TWO-PARTICLE PHOTODISINTEGRATION OF LIGHT NUCLEI WITH CONSERVED EM CURRENT

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The expression of gauge-invariant amplitude of nonlocal field disintegration into fragments is developed. Calculations are made on the basis of universality principle of photon interaction with charged matter fields. In addition, the charge and mass inseparability property is used. We also took into account the indifference property of electromagnetic (EM) field. The possibility to construct the interaction Lagrangian of EM and nonlocal field is discussed. Physical meaning of the regular part of amplitude is described. It considered as nonlocality measure of the bound state. The easiest opportunity to construct the regular part of amplitude is proposed.

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1. INTRODUCTION

Investigating the processes with photons, the difficulty to guarantee the gauge invariance of the amplitude emerges. Especially in that cases, when photon interacts with nonlocal target [1] – atomic nucleus. This requirement is a consequence of charge conservation law and photons null mass (its motion with velocity of light). To fulfill this demand we substitute the photon polarization vector for its 4-momentum in quantum electrodynamics (QED). This procedure leads to matrix element zeroing in the final analysis. The generalized space [2] (that we put into operation [4] helps to explore this material).

Gauge arbitrariness can be pulled off in QED. It can be made by inclusion of generalized Minkowskii space supplemented by charged tangent space [2, 3, 4]. This operation is made on the basis of universality principle of EM interaction and inseparability property of mass and charge for fundamental particles.

We use the rule of "parallel transition" to implement these statements. This regulation (correlation into the same world point) gives the ability to compare different charged matter fields. It means, mathematically, that covariant derivative of the field function must equal zero in the direction of tangent space. Namely, the additional "charged" coordinate $\psi_{ch}(x)$ introduces into consideration.$\psi_{ch}(x)$ must fulfill the equation:

$$\frac{dx_\mu}{d\tau} D^\mu \psi_{ch}(x) \mid_{x=x(\tau)}= \frac{dx_\mu}{d\tau} (\partial^\mu - ieA^\mu)\psi_{ch}(x) \mid_{x=x(\tau)}= 0 \,, \qquad (1)$$

where τ – natural parameter of trajectory $x_\mu(\tau)$ length, e – electric charge, A^μ – vector-potential of external EM field. Solution of equation (1), accounting initial condition $\psi_{ch}(a) = 1$, is:

$$\psi_{ch}(x) = Pe^{ie \int_a^x A^\nu(\xi) d\xi_\nu} \,, \qquad (2)$$

where P – space-time regulation operator lengthwise trajectory $x_\mu(\tau)$.

Total wave function is defined by the product of space-time and charged component in generalized configuration space:

$$\Psi(x; A) = \psi_{ch}(x)\psi(x) = Pe^{ie \int_a^x A^\nu(\xi) d\xi_\nu} \psi(x) \,. \qquad (3)$$

Vector-potential of gauge field acts as the connectivity of the main bundle in this space. It defines the matching rule of space-time manifold translations with fixed initial point a with its projections in associated space.

Theory of nonlocal matter field EM disintegration builds on the basis of local QED naturally generalized from the position of gauge field geometrical interpretation. This step guarantees the security of structural continuous conversion limit from nonlocal to local consideration. Satisfaction of the requirement of EM interaction universality property is necessary for this advance. This characteristic states in minimal coherence format. Moreover, it leads to conservation of gauge symmetry group in invariable shape. This term closely connected with the opportunity to describe continuously the EM phase variation during the time of interaction.

Inclusion of generalized configuration space leads to some revisions in local theory. Let us examine the opportunity to describe the translations of charged field in the external EM field. We'll make it according to the equation (3) for "charged" coordinate. The pattern of configuration space is the local decomposition in every space-time point. We distribute

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it into the product of space-time manifold and adjoint tangent space (with defined general "charged" coordinate). This statement is shown on Fig.1.

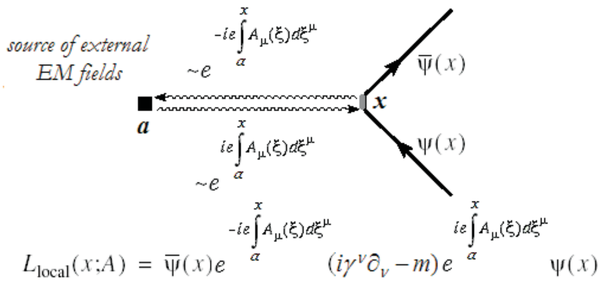


Fig.1. *EM field and fundamental matter field interaction local shape*

The structure [3] of field function in representation (3) reproduces local gauge symmetry of the electronic (4) and scalar (5) free field Lagrangians:

