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Authors

Randrup, J.
Ko, CM.

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REVISION OF CALCULATIONS FOR KAON PRODUCTION IN RELATIVISTIC NUCLEAR COLLISIONS

J. Randrup and C.M. Ko

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Revision of Calculations for Kaon Production in Relativistic Nuclear Collisions

J. Randrup

Nuclear Science Division, Lawrence Berkeley Laboratory
University of California, Berkeley, CA 94720, U.S.A.

and

C.M. Ko

Cyclotron Institute and Physics Department
Texas A M University, College Station, Texas 77843, U.S.A.

Abstract: Due to an elementary mistake in plotting the data, our previous calculations of kaon production in relativistic nuclear collisions are approximately a factor of two too small. The revised results are in good agreement with the data on total kaon yields.

In ref. [1]) we studied kaon production in relativistic nuclear collisions on the basis of a conventional multiple-collision model. The basic physical input was the differential cross sections for kaon production in elementary baryon-baryon collisions. These were estimated by simple means: The angular distributions were assumed to be isotropic in the appropriate CM frame and a simple functional form was taken for the spectral distribution. Furthermore, the dependence on energy was assumed to be given by p_{max}, the maximum momentum available to the produced kaon. Finally, the absolute sizes of the elementary production cross sections were based on proton-proton data combined with a one-pion exchange model relating unobserved reactions to observed ones.

The observed kaon production cross sections were taken from the compilation in ref. [2]) and plotted as functions of p_{max} in fig. 3 of ref. [1]). Unfortunately, in calculating the appropriate values of p_{max} (given by formula (3.1) in ref. [1])), the laboratory proton momentum p_{lab} (which appears in the first column in the tabulations in ref. [2])) was mistakingly used in place of the total CM energy E_{CM} [which appears in the third column]. As a consequence, the abscissas in fig. 3 are distorted and the extracted proportionality coefficients given in (3.13) are incorrect. The purpose of this note is to correct this error and rediscuss the situation.

Figure 1 shows the experimental data plotted versus the correctly calculated value of p_{max}. It differs quantitatively from the original figure (fig. 3 of ref. [1])). Using the linearly interpolated data at $p_{max} = m_K c \approx$ 0.5 MeV/c, we find the following relationships. 1) $\sigma_{pp \rightarrow \Delta^{++}\Sigma^{o}K^{o}}/\sigma_{pp \rightarrow \Delta^{+}\Sigma^{+}K^{o}}$ = 3/2 in accordance with our model expectations (cf. the discussion in ref. [1])). 2) $\sigma_{pp \rightarrow p\Sigma^{+}K^{o}}/\sigma_{pp \rightarrow \Delta^{+}K^{+}K^{o}} \approx 25/10$ to be compared with $F_{NN\pi}/F_{N\Delta\pi}$, which we assume to be around unity; as noted in ref. [1]) this difference can be eliminated if the first data point for the $pp \rightarrow p\Sigma^{+}K^{o}$ reaction is ignored, as may be justified in view of its large error and age. 3) $\sigma_{pp \rightarrow p\Lambda K^{+}}/\sigma_{pp \rightarrow \Delta^{+}\Lambda K^{+}} \approx 22/47$ to be compared with $F_{NN\pi}/F_{NA\pi}$ again; here the difference may arise from the fact that the first data point for $pp \rightarrow \Delta^{+}\Lambda K^{+}$ lies at p_{max} = 0.75 GeV/c so that our linear interpolation may yield a considerable overestimate (as is suggested by the behavior of the $pp \rightarrow p\Lambda K^{+}$ data). 4) $\sigma_{pp \rightarrow p\Lambda K^{+}}/\sigma_{pp \rightarrow \Delta^{++}\Sigma^{o}K^{o}} \approx 11/15$ to be compared with $F_{NN\pi}(G^{1/2}_{\pi N\Sigma K} + 4\ G^{3/2}_{\pi N\Sigma K})/3\ F_{N\Delta\pi}(G^{1/2}_{\pi N\Sigma K} + G^{3/2}_{\pi N\Sigma K})$; if again we assume $G^{1/2} \approx G^{3/2}$ and, as above, $F_{NN\pi} \approx F_{N\Delta\pi}$ we obtain a good correspondence with the data. 5) $\sigma_{pp \rightarrow \Delta^{++}\Lambda K^{o}}/\sigma_{pp \rightarrow \Delta^{+}\Lambda K^{+}} \approx 29/47$ to be compared with the expected value of 3; as argued in ref. [1]), these latter reactions may proceed mainly via the I = 3/2 πN resonance and the disagreement may therefore not be serious. Thus, as in ref. [1], on the whole our model appears to be in reasonable agreement with the available data and can be employed as a tool for generalizing from observed to unobserved reactions.

