$= 1$, $\Delta E_+ = \Delta E_- = \Delta E_0$)

$$\ln \sigma = \ln A - \Delta E_0/2kT,$$

and when $T \ll T_c$

$$\ln \sigma = \ln Ac_- - (\Delta E_0 + \alpha M_0^2 + \beta)/2kT.$$

Let us compare the term αM_0^2 with β. By virtue of the estimate (4), the "deformation" contribution to the change in the slope of $\ln \sigma$ will exceed the contribution due to magnetization when $NkT_c/\rho s^2 > \beta/\Delta E_0$. To this end it is sufficient to have $\beta/\sqrt{\Delta E_0 kT_c} < 0.1$ if the foregoing numerical estimates are used.

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PION ELECTROPRODUCTION AND AXIAL CURRENT

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We derive in the present note, using the algebra of single-time commutators, a generalization of the Kroll-Ruderman theorem [1] to include the case of electroproduction of pions at momentum transfers $\sim\mu^2$.

The amplitude for the production of a π^+ meson on a proton by a virtual γ quantum can be represented in the form

$$T_\mu = i\int dx \exp(iqx)(\Box - \mu^2)\langle p'|\theta(x_0)[j_\mu(0), \varphi(x)]|p\rangle. \tag{1}$$

Here j_μ is the electromagnetic current, φ the meson field operator, and p, p', and q the momenta of the proton, neutron, and meson, respectively.

When $q^2 = \mu^2$ we can replace, without any approximation, $\varphi(x)$ in (1) by the divergence of the axial current $c\partial_\nu a_\nu(x)$ $(c = -g_r K(0)/\sqrt{2}m\mu^2 g_A)$, which has a pion pole. Integrating (1) further by parts, we obtain

$$T_\mu = -ic\int dx\ \exp(iqx)(\Box - \mu^2)\langle p'|\delta(x_0)[j_\mu(0),\ a_0(x)]|p\rangle + cq_\nu\int dx\ \exp(iqx)(\Box - \mu^2)\langle p'|\theta(x_0)[j_\mu(0),\ a_\nu(x)]|p\rangle, \tag{2}$$

which goes over when $q \to 0$ into

$$\tilde{T}_\mu = \lim_{q\to 0}\left\{T_\mu - cq_\nu\int dx\ \exp(iqx)(\Box - \mu^2)\langle p'|\theta(x_0)[j_\mu(0),\ a_\nu(x)]|p\rangle\right\} = ic\mu^2\langle p'|[j_\mu(0),\ \int d\vec{x}\ a_0(\vec{x},\ 0)]|p\rangle. \tag{3}$$

We assume that the single-time commutator in (3) is equal to $a_\mu(0)$ [2]. (The consistency of the local commutation relations is discussed in a paper by Sokolov and Khriplovich [3].) Thus, at $q = 0$ the amplitude of the process under consideration is connected with the matrix element of the axial current, which can be written after separating the pion pole in the form [4]

$$\langle p'|a_\mu(0)|p\rangle = g_A\left\{h(k^2)g_{\mu\nu} - \frac{k_\mu k_\nu}{k^2}\left[h(k^2) + \frac{\mu^2}{k^2 - \mu^2}\frac{K(k^2)}{K(0)}\right]\right\}\bar{u}(p')\gamma_5\gamma_\nu u(p) = \frac{1}{ic\mu^2}\tilde{T}_\mu, \tag{4}$$

where $K(k^2)$ is a slowly varying function.

It must be pointed out that the first term in (2) vanishes when $q^2 = \mu^2$. However, it must be taken into account in any continuation off the mass shell, in order that the longitudinal part of T_μ coincide with that calculated in accord with the corresponding Ward identity [5].

