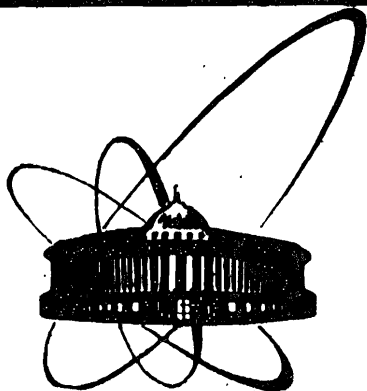


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E1-86-780

Bitsadze G.S. etc.

**DIFFERENTIAL CROSS SECTIONS
FOR REACTIONS $\pi^+ n \rightarrow K^+ \Sigma^0$
AND $\pi^+ n \rightarrow K^+ \Lambda$ AND RATIO
OF DIFFERENTIAL CROSS SECTIONS
FOR QUASI-BINARY PROCESSES
 $\pi^+ A \rightarrow K^+ Y + A'$ ON CARBON
AND DEUTERIUM NUCLEI AT 10.3 GeV/c**

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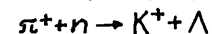
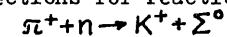
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The experimental results are presented for the studies of quasi-binary hypercharge-exchange reactions on carbon and deuterium nuclei.

Differential cross sections for reactions



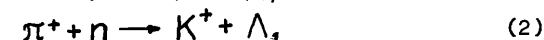
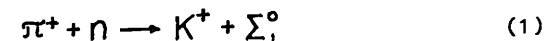
have been measured at the incident pion momentum 10.3 GeV/c. Earlier, these reactions were investigated only at energies up to 5.1 GeV/c^{1/1}.

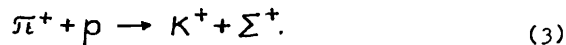
The experimental investigations of binary reactions with hypercharge exchange at different energies are of interest as they allow us to study the behaviour of cross sections and strange Regge-trajectories. Such experimental data are also useful for testing the existing theoretical models (see, e.g. /2/ and /3/).

Besides, we have measured the ratio A_{eff} of differential cross sections for quasibinary reactions on the carbon and deuterium nuclei. Interest in this measurement was provoked by the recent model^{/4/}, based on QCD principles, which predicts the growth of that ratio A_{eff} with increasing absolute value of the momentum transfer $|t|$, whereas the Glauber phenomenology and additive quark model give both $A_{\text{eff}} = \text{const.}$

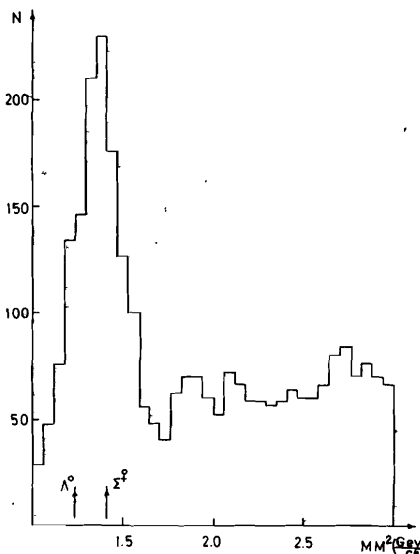
Differential cross sections. Measurements were carried out at the spectrometer HYPERON^{/5/} at Serpukhov accelerator. The measurement procedure and data analysis are described in detail in refs.^{/6,7/} in which the experimental results are also presented for the binary reaction $\pi^+ p \rightarrow K^+ \Sigma^+$ obtained with the same set-up. Statistics for the reactions $\pi^+ n \rightarrow K^+ \Sigma^0 / \Lambda$ was collected under the same conditions with the deuterium target.

The reactions under investigation were selected by analysing missing-mass-squared spectra for the forward-emitted K^+ meson; the distribution of events over the missing mass squared (MM^2) is plotted in Fig. 1; here a peak is clearly seen that is produced by the three reactions





It is just the events with $MM^2 < 2 \text{ GeV}^2/c^4$, that have been selected for further analysis. In each transfer-momentum interval missing-mass-squared spectra were histogrammed taking into account the acceptance of apparatus. In Fig. 2 a typical distribution is shown for weighted events in the transfer-momentum range $0.01 \leq |t-t_{\min}| = t' < 0.02 \text{ GeV}^2/c^2$.



Since the mass difference of Σ^+ and Σ^0 hyperons is small, $\Delta m^2 = 0.007 \text{ GeV}^2/c^4$, then by analysing the MM^2 spectra only a total contribution of reaction (1) and (3) can be determined. The contribution of each reaction can be found by using isotopic invariance relation:

Fig. 1. The missing-mass-squared distribution of events for deuterium target.

