# Cross section for the production of $K^0$ mesons emitted at large l.s. angles from carbon and xenon nuclei

G. A. Leksin and A. V. Smirnitskiĭ

*Institute of Theoretical and Experimental Physics*
(Submitted 19 June 1978)
Pis'ma Zh. Eksp. Teor. Fiz. **28**, No. 3, 179–183 (5 August 1978)

We measured the inclusive cross sections of the production of $K^0$ mesons emitted at large l.s. angles from C and Xe nuclei under the influence of 2.9-GeV/$c$ $\pi^-$ mesons. The $K^0$-meson spectra are satisfactorily described by the invariant function $f = Ed^3\sigma/d^3p = C\exp[-T/T_0]$ in the entire angle range $\theta_{lab} > 47°$ and momentum range $p_{lab} > 159$ MeV/$c$. The slope parameter $T_0$ changes from $12 \pm 14$ MeV at $47° < \theta_{lab} < 60°$ to $40 \pm 5$ MeV at $120° < \theta_{lab} < 180°$. The parameter $C$ is independent of the angle within the limit of errors.

PACS numbers: 13.75.Jz, 14.40.Fw, 25.80.+f

Continuing the study[1,2] of deep-inelastic nuclear reactions that lead to the production of neutral strange particles, we have obtained new data on the inclusive production of $K^0$ mesons emitted at large angles in the l.s. in the reaction

$$\pi^- + C,\ \ Xe \to K^0 + \text{all}. \tag{1}$$


0021-3640/78/150166-05$00.60

Selection of $K^0$ mesons with large l.s. emission angles decreases the admixture of $K^0$ mesons from the reaction on the quasifree nucleon, and increases by the same token the fraction of those produced in deep-inelastic nuclear interaction. This approach to the separation of the deep-inelastic nuclear interaction is all the more correct in our case, since the angular distribution of the $K^0$ mesons in the $\pi^- p$ c.m.s. has a sharp forward maximum—in the direction of the incoming $\pi^-$ mesons; on the contrary, such a distribution for $K^0$ mesons emitted from nuclei is substantially more isotropic (see, e.g.,[3]).

The $K^0$ mesons emitted in the reaction (1) at an angle $\theta_{\rm lab} > 47°$ (this corresponds in the $\pi^- p$ c.m.s. to an emission angle larger than $\sim 90°$) and with a momentum $p_{\rm lab} > 150$ MeV/$c$ were registered in the 129-liter propane-xenon chamber of our Institute,[4] placed in an 18.6-kG magnetic field. The chamber was exposed to a 2.9-GeV/$c$ $\pi^-$-meson beam. In a total of 20 000 frames we observed 354 events of the $K^0 \to \pi^+\pi^-$ decay. These events were already used by us to analyze the instrumental asymmetry in the determination of the polarization of cumulative $\Lambda^0$ hyperons[2] (in our conditions 47° is the angle limit for the production of $\Lambda^0$ on a free immobile nucleon).

Figure 1 shows the cross section $\sigma_{\rm C,Xe}$ for the production of $K^0$ mesons with a

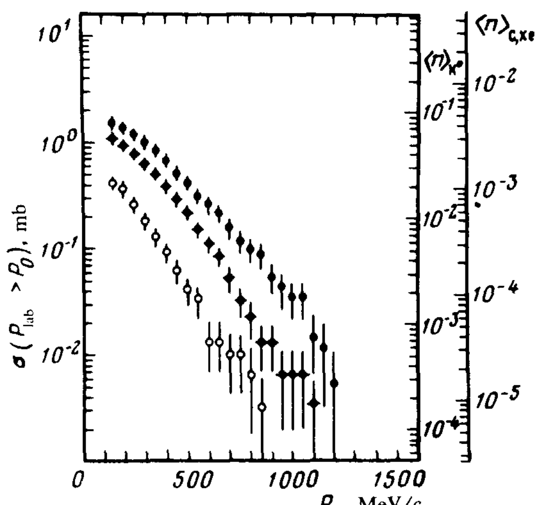


FIG. 1. Cross section for the production of $K^0$ mesons with momentum larger than a given $p_0$ on the effective mixture nucleus: ●—$\theta_{\rm lab} > 47°$, ● —$\theta_{\rm lab} > 60°$, ●—$\theta_{\rm lab} > 90°$.

momentum larger than the given $p_0$ on the effective mixture nucleus. On the right side are placed two other scales, one for the average $K^0$-meson multiplicity $\langle n\rangle_{\rm C,Xe} = \sigma_{\rm C,Xe}/\sigma^{in}_{\rm C,Xe}$, where $\sigma^{in}_{\rm C,Xe}$ is the total inelastic cross section for the interaction of a 2.9-GeV/$c$ $\pi^-$ meson with the effective nucleus of the mixture $\sigma^{in}_{\rm C,Xe} = (\sigma^{in}_{\rm C} n_C + \sigma^{in}_{\rm Xe} n_{\rm Xe})/(n_C + n_{\rm Xe}) = 366 \pm 11$ mb (here $n_{\rm C}$ and $n_{\rm Xe}$ are the numbers of the C and Xe nuclei per unit volume, and $\sigma^{in}_{\rm C}$ and $\sigma^{in}_{\rm Xe}$ are the total inelastic cross sections for the interaction of $\pi^-$ mesons with C and Xe nuclei[5,6]), while the second shows the fraction of all the $K^0$ mesons $\langle n\rangle_{K^0} = \langle n\rangle_{\rm C,Xe}/\langle n\rangle^{K^0}_{\rm C,Xe}$, where

