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A STUDY OF THE CHARGE EXCHANGE PROCESS
$K^+n \to K^0p$ at 10 GeV/c

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ABSTRACT

We present a study of the charge exchange reaction $K^+n \to K^0p$ using 10 GeV/c K^+ interactions on nuclei. The differential cross section is compared with that of the reaction $K^-p \to \bar{K}^0n$. The total cross section is estimated to be 76 ± 13 μb per nucleon which agrees with the SU3 prediction.

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An analysis has been made of the charge exchange reaction $K^+n \rightarrow K^0p$ at 10 GeV/c using the CERN heavy liquid bubble chamber placed in a magnetic field of 27 kG and filled with a propane-freon mixture (Ref. 1). This mixture had a radiation length of 25 cm giving a γ-detection probability of 72 %. A sample of 230.000 pictures, with an average of 2.8 incident tracks per picture, has been scanned twice. The scanning efficiency was estimated to be 95 %. In order to study the charge exchange process and the nuclear effect, events with an associated V^0 and any number of protons were selected. Events of this type with associated γ-rays were also retained to estimate the main source of background from the reaction $K^+n \rightarrow K^0p + n\pi^0$.

A total of 91 events was measured and analysed for the charge exchange process $K^+n \rightarrow K^0p$. This reaction has been studied by means of Monte Carlo generated events taking into account experimental errors and the Fermi momentum of the neutron target. The K^0 momentum distribution of the Monte Carlo events was calculated using the exponential and Regge model dependence (Ref. 2). The Monte Carlo calculation gave a probability less than 1 % of finding a K_1^0 with $p_{K_1^0} < 8$ GeV/c. Thus, only events with the K_1^0 momentum greater than 8 GeV/c were retained giving a final sample of 46 events corresponding to the charge exchange reaction. For this sample, the fitted K_1^0 and proton momentum distribution agree with the Monte Carlo results. No event with $p_{K_1^0} < 8$ GeV/c fitted the reaction $K^+n \rightarrow K^0p$.

The main source of background for the K^+n charge exchange is the reaction $K^+n \rightarrow K^0p + n\pi^0$. From a study of the events with associated γ-rays the contamination due to this source was estimated to be 3 events.

In order to calculate the cross section for the charge exchange reaction, the beam attenuation has been taken into account and the following corrections have been applied :

i) A factor of 5.30 ± 0.10 for losses due to K^0 decays and K^0 interactions inside the fiducial volume.

ii) 1.24 ± 0.02 for losses due to the scanning and measurement procedure.

iii) 2.10 ± 0.03 for the absorption effect inside the nucleus. This correction has been calculated using the Margolis formula (Ref. 3) on the basis of the Glauber theory of nucleon multiple scattering.

After including all corrections, the observed number of events gives a cross section for charge exchange process $K^+n \to K^0p$ of 76 ± 13 μb.

The differential cross section for this reaction, after applying corrections for experimental resolution and nuclear absorption, is shown in Fig. 1 together with the results of Astbury et al. (Ref. 4) for the reaction $K^-p \to \bar{K}^0n$ at 9.5 GeV/c. The differential cross sections for the two reactions are approximately equal

$$\frac{d\sigma}{dt}(K^+n \to K^0p) \simeq \frac{d\sigma}{dt}(K^-p \to \bar{K}^0n)$$

This result is consistent with the exchange degeneracy of the ρ and A_2 trajectories (Ref. 5).

The $K^+n \to K^0p$ differential cross section was fitted with the expression

$$\frac{d\sigma}{dt} = Ae^{-Bt}$$

using the measured distribution and taking into account nuclear absorption by means of the Margolis formula.

A maximum likelihood fit gave :

$$A = 377 \pm 76 \ \mu b/(GeV/c)^2$$
$$B = (4.9 \pm 0.7) \ (GeV/c)^{-2}$$

with a $\chi^2 = 3$ for 5 degrees of freedom.