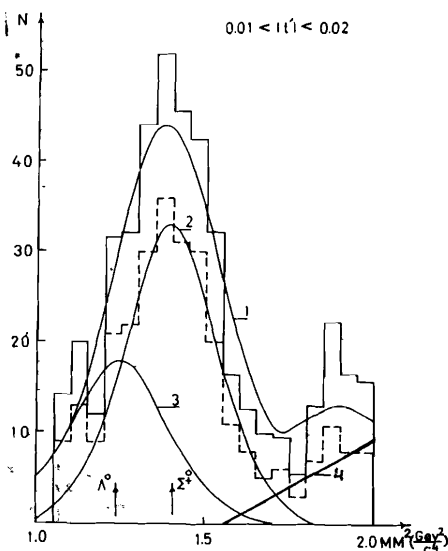


Fig. 2. The missing-mass-squared spectrum in $0.01 \leq t' = |t-t_{\min}| < 0.02 \text{ GeV}^2/c^2$ interval weighted with allowance for the apparatus acceptance; the dashed line is the distribution of nonweighted events; the solid lines: 1 is the fit with the approximating function, 2 is a summed contribution of reactions (1) and (3), 3 is a contribution of reaction (2), 4 - background from 3-particles final states.

$$2 \frac{d\sigma}{dt} (\pi^+ n \rightarrow K^+ \Sigma^0) = \frac{d\sigma}{dt} (\pi^+ p \rightarrow K^+ \Sigma^+) \quad (4)$$

The separated contributions of reactions (1)-(3) were determined by fitting of MM^2 -spectra (see /6/), similar to shown on Fig. 2. Particle masses were taken equal to its tabulated values. Peak widths are conditioned by facility resolution.

$ t $	$\pi^+ n \rightarrow K^+ \Sigma^0$	$\pi^+ n \rightarrow K^+ \Lambda^0$
0,00-0,01	120,3±26,2	183,8±40,0
0,01-0,02	98,9±21,9	137,2±33,3
0,02-0,03	81,0±14,9	139,2±28,0
0,03-0,05	91,3±15,7	101,8±23,3
0,05-0,10	54,7±10,2	114,6±20,4
0,10-0,20	28,6± 4,9	67,5±11,4
0,20-0,40	6,9± 3,4	13,2± 5,8

Table 1. Differential cross sections $d\sigma/dt [\mu\text{b}/(\text{GeV}/c)^2]$ for the reactions $\pi^+ n \rightarrow K^+ \Sigma^0$ and $\pi^+ n \rightarrow K^+ \Lambda$.

The results of measurement of the differential cross sections for reactions (1) and (2) in the momentum-transfer range $0 \leq t' < 0.4 \text{ GeV}^2/c^2$ are presented in Table 1 and Fig. 3 and compared with the results of approximation of the differenti-

al cross sections to the exponential function: $d\sigma/dt = A \exp(bt')$ the approximation parameters A and b being given in Table 2.

Foley et al. /8/ have measured the cross sections for the reactions $\pi^- p \rightarrow K^0 \Sigma^0 / \Lambda$, isospin conjugated to (1) and (2) at about the same energy, 10.7 GeV, and calculated the approximation parameters for these reactions, which we list

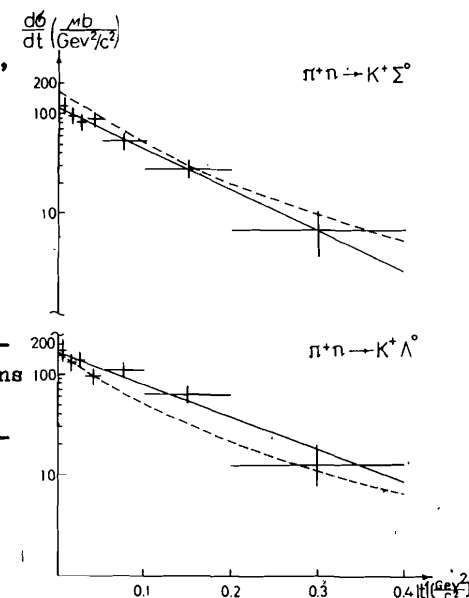


Fig. 3. Dependence of differential cross sections for the reactions $\pi^+ n \rightarrow K^+ \Sigma^0$ and $\pi^+ n \rightarrow K^+ \Lambda$ on $t' = |t-t_{\min}|$; solid lines denote the fit with the function $\frac{d\sigma}{dt} = A e^{bt'}$; dashed lines are predictions of the model /2/ for energy 10.7 GeV.

