ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

Лаборатория ядерных проблем

D.V.Neagu, E.O.Okonov, N.I.Petrov, A.M.Rosanova, V.A.Rusakov

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HYPERON PRODUCTION ON LEAD NUCLEI BY K_2^0 MESONS WITH A MEAN ENERGY OF ABOUT 100 MeV.

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Hyperon production by the K_2^0 has been observed by several experimental groups. However, up to now there are no data on the effective cross sections for this process *.

The reaction of hyperon production by the K_2^0 has been studied by us along with investigating the K_2^0 decay properties in the K_2^0 meson beam from the Joint Institute synchrophasotron using the cloud chamber in the magnetic field. A lead plate 5.8 g/cm^2 thick served as a target. It was mainly meant for analyzing the charged products of the K_2^0 - decay by the momentum loss in a plate.

The experimental conditions were, in the main, favourable for recording the Λ° decays while the predominant part of the charged hyperons failed to leave the lead plate because of the ionization slowing down**.

During the exposure of the chamber with a lead plate 440 V° events were detected. Out of them 39 events were selected visually in which one of the tracks was identified as a proton by its track density and by the magnetic curvature (Fig. 1).

The number of Λ°-emitted 'forward' and 'backward' are practically the same with respect to the direction of motion of the K_2^0 ($\frac{N_f}{N_b} = \frac{13}{15}$) what points out that the angular distribution of Λ° hyperons emitted from the plate is likely to be isotropic in the lab. system. For a conclusive identification of Λ° decays a kinematic analysis of the events selected has been made.

For the 35 events*** fully measured, there has been determined the deviation of the magnitude

$$\Lambda = E_+ E_- - p_+ p_- \cos \gamma \quad ^{****}$$

from its calculation value $C = 17{,}4.10^4$ (MeV)^2 for the $\Lambda^\circ \to p + \pi^-$ decay, as well as the experimental error $\delta\Lambda$, (E_+, E_-, p_+, p_- denote the total energies and momenta, correspondingly, and γ is the angle of divergence of the decaying particles).

As one can see from Table 1, the selected events satisfy the kinematics of the Λ° decay. The mean value of the mass of the decaying particle calculated for the identified decays comprises (1116 ± 8) MeV.

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* In a paper by Panofsky et al /1/, the total cross section for K_2^0 interaction on Cu has been measured in good geometry and turned out to be σ_{tot} = (1120 ± 250) mb, the mean energy of a K_2^0 meson being 130 MeV.

** The experimental conditions and arrangement are described in detail in /2/ .

*** Among them, as the kinematic analysis has shown, 11 hyperons emerged from the chamber walls and were excluded from the following consideration.

**** This magnitude is an invariant and equal to $C = (M_{\Lambda^\circ}^2 - M_p^2 - M_\pi^2)/2$.

It is in good agreement with the value of the Λ°-hyperon mass $M_{\Lambda^{\circ}} = (1115.45 \pm 0.12)$ MeV[3]. The mean energy of the detected Λ°-hyperons turned out to be 40 MeV, whereas the maximum energy - 80 MeV.

Thus, the analysis, we carried out, has shown that under the conditions of our experiment the selection of Λ° decays was made reliably enough.

The probability for other possible reactions (e.g., negative pion production on chamber gas nuclei by the beam neutrons), to immitate Λ°-decay is very small.* Therefore, all the 39 identified events should be regarded as the $\Lambda^{\circ} \to p + \pi^{-}$ decay.

To determine the real number of Λ°-hyperons, there were introduced the corrections for the 'neutral' decay $\Lambda^{\circ} \to n + \pi^{\circ}$, for the particle decays inside the target and outside the working volume of the chamber, and for the recording efficiency of the Λ°-hyperons which depends (as the measurements have shown) on the position of the decay plane with respect to the direction of photographing.

After all the corrections have been introduced the number of hyperons emitted from the plate is 133 ± 23. This error includes both the statistical ones and the errors arising after introducing the corrections.

