ALTERNATIVE CONSTRUCTION OF QED AND CORRECT INTRODUCTION IN THE THEORY OF NONLOCAL FIELDS. (I)

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We formulate a new approach to the construction of QED, which allows successively introduce the basis of common requirements for interaction of EM fields, as with local and nonlocal matter fields. An additional attraction to a set of axiomatic requirements of the local QED on the inseparability of the notion of charge from the notion of mass for fundamental particles and the indifference of EM forces in relation to other types of interactions, as well as the possibility of a coherent description of displacements of the masses and their corresponding charges due to the choice of a generalized configuration space to adequately describe the process of disintegrating of nonlocal field of matter into fragments. Selection as the primary sources for constructing a theory of nonlocal gauge-invariant 2- and 3-point Green's functions, the structure of the Heisenberg field operators which agreed with the structure of the configuration space makes it possible to determine the EM vertex according to their statistics, as well as align the vertexes with those of Green's function of free particles before and after the interaction. We derive generalized gauge-closed pole amplitude which exactly coordinated action of the laws of conservation of 4-momentum and charge. As a consequence, correct identification of non-locality in amplitude than the traditional pole number, binding is the presence of the regular part. The physical meaning of the regular part of the amplitude as a dynamic measure of the nonlocality connected matter fields and studied the local limit. Restructuring of the foundations of QED does not lead to any change in the results obtained previously in the framework of local quantum field theory.

1. Introduction

The uniqueness of non-local fields of matter lies in the fact that they are inherently one-sided structural asymptotic of local fields, where, in addition to long-range gravitational and EM interactions at sufficiently large distances, are beginning to dominate in areas of limited space structure-formatting interaction of higher intensity, which provides the necessary conditions for the creation of bound states of matter. Ground, where there is a formation of the hadronic world, is the energy interval with upper bound equal to the binding energy of atomic nuclei, and lower, corresponding to the confinement area, beyond which there is a "phasing out" of the color degrees of freedom of the quark-gluon interaction. Asymptotic behavior of quark-gluon forces outside the region of confinement is identified with the traditional nuclear forces. All the hadrons, which are open at present, are short-lived configuration in the form of related two-quark states (class mesons) or three quarks (baryons class). The only stable in the free state non-local field is a proton, due to which we are seeing steady macroscopic variety of our material world.

At the moment did not cause any doubts that the majority of the outstanding results obtained in the physics of the microcosm within the framework of local quantum-field approach. Opening of the principle of gauge symmetry helped unite different types of interactions through the use of a local Lagrangian approach, which led eventually to the establishment of the Standard theory of electroweak and strong interactions. The classic model of the local theory is QED, allowing her to describe the interaction of EM fields with fundamental matter fields on the basis of invariant local Lagrangian of a free electron field with respect to the requirements of the expansion of the global gauge symmetry to a local. As a result, the requirements of the interaction Lagrangian is not postulated, but derived, and thus ensures compliance with the *universal* property of the nature of interactions in the format *minimal coupled*.

The basis of the description of local interactions with the gauge of EM field methods are used Lagrangian description. Getting the interaction Lagrangian with fundamental matter fields are generated in accordance with a recipe associated with a heuristic replacement of conventional derivatives in the kinetic part of the free electron Lagrangian on the covariant derivatives, which leads to the localization of gauge symmetry and the withdrawal of the interaction Lagrangian. At the heart of the action, we made the following assumptions.

First, the local nature of the forms of writing the Lagrangian description of interacting fields is based on the requirement of *asymptotic additivity,* i.e. assumption about the disappearance of the interaction between the elements of a closed system and the possibility of representing the Lagrangian as a sum of Lagrangians, but the free states of the respective parts of the system separately. Since the EM interactions are long-range character, then, to justify the requirement of additivity, drawn *adiabatic ansatz,* the essence of which was "to slow" the inclusion of interaction.

Secondly, in the process of interaction with the EM field of electronic material field does not undergo any changes, i.e. the interaction remain *constant* mass and charge of the local field.

