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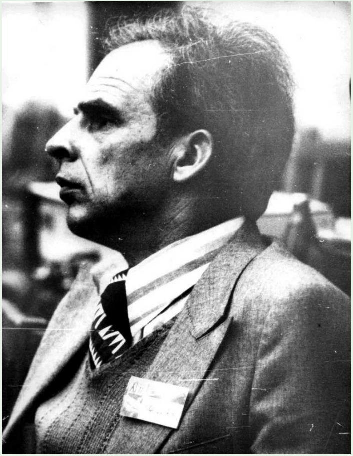

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A spin-dependent dipole polarizabilities and characteristics of the nucleon, related with parity violation

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An important role in the understanding of the interaction of electromagnetic fields with hadrons play low-energy theorems as they are based on general principles of quantum theory and decomposition of Compton scattering amplitudes for the photon energy [Maksimenko1991].

With the development of the Standard Model of electroweak interactions in recent years introduced a new electroweak characteristics of hadrons, related to violation of P-parity [R.J. P.F. Bedaque2000,M. Gorchtein2008,2015].

For a more reliable determination of polarizabilities and the characteristics of hadrons associated with parity violation, use a wide class of electrodynamic processes in which the dispersion is realized real and virtual photons, as well as two-photon production in hadron-hadron interactions.

The solution of such problems is possible to perform in the framework of the relativistic field-theoretical approach, describe the interaction of electromagnetic fields with hadrons with regard to their electromagnetic and electroweak characteristics [C.E. Carlson2011, N. Krupina2013] .

Currently, one of the most effective methods of investigation of electrodynamic processes is to use the effective Lagrangian obtained in the framework of field-theoretic approaches and consistent with the low-energy theorems [R.J. Hill2013].

Effective relativistic-invariant Lagrangians possible to obtain not only the physical interpretation of electromagnetic and electroweak characteristics of hadrons, but also information on the mechanisms of electromagnetic and electroweak photon-hadron interactions.

In [J.S.Anandan2000] for the construction of an effective relativistic invariant Lagrangian of the interaction of electromagnetic fields with the particles with constant electric and magnetic dipole moments introduced antisymmetric tensor of the dipole moments, which is independent of the electromagnetic field tensor $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$.

In this paper, a relativistic quantum field-invariant Lagrangian, which defines the tensor induced dipole moments, ie, this tensor, in contrast to [J.S.Anandan2000] depends on $F_{\mu\nu}$. Also provided is a variant of relativistic-invariant definition of spin dipole polarizabilities of the nucleon, which is based on the construction of the covariant induced dipole moments and phenomenological effective interaction Lagrangians of the electromagnetic field with these moments.

On the basis of the relativistic properties of P-transformation, as well as cross-symmetry set covariant spin structure of the amplitude of the Compton scattering, consistent with the low-energy theorems. It is shown that the proposed model and the characteristics of the spin polarizability of the nucleon connected with parity nonconservation, contribute to the expansion of the amplitude of Compton scattering from the third order with respect to the photon energy.

The scattering amplitude of the electromagnetic field of the spin $1/2$ particle in the dipole approximation

To get the low-energy scattering amplitude of the electromagnetic field on the spin of particles with polarizabilities will follow [L.D. Landau ThField]. However, the determination of the induced electric $\vec{d}$ and magnetic $\vec{m}$ dipole moments of the vectors of electric $\overrightarrow{E}$ and magnetic $\overrightarrow{H}$ electromagnetic field strengths using the relations [F.I. Fedorov ThGyr, V.G. Baryshevsky NuclOpt]:

$$\overrightarrow{d} = 4\pi\overset{\wedge}{\alpha}\overrightarrow{E}\ , \tag{2.1}$$

$$\overrightarrow{m} = 4\pi\overset{\wedge}{\beta}\overrightarrow{H}\ , \tag{2.2}$$

where $\overset{\wedge}{\alpha}$ and $\overset{\wedge}{\beta}$- the matrices, the matrix elements which are tensors of electric and magnetic polarizabilities. The diagonal elements of these matrices are expressed through the scalar electric and magnetic polarizability:

$$\alpha_{ij} = \alpha_1\delta_{ij},$$

$$\beta_{ij} = \beta_1\delta_{ij}.$$

Using (2.1) and (2.2) low-energy scattering amplitude of the electromagnetic field can be expressed through matrixes $\hat{\alpha}$ and $\hat{\beta}$ as follows [Maksimenko2014]:

$$M\left(\vec{n}_2\right) = 4\pi\omega^2\Big\{\left(\vec{e}^{(\lambda_2)*}\hat{\alpha}\,\vec{e}^{(\lambda_1)}\right) + \left(\vec{n}_2\vec{e}^{(\lambda_1)}\right)\left(\vec{n}_1\hat{\beta}\,\vec{e}^{(\lambda_2)*}\right) + \\ + \left(\vec{n}_1\vec{e}^{(\lambda_2)*}\right)\left(\vec{e}^{(\lambda_1)}\hat{\beta}\vec{n}_2\right) - \left(\vec{e}^{(\lambda_2)*}\vec{e}^{(\lambda_1)}\right)\left(\vec{n}_1\hat{\beta}\vec{n}_2\right) - \left(\vec{n}_1\vec{n}_2\right)\times \\ \times\left(\vec{e}^{(\lambda_1)}\hat{\beta}\,\vec{e}^{(\lambda_2)*}\right) + \left[\left(\vec{n}_2\vec{n}_1\right)\left(\vec{e}^{(\lambda_2)*}\vec{e}^{(\lambda_1)}\right) - \left(\vec{n}_2\vec{e}^{(\lambda_1)}\right)\left(\vec{n}_1\vec{e}^{(\lambda_2)*}\right)\right]\times \\ \times Sp\left(\hat{\beta}\right)\Big\}\,. \tag{2.3}$$

In expression (2.3) we have introduced the following notation: $\vec{e}^{(\lambda_1)}$ and $\vec{e}^{(\lambda_2)}$ – polarization vectors, $\vec{n}_1$ and $\vec{n}_2$ – single vectors of the falling and scattered radiation, ω – radiation frequency.

From definition $\vec{d}$ and $\vec{m}$ it agrees (2.1) and (2.2) follows, $\hat{\alpha}$ and $\hat{\beta}$ satisfy to the hermiticities condition.

In this case, as shown in work [M.V. Galynsky1986], tensors can α_{ij} and β_{ij} be presented as follows:

$$\alpha_{ij} = \alpha_1 \delta_{ij} + i\alpha_2 \varepsilon_{ijk} C_k,$$

$$\beta_{ij} = \beta_1 \delta_{ij} + i\beta_2 \varepsilon_{ijk} C_k,$$

where α_1, α_2, β_1 and β_2 – the real values, ε_{ijk}– a tensor Levi-Civita, C_k – pseudo-vector components.

In case of a spin particle as such pseudo-vector it is possible to choose a pseudo-vector – operator of the spin particle $\overset{\wedge}{\vec{S}}$. If to consider that matrixes $\overset{\wedge}{\alpha}$ and $\overset{\wedge}{\beta}$ depend from $\overset{\wedge}{\vec{S}}$, using algebra of operators $1/2$-spin:

$$\left[\hat{S}_i, \hat{S}_j\right] = i\varepsilon_{ijk} \hat{S}_k \ ,$$

$$\hat{S}_i \hat{S}_j = \frac{1}{4}\delta_{ij} + \frac{i}{2}\varepsilon_{ijk} \hat{S}_k \ ,$$

these tensors can be presented as follows

$$\alpha_{ij} = \alpha_1 \delta_{ij} + i\alpha_2 \varepsilon_{ijk} \hat{S}_k, \tag{2.4}$$

$$\beta_{ij} = \beta_1 \delta_{ij} + i\beta_2 \varepsilon_{ijk} \hat{S}_k. \tag{2.5}$$