Table 2. Values of the parameters of approximation of differential cross sections to the function $d\sigma/dt' = A \exp(bt')$:
 for $\pi^+n \rightarrow K^+\Sigma^0/\Lambda$ - data from the HYPERON
 for $\pi^-p \rightarrow K^0\Sigma^0/\Lambda$ - data by Foley et al. ^{/8/} at 10.7 GeV.

	$\pi^+n \rightarrow K^+\Sigma^0$	$\pi^+n \rightarrow K^+\Lambda^0$	$\pi^-p \rightarrow K^0\Sigma^0$	$\pi^-p \rightarrow K^0\Lambda^0$	
A	$115,3 \pm 12,7$	$170,0 \pm 18,8$	103 ± 3	117 ± 3	$\mu b / (\text{GeV}/c)^2$
b	$9,4 \pm 1,2$	$7,4 \pm 1,1$	$9,38 \pm 0,24$	$7,85 \pm 0,18$	$(\text{GeV}/c)^{-2}$

for comparison in Table 2; the parameters found by Foley et al. are in good agreement with ours except the parameter A for reaction (2).

Our results of measurement and approximation are also compared in Fig. 3 with predictions of the quasi-eikonal model ^{/2/} treating a wide class of processes of pseudoscalar meson-nucleon scattering; a satisfactory agreement can be seen.

The integrated cross sections σ were found to equal for reaction (1) $(11.8 \pm 1.1) \mu b$ and for (2) $(21.7 \pm 2.2) \mu b$; for reaction (3) $\sigma = (23.6 \pm 2.2) \mu b$ was obtained by using relation (4), in agreement with the value $(25.7 \pm 2.4) \mu b$ found by interpolating the results of measurements at the HYPERON at 12 GeV/c ^{/6/} to 10.3 GeV/c beam momentum.

The ratio of cross sections on carbon and deuterium nuclei. As it has been mentioned, different theoretical models predict different ratios of the differential cross sections for exchange meson scattering on nuclei to the ones on the free nucleon as a function of the momentum transfer. We have calculated this dependence for a carbon nucleus by using the cross sections for reactions on the deuteron rather than on the nucleon:

$$A_{\text{eff}}(t') = \frac{d\sigma/dt(\pi^+C \rightarrow K^+Y + A')}{d\sigma/dt(\pi^+D \rightarrow K^+Y + N)}$$

because on the deuterium, as on the carbon, the same quasibinary reactions (1)-(3) take place. And since both the nuclei are symmetric, the relative contribution of these reactions is the same for carbon as for deuterium, which allows us to determine A_{eff} by using summed cross sections, without separating the reaction channels. In doing so, we have neglected the Glauber screening of nucleons in the deuteron.

As the carbon target, we made use of a scintillation counter in front of the deuterium target (a high interaction point resolution allowed us to separate the events generated by interactions in the counter substance). For this case we find that in the distribution

of events over the missing-mass-squared a peak from reactions (1)-(3) is clearly observed (see Fig. 4).

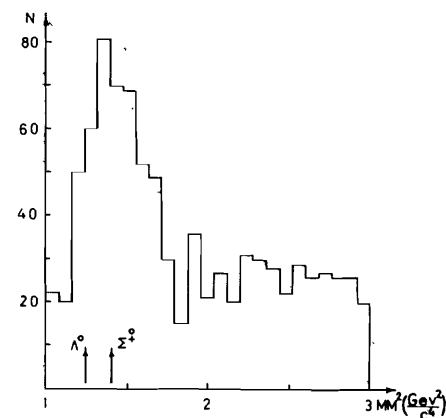


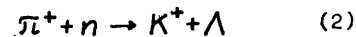
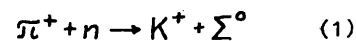
Fig. 4. The missing-mass-squared distribution of events for carbon.

In Fig. 5 we plot the experimental results for A_{eff} . The obtained dependence tends to increase, in agreement with predictions of the model given in ^{/4/}. By this model, A_{eff} is growing because meson-nucleon scattering "chooses", from the meson form factor, transverse fluctuations (distances between quarks)

$\tau \sim 1/t'$. Therefore, if scattering proceeds in an absorbing nuclear matter, the meson-absorption cross section being proportional to τ^2 will strongly depend on t' . For heavy nuclei, the magnitude of A_{eff} should sharply increase from $A^{1/3}$ for $t' \ll m_\pi^2$ to A for $t' \gg m_\pi^2$. Note is to be made that the growth of A_{eff} may also be caused by multiple rescattering if it is not suppressed, as in our case, by kinematical constraints of binary reactions.