There is currently no accurate method of constructing a nonlocal Lagrangian matter fields through its virtual fragments in a fixed energy scale structure formation. The main obstacle that prevents local QED implement a procedure for the correct description of the emerging pattern of interaction, due to the presence of unexplored processes in the structure-forming interactions (in addition to electromagnetic) which has a limited region and high intensity. Within local QED to describe this situation we introduce a phenomenological formalism of form factors. The situation is exacerbated when in the field of structure-forming interaction under the influence of EM field is the disintegrating of nonlocal field of matter into its component parts. As a result of the interaction process is accompanied by a *redistribution* of mass and charge of non-local field between the source of his registrable fragments in the final state.

Universal recommendations for an adequate description of such situations in QED using the Lagrangian approach are no proposed. To satisfy the principle of additivity of the full Lagrangian, when it also contains two interactions differ significantly as the radius of action and intensity that is impossible. Indeed, the "Separation" of interacting fields at sufficiently large distance leads inevitably to the loss of information about the structure-strength. In this case, it is appropriate, most likely, speak not of the Lagrangian, and on the amplitude off the mass shell, corresponding to virtual transitions of nonlocal field in the state of related fragments, which move in the shell as a result of interaction with the EM field.

How to build such amplitude and how to order chronologically the accents of building in relation to the already established physical facts, to save all the results of local QED and simultaneously introduce the nonlocal material field on the basis of common principles of design theory in general?

First, we use the experimental fact, the essence of which will be further defined as the property of *the inseparability* of the notion of electric charge from the notion of mass for fundamental particles. In nature not detected electric charge as an independent creature outside of the masses.

Secondly, we use the property of *indifference* EM forces in relation to the simultaneous presence of other types of interactions. No vertexes of the EM field interaction with gluons and gravitons, because they have no electric charge. EM forces are not distorted by all other known at the present time interactions. Et his property due to greater penetration of photons, which are so freely to overcome as the cosmic scale, and easily penetrate into the region of confinement.

Involvement in the review of the properties of *inseparability* and *indifference,* as will be shown below, to retain the structure group U(1) local gauge symmetry in an unchanged form, i.e. without imposing any form factors corresponding to the integration of "smearing" the charge on the field of non-locality [1].

We as is well known that all the fundamental matter fields are massive sets of leptons and quarks, which are fermions and carry an electrical charge. If the neutrino mass is detected, then this assertion will be violated. All non-local matter fields are related configurations of fundamental fields in different energy scales.

There is a need for a correct quantitative description of the movement of mass and charge in the Minkowski space in the presence of external EM fields, which are created by other external sources, taking into account long-range nature of their actions. Free movement of masses of fundamental particles are described by the relevant Lagrangians, where the idealized conditions in which excluded the impact of the EM field and the presence of the particle charge has no effect on the character of free movement.

How to compare the charge state of the fields? To do this they must relate to one and the same space-time point. It is necessary to define a "coordinate", which is a fixed frame, where the presence of an external EM field is identified by "position" of the charged particle. Such coordinates must have the property *of continuity,* to maintain control of the EM field of the movement of particles along the chosen path at any point. The importance of this condition was pointed out by Weyl [2] at the beginning of last century, and later Mandelstam [3]. This requirement makes it possible to identify the device recorded the particle in the final state and, as of the associated to the field of structure-forming interactions, clearly confirm that it belongs only to this area and to provide "binding" to charge the coordinate source of nonlocal field regardless of the specification details the structure-forming interaction *(indifference),* and additionally to the harmonization of the laws of conservation of energy-momentum (property of *inseparability).*

A positive solution of the above issues can be complex, involving the ideology of the quantum theory of gauge fields and its geometrical interpretation.