The optical theorem corresponding to the charge exchange reaction gives for the contribution of the imaginary part of the amplitude :

$$\frac{d\sigma}{dt}(\mathrm{Imf})\Bigg|_{t=0}^{\mathrm{ch.ex.}} = \frac{1}{16\pi}\left[\sigma_{tot}(K^+p) - \sigma_{tot}(K^+n)\right]^2$$

$$= (2 \pm 8)\ \mu b/(GeV/c)^2$$

using the values $\sigma_{tot}(K^+p) = 17.3 \pm 0.1$ mb,

$\sigma_{tot}(K^+n) = 17.5 \pm 0.4$ mb (Ref. 6).

The extrapolated forward scattering cross section using the exponential fit is much larger than that predicted by the optical theorem indicating that the amplitude is dominated by the real part. This also is in agreement with the exchange degeneracy of the ρ and A_2 trajectories. Fig. 2 shows the exponential fit and the theoretical curve derived from the Sarita and Schwarzschild model (Ref. 2) assuming exchange of ρ, A_2 and ρ' trajectories.

Fig. 3 shows the data on K^+n charge exchange total cross section as a function of incident momentum. The K^+n data are fitted with a function of the form $\sigma(p_{lab}) = Kp_{lab}^{-n}$. The fitted parameters are $K = (7.3 \pm 0.1)$ mb, $n = 2.07 \pm 0.02$ with a $\chi^2 = 6$ for 5 degrees of freedom. The p^{-2} dependence of the K^+n charge exchange cross section agrees with the conclusion of Firestone et al. (Ref. 7).

For charge exchange processes, SU3 sum rules predict the relation

$$\sigma(K^+n \to K^0p) = \sigma(\pi^-p \to \pi^0n) + 3\,\sigma(\pi^-p \to \eta^0n) - \sigma(K^-p \to \bar{K}^0n).$$

Using fitted results from data of π^-p reactions and K^-p charge exchange (Ref. 8), the corresponding K^+n charge exchange cross section is calculated to be (65.5 ± 9.2) μb. Thus, the value of the K^+n total cross section obtained in this experiment (76 ± 13 μb) is in good agreement with the SU3 prediction.

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Figure Captions

Figure 1 — $d\sigma/dt$ distribution for $K^+n \rightarrow K^0p$ at 10 GeV/c together with $K^-p \rightarrow \bar{K}^0n$ at 9.5 GeV/c.

Figure 2 — $d\sigma/dt$ distribution for $K^+n \rightarrow K^0p$ at 10 GeV/c compared with an exponential dependence and Rarita and Schwarzschild model.

Figure 3 — Total cross section for $K^+n \rightarrow K^0p$ versus incident momentum.

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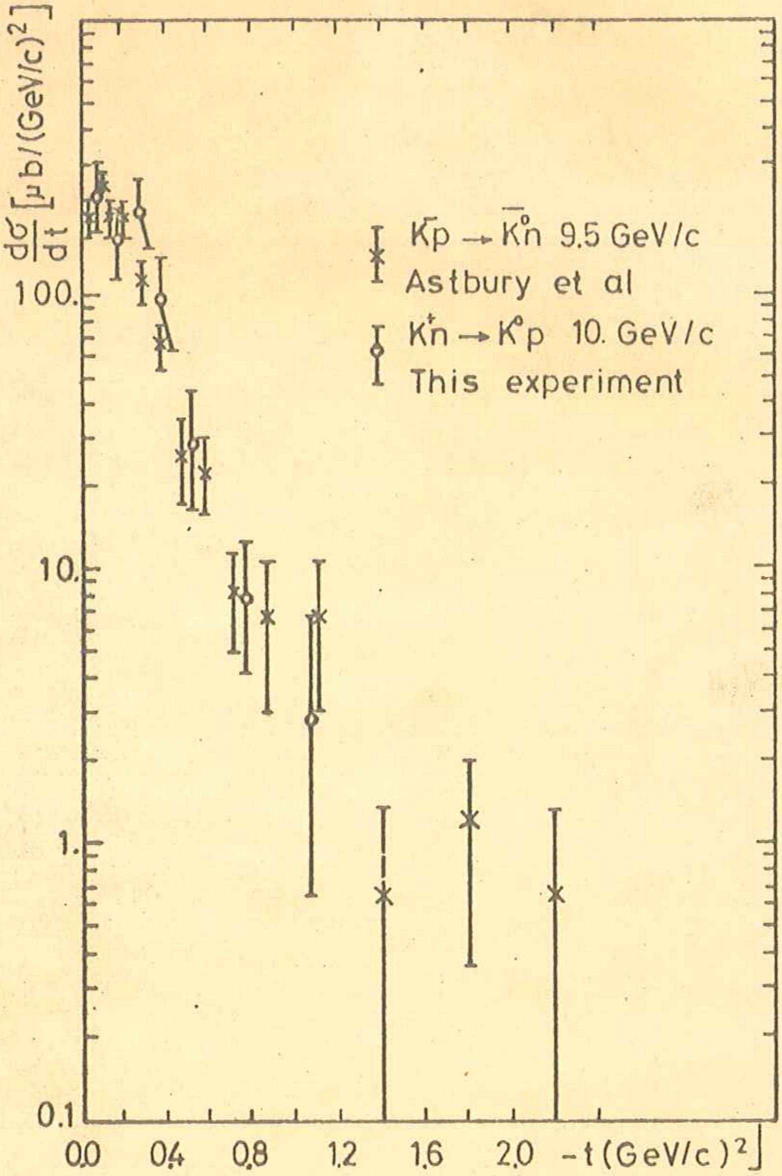