Let us compare (4) with the contribution made to $\tilde{T}_\mu$ by the single-nucleon and single-meson states as $q \to 0$. Regardless of the manner of taking the limit, we obtain

$$\frac{1}{ic\mu^2}T^n_\mu = g_A\left[F^V_1(k^2)g_{\mu\nu} - \frac{k_\mu k_\nu}{k^2 - \mu^2}\frac{F_\pi(k^2,\ 0)}{K(0)}\right]\bar{u}(p')\gamma_5\gamma_\nu u(p). \tag{5}$$

We have left out a term proportional to the small isoscalar magnetic form factor. It has the wrong G-parity and should cancel out the contribution of the non-pole diagrams. In (5), $F^V_1(k^2)$ is the isovector electric form factor, and $F_\pi(k^2,\ 0)$ is the form factor of the pion at $q^2 = 0$.

When $|k^2| \sim \mu^2$ we can take into account only the strongest dependence on k^2, given by the pion pole. Putting here $h(k^2) \approx K(k^2)/K(0) \approx F_\pi(k^2,\ 0)/K(0) \approx F^V_1(k^2) \approx 1$, we see that (4) and (5) coincide. Since only pole terms contribute to the second term of $\tilde{T}_\mu$ when $q \to 0$, we conclude that the non-pole part of the electroproduction amplitude is small at this point. This part of the amplitude is expected to change little on going to $q_0 = \mu$ and $\vec{q} = 0$. In this case the amplitude will be essentially described by the pole diagrams, as before, at the pion production threshold, too. This statement generlizes the well-known low-energy Kroll-Ruderman theorem to include the process of electroproduction of a pion in the momentum-transfer region $\sim\mu^2$. The difference lies in the need for taking account in this case of the diagram with the pion pole. At the threshold, this diagram describes interaction only with time-dependent quanta, which are not present in the photoproduction process.

It is interesting to note that the validity of the Kroll-Ruderman theorem is evident simply from the fact that all the transverse covariants, in terms of which the photoproduction amplitude is expressed [6], viz. $\gamma_5\sigma_{\mu\nu}k_\nu$, $\gamma_5[P_\mu(qk) - q_\mu(Pk)]$, $\gamma_5[\gamma_\mu(qk) - q_\mu\hat{k}]$, $2\gamma_5[\gamma_\mu(Pk) - P_\mu\hat{k}] - m\gamma_5\sigma_{\mu\nu}k_\nu$ $(P = (p + p')/2)$ vanish when $k = 0$. Therefore a zero contribution will be made only by the pole diagrams containing the characteristic infrared factors $(pk)/2$ etc.

In conclusion we point out that the assumption that the functions $h(k^2)$ and $K(k^2)$ are slowly varying enables us to calculate the effective-pseudoscalar constant in μ capture. In this case the momentum transfer is equal to $k^2 = -0.52\ \mu^2$. The sought constant can be written in the form

$$g_P = g_A \frac{2mm_\mu}{k^2}\left[h(k^2) + \frac{\mu^2}{k^2 - \mu^2}\frac{K(k^2)}{K(0)}\right] \tag{6}$$

(m_μ is the muon mass). Putting again $h(k^2) \approx K(k^2)/K(0) \approx 1$, we obtain

$$g_P = -\,6.7g_A. \tag{7}$$

Estimates leading to a similar result [7] are widely known. We wish to emphasize, however, that the obtained value is not merely of the correct order of magnitude. Allowance for the change in $K(k^2)$, with the aid of linear extrapolation ($K(0) = 0.87$, $K(\mu^2) = 1$), leads to a value $-7.5g_A$. Thus, the true value of g_P can hardly differ from (7) by more than 10 - 15%.

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SCATTERING OF KILOVOLT NEUTRONS BY LEAD AND ELECTRIC POLARIZABILITY OF THE NEUTRON

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Experimental determination of the nucleon-polarizability coefficients yields very useful information connected with the internal structure of the nucleon. Gol'danskii et al. [1] obtained for the proton electric polarizability coefficient a value $\alpha_p = (0.9 \pm 0.4) \times 10^{-42}$