Modern (common) interpretation of the gauge field as a principal bundle connection and configuration of the adjoin space charge determines the direction of the evolving situation with regard to proper introduction to the theory of nonlocal fields. It is known [4, 5] that in the generalized configuration space, supplemented by adjoin tangent space in which the vector potential of the EM field (identified with the principal bundle connection) determines the rule harmonization of displacements in the base space-time various with a given initial 4-point with their projections in the adjoin charge space. This is achieved by introducing a generalized charge coordinates in the form of the exponential phase [6 - 8], in the exponent which there is a curvilinear integral of the vector potential of the EM field along the trajectory with a variable upper limit of integration. Multiplicative structure of the total wave function of a charged particle as a product of its time-space of the generalized charge coordinates and ensures consistent description of the evolution of the state, both external and internal spaces with the movements in it anywhere.

The purpose of this report is that of constructing an alternative justification for QED; discuss additional requirements necessary to ensure an adequate study of the structure of nonlocal strongly coupled matter fields in the EM process of disintegrating, as well as interactions with the local fields on the basis of uniform principles.

2. Generalized configuration space and the Lagrangian

The original formulation of the problem to build a theory of nonlocal interactions on the basis of already existing local theory from a mathematical point of view is ill-posed problems. An attempt to synthesize the local theory in the same condition on the nonlocal interactions, where the concept of locality and appears in the structural aspects of one-sided asymptotic behavior of non-locality, and to restore the theory on the asymptotic behavior is not well-posed problem. The opposite possibility of constructing such a theory is connected with the choice as the original "first principles" of non-local structures, which at a certain stage of the permit-known local structural limit.

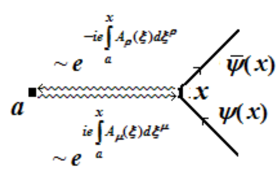
In published studies [9 - 12] have shown that kind of harmonization of the fundamental field operator (local) matter fields to the structure of space-time manifold and attached to the inner space of U(1) symmetry, which is defined rule [5], which allows to determine the change the total wave function of the field not only due to its displacement on a 4-dimensional trajectory with given initial 4-point in the core area, but also to coordinate the change with a change in its charge component in the adjoins space by introducing a "generalized coordinates of the charge" - phase exponential [4]. P-ordered exponent determines a quantitative change in the field function of the charged matter fields in accordance with the requirement of the vanishing of the covariant derivative of this function in the direction of the tangent space with a fixed initial 4-point

$$\frac{dx_\mu(\tau)}{d\tau}\cdot D^\mu\psi(x)\Big|_{x=x(\tau)}=\frac{dx_\mu(\tau)}{d\tau}\cdot\left(\partial^\mu+ieA^\mu\right)\psi(x)\Big|_{x=x(\tau)}=0\,, \tag{1}$$

where τ - setting its own path length $x_\mu(\tau)$; e - charge of the particle; A^μ - vector potential of the EM field. Solution of equation (1) has the form

$$\psi(x')=P\cdot e^{ie\int_x^{x'}A_\nu(\xi)d\xi^\nu}\cdot\psi(x)\,, \tag{2}$$

where P - operator of the space-time ordering along the trajectory $x_\mu(\tau)$.



$$\mathcal{L}_{local}(x;A)=\bar\psi(x)e^{-ie\int_a^x A_\rho(\xi)d\xi^\rho}(i\gamma^\nu\partial_\nu-m)e^{ie\int_a^x A_\mu(\xi)d\xi^\mu}\psi(x)$$

Fig. 1. The local nature of the interaction of EM fields with the fundamental electronic field.

As already noted, bringing the kind of the wave function of a charged particle with the structure of the chosen space $\psi(x)\to\Psi(x;A)=P\cdot e^{ie\int_a^x A_\mu(\xi)d\xi^\mu}\cdot\psi(x(a))$ in accordance with expression (1) leads to the restoration of local gauge symmetry of the free electron Lagrangian in the presence of the EM field, but leaves the consideration of the local approach (Fig. 1), and locally Lagrangian in terms of the function $\Psi(x;A)$ becomes

$$\mathcal{L}_{local}(x;A=0)=\bar\psi(x)(i\gamma^\mu\partial_\mu-m)\psi(x)\;\Rightarrow \tag{3}$$

$$\mathcal{L}_{local}(x;A)=\bar\Psi(x;A)(i\gamma^\mu\partial_\mu-m)\Psi(x;A)=$$

$$=\bar\psi(x)e^{-ie\int_a^x A_\nu(\xi)d\xi^\nu}(i\gamma^\mu\partial_\mu-m)e^{ie\int_a^x A_\nu(\xi)d\xi^\nu}\psi(x)=\bar\psi(x)\,i\gamma^\mu(\partial_\mu+ieA_\mu(x))\psi(x)-m\cdot\bar\psi(x)\psi(x)\,.$$

A similar situation is observed in scalar QED.