$\frac{d\sigma}{dt}$ [μb/(GeV/c)^2]
100.
10.
1.
0.1
0.0
0.4
0.8
1.2
1.6
2.0
-t (GeV/c)^2
$K^-p \rightarrow \bar{K}^0n$ 9.5 GeV/c
Astbury et al
$K^+n \rightarrow K^0p$ 10. GeV/c
This experiment

Fig. 1

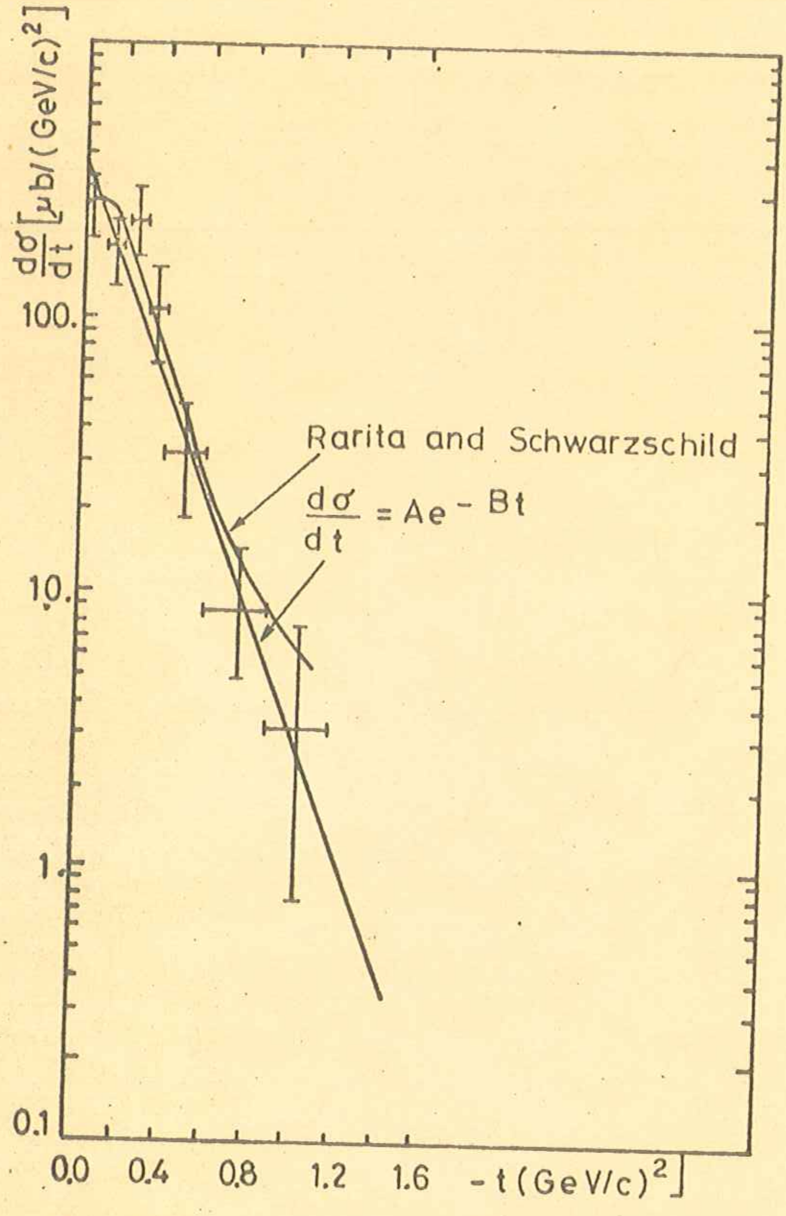
dσ/dt [μb/(GeV/c)²]
100.
10.
1.
0.1
0.0
0.4
0.8
1.2
1.6
-t (GeV/c)²
Rarita and Schwarzschild
dσ/dt = Ae - Bt

