To observe the T-noninvariant term it is best to measure the plane polarization of the photons in a direction making a 45° angle with the vectors $\vec{n}_1$ and $\vec{n}_2$, when this term is a maximum. In the absence of such a term the probability that the photon will be polarized in this direction is equal to 1/2. To estimate the expected effect in the case of T-noninvariance we write the probability **w**, integrated with respect to the energy of the γ quantum from x_{min} to 1, in the form

$$w = \tfrac{1}{2}(1 + \lambda''f(\theta)). \tag{10}$$

From the experimental data [3] we can determine only the connection between $|\lambda|^2$ and λ'. (We assume [6] that $\tau_{\pi^0} = 0.74 \times 10^{-16}$ sec.)

$$|\lambda|^2 + 1.72\lambda' - 0.7 = 0. \tag{11}$$

$1 - \cos\theta$	1.0	1.2	1.4	1.6	1.8	2.0
$f(\theta)$	0.21	0.29	0.43	0.58	0.44	0.00

The values of $f(\theta)$ for $|\lambda|^2 = 2$ and $x_{min} = 0.3$ are gathered in the table. $f(\theta)$ reaches a maximum value of 0.58 at $\theta \approx 127°$. If we assume that in the case of total violation of T-invariance $\lambda'' \sim 1$, then the effect turns out to be rather large.

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DIFFERENTIAL CROSS SECTION OF CHARGE EXCHANGE OF 4.8-GeV/c π^- MESONS WITH PROTONS

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Azimov et al. [1] described a method of detecting high-energy π^0 mesons with the aid of a spark chamber and a total-absorption Cerenkov counter. Unlike the already described method of detecting π^0 mesons with the aid of cascade spark chambers [3,4], this method makes it possible to measure with good accuracy both the angle and the energy characteristics of γ quanta from π^0 meson decays. We present below preliminary results of the measurement of the differential cross section of the reaction

$$\pi^- + p \to n + \pi^0 \quad (1)$$

with the aid of this procedure.

The setup was irradiated in a beam of 4.8-GeV/c π^- mesons from the JINR proton synchrotron. The measurements were made by a difference method using polyethylene and carbon targets. Approximately 1500 photographs of the spark chamber with γ quanta were obtained. The energy released in the Cerenkov counter was registered in each case.

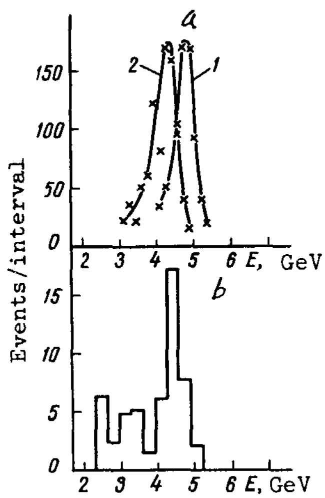

Fig. 1

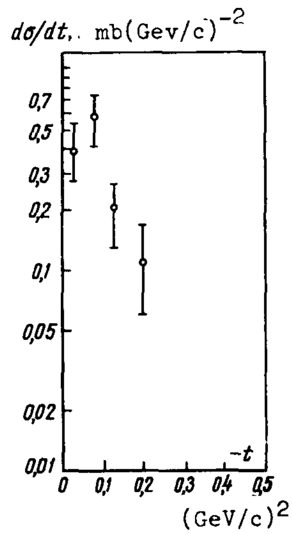

Fig. 2

The photographs were scanned to select the cases when two γ quanta were registered in the chamber. Figure 1 shows the energy distribution of these cases, obtained by subtracting the corresponding distributions from CH_2 and C targets (b). For comparison, we show the calibration spectra obtained by irradiating a Cerenkov counter with 4.8-GeV/c electrons (a) (the calibration procedure is described in [2]). Curve 2 was obtained for the case when a converter (10 mm of lead) was placed in front of the spark chamber, and curve 1 for the case when the converter was removed. As seen from the figure, the energy spectrum shows a peak due to the decays of the π^0 mesons from the reaction (1). The remainder of the spectrum is the background due to the decays of the π^0 mesons from inelastic interactions of the type

$$\pi^- + p \to n + m\pi^0 \qquad (m = 2, 3, \ldots) \quad (2)$$

For those cases with two γ quanta of energy larger than 3.6 GeV (start of peak in the energy spectrum), we plotted the distributions of the angles between the outgoing γ quanta ($\theta_{\gamma\gamma}$). The distribution of $\theta_{\gamma\gamma}$ obtained by a difference method agrees within the limits of error, with the distribution obtained from the kinematics of the reaction (1).

To construct the angular distribution of the π^0 mesons formed in the charge-exchange reaction, we used cases whose energies were higher than 3.6 GeV and with angle $\theta_{\gamma\gamma} \leq 6°$. The π^0-meson direction was assumed to be the bisector of the angle $\theta_{\gamma\gamma}$. The resultant error in the determination of the angle of emission of the π^0 meson is on the average ±1.1° for the chosen range of $\theta_{\gamma\gamma}$. Together with the measurement errors and the angle scatter of the primary π^- mesons, the accuracy in the determination of the angle of emission of the π^0 meson is $\pm 1.6°$.