If a charged scalar field in the presence of the EM field in the configuration space is described as a product of the generalized charge coordinates in the space of internal symmetry and the wave functions in the space-time manifold $\Phi(x;A)=e^{ie\int_a^x A_\mu(\xi)d\xi^\mu}\cdot\phi(x)$. The locally gauge-invariant Lagrangian takes the form

$$\begin{aligned}\mathcal{L}_{local}(x;A=0)&=[\partial_\mu\phi(x)]^+[\partial^\mu\phi(x)]-\mu^2\phi(x)^+\phi(x)-\frac{\lambda}{4}(\phi(x)^+\phi(x))^2\;\Rightarrow\\ \mathcal{L}_{local}(x;A)&=[\partial_\mu\Phi(x;A)]^+[\partial^\mu\Phi(x;A)]-\mu^2\Phi(x;A)^+\Phi(x;A)-\frac{\lambda}{4}(\Phi(x;A)^+\Phi(x;A))^2=\\ &=[\partial_\mu e^{ie\int_a^x A_\nu(\xi)d\xi^\nu}\phi(x)]^+[\partial^\mu e^{ie\int_a^x A_\nu(\xi)d\xi^\nu}\phi(x)]-\mu^2\phi(x)^+\phi(x)-\frac{\lambda}{4}(\phi(x)^+\phi(x))^2=\\ &=[(\partial+ieA)_\mu\phi(x)]^+[(\partial+ieA)^\mu\phi(x)]-\mu^2\phi(x)^+\phi(x)-\frac{\lambda}{4}(\phi(x)^+\phi(x))^2.\end{aligned} \tag{4}$$

It is easy to see in the exponent of the exponential phase action of the classical field theory, corresponding to the description of the motion of electric charge in the presence of an external field. Redefining the field function fundamental matter fields in conformity with conditions (1 - 2) at the stage of constructing locally gauge-invariant Lagrangian of the theory does not make any additional changes. Lagrangian is invariant under the transformations of the local gauge group.

3. Alternative construction of QED, the Green's function, vertices and nonlocal amplitude

As shown in [9 - 12] alternative building local QED can be achieved through the initial use of nonlocal gauge-invariant 2-point Green function (GF) (Fig. 2). Thus, without loss of generality, but only for the purpose of clarity, consideration of conduct by the example of a scalar field

$$D_{\text{nonlocal}}(x,y;A) = i\langle P(\phi(x)e^{ie\int_y^x A_\nu(\xi)d\xi^\nu}\phi^+(y))\rangle, \tag{5}$$

Note that since we do not involve consideration of the construction phase of the interaction Lagrangian and *S-matrix.* The expression for GF (5) is invariant under the transformation of the field $\phi(x)$ and the vector-potential $A_\rho(\xi)$ EM field

$$\phi(x)\to\phi(x)e^{-ie\alpha(x)}, \quad \phi^+(y)\to e^{ie\alpha(y)}\phi^+(y), \quad A_\mu(\xi)\to A_\mu(\xi)+\partial_\mu\alpha(\xi). \tag{6}$$