$$L_{local}(x; A = 0) = \overline{\psi}(x)(i\gamma^\mu\partial_\mu - m)\psi(x) \Rightarrow$$
$$L_{local}(x; A) = \overline{\Psi}(x; A)(i\gamma^\mu\partial_\mu - m)\Psi(x; A) =$$
$$\overline{\psi}(x)(\overline{Pe^{ie\int_a^x A^\nu(\xi)d\xi_\nu}})(i\gamma^\mu\partial_\mu - m)\times$$
$$Pe^{ie\int_a^x A^\nu(\xi)d\xi_\nu}\psi(x) =$$
$$\overline{\psi}(x)e^{-ie\int_a^x A^\nu(\xi)d\xi_\nu}(i\gamma^\mu\partial_\mu - m)e^{ie\int_a^x A^\nu(\xi)d\xi_\nu}\psi(x) =$$
$$\overline{\psi}(x)i\gamma^\mu(\partial_\mu + ieA_\mu(x))\psi(x) - m\overline{\psi}(x)\psi(x), \quad (4)$$

$$L_{local}(x; A = 0) = [\partial_\mu\phi(x)]^+[\partial^\mu\phi(x)]-$$
$$\mu^2\phi^+(x)\phi(x) - \frac{\lambda}{4}(\phi^+(x)\phi(x))^2 \Rightarrow$$
$$L_{local}(x; A) = [D_\mu\phi(x)]^+[D^\mu\phi(x)]-$$
$$\mu^2\phi^+(x)\phi(x) - \frac{\lambda}{4}(\phi^+(x)\phi(x))^2 \Rightarrow \quad (5)$$

Derivation of interaction Lagrangian in local theory settles on heuristic principle. This principle formulates as "prescription" to change derivatives in kinetic part of free Lagrangian to the covariant ones. This operation fulfills the physical content in generalized space.

The QED construction with adequate configuration space doesn't leads to any changes in previous results of local theory. We provided the opportunity to describe the continuous EM phase shift, coordinated with space-time shifts. This leads to coordination of 4-momentum and charge conservation laws in the amplitude. The advantage of QED construction with generalized configuration space is obvious for the theory of nonlocal matter fields which uses unified principles [3]. Moreover, inclusion of quantitative characteristic allows reacting to changes assigned to electric charge transition in presence of external EM field. Such changes don't influence to the local theory.

2. EM VERTICES AND GENERALIZED GAUGE-INVARIANT AMPLITUDE

Those changes in theory [3, 4] allowed determining the EM vertices as inserts into 2-point Greens functions (GF). Indeed, it is the first step towards nonlocality.

The bases of the theory construction are 2-point and 3-point GF. Their structure satisfies the *inseparability* and *indifference* properties. The equation for nonlocal 2-point and 3-point GF (taking into account the geometrical interpretation of gauge field [1, 2, 3]):

$$D_{nonlocal}(x, y; A) =$$
$$i < P(\phi(x)e^{ie\int_y^x A^\nu(\xi)d\xi_\nu}\phi^+(y)) >,$$

$$G(x, y, z; A) =< P(\phi(z)\times$$
$$e^{ie_1\int_x^z A^\nu(r)dr_\nu}\phi_1^+(x)e^{ie_2\int_y^z A^\sigma(r)dr_\sigma}\phi_2^+(y)) > . \quad (6)$$

It's easy to show that equations (6) are invariant relatively the group of local gauge transformations:

$$\phi(x) \to e^{-ie\alpha(x)}\phi(x), \phi^+(y) \to e^{ie\alpha(y)}\phi^+(y),$$
$$A_\mu(\xi) \to A_\mu(\xi) + \partial_\mu\alpha(\xi),$$

$$\phi(z) \to e^{-ie\alpha(z)}\phi(z),$$
$$\phi^+(x) \to e^{ie_1\alpha(x)}\phi^+(x), \phi^+(y) \to e^{ie_2\alpha(y)}\phi^+(y),$$
$$A_\mu(r) \to A_\mu(r) + \partial_\mu\alpha(r) . \quad (7)$$

The structure of 2-point gauge-invariant GF is shown on Fig.2. Reference point a of external EM field source (constant uniform or plane wave) excludes from consideration while generating bilinear expression.

Notice, that line contour integral (6) doesn't depend from the trajectories shape in considered case. Moreover, it synchronized with mass translation because of inseparability property. Therefore, the variety of different patches of integration $\eta_1(x, y)$ and $\eta_2(x, y)$ (see (6) and Fig.2.) that connecting final points can be replaced by "rectilinear" trajectory $\eta(x, y)$.

It was shown [3, 4, 5], that 2-point gauge-invariant GF (6) contain all ample information about interaction of fundamental field[1] (and its statistics) with EM field in compact form. We should calculate a functional derivative by vector-potential of EM field from GF and transit to momentum representation to make it sure. We obtain standard expression for EM vertices in local QED as the result. Matching of vertex with GF (before and after interaction with photon) shows nonlocal structure of expression (6):

[1] or, conventionally, local fields, which doesn't reallocate mass and charge after interaction, i.e. they conserve its individuality.

