CONCERNING ONE POSSIBILITY OF DETERMINING THE CHARGE FORM FACTOR OF THE NUCLEON

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It is known that at large momentum transfers the differential cross section of elastic e-p scattering of unpolarized particles is not sensitive to the contribution of the charge form factor of the proton.

It was shown in [1] that for an effective determination of G_E^p in the $ep \to ep$ reaction, it is necessary to perform polarization experiments.

In this paper we propose another method of determining the electric form factor of the nucleon, based on an investigation of the process $ep \to en\pi^+$ at high energies s and small |t| (t is the square of the total energy of the πN system in the c.m.s. of the produced hadrons, $t = -(k - q)^2$, and k and q are the four-momenta of the virtual γ quantum and π meson).

We make use of the fact that in this kinematic region a simple model, which takes into account only the contribution of the Born mechanism, is applicable for the processes of electric production of charge pions (the γ quantum interacts only with the particle charges). This model explains successfully the experimental data obtained on the processes $\gamma p \to n\pi^+$ and $\gamma n \to p\pi^-$ at high energies and small momentum transfers [2]. The most recently published experimental data [3] for $ep \to en\pi^+$ do not contradict this simple model. It was noted for the first time in [4] that the reaction $ep \to en\pi^+$ can serve for the determination of the pion form factor in the discussed kinematic region.

If an electron and pion are registered in the final state in the reaction $ep \to en\pi^+$, then the differential cross section can be written in the form

$$\frac{d\sigma}{d\Omega_e dE' d\Omega_\pi} = N\{W_1 + \epsilon \sin^2\theta \cos 2\phi\, W_2 - \sqrt{2\epsilon(1+\epsilon)k^2}\sin\theta\cos\phi\, W_3 + \epsilon k^2 W_4\} \quad (1)$$

$$N = \frac{\alpha}{2\pi^2}\,\frac{E'}{E}\,\frac{|\mathbf{k}|}{k^2}\,\frac{1}{1-\epsilon}, \qquad \epsilon = \left[1 + 2\frac{\mathbf{k}^2}{k^2}\,\frac{s}{m^2}\,\mathrm{tg}^2\frac{\theta_e}{2}\right]^{-1},$$

where θ and ϕ are the angles determining the direction of pion emissions, θ_e is the electron scattering angle in the lab, $\vec{k}$ is the three-momentum of the virtual photon in the c.m.s. of the πN system, and E (E') is the energy of the initial (final) electron in the lab.

Within the framework of the minimal gauge-invariant model, which takes into account interactions of the γ quantum only with the particle charges, the quantities W_i are determined by the following expressions (which are valid at $s \gg m^2, k^2, |t|$):

$$W_1 = \frac{\alpha}{8\pi}\,\frac{g_{\pi NN}^2}{s}\left\{F_1^{v\,2} + 2F_1^v F_\pi \frac{t}{m_\pi^2 - t} + 2F_\pi^2\left(\frac{t}{t - m_\pi^2}\right)^2\right\},$$

$$W_2 = \frac{\sqrt{s}}{2}W_3 = \alpha\frac{g_{\pi NN}^2}{16\pi}\,\frac{1}{t - m_\pi^2}\,F_\pi\left(F_1^v + F_\pi\frac{t}{m_\pi^2 - t}\right), \quad (2)$$

$$W_4 = -\frac{\alpha}{8\pi}\frac{g^2_{\pi NN}}{s}\frac{t}{(t - m^2_\pi)^2}F^2_\pi$$

where

$$F_1^v = F_1^p - F_1^n, \quad F_1 = \left(G_E + \frac{k^2}{4m^2}G_M\right)/(1 + k^2/4m^2).$$

We see from these formulas that the cross section for the production of pions by longitudinally polarized photons is determined by F^2_π, whereas the cross section for the absorption of unpolarized transverse photons W_1 is sensitive to the contribution of the charge form factor of the nucleon. The quantities W_2 and W_3 are determined by the product of $F_1{}^V F$ and F^2_π, and a verification of the relation $2W_1 = \sqrt{s}W_3$ can serve as a criterion for the validity of the model.

Thus, the proposed reaction makes it possible to determine not only the absolute values of the form factors F_π and F^V_1, but also their relative sign. The latter is particularly important for the determination of the relative sign of the neutron electric form factor G^n_E at large k^2.

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ARGAND DIAGRAMS FOR THE QUASIPOTENTIAL AMPLITUDE OF pp AND $\bar{p}$p SCATTERING

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As is well known, the Regge asymptotic amplitude approximated in the low-energy region gives rise to spirals, called Schmid loops, on the Argand diagram [1]. It is also known that to describe data on scattering at high energies it is necessary to take into account, besides the Regge poles, also the contribution from the cuts in the I-plane, which naturally affects the behavior of the partial amplitudes at low energies. Such an influence of the cuts was investigated in [2] within the framework of the eikonal model.

In the present paper we consider Argand diagrams for the quasipotantial scattering amplitude. The quasipotential equation [3] is more general than the eikonal approximation and is valid at high and at low energies, so that it becomes possible to explain the resonant nature of the Schmid spirals.

In the simplest case of scattering of two spinless particles with equal mass, the quasipotential equation is

$$A(\mathbf{p},\mathbf{k}) = V(\mathbf{p},\mathbf{k}) + \int \frac{d\mathbf{q}V(\mathbf{p},\mathbf{q})A(\mathbf{q},\mathbf{k})}{\sqrt{m^2 + \mathbf{q}^2}\,(\mathbf{q}^2 - \mathbf{p}^2 - i0)}, \tag{1}$$