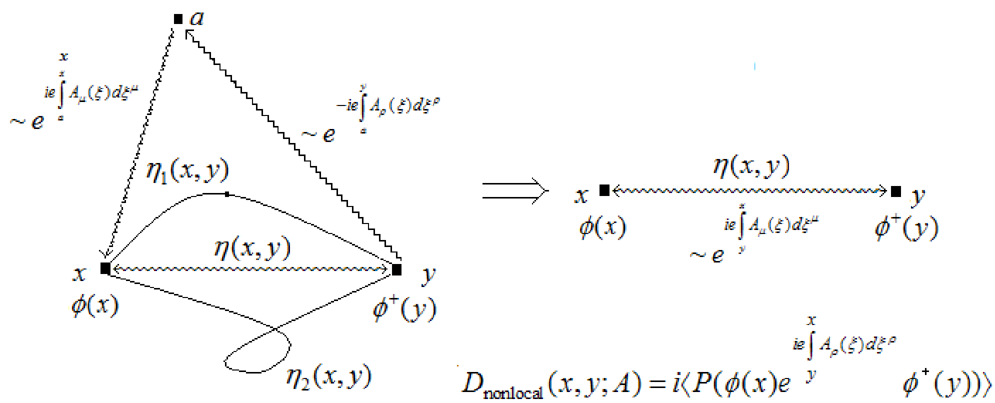


Fig. 2. Nonlocal gauge-invariant 2-point GF.

Note that if the material field $\phi(x)$ in expression (5) nonlocal and when it is moved from the 4-point x the point y in the presence of the EM field, it retains its integrity (identity), i.e. information about the structure-force remains outside consideration; it is indistinguishable from the description of the fundamental fields of the same expression.

As a result, calculations of the GF (5) the functional derivative of the vector potential of the gauge field leads to the momentum representation to the expression for the corresponding EM vertices in the light of statistical material field, which is consistent with the GF -free particles before and after the interaction [11]

$$\left.\frac{\delta D_{\text{nonlocal}}(x,y;A)}{\delta A_\mu(r)}\right|_{A=0} A_\mu(r)\to \tag{7}$$

$$(2\pi)^4\delta(p+q-p')e\varepsilon_\mu\int_0^1 d\lambda\frac{\partial D(p+\lambda q)}{\partial(p+\lambda q)_\mu} = (2\pi)^4\delta(p+q-p')D(p+q)\left\{-e\varepsilon_\mu(p+p')^\mu\right\}D(p),$$

where $D(p)=1/(p^2-m^2+i0)$ GF scalar particles.

In other words, all the necessary information about the nature of EM interactions with material fields, taking into account statistics of particles in QED in a compact form is contained in the nonlocal gauge-invariant 2-point structure (5), irrespective of whether meeting the Heisenberg field in GF local or nonlocal particle if only its mass and charge remained unchanged during the whole interaction time.

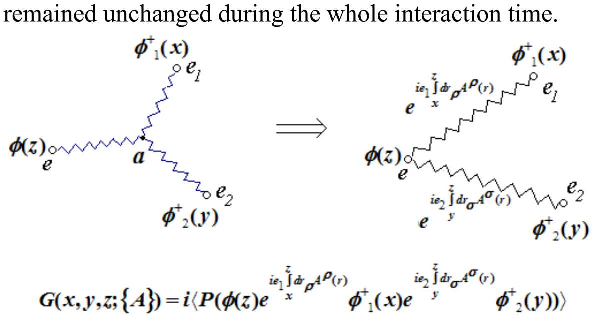


Fig. 3. Gauge-invariant vertex function.

If the scalar field $\phi(z)$ under the action of the EM field is divided into two scalar fragment $\phi_1(x)$, $\phi_2(y)$, the corresponding 3-point nonlocal gauge invariant GF, but rather only its strongly connected vertex part (Fig. 3) (outer ends - 2-point GF (5) are removed and their review is no different from above carried out), then interest structure has the form [11]

$$G(x,y,z;A) = i\langle P(\phi(z)e^{ie_1\int_x^z dr_\rho A^\rho(r)}\phi_1^+(x)e^{ie_2\int_y^z dr_\sigma A^\sigma(r)}\phi_2^+(y))\rangle. \tag{8}$$