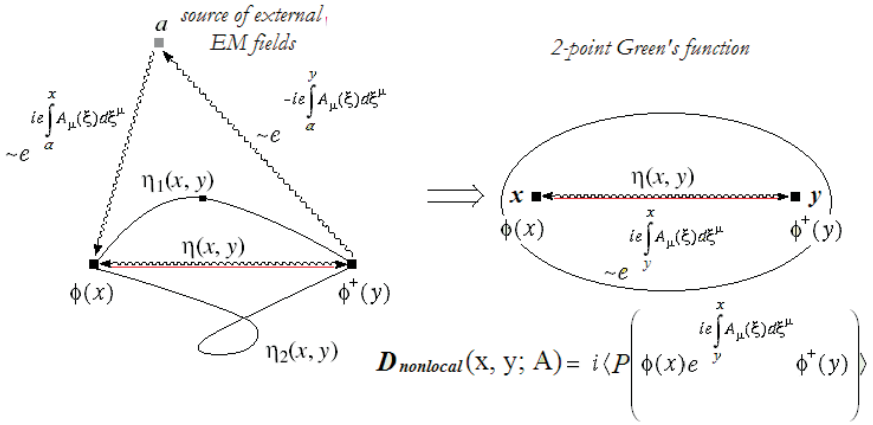


Fig.2. *Gauge-invariant nonlocal 2-point GF*

$$\frac{\delta D_{nonlocal}(x, y; A)}{\delta A_\mu(r)}|_{A=0} A_\mu(r) \to$$
$$(2\pi)^4 e\delta(q + p - p')\varepsilon_\mu \int_0^1 d\lambda \frac{\partial D(p + q\lambda)}{\partial(p + q\lambda)_\mu} =$$
$$(2\pi)^4 \delta(q + p - p') D(p + q)\{-e\varepsilon_\mu (p + p')^\mu\} D(p)\,, \quad (8)$$

where in left part of equation (8) we use the expression $D(p) = \frac{1}{(p^2-m^2+i0)}$ for free scalar particle GF. Synchronization of mass translations and appropriate charges (inseparability property) leads to agreement of 4-momentum and charge conservation laws.

Further consideration is made on strongly connected 3-point GF. This function describes virtual disintegration of nucleus in point z' into two fragments in x' and y' (Fig.3).The external ends (connections between prime and not prime points, i.e. x and x') conform to the 2-point GF. We should insert the EM field into all external ends and into vertex part of 3-point GF. We suggest that GF's have such charges conservation law $e = e_1 + e_2$ is satisfied after disintegration. Insertion of EM field generates the set of diagrams (Fig.4).

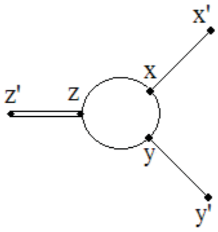


Fig.3. *Strongly connected 3-point GF*

As the result, we have first three diagrams which correspond to the pole row with known EM vertices. We'll show further, that fourth diagram provides conservation of charge e in the large for all process of disintegration and splitting into e_1 and e_2. Consideration is made in general view to avoid artificiality. We attach mathematical shape in EM vertex definition and provide gradient invariance of process amplitude. Simply, we should answer the question "How can the interaction of EM field be described while we know 2- and 3-point GF in our theory?".

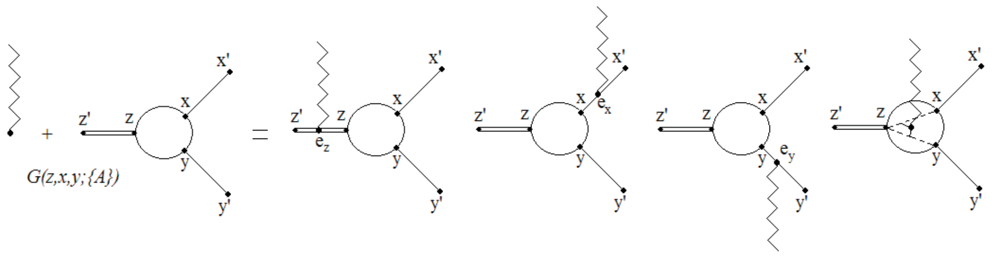
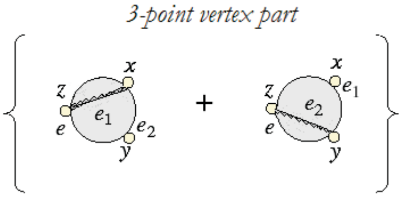


Fig.4. *Insertion of EM field into strongly connected 3-point GF*

Matrix element of one or another process can be obtained by amputation of external 2-point GF. This GF should be substituted by wave functions of the particles.

The aim of investigation we made is: generation of amplitude of nonlocal field EM disintegration process into fragments. Wherein, we should satisfy the universality requirement in minimum connection form and also conserve the structure of gauge symmetry group. Moreover, we should consistently take into account the dynamics of strong interaction vertices against the background of completely covariant description. We discuss the opportunity to construct alternatively (according to universality property) the analogue of interaction Lagrangian of nonlocal and EM field.