The total flux of incident K_2^0 mesons was determined from the number of the detected K_2^0 -decays in the illuminated region of the chamber by assuming that K_2^0 mesons have the mean energy close to that determined earlier in[2]. With account of the correction for the recording efficiency and for the decay $K_2^0 \to 3\pi^{\circ}$** the number of K_2^0 mesons passing through the plate turned out to be $(41 \pm 10) \cdot 10^3$.

Such a large uncertainty of the flux is due to the inaccuracy in determining the mean lifetime of the K_2^0 mesons ($\tau_{K_2^0} = (6.1 {}^{+1.6}_{-1.1})\ 10^{-8}$ sec).

The found values of the real number of Λ° hyperons and of the K_2^0 meson flux through the plate yield the following estimate $\sigma = (200 \pm 70)$ mb for the cross section for Λ°-hyperon production on lead nuclei. However, this may turn out to be underestimated because of possible missing Λ°-hyperons which are difficult to be detected, e.g., the ones emitted at small angles with the plate.

We take into consideration that the recorded Λ° decay may appear both from Λ°-hyperons produced in the lead nuclei as well as from the decay of Σ° produced in the same manner.

In order to obtain the information on the mechanism of hyperon production the nature of charged particles emitted from the plate together with Λ°-hyperons was studied. In six events (out of 28) either a positive pion

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* Only 5 events of π^{-} meson production in the many-prong stars have been recorded in the chamber.

** According to our data[2], the relative probability of this decay is ~20%.

or an electron-positron pair is emitted together with a Λ^o-hyperon. In other 9 events the emission of a Λ^o-hyperon is accompanied by a proton emission. In these cases there appears no correlation in the opening angles of a Λ^o and a proton whereas in case of K^o meson absorption by two nucleons it is natural to expect that the opening angles close to 180^o must predominate. These data point out that under our conditions the process of K^o meson absorption by two nucleons (just as in the case of K^- -meson absorption in flight[5]) is not predominant.

Among V^o events one of the tracks of which leaves the plate, one event of the decay $\Sigma^- \to \pi^- + n$ was identified by the kinematics and estimate of the ionization. Although the efficiency of recording such a decay is small (it constitutes ~15%) the observation of only one charged hyperon point to their small yield if compared with Λ^o-particles. At the same time in K^- -meson interaction with a deuteron the yields of neutral and charged hyperons are comparable by a magnitude [6]. A small yield of charged hyperons is due, very likely, to their strong absorption inside a nucleus.

In the course of an analysis of V^o - events which could be the decays of K_1^0 mesons emitted from the plate there was found one event satisfying the kinematics of the $K_1^0 \to \pi^- + \pi^+$ decay within one standard error. This gives the value much less than unity (~5.10^{-2}) for the ratio of the cross sections for the regeneration and hyperon production in lead. In this connection it should be noted that according to the calculations made by Biswas[7], this ratio for K_2^0-p -interaction at an energy of 100 MeV has the values from 0.2 up to 5 for four possible K^--p - scattering amplitudes found by Dalitz and Tuang[8].

In conclusion we note that for Λ^o decays there have been determined the ratios of the numbers of the decay protons emitted forward and backward in the center-of-mass system of the Λ^o - particle, as well as similar ratios for particles emitted upwards and downwards with respect to the plane of the Λ^o-hyperon production. The results are given in Table 2. It is to be said that in this case one should not expect a strong polarization of Λ^o particles in the production since the interaction is, evidently, occurs mainly in the S-state. Moreover, possible asymmetries may be spoiled because of the motion of nucleons in the nuclei.

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Table 1.

The value $\frac{\Lambda - C}{\delta\Lambda}$ *	$0 \div I$	$I \div 2$	$2 \div 3$	3
The number of Λ^o-events	2I	6	I	0

* under the experimental conditions $\frac{\delta\Lambda}{\Lambda} \approx 7\%$

Table 2.

The asymmetry coefficient $a = \frac{3\sum \cos\theta_i}{N} \pm \sqrt{\frac{3 - a}{N}}$ **

Asymmetry	The number of Λ^o hyperons	target	a	Δa
forward-backward	28	Pb	-0,22	±0,34
	II	glass	-0,39	±0,50
	39	Pb + glass	-0,27	±0,29
upward-downward	28	Pb	-0,II	±0,34
	II	glass	-0,42	±0,5I
	39	Pb + glass	-0,I9	±0,28
right-left	39	Pb + glass	+0,24	±0,27

** N is the number of events, θ is the angle of the proton emergence; the summation is being made by the number of events.