Expression (8) is responsible, for example, disintegrating of the scalar field ϕ in 4-point z under the action of EM field on the two charged fragments with charges e_1 and e_2 at points x and y respectively. The structure of expression (8) is invariant under local transformations *U*(1) gauge group

$$\phi(z)\to\phi(z)e^{-ie\alpha(z)},\ \phi_1^+(x)\to\phi_1^+(x)e^{ie_1\alpha(x)}, \tag{9}$$

$$\phi_2^+(y)\to\phi_2^+(y)e^{ie_2\alpha(y)},\ \ A_\mu(r)\to A_\mu(r)+\partial_\mu\alpha(r)$$

subject to charge conservation $e=e_1+e_2$. It is important to note that the gauge symmetry of expression (8) is provided for nonlocal field in the Heisenberg representation $\phi(z)$ and its fragments $\phi_1(x),\ \phi_2(y)$ regardless of the need to specify the details of the strong interaction between them. This is a consequence of the properties of *indifference* EM forces in relation to the structure-forming interactions. In addition, in GF (8) a correlation between the requirement of invariance with respect to gauge transformations (9) and the additive law of conservation of charge (otherwise, when $e\neq e_1+e_2$ phase exponential factors is not reduced). At this stage of the review is "separation" aspect of EM studies on the direction of studying the structure.

Calculating the functional derivative of expression (8) and acting similarly as in deriving (7) we obtain [11] in the momentum representation (Fig. 4),

$$\left.\frac{\delta G(x,y,z;\{A\})}{\delta A_\mu(r)}\right|_{A=0} A_\mu(r)\to \tag{10}$$

$$M_{reg}=(2\pi)^4\,\delta(p+q-p_1-p_2)\,\varepsilon_\mu\int_0^1 d\lambda\left\{e_1\frac{\partial G(p_1-\lambda q;p_2)}{\partial(p_1-\lambda q)_\mu}+e_2\frac{\partial G(p_1;p_2-\lambda q)}{\partial(p_2-\lambda q)_\mu}\right\},$$

where $e_i,\ p_i,\ i=[1,2]$ charges and moments of the fragments, respectively.

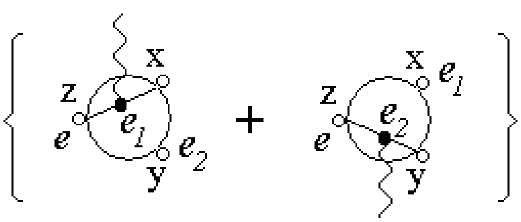


Fig. 4. Regular part of the amplitude with the inclusion of a photon in the vertex function.

The total amplitude of the splitting of non-local field is obtained by successive inclusion of the photon in the outer ends of the three-point GF, which leads to the traditional pole number and the inclusion of a photon in a strongly connected vertex part (10) and leads to a regular part of the generalized polar gauge-closed amplitudes [9 - 12].

Exponential phase provided an opportunity to harmonize the local displacements in the space-time manifold and the associated space of internal symmetries, due to the redistribution of mass and charge of non-local field of matter and its fragments. The said agreement held not only in the asymptotic in - and out -states (the pole part of the generalized amplitude), but also in the field of intensive structure forming a limited power range (the regular component of it). In other words, we ensured the continuity of change in the charge coordinates - EM phase throughout the entire interaction time. Harmonization of displacements of the masses and their corresponding charges in the space-time manifold and the associated charge space, as well as maintaining the structure of local gauge symmetry due to the exponential phase amplitude provides a *concerted action of the laws of conservation of energy-momentum and charge conservation.* In addition, the involvement of additional properties of indifference allows you to save the *universal* property of the EM interactions in terms of *minimal regard* for nonlocal fields, which allows us to separate the EM aspect in studies of non-local fields on the direction associated with the purely structural studies.

A characteristic feature of the regular part of a generalized pole of the amplitude is the presence in it of the derivative from the vertex of the strong interaction, i.e. regular part of the amplitude is determined by the rate of change of the vertex. While part of the pole is determined by only the very vertex of the function. Amplitude automatically satisfies the requirement of the dynamic conservation of total hadronic current regardless of the explicit functional form the very vertex (a consequence of the properties of *indifference).* Otherwise, the vertex of the function of the strong interaction is endowed with *functional* properties of a *free parameter,* which ensures the invariance of the amplitude on the evolution of a hierarchical structure-interactions and a set of components of the nonlocal field. This property makes it possible to find the vertex function at every available scale structure of matter as the solution of the exact Bethe-Salpeter's equation or its quasipotential analogues and test it in the EM process of disintegrating.