Fig. 2

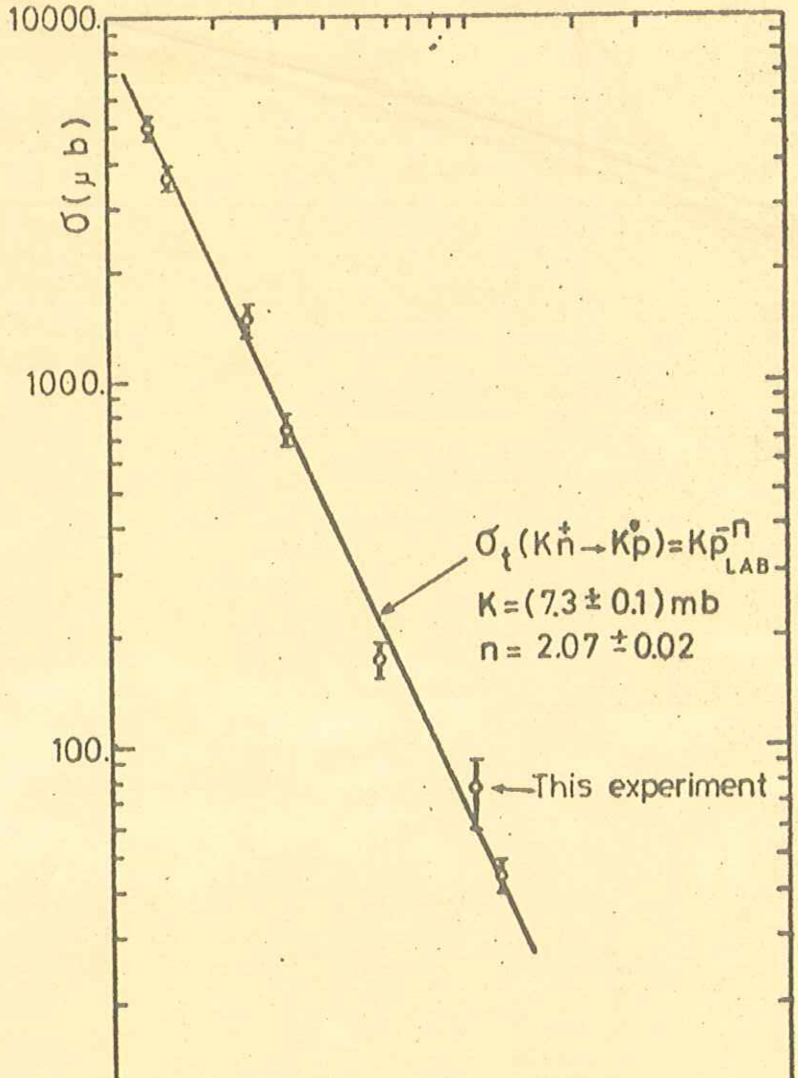
10000.
1000.
100.
10.
σ(μb)
σt(K+n→K0p)=Kp-n LAB
K=(7.3±0.1)mb
n= 2.07 ±0.02
This experiment
1.
5.
10.
20.
P LAB (GeV/c)

Fig. 3