Strongly connected vertex part of 3-point GF (6) with external ends (2-point GF satisfying symmetry condition (7)) can be represented graphically as in Fig.5. External ends aren't shown on the picture. Region of structure formation interaction is shown as blackout circle.



$$G(x,y,z;\{A\}) = i\langle P\left(\phi(z)e^{ie_1\int_x^z A_\mu(\xi)d\xi^\mu}\phi_1^+(x)e^{ie_2\int_y^z A_\mu(\xi)d\xi^\mu}\phi_2^+(y)\right)\rangle$$

Fig.5. *Strongly connected 3-point vertex part*

Functional derivative from expression (6) should be calculated to obtain the EM pasting into 3-point vertex. These calculations are made analogues to the derivation of expression (8). Therefore [3, 4], the expression for regular part of generalized pole amplitude in momentum representation is:

$$\frac{\delta G_{nonlocal}(x,y,z;\{A\})}{\delta A_\mu(r)}|_{A=0}A_\mu(r)\rightarrow$$
$$\mathbf{M}_{reg} = (2\pi)^4\delta(q+p-p_1-p_2)\varepsilon_\mu\times$$
$$\int_0^1 d\lambda\{e_1\frac{\partial G(p_1-q\lambda;p_2)}{\partial(p_1-q\lambda)_\mu}+e_2\frac{\partial G(p_1;p_2-q\lambda)}{\partial(p_2-q\lambda)_\mu}\} =$$
$$(2\pi)^4\delta(q+p-p_1-p_2)\frac{\varepsilon(p_1-p_2)}{q(p_1-p_2)}\times$$
$$\{e_1G[(p_1-p_2-q)^2]+e_2G[(p_1-p_2+q)^2]-eG[(p_1-p_2)^2]\}\,, \tag{9}$$

where $e_i, p_i, i = \{1,2\}$ fragments charge and mass appropriately. The integral should be calculated to show last equation in (9). Indeed, vertex function depends on square of relative momentum $k_s = \frac{E_2}{w}p_1 - \frac{E_1}{w}p_2 = \eta_2p_1 - \eta_1p_2$, where $\eta_i = \frac{E_i}{w}, i = \{1,2\}$, and $w = E_1+E_2$. In fragments center inertia system $k_s = (0;\overrightarrow{p}), p_1 = (E_1;\overrightarrow{p}), p_2 = (E_2;-\overrightarrow{p})$. Let us consider first summand in integral and reproduce the dependence from current value of appropriate momentum square $\varepsilon_\mu\int_0^1 d\lambda\{e_1\frac{\partial G(p_1-q\lambda;p_2)}{\partial(p_1-q\lambda)_\mu}+ ...\} = \varepsilon_\mu\int_0^1 d\lambda\{e_1\frac{\partial(k-\lambda\eta_2q)^2}{\partial(p_1-q\lambda)_\mu}\frac{\partial G[(k-\lambda\eta_2q)^2]}{\partial(k-\lambda\eta_2q)^2}+...\}$, where argument $(p_1-q\lambda;p_2)$ of vertex function in terms of appropriate momentum square $k_{st}^2(\lambda) = (\eta_2(p_1-q\lambda)-\eta_1p_2)^2 = k_s^2-2\lambda k\eta_2\cdot q, k_{st}^2(1) = k_t^2, k_{st}^2(0) = k_s^2$, defined as $G[(k-\lambda\eta_2q)^2]$. Now we overwrite integral taking into account defined argument $\varepsilon_\mu\int_0^1 d\lambda\{e_1\frac{\partial k_{st}^2}{\partial(p_1-q\lambda)_\mu}\frac{\partial G[k_{st}^2]}{\partial k_{st}^2}+...\}$. Further, we calculate derivative $\varepsilon_\mu\frac{\partial k_{st}^2}{\partial(p_1-q\lambda)_\mu} = \varepsilon_\mu\frac{\partial(\eta_2(p_1-q\lambda)-\eta_1p_2)^2}{\partial(p_1-q\lambda)_\mu} = 2(k-\lambda\eta_2q)_\beta\eta_2g^{\beta\mu}\varepsilon_\mu = 2\varepsilon\cdot k\eta_2$, where accounted transversal condition $\varepsilon q = 0$. Primary integral takes the form: $\varepsilon_\mu\int_0^1 d\lambda\{e_1\frac{\partial(k-\lambda\eta_2q)^2}{\partial(p_1-q\lambda)_\mu}\frac{\partial G[(k-\lambda\eta_2q)^2]}{\partial(k-\lambda\eta_2q)^2}+...\} = \varepsilon\cdot k\int_0^1 d\lambda\cdot 2\eta_2\{e_1\frac{\partial G[k_{st}^2(\lambda)]}{\partial k_{st}^2(\lambda)}+...\}$. This expression can be divided and multiplied by kq. Therefore, integrating by λ reduces to new variable $d2\lambda\eta_2kq = -dk_{st}^2(\lambda)$. Finally, we have $\varepsilon k\int_0^1 d\lambda\cdot 2\eta_2\{e_1\frac{\partial G[k_{st}^2(\lambda)]}{\partial k_{st}^2(\lambda)}+...\} = -\frac{\varepsilon k}{qk}\int_0^1 dk_{st}^2(\lambda)\{e_1\frac{\partial G[k_{st}^2(\lambda)]}{\partial k_{st}^2(\lambda)}+...\} = -\frac{\varepsilon k_s}{qk_s}\{e_1G[k_{st}^2(1)]-e_1G[k_{st}^2(0)]\}$. Now, we calculate integral with second charge e_2 and unify the results (taking into account the charge conservation law $e = e_1+e_2$). We receive $-(2\pi)^4\delta(p+q-p_1-p_2)\frac{\varepsilon k_s}{qk_s}\{e_1G[k_t^2]+e_2G[k_u^2]-eG[k_s^2]\}$. Expression (9) doesn't contain any kinematic singularities and defined by sum of change "velocities" of structure formation interaction in every point of nonlocality area.