$\langle n\rangle^{K^0}_{C,Xe}$ is the average multiplicity of all the $K^0$ mesons, which we have assumed equal to $5.2\times10^{-2}$.[7] The admixture of the $K^0$ mesons produced on quasi-free nucleons does not exceed, roughly speaking, 40% for $\theta_{lab}>47°$, 30% for $\theta_{lab}>60°$, and 20% for $\theta_{lab}>90°$.

The $K^0$-meson spectra are shown in Fig. 2 in the form of the invariant function

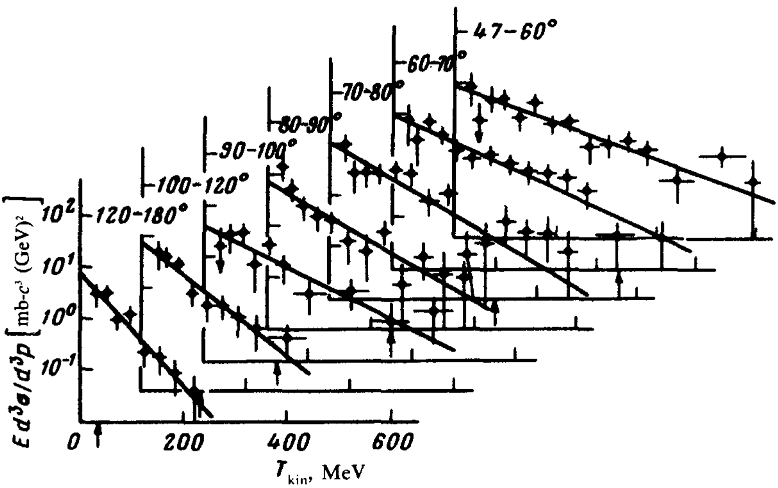


FIG. 2. The function $f=Ed^3\sigma/d^3p$ of the $K^0$ mesons vs $T_{kin}$ for various emission-angle intervals. Solid lines—approximation in the form $f=C\exp[-T/T_0]$. The arrows show the boundaries of the $K^0$-meson cumulativity region.

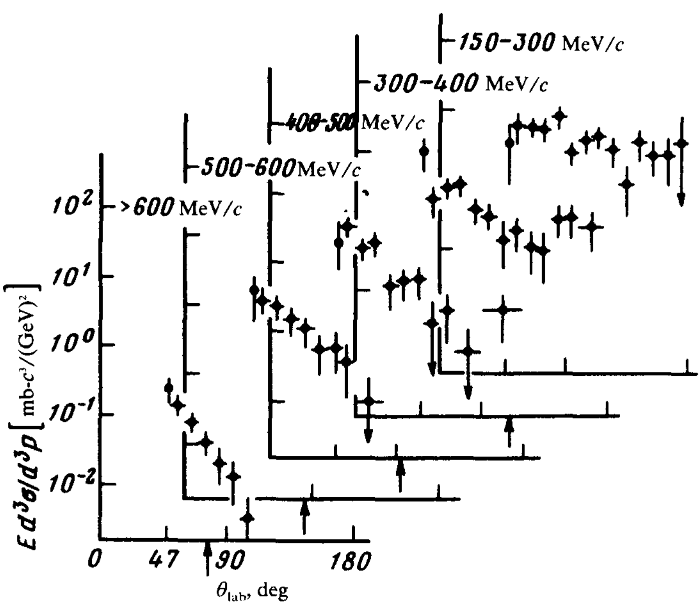


FIG. 3. The function $f=Ed^3\sigma/d^3p$ of $K^0$ mesons vs the emission angle for various momentum intervals. The arrows show the boundaries of the $K^0$-meson cumulativity region.