Substituting (2.4) and (2.5) in the equation (2.3), we will obtain:

$$M\left(\vec{n}_2\right) = 4\pi\omega^2 \chi_f^+ \left\{ \alpha_1 \left(\vec{e}^{(\lambda_2)*} \vec{e}^{(\lambda_1)} \right) + \beta_1 \left(\left[\vec{e}^{(\lambda_2)*} \vec{n}_2 \right] \cdot \left[\vec{e}^{(\lambda_1)} \vec{n}_1 \right] \right) + \right.$$
$$\left. + i\alpha_2 \left(\overset{\wedge}{\vec{S}} \cdot \left[\vec{e}^{(\lambda_2)*} \vec{e}^{(\lambda_1)} \right] \right) + i\beta_2 \left(\overset{\wedge}{\vec{S}} \cdot \left[\left[\vec{e}^{(\lambda_2)*} \vec{n}_2 \right] \cdot \left[\vec{e}^{(\lambda_1)} \vec{n}_1 \right] \right] \right) \right\} \chi_i \,, \tag{2.6}$$

where χ_i and χ_f – spinor of an initial and final particle.

If the amplitude (2.6) require the condition of crossing symmetry, the equation (2.6) will be only the first two terms

$$M\left(\overrightarrow{n_2}\right) = 4\pi\omega^2\left\{\alpha_1\left(\overrightarrow{e}^{(\lambda_2)*}\overrightarrow{e}^{(\lambda_1)}\right) + \beta_1\left(\left[\overrightarrow{e}^{(\lambda_2)*}\overrightarrow{n_2}\right]\cdot\left[\overrightarrow{e}^{(\lambda_1)}\overrightarrow{n_1}\right]\right)\right\}, \quad (2.7)$$

which is consistent with the spin structure of the amplitude of the low-energy Compton scattering with the electric and magnetic polarizabilities [M.V. Petrunkin1981].

In the case of Compton forward scattering amplitude has a total spin structure of the form [M.V. Damashek1978]

$$M = g\left(\omega\right)\left(\overrightarrow{e}^{(\lambda_2)*}\overrightarrow{e}^{(\lambda_1)}\right) + ih\left(\omega\right)\left(\overrightarrow{S}\cdot\left[\overrightarrow{e}^{(\lambda_2)*}\overrightarrow{e}^{(\lambda_1)}\right]\right). \quad (2.8)$$

In this definition, the amplitude of the scalar function $g\left(\omega\right)$ is even, and $h\left(\omega\right)$ - with respect to cross-odd symmetry. Consequently, since the polarizability contribute to the amplitude (2.8) starting from the second-order and higher, the spin structure of the second term in (2.8) is determined by the contributions polarizabilities from the third-order.

Amplitude of low-energy Compton scattering in covariant dipole representation

We now define the Lagrangian and the Compton scattering amplitude in the covariant representation of the dipole.

In [J.S.Anandan2000] for the construction of an effective relativistic invariant Lagrangian of the interaction of electromagnetic fields with the particles with constant electric and magnetic dipole moments introduced antisymmetric tensor of the dipole moments, which is independent of the electromagnetic field tensor $F_{\mu\nu}$:

$$G^{\mu\nu} = (d^{\mu}u^{\nu} - u^{\mu}d^{\nu}) + \varepsilon^{\mu\nu\rho\sigma}m_{\rho}u_{\sigma}, \tag{3.1}$$

where d^{μ} and m^{μ} – the components of the electric and magnetic moments presented in a covariant form; u^{μ} – particle 4-speed components, $\varepsilon^{\mu\nu\rho\sigma}$ – 4-dimensional tensor Levi-Civita.

An effective Lagrangians interaction of an electromagnetic field with particles with the constant dipole moments is represented as follows:

$$L = -\frac{1}{2}\left(e_\mu d^\mu + h_\mu m^\mu\right) \ , \tag{3.2}$$

where $e_\mu = F_{\mu\nu}u^\nu$, $h_\mu = \tilde{F}_{\mu\nu}u^\nu$, $\tilde{F}_{\mu\nu} = \frac{1}{2}\varepsilon_{\mu\nu\rho\sigma}F^{\rho\sigma}$.