Here we can draw the analogy with the classical Lagrange description. Initial state of nonlocal field before interaction with EM field is identical to strongly connected 3-point GF (6). One can be considered as analogue of free Lagrangian. In point of fact, 3-point GF is an amplitude beyond the mass surface. It describes virtual transition of nonlocal field into condition of its fragments and vice-versa(expression in braces on Fig. 6). The result of interaction with photon (which energy is more than binding energy) is following. Virtual amplitude stands on the mass surface and disintegration process becomes real. Derivation of interaction Lagrangian is made on the basis of consistent differentiation by vector-potential of EM field. We should differentiate the external ends (2-point GF) and vertex part of 3-point GF (Fig.6) according to the equations (8) and (9).

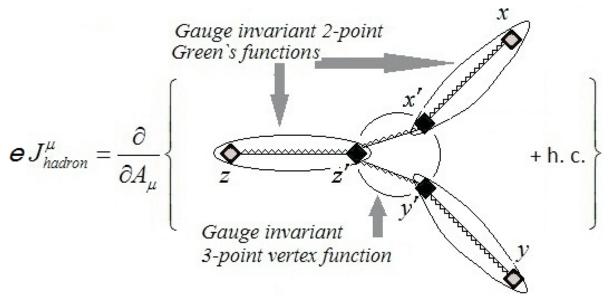


Fig.6. *Derivation of nonlocal hadronic current in process of EM disintegration*

Now, we gathering together the results of insertion of EM field into 2-point GF (8) and strongly connected vertex part (9). We receive the final expression for matrix element. This expression of total gauge-invariant amplitude (according to the universality property) takes the standard form:

$$M_{tot} = eA_\mu J^\mu_{hadron} = A_\mu\frac{\partial G(x,y,z;A)}{\partial A_\mu},$$
$$eJ^\mu_{hadron} = \frac{\partial G(x,y,z;A)}{\partial A_\mu}\,. \tag{10}$$

The structure of amplitude is sum of traditional pole set (three left diagrams on Fig.2) and regular part (remaining diagram on Fig.2) of generalized gauge-invariant amplitude. Regular part forms as the result of photon insertion into vertex part of "threetail".

At last, analytical expression of total matrix element with pole current J^μ_{pol} and fragment appropriate momentum k_s takes form:

$$\mathbf{M}_{tot} = e(\varepsilon_\mu J^\mu_{pol}) - e\frac{(\varepsilon_\nu k_s^\nu)}{(q_\xi k_s^\xi)}(q_\rho\cdot J^\rho_{pol}) =$$
$$e(\varepsilon_\mu - \frac{\varepsilon k_s}{qk_s}q_\mu)\cdot J^\mu_{pol} = e\frac{F_{\mu\nu}J^\mu_{pol}k_s^\nu}{qk_s}\,, \tag{11}$$

where $F_{\mu\nu} = \varepsilon_\mu q_\nu - \varepsilon_\nu q_\mu$ - EM field tensor. This formula obtained for the particles with half-integer spin or spin 1. One is identical for spin zero [4]. Amplitude (11) satisfies the continuous description of EM phase shift not only in asymptotical in- and out- states (pole part of generalized amplitude). This shift is harmonized with the scope of structure formation forces (regular part of the amplitude) and charge conservation law. The case of EM interaction with absence of bound state disintegration characterized by the absence of regular part. Gauge invariance ensures by the first term in (11) only. Application of this formula gives the opportunity to write down matrix elements of different EM processes (covariance of the approach conserves).

3. TWO-PARTICLE PHOTODISINTEGRATION OF LIGHT NUCLEI

Asymmetrical structure of charged states in the system of generated particles excited interest in the experiment. The charge is present on the proton and deuteron in the final state for the first reaction. For the other reaction, the charge is present only on deuteron. We suppose that nuclei forces are charge independent. This fact should find the reflection in our theory. Obtained results for one reaction shouldn't heavily differ from the results for second reaction. Naturally, charge, mass and magnetic moment values should be substituted appropriately.

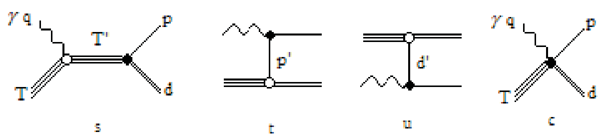


Fig.7. *Diagrams of processes* $^3He(\gamma,p)^2H$ *or* $^3H(\gamma,p)^2H$

We use developed approach to write down the matrix element. In this approach the nucleus consideres as elementary particle. The set of diagrams for generalized pole row (Fig.7) is:

$$\mathbf{M} = e\varepsilon^{\mu}\overline{u}(p)\sum_{i=s,t,u,c}(T^{(i)}_{\mu\nu})u(T)U^{*\nu}(d);$$
$$T^{(s)}_{\mu\nu} = A_{\nu}(-k_s^2)\gamma_5\frac{\widehat{T}'+m_T}{s-m_T^2}F^{(T)}_{\mu};$$
$$T^{(t)}_{\mu\nu} = F^{(N)}_{\mu}\frac{\widehat{p}'+m_N}{t-m_N^2}A_{\nu}(-k_t^2)\gamma_5;$$
$$T^{(u)}_{\mu\nu} = A_{\alpha}(-k_u^2)\gamma_5\frac{-g^{\alpha\beta}+\frac{d'^{\alpha}d'^{\beta}}{d'^2}}{u-m_d^2}F^{(d)}_{\mu\nu\beta};$$
$$T^{(u)}_{\mu\nu} = -\frac{(k_s^2)_{\mu}}{qk_s}\times$$
$$[z_H A_{\nu}(-k_s^2) - z_t A_{\nu}(-k_t^2) - z_u A_{\nu}(-k_u^2)]\gamma_5, \quad (12)$$

where $A_{\nu}(-k_i^2) = A(-k_i^2)(\gamma_{\nu} + \frac{\sqrt{T^2}+\sqrt{p^2}}{d^2}d_{\nu}) + \frac{B(-k_i^2)}{2m}(2p_{\nu} + \frac{d^2-T^2+p^2}{d^2}d_{\nu}), i=\{s,t,u\}$ - breakdown vertex of three nucleon system into nucleon and deuteron. Ortogonality requirement $\overline{u}(p)A_{\nu}\gamma_5 u(T)d^{\nu} = 0$ provides the form of vertex. EM vertices are $F^{(N,T)}_{\mu} = z_{(N,T)}\gamma_{\mu} + \kappa_{(N,T)}\widehat{q}\gamma_{\mu}; F^{(d)}_{\mu\nu\beta} = -2z_d d_{\mu}g_{\nu\beta} - 2\mu_d(g_{\mu\nu}q_{\beta} - g_{\mu\beta}q_{\nu}); k_i$ - appropriate spatially similar momentum of vertex with strong interaction.

Matrix element (12) can be written in compact form:

$$\mathbf{M} = e\frac{F_{\mu\nu}J^{\mu}_{pol}k^{\nu}_s}{q\cdot k_s},$$
$$J^{\mu}_{pol} = \overline{u}(p)(\sum_{i=s,t,u}T^{(i)}_{\mu\nu})U^{*\nu}(d)u(T). \quad (13)$$

We don't take into account the amplitude of deuteron generation in intermediate $^1S_0$ -state (matrix element is gauge invariant $\sim \frac{\varepsilon_{\mu\nu\rho\sigma}\varepsilon^{\mu}q^{\rho}U^{\nu}d^{\sigma}}{m}$ and investment into cross section with generation of deuteron is negligible).

The example of matrix element for reaction $^4He(\gamma,N)T$:

$$\mathbf{M} = e\varepsilon^{\mu}\overline{u}(p)(\sum_{i=s,t,u,c}M^{(i)}_{\mu})v(T);$$
$$M^{(s)}_{\mu} = \frac{G^{(s)}}{s-m_H^2}j^{(s)}_{\mu}\gamma_5;$$
$$M^{(t)}_{\mu} = G^{(t)}j^{(t)}_{\mu}\frac{\widehat{p}'+m}{t-m^2}\gamma_5;$$
$$M^{(u)}_{\mu} = G^{(u)}\gamma_5\frac{\widehat{T}'+m_T}{u-m_T^2}j^{(t)}_{\mu};$$
$$M^{(c)}_{\mu} = -\frac{k_{s_{\mu}}}{q\cdot k_s}[z_H G(-k_s^2) - z_N G(-k_t^2) - z_T G(-k_u^2)]\gamma_5;$$
$$j^{(s)}_{\mu} = z_H(H+H')_{\mu};$$
$$j^{(t)}_{\mu} = z_N\gamma_{\mu} - \sigma_{\mu\nu}q^{\nu}\frac{\mu_N}{2m};$$
$$j^{(u)}_{\mu} = z_T\gamma_{\mu} - \sigma_{\mu\nu}q^{\nu}\frac{\mu_T}{2m_T};$$
$$s=(q+H)^2, t=(q-p)^2, u=(q-T)^2. \quad (14)$$

Relative 4-momentum that characterize vertex $^4He \longrightarrow NT$, in pole diagrams are:

$$k_s = p - \frac{pH}{H^2}H \equiv \frac{TH}{H^2}H - T;$$
$$k_t = k_s - \frac{TH}{H^2}q; k_u = k_s + \frac{pH}{H^2}q. \quad (15)$$

Vertex function G describes virtual collapse $^4He \longrightarrow NT$, and due to relativistic invariance depends on square of appropriate 4-momentum. Vertex functions $G^{(i)} \equiv G(-k_i^2), i=\{s,t,u\}$. Final expression for amplitude $\mathbf{M}$ is:

$$\mathbf{M} = e\frac{F_{\mu\nu}J^{\mu}_{pol}k^{\nu}_s}{q\cdot k_s},$$
$$J^{\mu}_{pol} = \overline{u}(p)(\sum_{i=s,t,u}M^{(i)}_{\mu})v(T). \quad (16)$$

We can equal to a constant vertex functions of strong interaction in expressions for contact set. Diagrams will equal zero as a consequence of charge conservation law. Amplitudes of all considered processes became gage invariant on the level of only pole diagrams. Additional interaction accounting leads to appearance of regular mechanisms.

that proton peak disappeared at this energy. Yet, our calculations (dashed line) don't confirm this statement.