In calculating the differential cross section of reaction (1) we took into account corrections for the following effects: (a) probability of conversion of two γ quanta in the lead converter, (b) probability of conversion of at least one of the γ quanta in the target or in the scintillation-counter material, (c) muon contamination of the beam, and (d) attenuation of the beam in the target. The differential cross section of the reaction $\pi^- + p \rightarrow n + m\pi^0$ in units of the 4-momentum transfer squared (-t) is shown in Fig. 2. The variation of the cross section agrees in general outline with the data obtained by the method of cascade spark chambers at other energies [3,4]. In the region $-t < 0.1$ a characteristic flat top was observed, with a tendency to decrease at lower values of -t. The forward charge-exchange cross section averaged over the interval $0 \leq -t \leq 0.1$ is equal to

$$\frac{d\sigma}{dt}(t = 0)_{ex} = (0.49 \pm 0.1) \quad mb/(GeV/c)^2$$

or in units of solid angle (c.m.s.)

$$\frac{d\sigma}{d\Omega}(0°)_{ex} = (0.33 \pm 0.07) \quad mb/sr.$$

Calculation based on the dispersion relations and the known data on the total cross sections of the π^+p and π^-p interactions [5] yields for an incident π^- meson with momentum 4.8 GeV/c

$$\frac{d\sigma}{d\Omega}(0°) = 0.28 \text{ mb/sr},$$

which agrees with the experimental value within the limits of error.

It must be noted that the available measurement data on the quantity $\frac{d\sigma}{d\Omega}(0°)_{ex}$ are relatively scanty in the energy region 4 - 5 GeV [6], and that these data are furthermore in poor agreement with the experimental curve. It is therefore of considerable interest to further refine the data on charge exchange in this energy interval.

The total cross section of the reaction (1), calculated with account of the experimental geometry and the data of [4] on the differential charge-exchange cross section at large -t, is equal to

$$\sigma_{ex} = (0.11 \pm 0.02) \text{ mb}.$$

The apparatus has also made it possible to measure the total cross section of the "neutral processes" (reaction (2)), which was found to be

$$\sigma(\pi^- + p \rightarrow n + m\pi^0) = (1.3 \pm 0.2) \text{ mb}.$$

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THE CROSS SECTION OF QUARK GENERATION

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The absence of quarks from pN collisions in accelerators or cosmic rays has led to the conviction that their mass m_q is much higher than the generation threshold, $m_q \sim (8 - 16)m_N$ and more (m_N is the nucleon mass); it is furthermore assumed that their generation cross section σ_q can not be much smaller than $\sim(10^{-3} - 10^{-4})\sigma_0$, where $\sigma_0 \approx 30$ mb is the cross section of inelastic NN collision. We shall show, however, that both independent experiment and the theory lead to $\sigma_q \sim \exp(-2m_q/\mu)$, where μ is the pion mass, so that any increase of m_q by an amount equal to m_N reduces σ_q by ~5 orders of magnitude. Even when $m_q = 2.5m_N$ we get $\sigma_q \sim 10^{-10}\sigma_0$. The experiments performed mean only that $m_q > 2.5m_N$, and the detection of quarks is exceedingly difficult. The reason for this is the competition of the channels with π generation; there is a much larger statistical probability of emission of $2m_q/\mu$ pions than of a $\tilde{q}q$ pair. We assume here (and this is of fundamental significance) that at distances $\sim m_N^{-1}$ to μ^{-1} the qN or qπ interaction is essentially the usual one for NN and πN: inasmuch as the virtual decay $q \to q + (q + \tilde{q}) \equiv q + \pi \to q$ is possible, the q should have the usual pion shell (and the other usual shells of smaller radius).

1. Experiment. The dependence of the cross section for the generation of pairs of heavy strongly-interacting particles on their mass can be deduced from accelerator experiments on the generation of $\tilde{p}$ and $\tilde{d}$, and also $\tilde{\Sigma}^-$ and $\tilde{Y}_1^{-*}$. For the ratio of their numbers $n_{\tilde{p}}$ and $n_{\tilde{d}}$ to the number of pions n_{π^-} in the p-Be collision act (which is practically the same as for the pN collision), and for $d^2\sigma_{\tilde{d}}/d\Omega dp$ for $\tilde{d}$ on Be, for example at $E_{lab} = 30$ GeV, an emission angle $\theta_{lab} = 4.5°$, and a secondary pion momentum p = 5 GeV/c, we get [1,2]

$$\frac{n_{\tilde{p}}}{n_{\pi^-}} = (1 \pm 0.1) \times 10^{-2}; \quad \frac{n_{\tilde{d}}}{n_{\pi^-}} = (5.5 \pm 1.5) \times 10^{-8}; \quad \frac{d^2\sigma_{\tilde{d}}}{d\Omega dp} = 7 \times 10^{-33}\ \mathrm{cm^2 sr/(GeV/c)}.$$