We are assuming that the form of a tensor (3.1) can be given and for the induced dipole moments. We will write down in a covariant form taking into account conservation law of parity and definition of a vector of Paulie-Lyubansky W^μ components of vectors of the electric and magnetic moments

$$d^\mu = 4\pi\alpha^{\mu\nu}e_\nu + 4\pi\kappa^{\mu\nu\delta}\left(\partial_\delta\right)e_\nu \ , \tag{3.3}$$

$$m^\mu = 4\pi\beta^{\mu\nu}h_\nu + 4\pi\tilde{\kappa}^{\mu\nu\delta}\left(\partial_\delta\right)h_\nu \ . \tag{3.4}$$

In equations (3.3) and (3.4) introduced the notation:

$$\alpha^{\mu\nu} = \alpha_1 g^{\mu\nu}, \kappa^{\mu\nu\delta} = \varepsilon^{\mu\nu\rho\varepsilon}W_\rho \ ,$$

$$\beta^{\mu\nu} = \beta_1 g^{\mu\nu}, \tilde{\kappa}^{\mu\nu\delta} = \tilde{\varepsilon}^{\mu\nu\rho\delta}W_\rho \ .$$

In case of a particle the spin $1/2$ vector $\hat{W}^{\mu}$ has the form:

$$\hat{W}^{\mu} = -\frac{1}{2m}\gamma^{5}\left(\gamma^{\mu}\hat{p} - p^{\mu}\right) ,$$

where $\hat{p} = \gamma_{\mu}p^{\mu}$, p^{μ} is 4-momentum of particle, γ^{μ} – the matrixes satisfying to permutable ratios $\gamma^{\mu}\gamma^{\nu} + \gamma^{\nu}\gamma^{\mu} = 2g^{\mu\nu}$. Equations (3.3) and (3.4) follows from expressions, d^{μ} as m^{μ} consist of symmetric and antisymmetric parts of the permutation of indexes μ and ν. As will be shown below, this presentation is consistent with the condition of crossing symmetry amplitude Compton scattering.

The Lagrangian (3.2), with which you can get the Compton scattering amplitude and align it with the low-energy theorems, within the field-theoretical covariant approach has the form [Maksimenko2011]:

$$L(x) = \frac{i\pi}{4m}\times$$
$$\times\left[\bar{\Psi}\gamma^{\nu}\hat{L}_{\nu\sigma}\overset{\leftrightarrow}{\partial^{\sigma}}\Psi + \bar{\Psi}\hat{L}_{\nu\sigma}\gamma^{\nu}\overset{\leftrightarrow}{\partial^{\sigma}}\Psi + \bar{\Psi}\gamma^{\sigma}\hat{L}_{\nu\sigma}\overset{\leftrightarrow}{\partial^{\nu}}\Psi + \bar{\Psi}\hat{L}_{\nu\sigma}\gamma^{\sigma}\overset{\leftrightarrow}{\partial^{\nu}}\Psi\right], \quad (3.5)$$

where $\Psi(x)$ is the bispinor of Dirac field, $\overleftrightarrow{\partial^{\nu}} = \overrightarrow{\partial^{\nu}} - \overleftarrow{\partial^{\nu}}$, shooters specify the directions of action of derivatives.

As was it is shown in work [Maksimenko2014] tensor $\hat{L}_{\nu\sigma}$ in expression (3.5) has to be is presented definitely that Lagrangian $L(x)$ satisfied to parity conservation law, and spin structures of amplitude of Compton scattering – cross symmetry:

$$\hat{L}_{\nu\sigma} = \hat{L}{}^{(\alpha_1)}_{\nu\sigma} + \hat{L}{}^{(\beta_1)}_{\nu\sigma} + \hat{L}{}^{(\kappa)}_{\nu\sigma} + \hat{L}{}^{(\tilde{\kappa})}_{\nu\sigma}. \tag{3.6}$$