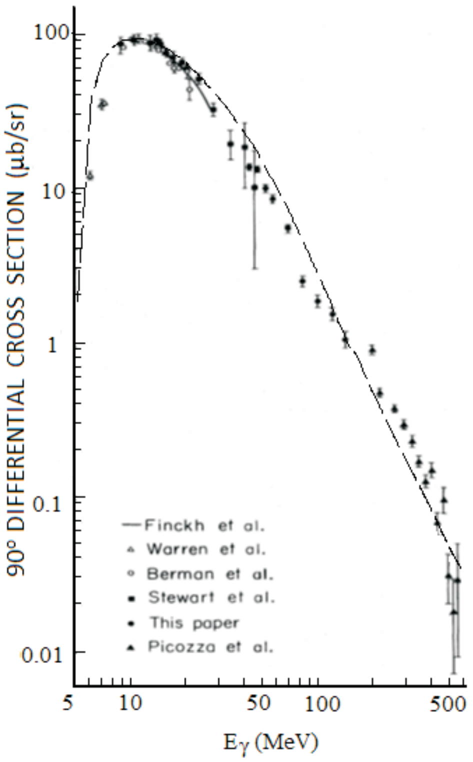


Fig.8. *Dependence of differential cross section* $^3He(\gamma,p)^2H$ *from energy at proton angle* $\theta_p = \pi/2$ *in c.m. system*

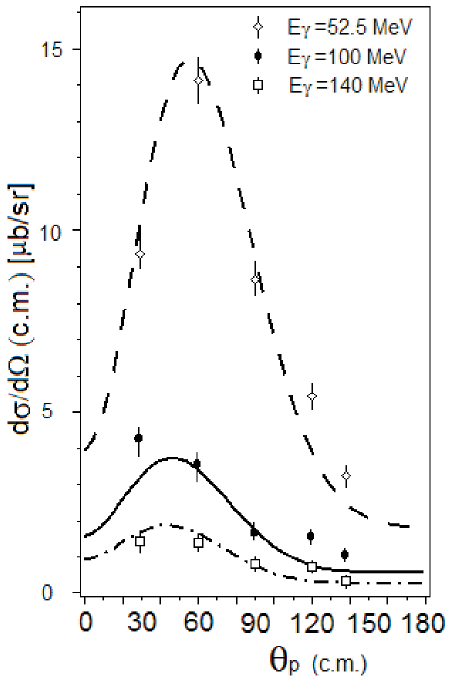


Fig.10. *Angular dependence of differential cross section* $^3He(\gamma,p)^2H$ *at intermediate photon energies in lab. system*

The example of experimental data description in given approach is given in [8]. This article is closest to our work in ideological terms. Fig.8 represents dependence of differential cross section from energy at proton angle $\theta_p = \pi/2$ in c.m. system [10]. Calculations are made on the basis of amplitude (12) with wave functions from [11]. We achieved good agreement in description of cross section (long dashed line represents our calculations).

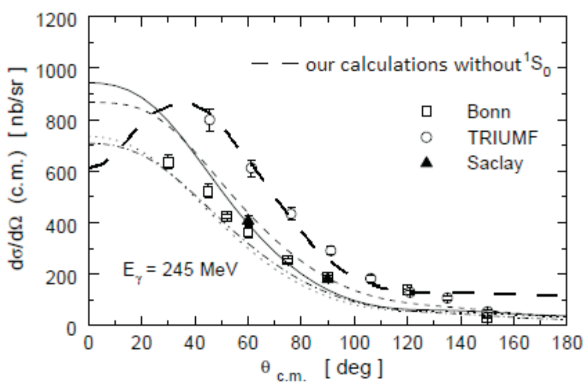


Fig.9. *Angular dependence of differential cross section* $^3He(\gamma,p)^2H$ *at photon energy* $245\,MeV$ *in lab. system*

We can trace variation of the cross section's shape with the respect to energy increase. We should unroll the cross section by the angle of outgoing proton at the constant photon energy. Fig.9 represents the angle dependence of differential cross section at photon energy $245\,MeV$ [8]. Long dashed line denotes our calculations by formula (12) without contribution of $^1S_0$ state. Sense of other lines was commented in [8]. We mark

Let's discuss this situation at lower energies. The example of disintegration at intermediate photon energies is Fig.10 [11].

Fig.10 shows that peak doesn't disappear. Such situation emerges even if we consider higher-energy spectrum. One measured at photon energy $208\,MeV$ (Fig.11).Seems like article [8] violates balance between electric and magnetic components in amplitude.

