Estimate of the contribution of the central production of $\bar{\Lambda}$ hyperons to the cross section of the reaction $K^+p \to \bar{\Lambda} + X$ at 32 GeV/*c*

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The contribution of the central production of $\bar{\Lambda}$ hyperons to the cross section of the reaction $K^+p \to \bar{\Lambda} + X$ at 32 GeV/*c*, which amounts to $(12 \pm 6)\%$ of the total cross section for the production of $\bar{\Lambda}$ hyperons, is estimated. This estimate is used to find the ratio $\bar{\Lambda}/K^0$ in the central and fragmentation regions and the coefficient for the suppression of strangeness, $\lambda = 0.16 \pm 0.07$.

In many phenomenological models which attempt to describe soft hadron collisions it is assumed that antibaryons are produced primarily in the "central" collisions during the production of baryon-antibaryon pairs; i.e., it is assumed that they are produced entirely from sea quarks. Such a "central" antibaryon-production mechanism even at moderate energies is incorporated, for example, in a widely known quark-recombination model which was proposed by Anisovich *et al.*[1] The experimental studies of the inclusive production of $\bar{\Lambda}$ hyperons in the reaction

$$K^+p \to \bar{\Lambda} + X \tag{1}$$

at primary momenta $\leqslant 16$ GeV/*c* seem to be consistent (see, e.g., Ref. 2) with this concept. Subsequent K^+p experiments at 32 GeV/*c* (Refs. 3 and 4) and 70 GeV/*c* (Ref. 5) carried out using Mirabelle and BEBS bubble chambers showed, however, that the dominant mechanism for the production of strange antibaryons in K^+p reactions is the fragmentation of the valence s quark of the K^+ meson, rather than the central processes. The measured total inclusive cross sections of $\bar{\Lambda}$, $\bar{\Xi}^+$, and $\bar{\Sigma}^{*\pm}$ (1385), on the other hand, turned out to be smaller by several factors than those predicted by the quark recombination model.[2)] It is relevant to note here that the divergence of the experimental data on strange antibaryons from the predictions of the model may be even of a more general nature, since neither this model nor most of the other currently popular quark-parton models can in fact predict the absolute yield of the baryon-antibaryon pairs. The quark recombination model,[1] for example, uses the ratio 6:1:1 for the meson, baryon, and antibaryon production probabilities in the central region, which was obtained by Anisovich and Shekhter[7] on the basis of rather crude assumptions. In the Lund quark-fragmentation model[8] the cross section for the production of baryon-antibaryon pairs is determined by the suppression (determined experimentally) of (qq)–$(\bar{q}\bar{q})$ diquark pairs (in contrast with the $q\bar{q}$ quark pairs), which are extracted from the sea. It would thus be of considerable interest to estimate experimentally the cross sections for the central production of baryon-antibaryon pairs.

Our purpose in the present study is to estimate the cross section for the central production of $\bar{\Lambda}$ in the region (1) at 32 GeV/c. This estimate was found from the experimental cross sections of reaction (1) and of the reactions

$$K^+p \rightarrow \bar{\Lambda} + K^n + X, \quad (2)$$
$$\rightarrow \bar{\Lambda} + \Lambda + X, \quad (3)$$
$$\rightarrow \bar{\Lambda} + \Lambda + K^n + X \quad (4)$$

at 32 GeV/c (Refs. 3 and 9), where the symbol K^n is understood as the mixture of K^0 and $\bar{K}^0$ mesons. The following procedure was used to obtain this estimate.

