THE CHARGE EXCHANGE $K^- + p \to \bar{K}^0 + n$ AT 9.50 GeV/c*, **

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We have measured the total and differential cross sections for the reaction $K^- + p \to \bar{K}^0 + n$. The data were obtained during a three-and-a-half

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days' run at the CERN proton synchrotron, using a large magnetic spark chamber in a negative particle beam of 9.50 GeV/c ± 0.20 GeV/c.

A counter telescope defined the beam, and the K^- were selected by two gas threshold Čerenkov counters of the Vivargent type [1]. The average beam intensity was 1.2×10^5 particles per pulse; the ratio of $\pi^- : K^- : \bar{p}$ was 1 : 0.0053 : 0.0009.

A 40 cm long hydrogen target was mounted inside a 60 cm long anticoincidence counter to discriminate against charged particles and γ rays emitted forwards and sideways. The counter consisted of alternate layers of scintillator and lead (2.8 cm Pb in the forward direction, 2 cm of Pb and 1 cm of Cu at the side).

Thus the trigger system accepted K^- interactions in which no charged particles or π^0 mesons were produced. The accepted interactions were observed in a magnetic spark chamber starting 22 cm downstream from the end of the hydrogen target. The chamber had a useful volume of $60 \times 67 \times 170$ cm^3; it consisted of seventy-two 8 mm gaps defined by 25 μ aluminium foils, giving a radiation length of 30 m. The magnetic field in the chamber was 10.5 kG, and a typical momentum resolution of $\Delta p/p = 0.017$ was obtained on 160 cm long, 9.5 GeV tracks. With two charged particles passing through the chamber, the percentage of visible sparks was 95%, and with eight particles 60%.

The 7000 photographs taken were scanned twice for V^0 decays; the scanning efficiency on the two scans being estimated as 96% and 99%. In a fiducial volume of $106 \times 60 \times 50$ cm^3, 412 events were measured at CERN on IEP measuring projectors and analysed by a modified version of the THRESH-GRIND series of programmes.

The charge exchange events were identified by the following criteria:
1) The counter logic must indicate an incoming K^- and no outgoing charged particles or π^0's.
2) The V^0 photographed in the spark chamber must fit kinematically the decay of a K^0_1.
3) The momentum and scattering angle of the K^0_1 must fit kinematically the process $K^- + p \rightarrow \bar{K}^0 + n$.

The observed V^0's were tested for consistency with the hypotheses K^0_1, Λ^0, $\bar{\Lambda}^0$. Of the 412 events, 323 satisfied criterion 2), 42 were identified as Λ^0, 1 as $\bar{\Lambda}^0$, 12 gave no fit and 34 were bad measurements.

The 323 events fitting K^0_1 decay were considered as candidates for charge exchange. To apply the criterion 3), a parameter Δ was defined as:

$$\Delta = (P_{K^0_1} - P_\Theta)/\sqrt{(\sigma^2_{K^0_1} + \sigma^2_{K^-})}$$

where $P_{K^0_1}$ and $\sigma_{K^0_1}$ are the fitted momentum of the K^0_1 observed in the spark chamber and its error, P_Θ is the momentum of a K^0 produced in a charge exchange interaction of a 9.50 GeV/c K^- at the observed scattering angle Θ, and σ_{K^-} is the momentum spread of the beam.

The distribution of Δ is shown in fig. 1, together with a normal distribution which has a standard deviation of 1.0. The 286 events having a value of $|\Delta|$ less than 3.0 have been accepted as a charge exchange, together with a further eight which did not quite satisfy this criterion, but on closer inspection could not be given an alternative interpretation.

These accepted events still contain a number of ambiguous fits (23 K^0_1 or Λ^0; 14 K^0_1 or $\bar{\Lambda}^0$). The distribution of the decay angle in the c.m.s. of the assumed K^0_1 is, however, consistent with negligible contamination by Λ^0's.

A run with the hydrogen target empty gave no events, putting an upper limit of 3% on the background due to interactions in the target walls, etc. From the measured resolving power of the Čerekov counters, we expect that the background in the charge-exchange peak due to π^- and $\bar{p}$ interactions, the incident particle being misidentified as a K^-, is negligibly small. Experiments using the same set-up of trigger counters and π^- or $\bar{p}$ as incident particle have shown that a π^- background would be signalled by a large number of low-energy K^0 and a $\bar{p}$ background would be signalled by a large number of high-energy $\bar{\Lambda}$, neither of which is observed.

The background from other K^- interactions must be negligible as the particle or particles associated with a K^0_1 in the charge-exchange peak must have even strangeness, baryon number one and little energy. The last condition rules out Ξ^0 or a $\Lambda^0 K^0$ combination as these would decay before passing the anticoincidence shield.

After applying all corrections, the total cross section was determined as 70 ± 10 μbarns. The main correction factors are as follows: a factor of 3* for the ratio $(K^0_1 + K^0_2)/(K^0_1 \rightarrow \pi^+ + \pi^-)$, 2.57 ± 0.03 for the probability of decaying inside the fiducial volume, 1.42 ± 0.06 for the loss of events due to chance anticoincidences. Other corrections were applied for losses due to inter-

* We have taken $\frac{2}{3}$ as the branching ratio $(K^0_1 \rightarrow \pi^+ + \pi^-)$/all K^0_1 according to the $\Delta I = \frac{1}{2}$ rule and neglecting the small difference due to phase space. The corresponding experimental value is 0.694 ± 0.051 [2].

