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ELECTRICAL POLARIZABILITY OF THE MESON CLOUD IN A NUCLEON

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The analysis of the experiments on scattering of fast electrons on hydrogen and deuterium and of slow neutrons on atoms leads to the result that the root-mean-square "electric radius" of a neutron is not practically different from zero. This result strongly contradicts to the conclusions of the modern meson theory. In this connection it becomes of great importance to consider other effects in which the "electromagnetic structure" of the nucleon may display itself. One of these effects is the scattering of slow nucleons in the inhomogeneous electric field (in particular, of the neutrons in the Coulomb field of a nucleus[1-3]) which stretches the cloud of the charges with different signs in the nucleon and reconstructs the nucleon into the electric dipol with the induced momentum. The electrical polarizability of the charges in the nucleon displays itself in the Compton effect and in the photopion production on the nucleons[4] as well as in the scattering of slow neutrons on atoms.[1]

We made use of the first approximation of the Chew theory[6] in order to evaluate the magnitude of the electrical polarizability of the meson cloud in the nucleon. (see Fig.). The corresponding matrix element is given by

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* The contribution of the effect of the electrical polarizability into the effective cross section calculated for case of fast electron scattering on protons was evaluated in[5] as 0.5% with respect to the main effect of the Coulomb interaction.

$$M = -\left(\frac{f}{\mu}\right)^2 e^2 \pi \int \frac{u(K)u(K')V(q-K)V(P-q)}{\omega_K^2\,\omega_P^2\,\omega_q^2}(\omega_K+\omega_q)(\omega_P+\omega_q)\times \quad (1)$$

$$\times (KP)\, d^3K/(2\pi)^3 \cdot d^3P/(2\pi)^3 \cdot d^3q/(2\pi)^3 \quad (2)$$

Here

$$W_K^2 = K^2 + \mu^2$$
$$u(K) = \int u(x) e^{-iKx} d^3x$$

is the form-factor of the source

$$V(K) = \int V(x) e^{-iKx} d^3x \quad (3)$$

is the scalar electric potential. The rest notations are standard.

Since the vector part of the electromagnetic field in the case under consideration is equal to zero, the interaction with the electromagnetic field may be written digitly and the theory is the gauge invariant /cf. |7|/.

For case of homogeneous field

$$V(K) = i(2\pi)^3 E_m \frac{\partial}{\partial K_m} \delta(\bar{K}) \quad (4)$$

the matrix element (1) may be given by

$$M = -\frac{1}{2}\alpha E_m^2 \quad (5)$$

where the electrical polarizability

$$\alpha=\left(\frac{f}{\mu}\right)^2 e^2 \frac{2}{3\pi\mu}\int_0^\infty \frac{K^2}{\omega_K^9}\left\{u^2(K)(27K^4-34K^2\omega_K^2)-\left(\frac{du(K)}{dK}\right)^2 4K^2\omega_K^4\right\}dK \tag{6}$$

$$\omega_K^2 = K^2+1$$

(we made use of the coordinate system where $E_1 = E_2 = E_3$).

It should be expected that as well as when calculating the nucleon magnetic moment and the neutron-electron interaction potential [9] the heigher terms of the expansion over the coupling constant f/μ do not essentially change the result [6]. For $u(K)=\frac{1}{1+\left(\frac{K}{5,6}\right)^2}$ $\alpha=1,6\cdot 10^{-42}cm^3$; For $u(K)=exp\left[-\frac{(K)^2}{2(5,6)^2}\right]$

$$\alpha = 1,8\cdot 10^{-42} cm^3$$

(The form-functions are chosen the same as in (8). The values α have been obtained for $\frac{f^2}{\hbar c}$ = 0. 08. The results of the calculation are not very sensitive to the specific choice of $u(K)$.

The calculated magnitude α is close to that obtained by Baldin from the analysis of experiments on photopion production and on Compton effect on the nucleon [4]. $4\cdot 10^{-43} cm^3 \le \alpha \le 1,4\cdot 10^{-42} cm^3$. But it is considerably less than the value α obtained by Aleksandrov from the experiments on slow neutron scattering. [2-3] $\alpha \sim 5\cdot 10^{-41} cm^3$. A more thorough analysis of these experiments is required. Note that the effects associated with the polarizability of α increase rapidly with the energy decrease of the scattering neutron.

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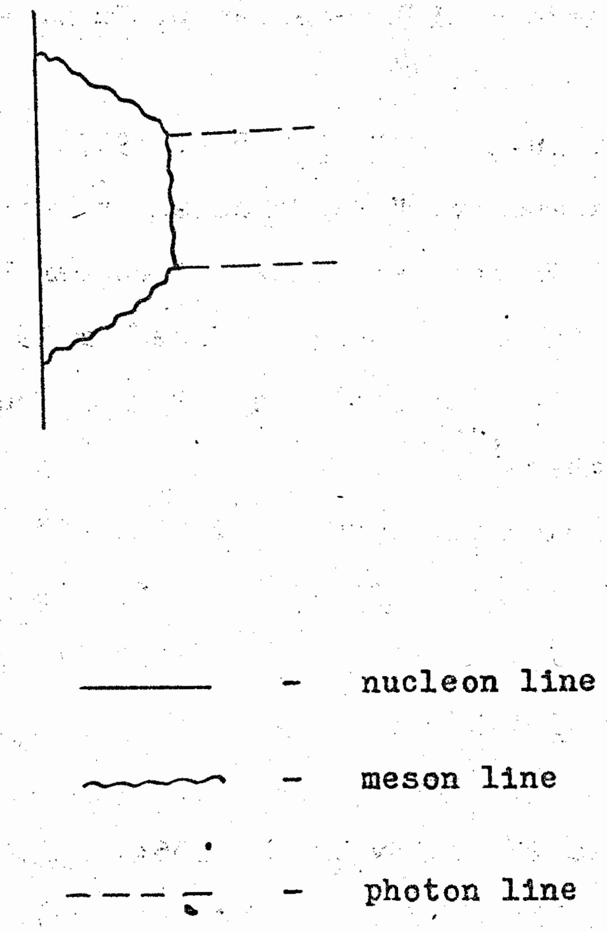

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