Let us consider the reactions

$$K^+p \rightarrow \bar{\Lambda} + X_s, \quad (5)$$
$$\rightarrow \bar{\Lambda} + X_{ns}, \quad (6)$$

in which the system X_s (X_{ns}) contains (does not contain) strange particles. Ignoring the channels with more than three final-state strange particles (whose cross sections are very small[9,10]), we can write the cross section of reaction (5) as a sum of the cross sections of the reactions

$$K^+p \rightarrow \bar{\Lambda}K^0\bar{K}^0X_{ns}, \quad (7)$$

$$K^+p \rightarrow \bar{\Lambda}K^+\bar{K}^0X_{ns}, \quad (8)$$

$$K^+p \rightarrow \bar{\Lambda}K^0K^-X_{ns}, \quad (9)$$

$$K^+p \rightarrow \bar{\Lambda}K^+K^-X_{ns}, \quad (10)$$

$$K^+p \rightarrow \bar{\Lambda}\Lambda K^0X_{ns}, \quad (11)$$

$$K^+p \rightarrow \bar{\Lambda}\Lambda K^+X_{ns}, \quad (12)$$

$$K^+p \rightarrow \bar{\Lambda}\Sigma^{\pm}K^0X_{ns} \quad (13)$$

$$K^+p \rightarrow \bar{\Lambda}\Sigma^{\pm}K^+X_{ns}. \quad (14)$$

We have further assumed that the differential cross sections $d\sigma/dx$ of $\bar{\Lambda}$ in reactions (7) and (10) are the same and that in reactions (11) and (13) [just as in reactions (12) and (14)] these cross sections differ only in the factor α, which is equal to the ratio of the total cross sections for the production of $\Sigma^{\pm}$ and Λ in K^-p interactions at 14.3 GeV/c (Ref. 11) and 10- and 16 GeV/c (Ref. 12): $\alpha = 0.58 \pm 0.03$. The differential cross sections $d\sigma/dx$ of $\bar{\Lambda}$ in reactions (5) and (6) can then be expressed in terms of the experimentally measured x spectra of $\bar{\Lambda}$ in the reactions (1)–(4) (Refs. 3 and 9):

$$d\sigma_5 = d\sigma_2 + (1+\alpha)(d\sigma_3 - d\sigma_4), \quad (15)$$

$$d\sigma_6 = d\sigma_1 - d\sigma_5, \quad (16)$$

where σ_k is understood as the cross section of $\bar{\Lambda}$ in the reaction (k).

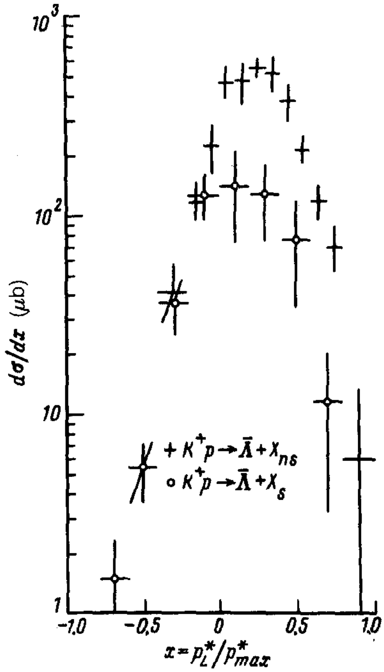

FIG. 1. $d\sigma/dx$—Distribution of $\bar{\Lambda}$ hyperons in reaction (5) (points) and in reaction (6) (crosses) at 32 GeV/c.

The $d\sigma/dx$ profiles of $\bar{\Lambda}$ in reactions (5) and (6) at 32 GeV/c, which were found from Eqs. (15) and (16), are shown in Fig. 1. The corresponding total cross sections and the asymmetry parameters $A_k = (\sigma_k^B - \sigma_k^H)/(\sigma_k^B + \sigma_k^H)$, where $\sigma_k^B(\sigma_k^H)$ is the cross section of $\bar{\Lambda}$ in the forward (rear) c.m. hemisphere, are

$$\sigma_5 = 103 \pm 35\ \mu\text{b}, \qquad \sigma_6 = 319 \pm 39\ \mu\text{b},$$

$$A_5 = 0{,}37 \pm 0{,}14, \qquad A_6 = 0{,}726 \pm 0{,}043.$$

The larger value of the asymmetry parameter A_6 is attributable to the fact that only the kaon fragmentation process contributes to reaction (6), whereas both the central $\bar{\Lambda}$ production processes and kaon fragmentation process contribute to reaction (5).