We may therefore proceed as in ref. [1]. We then only need extract the three proportionality coefficients, namely the values of $\sigma_{pp \to p\Lambda K^+}$, $\sigma_{pp \to p\Sigma^o K^o}$, and $\sigma_{pp \to p\Sigma^+ K^o}$ at $p_{max} = m_K c$. After inspection of fig. 1, we find that these values are all approximately a factor of two larger than those extracted in ref. [1] (eq. (3.13)), i.e.,

$$\sigma_{pp \to p\Lambda K^+}\ (p_{max} = m_K c) \approx 24\ \mu b \tag{1a}$$

$$\sigma_{pp \to p\Sigma^o K^+}\ (p_{max} = m_K c) \approx 12\ \mu b \tag{1b}$$

$$\sigma_{pp \to p\Sigma^+ K^o}\ (p_{max} = m_K c) \approx 12\ \mu b \tag{1c}$$

We thus arrive at the result that the error committed in ref. [1] can be corrected by simply renormalizing all cross sections by a factor of two. The calculations made in ref. [1], and those made in ref. [3] later on, are therefore still valid, except that the results be doubled.

Our original results, and those of ref. [3], where kaon rescattering was included in a schematic manner, have been compared with the data taken by Schnetzer et al.[4] This comparison indicated that the original calculation underestimated the total kaon production cross section by approximately a factor of two. This apparent discrepancy has given rise to speculations about the production mechanism for the remaining kaons.[5] With the present revision of our calculated results, there is no longer any substantial discrepancy between theory and data with regard to the total production cross section. In view of this fact, it appears less likely that more exotic production mechanisms (such as $\pi N \to K\Lambda$, $K\Sigma$) play an important role in the studied reactions.

We are very grateful to Rosalyn Lombard for drawing our attention to the inconsistency between fig. 3 in ref. [1]) and the data. J.R. was supported by the Director, Office of Energy Research, Division of Nuclear Physics of the Office of High Energy and Nuclear Physics of the U.S. Department of Energy under Contract DE-AC03-76SF00098, and C.M.K. was supported in part by NSF grant under Contract No. PHY81-09019.

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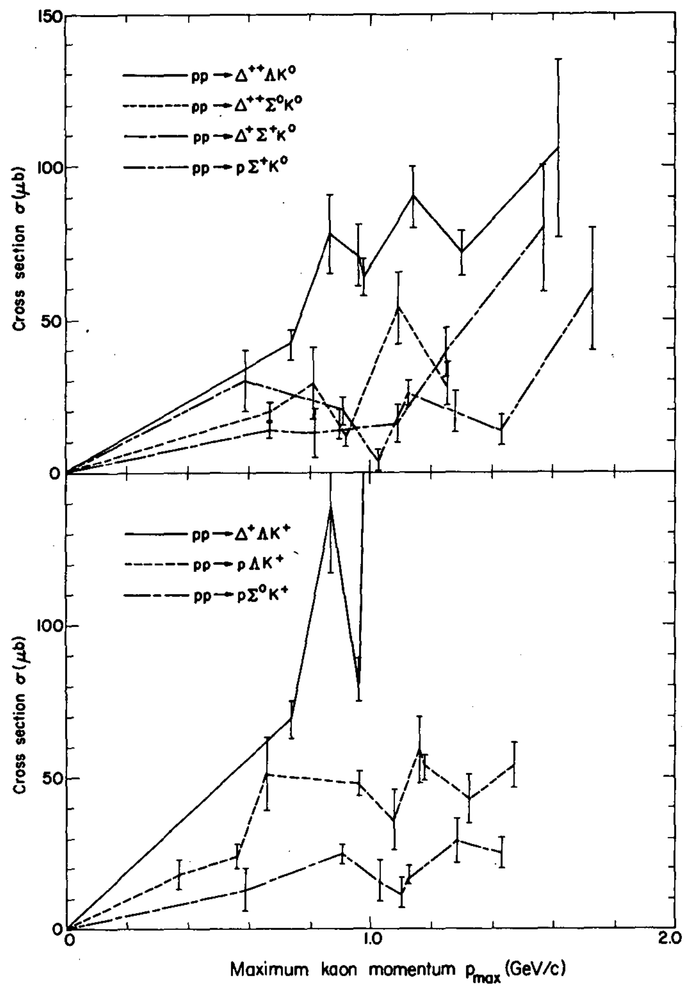
Figure Caption

Fig. 1. The measured total cross section for the various elementary kaon production processes, as taken from ref. [2]), plotted as functions of the maximum momentum available to the produced kaon.



pp → Δ⁺⁺ΛK⁰
pp → Δ⁺⁺Σ⁰K⁰
pp → Δ⁺Σ⁺K⁰
pp → pΣ⁺K⁰
pp → Δ⁺ΛK⁺
pp → pΛK⁺
pp → pΣ⁰K⁺
Cross section σ(μb)
150
100
50
0
1.0
2.0
Maximum kaon momentum p_max (GeV/c)

Fig. 1

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LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720