In turn, the tensor of (3.6) are consistent with the definitions (3.3) and (3.4) are as follows:

$$\hat{L}{}^{(\alpha_1)}_{\nu\sigma} = F_{\nu\mu} \overset{\wedge}{\alpha}{}^{\mu\rho}(\alpha_1) F_{\rho\sigma}, \tag{3.7}$$

$$\hat{L}{}^{(\kappa)}_{\nu\sigma} = F_{\nu\mu} \overleftrightarrow{\partial}_{\delta} F_{\rho\sigma} \overset{\wedge}{\kappa}{}^{\mu\rho\delta}(\kappa), \tag{3.8}$$

where have introduced the following notations $\alpha^{\mu\nu} = \alpha_1 g^{\mu\nu}, \kappa^{\mu\nu\delta}(\kappa) = \varepsilon^{\mu\nu\rho\varepsilon} \hat{W}_{\rho}$. The derivative $\overleftrightarrow{\partial}_{\delta}$ operate only to tensors of an electromagnetic field $F_{\mu\nu}$, and the operator $\hat{W}_{\rho}$ operate to wave functions Ψ and $\bar{\Psi}$.

If in tensors (3.7) and (3.8) to make replacement $F_{\mu\nu} \rightarrow \tilde{F}_{\mu\nu}$, we will receive expressions for $\hat{L}{}^{(\beta_1)}_{\nu\sigma}$ and $\hat{L}{}^{(\tilde{\kappa})}_{\nu\sigma}$.

Thus, effective relativistic-invariant Lagrangian, allowing to consider scalar electric and magnetic dipole polarizabilities of a nucleon, it is possible to present in the form:

$$L^{(\alpha_1)} + L^{(\beta_1)} = \frac{2\pi}{m}\left(\alpha_1 F_{\nu\mu} F^{\mu}_{\sigma} + \beta_1 \tilde{F}_{\nu\mu} \tilde{F}^{\mu}_{\sigma}\right) \theta^{\nu\sigma}, \tag{3.9}$$

where $\theta^{\nu\sigma} = \frac{i}{2} \bar{\Psi} \gamma^{\nu} \overleftrightarrow{\partial}^{\sigma} \Psi$.

Amplitude of Compton scattering taking into account a Lagrangian (3.9) has the form [Maksimenko2011]

$$M^{(\alpha_1)} + M^{(\beta_1)} = \left(\frac{2\pi}{m}\right)\left[\alpha_1 \left(F^{(2)}_{\nu\mu} F^{(1)\mu}_{\sigma} + F^{(1)}_{\nu\mu} F^{(2)\mu}_{\sigma}\right) + \right. \\ \left. + \beta_1 \left(\tilde{F}^{(2)}_{\nu\mu} \tilde{F}^{(1)\mu}_{\sigma} + \tilde{F}^{(1)}_{\nu\mu} \tilde{F}^{(2)\mu}_{\sigma}\right)\right] \bar{U}^{(r_2)}\left(\overrightarrow{p}_2\right) \gamma^{\nu} P^{\sigma} U^{(r_1)}\left(\overrightarrow{p}_1\right). \tag{3.10}$$

In the equation (3.10) have introduced the notations:

$$F_{\mu\nu}^{(n)} = \left(k_{(n)\mu}e_{\nu}^{(\lambda_n)} - k_{(n)\nu}e_{\mu}^{(\lambda_n)}\right) \ ,$$

$\tilde{F}_{\mu\nu}^{(n)} = \frac{1}{2}\varepsilon_{\mu\nu\rho\sigma}F^{(n)\rho\sigma}$, parameter n has the values 1 and 2, $e_{\mu}^{(\lambda_1)}$ and $e_{\mu}^{(\lambda_2)*}$ are vectors of polarization of initial and final photons, $P = \frac{1}{2}\left(p_1 + p_2\right)$, k_1, p_1 and k_2, p_2 are four-momenta of initial and final photons and nucleons, $U^{(r_1)}\left(\overrightarrow{p}_1\right)$ and $\bar{U}^{(r_2)}\left(\overrightarrow{p}_2\right)$ are bispinors of initial and final nucleons.