$f=Ed^3\sigma/d^3p$ ($E$ is the total $K^0$ energy) for different emission-angle ranges. The angular distributions for the different momentum ranges are shown in Fig. 3. The arrows mark the boundaries of the cumulative region for the $K^0$ mesons: the points to the left of the arrows are outside the cumulative region, and those to the right correspond to the production of $K^0$ mesons. The $K^0$ mesons with momenta 150 MeV/$c < p_{\text{lab}} < 300$ MeV/$c$ or with emission angle $47° < \theta_{\text{lab}} < 60°$ are almost all outside the cumulativity region. Conversely, the $K^0$ mesons with emission angle $\theta_{\text{lab}} > 120°$ are almost all cumulative. We see no irregularities whatever on the boundary of the cumulativity region. The solid lines in Fig. 2 show the approximation of the function $f$ in the form $f=C\exp[-T/T_0]$ for $p_{\text{lab}} > 150$ MeV/$c$, i.e., including the noncumulative region. The best parameters $C$ and $T_0$ as well as $\chi^2$ per degree of freedom are listed in Table I as

TABLE I.

| Angle ranges, deg | $C$ mb·$c^3$/(GeV)$^2$ | $T_0$, MeV | $\chi^2$/deg. freedom |
|---|---|---|---|
| 47 – 60 | 9 ± 2 | 124 ± 14 | 1.4 |
| 60 – 70 | 10 ± 2 | 97 ± 9 | 1.4 |
| 70 – 80 | 11 ± 3 | 73 ± 8 | 3.5 |
| 80 – 90 | 7 ± 3 | 77 ± 14 | 1.1 |
| 90 – 100 | 4 ± 2 | 86 ± 17 | 0.8 |
| 100 – 120 | 8 ± 3 | 56 ± 9 | 0.8 |
| 120 – 180 | 8 ± 3 | 40 ± 5 | 0.4 |

functions of the $K^0$-meson emission angle in the lab. It is seen that the function $f$ is satisfactorily described everywhere by the exponential that is characteristic of cumulative particles[8,11]; the slope parameter $T_0$ depends strongly on the angle, but the coefficient $C$ is independent of angle within the limits of error.

Besides the $K^0$ mesons we registered also the secondary protons produced on a mixture of C and Xe nuclei together with the $K^0$ mesons. The distributions in the number of such protons are evidently greatly different for the C and Xe nuclei,[10] and we have attempted to use this fact to estimate the fraction of the $K^0$ mesons emitted from the C and Xe nuclei separately. In accord with the known properties of the deep-inelastic nuclear interaction (see, e.g.,[11]), we have assumed that the protons are emitted in independent fashion, and approximated the distribution in the number of protons by a sum of two Poisson distributions. We have determined in this manner both the average values of the number of protons for C and Xe, and the number of events in each of these Poisson distributions separately, i.e., the number of $K^0$ mesons emitted from C and from Xe. Knowing, in addition, the content of the C and Xe in the working medium of the chamber and the cross sections $\sigma_{\text{C}}^{in}$ and $\sigma_{\text{Xe}}^{in}$, we can attempt to estimate the $A$ dependence of the $K^0$-meson yield in the form $\sigma_A/\sigma_A^{in} \sim A^{\alpha}$. The estimate obtained in this manner does not contradict the assumption $\alpha=0$ for $K^0$ with $\theta_{\text{lab}} > 47°$ and $p_{\text{lab}} > 150$ MeV/$c$.

In conclusion, we wish to thank A.G. Meshkovskiĭ and the members of his laboratory for the films from the propane-xenon chamber, and I.I. Vorob'ev and L.S. Novikov for great help in organizing and performing the work.

[1)]There are no published data on the function $f$ for cumulative $K^0$ mesons. There are data for $K^+$ mesons.[9]

---

[1]I.I. Vorob'ev, G.A. Leksin, L.S. Novikov, and A.V. Smirnitskiĭ, Pis'ma Zh. Eksp. Teor. Fiz. **22**, 390 (1975) [JETP Lett. **22**, 184 (1975)].
[2]G.A. Leksin and A.V. Smirnitsky, Proc. 7th Internat. Conf. on High Energy Physics and Nuclear Structure, Zurich, 1977; G.A. Leksin and A.V. Smirnitsky, Preprint ITEP-87, 1977.
[3]N.S. Amaglobeli *et al.*, JINR Preprint R1-9513, 1976.
[4]I.I. Pershin *et al.*, Prib. Tekh. Eksp. No. 3, 43 (1967).
[5]L.V. Vlasov *et al.*, Yad. Fiz. **27**, 413 (1978) [Sov. J. Nucl. Phys. **27**, 222 (1978)].
[6]V.V. Barmin *et al.* Preprint ITEF-22, 1977.
[7]A.K. Ponosov, Dissertation, Moscow, 1970.
[8]G.A. Leksin, Proc. 18th Internat. Conf. on High Energy Physics, Tbilisi, 1976; V.S. Stavinski, *ibid.*
[9]A.M. Baldin *et al.*, Yad. Fiz. **20**, 1201 (1974) [Sov. J. Nucl. Phys. **20**, 629 (1975)].
[10]A.V. Arefyev *et al.*, Preprint ITEP-18, 1978.
[11]L.S. Vorob'ev, V.B. Gavrilov, P.V. Dgtyarenko, V.I. Efremenko, Yu. M. Zaĭtsev, G.A. Leksin, and D.A. Suchkov, Pis'ma Zh. Eksp. Teor. Fiz. **26**, 113 (1977) [JETP Lett. **26**, 105 (1977)]; A.V. Aref'ev *et al.*, Preprint ITEP-51, 1978.