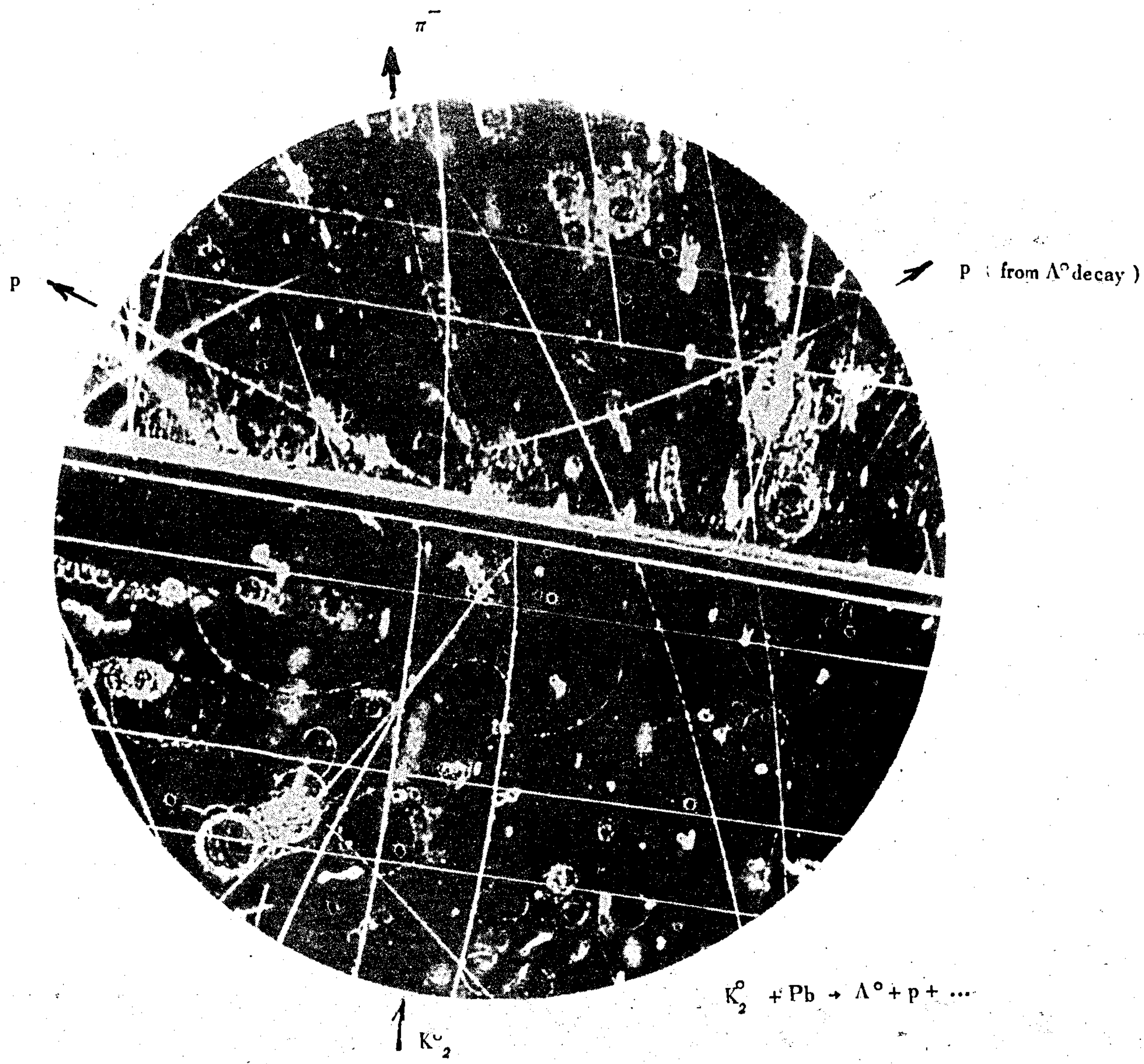

Fig. 1.

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