Follows from (3.10) a ratio that the part of amplitude of Compton scattering caused by electric α_1 and magnetic β_1 scalar polarizabilities meets a condition of cross symmetry and makes a contribution, since the second order on energy of photons. In system of rest of a target and in the second order on energy of photons from (3.10) the ratio follows:

$$M^{(\alpha_1)} + M^{(\beta_1)} =$$
$$= 4\pi\omega_1\omega_2\chi_f^{+}\left[\alpha_1\left(\overrightarrow{e}^{(\lambda_2)*}\overrightarrow{e}^{(\lambda_1)}\right) + \beta_1\left(\left[\overrightarrow{e}^{(\lambda_2)*}\overrightarrow{n_2}\right]\cdot\left[\overrightarrow{e}^{(\lambda_1)}\overrightarrow{n_1}\right]\right)\right]\chi_i \ ,$$

which will be coordinated with (2.7).

Dipole spin polarizabilities and the characteristics of a nucleon, connected with violation parity

The electromagnetic characteristics of hadrons connected with not preservation of parity [Bedaque2000,Gorchtein2015] possess properties of the giration used in optics [Fedorov ThGy]. In this section we will consider relativistic-invariant determination of dipole spin polarizabilities and the giration of a nucleon connected with parity not preservation, and also we will pay attention to distinction of their deposits to amplitude of Compton scattering. Follows from (3.6) a ratio that effective Lagrangian, corresponding to deposits of spin dipole polarizabilities κ and $\tilde{\kappa}$, has an appearance:

$$L^{(\kappa)} + L^{(\tilde{\kappa})} = \frac{i\pi}{4m}\left(\varepsilon^{\mu\rho\kappa\delta}\right)\left[\kappa F_{\nu\mu}\overleftrightarrow{\partial}_{\delta}F_{\rho\sigma} + \tilde{\kappa}\tilde{F}_{\nu\mu}\overleftrightarrow{\partial}_{\delta}\tilde{F}_{\rho\sigma}\right]\times$$
$$\times\bar{\Psi}\left[\left(\gamma^{\nu}\hat{W}_{\kappa} + \hat{W}_{\kappa}\gamma^{\nu}\right)\overleftrightarrow{\partial}^{\sigma} + \left(\gamma^{\sigma}\hat{W}_{\kappa} + \hat{W}_{\kappa}\gamma^{\sigma}\right)\overleftrightarrow{\partial}^{\nu}\right]\Psi\,. \tag{4.1}$$

The part of amplitude of Compton scattering calculated on the basis of this Lagrangian is defined as follows:

$$M^{(\kappa)}+M^{(\tilde{\kappa})}=\frac{i\pi}{4m^2}\left(\varepsilon^{\mu\rho\kappa\delta}\right)(k_1+k_2)_\delta\left[\kappa\left(F^{(2)}_{\nu\mu}F^{(1)}_{\rho\sigma}-F^{(2)}_{\sigma\rho}F^{(1)}_{\mu\nu}\right)+\right.$$
$$\left.+\tilde{\kappa}\left(\tilde{F}^{(2)}_{\nu\mu}\tilde{F}^{(1)}_{\rho\sigma}-\tilde{F}^{(2)}_{\sigma\rho}\tilde{F}^{(1)}_{\mu\nu}\right)\right]\bar{U}^{(r_2)}\left(\vec{p}_2\right)\gamma^5[(\delta^\nu_\tau\gamma_\kappa-\delta^\nu_\kappa\gamma_\tau)P^\sigma+$$
$$+(\delta^\sigma_\tau\gamma_\kappa-\delta^\sigma_\kappa\gamma_\tau)P^\nu]P_\tau U^{(r_1)}\left(\vec{p}_1\right). \tag{4.2}$$

Expression (4.2) is testified of an invariant of cross symmetry. The contribution of spin polarizabilities κ also $\tilde{\kappa}$ begins with the third order on energy of photons. If determine amplitude (4.2) in the rest frame and to neglect an impulse of return of a nucleon, we will obtain

$$M^{(\kappa)}+M^{(\tilde{\kappa})}=4\pi i(\omega_1+\omega_2)(\omega_1\omega_2)\left\{\kappa\left(\vec{S}\left[\vec{e}^{(\lambda_2)*}\vec{e}^{(\lambda_1)}\right]\right)+\right.$$
$$\left.+\tilde{\kappa}\left(\vec{S}\left[\left[\vec{e}^{(\lambda_2)*}\vec{n_2}\right]\cdot\left[\vec{e}^{(\lambda_1)}\vec{n_1}\right]\right]\right)\right\}. \tag{4.3}$$

According to from the equations (4.1) and (4.3) Lagrangian by means of which the contribution of spin dipole polarizabilities κ and $\tilde{\kappa}$ to amplitude of Compton scattering is considered is even concerning inversion of space.

