600 MeV/c, only 22 protons are present, i.e., 13% of the total number of protons,[10)] while the same part of the spectrum contains ~ 30% of the protons in the momentum spectrum from π^-p interactions with pion multiple production.[16]

A comparison of the angular distributions of the π^- mesons (in the c.m.s.) accompanying the production of $K\bar{K}$ pairs (Fig. 9, shaded region) and ΛK pairs (Fig. 8a), for which the probability of agreement is 13%,[11)] and the corresponding momentum spectra of protons and Λ hyperons in the l.s. in the momentum interval up to 600 MeV/c (13 and 24%, respectively, of the total spectrum) appears to indicate that the $K\bar{K}$ pairs are produced in more central collisions of π^- mesons with protons than the ΛK pairs.

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[10)] According to Table III we have ~400 interactions with the production of $K\bar{K}$ pairs from reactions (3)-(5). According to the statistical theory calculations, there should be ~170 protons.

[11)] According to the Kolmogorov-Smirnov test.

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