It can be assumed that the asymmetry parameters for $\bar{\Lambda}$ produced in reactions (5) and (6) in the kaon fragmentation processes are the same, while the asymmetry parameter for $\bar{\Lambda}$ produced in the central processes is zero. The sought-for estimate of the cross section for the production of $\bar{\Lambda}$ in the central processes can then be easily found:

$$\sigma_{\text{central}}(\bar{\Lambda}) = (1 - A_5/A_6)\sigma_5 = 51 \pm 27\ \mu\text{b}. \qquad (17)$$

This value is $(12 \pm 6)\%$ of the total cross section of reaction (1) at 32 GeV/c. An estimate that comes close to this value (but one with a large error) is found by assuming that the distributions of $\bar{\Lambda}$ hyperons produced in reactions (5) and (6) in the kaon fragmentation processes have the same shape, while the contribution from the central production of $\bar{\Lambda}$ with $x > 0.4$ can be ignored. We would then have

$\sigma_{central}(\bar{\Lambda}) = \sigma_5 - \sigma_6\sigma_5(x>0.4)/\sigma_6(x>0.4) = 40 \pm 50\ \mu b$.

On the basis of the total inclusive cross sections $\sigma(\bar{\Lambda}) = 0.422 \pm 0.018$ mb, $\sigma(K^n) = 7.76 \pm 0.18$ mb (Ref. 3), and $\sigma(\bar{K}^0) = 0.67 \pm 0.05$ mb (Ref. 13) at 32 GeV/c and on the basis of estimate (17) we find the ratios of the cross sections of $\bar{\Lambda}$ and K^0 separately for the central region and the kaon fragmentation region

$$(\bar{\Lambda}/K^0)_{central} = 0.08 \pm 0.04, \qquad (\bar{\Lambda}/K^0)_{fragm.} = 0.06 \pm 0.01. \qquad (18)$$

The values of $(\bar{\Lambda}/K^0)$ which we obtained are approximately equal, according to the data obtained from SPEAR, PETRA, and PEP (see Ref. 14), to the parameter for the suppression of sea diquarks which was used in the Lund model. Our values are, however, an order of magnitude lower than the value $(\bar{\Lambda}/K^0)_{central} = 0.43$ used in the quark recombination model.[1]

Finally, the value $\sigma_{central}(\bar{\Lambda})$ can be used to find an unbiased estimate of the strangeness-suppression coefficient which is determined by the ratio of the cross sections of reactions (5) and (6) if $\bar{\Lambda}$ in reaction (5) is produced only in the fragmentation of an $\bar{s}$ quark in a K^+ meson, i.e., if $\sigma_{central}(\bar{\Lambda})$ is subtracted from the cross section of reaction (5). The value $\lambda = 0.16 \pm 0.07$ which is obtained is in good agreement with other equally low estimates, $\lambda = 0.16 \pm 0.01 \pm 0.01$, $\lambda = 0.15 \pm 0.02 \pm 0.01$, and $\lambda = 0.17 \pm 0.02 \pm 0.01$, which were obtained recently in K^+p experiments at 32, 70, and 250 GeV/c (Ref. 15) in the measurement of the inclusive production of ϕ and $K^{*0}(892)$ in the kaon fragmentation region.

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[2)]We note that the domination of the fragmentation processes of the valence quark of a primary meson and the suppression of the central processes in the production of antihyperons in meson-nucleon collisions at moderate energies are characteristic not only of the reactions initiated by kaons (see, e.g., Ref. 6), although the fact that a heavier strange quark is the leading quark and that the sea of strange quarks is suppressed increases the relative contribution of the fragmentation processes in the KN reactions.

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