By analogy with Lagrangian (4.1) we will construct new Lagrangian by which we will define contributions of girations (the characteristics connected with parity not preservation) to amplitude of Compton scattering. For this purpose it is enough in (4.1) to make replacement $\hat{W}_\kappa \to 1/m \overset{\leftrightarrow}{\partial}_\kappa$. As a result we will obtain:

$$L = \frac{i\pi}{2m^2}\left(\varepsilon^{\mu\rho\kappa\delta}\right)\left[\delta_E F_{\nu\mu}\overset{\leftrightarrow}{\partial}_\delta F_{\rho\sigma} + \delta_M \tilde{F}_{\nu\mu}\overset{\leftrightarrow}{\partial}_\delta \tilde{F}_{\rho\sigma}\right]\times$$
$$\times\bar{\Psi}\left[\left(\gamma^\nu \overset{\leftrightarrow}{\partial}_\kappa \overset{\leftrightarrow}{\partial}^\sigma + \gamma^\sigma \overset{\leftrightarrow}{\partial}_\kappa \overset{\leftrightarrow}{\partial}^\nu\right)\right]\Psi\,, \qquad (4.4)$$

where δ_E and δ_M are electric and magnetic girations.

Amplitude of Compton scattering which is obtained on the basis of a Lagrangian (4.4), in system of rest of a target and in neglect an impulse of return of a target, is defined so

$$M = 4\pi\omega_1\omega_2\chi_f^+\Big\{\delta_E\left(\left(\vec{k}_1+\vec{k}_2\right)\cdot\left[\vec{e}^{(\lambda_2)*}\vec{e}^{(\lambda_1)}\right]\right)+ \\ +\delta_M\left(\left(\vec{k}_1+\vec{k}_2\right)\cdot\left[\vec{\Sigma}_2\vec{\Sigma}_1\right]\right)\Big\}\chi_i\ , \tag{4.5}$$

where $\vec{\Sigma}_2=\left[\vec{e}^{(\lambda_2)*}\vec{n_2}\right],\quad \vec{\Sigma}_1=\left[\vec{e}^{(\lambda_1)}\vec{n_1}\right]$.

The ratio (4.5) will be coordinated with low-energy determination of amplitude (2.3) if to present tensors of polarizabilities through δ_E and δ_M [Fedorov ThGy]

$$\alpha_{ij}=\alpha_1\delta_{ij}+i\delta_E\varepsilon_{ijk}\partial_k\ ,$$

$$\beta_{ij}=\beta_1\delta_{ij}+i\delta_M\varepsilon_{ijk}\partial_k\ ,$$

where the derivative ∂_κ action to vectors of an electromagnetic field.

Thus, from the equations (4.3) and (4.5) follows:

1) in both amplitudes the condition of cross symmetry is satisfied;
2) if in the ratio (4.3) the invariance condition concerning inversion of space is satisfied, in the ratio (4.5) this condition is violated;
3) deposits of a giration and spin dipole polarizabilities to amplitude of Compton scattering on a nucleon begins with the third order on energy of photons.

Conclusion

In this work the proposal relativistic-invariant definition of spin dipole polarizabilities and girations which foundation on covariant build of the induced dipole moments and phenomenological effective Lagrangians of interaction of an electromagnetic field with these moments of a structural particle a spin $1/2$ is offered.

It is shown that in the offered model taking into account cross symmetry, gauge-invariant and properties of a Lagrangian to inversion of space spin dipole polarizabilities and a giration make a contribution to decomposition of amplitude of Compton scattering since the third order on energy of photons according to low-energy theorems of Compton scattering on a nucleon.

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Thank you !!!