Summary

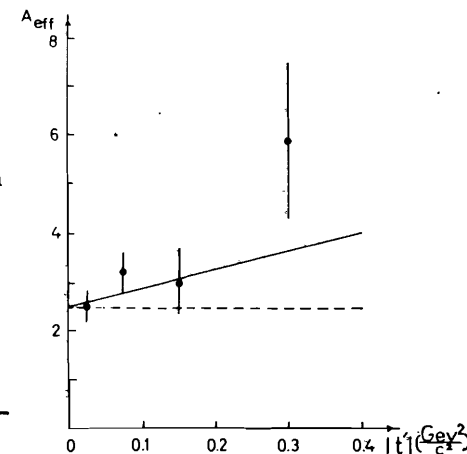
1. The differential cross sections for hypercharge-exchange binary reactions



at energy 10.3 GeV have been measured.

The obtained results are in rough agreement with the data found

Fig. 5. The dependence $A_{\text{eff}}(t')$. The solid line represents the prediction of the model ^{/4/}. The dashed line is the Glauber approximation.



by Foley et al. /8/ on measurement of reactions $\pi^- p \rightarrow K^0 \Sigma^0 \Lambda$ isospin conjugated to (1) and (2).

The t' dependence of differential cross sections for reactions (1) and (2) agree satisfactorily with the functions calculated within the quasi-eikonal model /2/.

2. The ratio A_{eff} is obtained for the differential cross sections of quasibinary reactions $\pi^+ A \rightarrow K^+ Y + A'$ on carbon and deuterium nuclei versus the momentum transfer. A_{eff} is observed to tend to grow with t' , in agreement with predictions of the model /4/.

The authors are grateful to the JINR and IHEP Directorates for the possibility of carrying out the experiment; to B.Z.Kopeliovich for useful discussions and to A.E.Nazaryan for supplying the results of theoretical calculations of differential cross sections.

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Бицадзе Г.С. и др.

E1-86-780

Дифференциальные сечения реакций $\pi^+n \rightarrow K^+\Sigma^0$ и $\pi^+n \rightarrow K^+\Lambda$ и отношение дифференциальных сечений квазибинарных процессов $\pi^+A \rightarrow K^+Y + A'$ для ядер углерода и дейтерия при энергии 10,3 ГэВ/с

Представлены результаты изучения реакций $\pi^+n \rightarrow K^+\Sigma^0/\Lambda$ при 10,3 ГэВ/с. Измерения были выполнены на спектрометре недостающих масс "Гиперон", на ускорителе ИФЭЗ. Измерены дифференциальные сечения в интервале переданных импульсов $0 \leq |t - t_{\min}| < 0,4$ (ГэВ/с)². Интегральные сечения в исследуемом интервале переданных импульсов составили: $(11,8 \pm 1,1)$ мкб и $(21,7 \pm 2,2)$ мкб для реакций $\pi^+n \rightarrow K^+\Sigma^0$ и $\pi^+n \rightarrow K^+\Lambda$ соответственно. Полученные результаты сравнивались с предсказаниями квазиейкопальной модели и с другими экспериментальными данными. Измерено отношение $A_{\text{eff}}(t)$ дифференциальных сечений реакций $\pi^+A \rightarrow K^+Y + A'$ на ядрах углерода и дейтерия. A_{eff} имеет тенденцию к росту с возрастанием $|t|$ в соответствии с предсказанием модели, основанной на КХД.

Работа выполнена в Лаборатории ядерных проблем ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1986

Bitsadze G.S. et al.

E1-86-780

Differential Cross Sections for Reactions $\pi^+n \rightarrow K^+\Sigma^0$ and $\pi^+n \rightarrow K^+\Lambda$ and Ratio of Differential Cross Sections for Quasi-Binary Processes $\pi^+A \rightarrow K^+Y + A'$ on Carbon and Deuterium Nuclei at 10.3 GeV/c

The results of the study of $\pi^+n \rightarrow K^+\Sigma^0/\Lambda$ reactions at 10.3 GeV/c are presented. The measurements were carried out at missing mass spectrometer HYPERON at IHEP accelerator. The differential cross sections in $0 \leq |t - t_{\min}| < 0.4$ (GeV/c)² momentum transfer range are measured. The integrated cross sections in the studied t -interval are (11.8 ± 1.1) μb and (21.7 ± 2.2) μb for reactions $\pi^+n \rightarrow K^+\Sigma^0$ and $\pi^+n \rightarrow K^+\Lambda$, respectively. The obtained results were compared with the predictions of quasi-eikonal model and with other experimental data. The ratio $A_{\text{eff}}(t)$ of differential cross sections for $\pi^+A \rightarrow K^+Y + A'$ reactions on carbon and deuterium nuclei are measured. The $A_{\text{eff}}(t)$ tend to grow with increasing $|t|$ in agreement with the predictions of QCD-based model.

The investigation has been performed at the Laboratory of Nuclear Problems, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna 1986