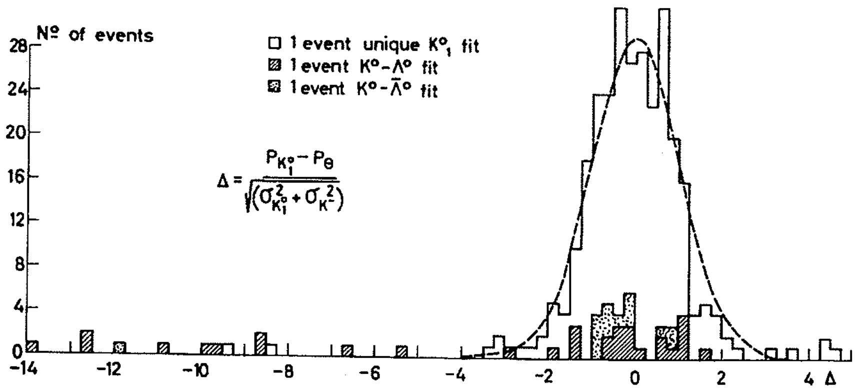

Fig. 1. Distribution of the parameter Δ.

actions of K^- and K^0 in the target and anticoincidence shield, and also for loss of events due to bad measurements (these were consistent with being an unbiased sample of the events). The neutron detection efficiency of the anticoincidence counter was calculated by a Monte Carlo programme and was consistent with previous experiments [3].

The differential cross section is shown in fig. 2. The mean error on t is 0.005 at $t = -0.05$ increasing linearly with t to 0.04 at $t = -1.0$. The detection efficiency due to decay probability is effectively constant up to the highest momentum transfer observed $[-2.2\ (\mathrm{GeV}/c)^2]$ corresponding to a scattering angle of 170 mrad in the laboratory.

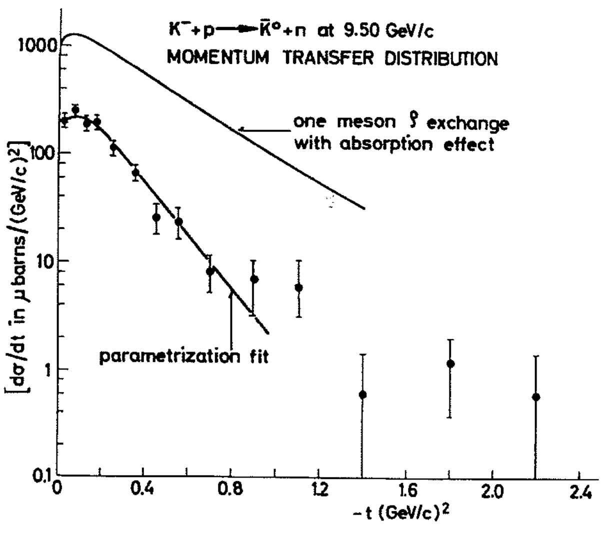

Fig. 2. Differential cross section of $K^- + p \to \bar{K}^0 + n$ at 9.50 GeV/c.

Table 1

$\left(\frac{d\sigma}{dt}\right)_{t=0}$ in μbarns/(GeV/c)^2 for $K^- + p \to \bar{K}^0 + n$ at 9.50 GeV/c.

Optical theorem assuming a purely imaginary amplitude	185 ± 88
ρ Exchange	370 ± 176
(ρ+R) Exchange	245 ± 50
Experimental value at t = 0.05 (GeV/c)^2	200 ± 30

At twice this momentum transfer, the detection efficiency has fallen by less than a factor of 2; the quoted value of the total cross section is thus reliable, provided there is no backward peaking. The shape of the differential cross section is clearly inconsistent with exponential behaviour at low t and similar to the one found for $\pi^- + p \to \pi^0 + n$ [4].

We have compared our $d\sigma/dt$ with different theoretical models. Table 1 shows the comparison at $t = 0$ with the optical theorem, using the experimental values of $\sigma_{tot}(K^-p)$ and $\sigma_{tot}(K^-n)$ obtained by Galbraith et al. [5]. It also shows a theoretical prediction made by a Regge pole model with the exchange of a ρ and (ρ+R) [6]. Due to the large error in the difference between the experimental total cross sections, $[\sigma_{tot}(K^-p) + - \sigma_{tot}(K^-n) = 1.90 \pm 0.45$ mb], it is not possible to draw any conclusion on the real part of the forward scattering amplitude and on the relative merit of ρ and (ρ+R) exchange.

In fig. 2 is plotted the prediction of a modified one meson exchange model, including absorption effect [7], which is clearly inconsistent with the experimental data. In the same figure we plot the curve obtained by fitting helicity amplitudes [8]; setting

$$\frac{d\sigma}{dt} = \frac{\pi}{q^2}\left[\left(1 - \frac{t}{4M^2}\right)|G|^2 - \frac{t(t+4q^2)s}{4(4M^2-t^2)M^2}|H|^2\right]$$

where we have assumed

$$|G|^2 = A\,e^{\alpha t}; \qquad |H|^2 = Be^{\alpha t}$$

we fitted the following values:

$$A = 229\frac{\mu b}{ster}; \quad B = 114\frac{\mu b}{ster}; \quad \alpha = 7.4\ (GeV/c)^{-2}.$$

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