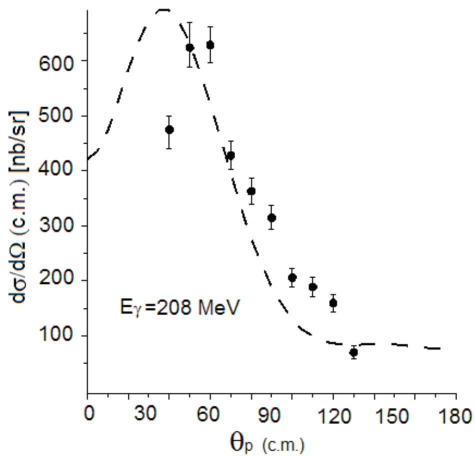


Fig.11. *Angular dependence of differential cross section* $^3He(\gamma,p)^2H$ *at photon energy* $208\,MeV$ *in lab. system[12]*

Similar situation emerges describing other experimental data made in [11].

4. CONCLUSIONS

We have offered new approach of QED formulation. This method provides adequate picture of EM and nonlocal matter field interaction and its disintegration into fragments. Consistent theory of correct description of EM and nonlocal field interaction is absent nowadays. Difficulties emerge in that situation, when original field's mass and charge redistributes between fragments in bounded region of structure formation interaction. Lagrangian of nonlocal field (bound state) with unknown interaction of its structure elements is absent. Consequently, we can't use directly QED "prescription" for gauge symmetry localization interaction Lagrangian construction.

Geometrical interpretation of gauge fields (attraction of electric charge and mass inseparability property and EM force indifference property with the respect to other types of interaction) supports consistent implementation of local and nonlocal matter fields into the theory. Additional properties weren't asked-for in local QED and had hidden nature. The reason is constant charge and mass of particle and only EM vertex presence in processes.

The approach is formulated on the basis of generalized configuration space. Namely, Minkowskii space supplemented by additional inner (charge) symmetry space. Generalized charge coordinate is phase exponent. Here, gauge field (as connectivity of main stratification) defines the agreement rule of space-time continuum (with given initial point in basis space) translations with projections in attached charged space. This leads to the balanced action of energy-momentum and charge conservation laws in amplitude. Nonlocal gauge-invariant 2- and 3-point GF are the basis of the approach. Heisenberg field operator structure reduced according to space structure in GF. Functional derivatives of 2-point GF by gauge field and subsequent conversion into momentum representation defines QED EM vertices. We take into account statistics of matter fields and match them with free field GF before and after interaction. Conservation of gauge symmetry group guarantees continuous description of EM phase shift. Therefore, total hadronic current conserves. 3-point GF leads to generalized gauge-invariant amplitude. One contains (consequence of nonlocality accounting) regular part besides traditional pole part (11), (13), (14). Physical meaning of amplitude regular part is dynamical measure of nonlocality degree. One fixes the distinction of fragments relative motion wave function from Yukawa's asymptotical behavior.

We also shown that, process amplitude contains regular part (besides traditional pole part of the row) when the process comes in presence of other interaction (not only EM). This part ensures the requirement of processes gauge invariance in the large. If the process characterized only by EM interaction then gauge invariance satisfies on the level of pole part only. The regular part is absent in this case.

We have the following advantages of developed approach. First, this approach don't change any result of local QED. Second, exact conservation of hadronic current secures finite limit (by the square of transited momentum) to photon point in amplitude with virtual photons. This makes unique condition to investigate the role of different reaction mechanisms in the processes with electrons and photons simultaneously. Third, vertex function of strong interaction can be chosen as the solution of Bethe-Solpiter equation or its quasipotential analogue. We draw parallel between nonlocal field disintegration in EM processes amplitude construction and derivation of local field interaction Lagrangian.

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ДВУХЧАСТИЧНОЕ ФОТОРАСЩЕПЛЕНИЕ ЛЁГКИХ ЯДЕР С СОХРАНЯЮЩИМСЯ ЭМ-ТОКОМ

Ю.А. Касаткин, В.Ф. Клепиков, Ф.Е. Кузнецов

В соответствии с принципом универсальности взаимодействия фотона с заряженным полем материи, дополненного свойством неотделимости заряда от массы, а также свойством индифферентности ЭМ-взаимодействий, получено выражение для калибровочно-замкнутой амплитуды расщепления нелокального поля на фрагменты. Обсуждается возможность построения лагранжиана взаимодействия ЭМ-поля с нелокальным полем. Выявлен физический смысл регулярной части амплитуды, как меры нелокальности связанного состояния. Предложена простейшая возможность построения регулярной амплитуды.

ДВОЧАСТКОВЕ ФОТОРОЗЩЕПЛЕННЯ ЛЕГКИХ ЯДЕР ІЗ ЗБЕРІГАЮЧИМСЯ ЕМ-ТОКОМ

Ю.А. Касаткін, В.Ф. Клепіков, П.Е. Кузнєцов

Відповідно принципу універсальності взіємодії фотона з зарядженим полем матерії, доповненого властивістю невід'ємності заряду від маси, а також властивістю індиферентності ЕМ-взаємодій одержано вираз для калібрувально-замкнутої амплітуди розщеплення нелокального поля на фрагменти. Обговорюється можливість побудови лагранжиану взаємодії ЕМ-поля з нелокальним полем. Виявлено фізичний зміст регулярної частини амплітуди, як міри нелокальності зв'язаного стану. Пропонується найпростіша можливість побудови регулярної амплітуди.