Defined above rules define a generalized gauge-closed amplitude (Fig. 5), in which the outer lines - two-point gauge-invariant GF. The first three diagrams form a traditional part of the pole after the activation of a photon in the outer ends - 2-point GF, and the remaining figure corresponds to the regular component (10). As a result of the procedure remains the continuity of the generalized charge coordinates.

Fig. 5 can be interpreted differently: - EM field interacting with nonlocal vertex fixes the charge for each line and checks for its redistribution within the field of non-locality, thus ensuring the continuity of change in the EM phase.

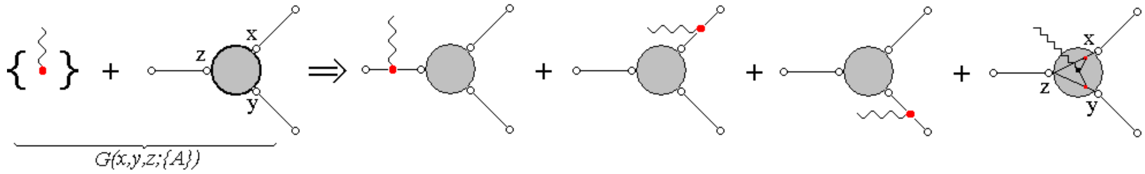


Fig. 5. Structure of the generalized gauge-closed amplitude. The first three diagrams on the right side of the picture determine the pole part of the generalized amplitude; the latter figure corresponds to the regular component.

As is well known in QED [5], all members of the same order of the semi classical expansion S-matrix or the generating functional for the GF is the invariant set of diagrams with the same properties of symmetry, which has S-matrix, i.e. all the symmetry properties S-matrices are carried out independently for a given set of diagrams. In the review in virtue of the known difficulties arise reverse pattern – the interaction of the gauge field is strongly associated with the composite material field, where in addition to the EM is a strong interaction occurs with an unknown Lagrangian and, consequently, S-matrix. However, at the level of amplitude - a number of diagrams (Fig. 5) with a strongly connected GF, it is possible to implement the requirements of covariance and gauge invariance and, consequently, the amplitude at the level of generalized gauge-closed pole number will have the same symmetry properties as the amplitude in QED, but in the presence of strong interaction.

Mathematical record amplitude, corresponding to the diagram in Fig. 5 in accordance with the rules set forth above becomes:

$$\begin{aligned}
&\{D(p)G(p;p_1,p_2)D(p_1)D(p_2)\}+\{e\varepsilon_\mu\}\rightarrow\left\{-e\varepsilon_\mu z\int_0^1 d\lambda\frac{\partial D(p+\lambda q)}{\partial(p+\lambda q)_\mu}\right\}G(p+q;p_1,p_2)D(p_1)D(p_2)+\\
&+D(p)G(p;p_1-q,p_2)\left\{-e\varepsilon_\mu z_1\int_0^1 d\lambda\frac{\partial D(p_1-\lambda q)}{\partial(p_1-\lambda q)_\mu}\right\}D(p_2)+\\
&+D(p)G(p;p_1,p_2-q)D(p_1)\left\{-e\varepsilon_\mu z_2\int_0^1 d\lambda\frac{\partial D(p_2-\lambda q)}{\partial(p_2-\lambda q)_\mu}\right\}+\\
&+D(p)\left\{-e\varepsilon_\mu\int_0^1 d\lambda\left\{z_1\frac{\partial G\left(p+(1-\lambda)q;p_1-\lambda q,p_2\right)}{\partial\left(p_1-\lambda q\right)_\mu}+z_2\frac{\partial G\left(p+(1-\lambda)q;p_1,p_2-\lambda q\right)}{\partial\left(p_2-\lambda q\right)_\mu}\right\}\right\}D(p_1)D(p_2).
\end{aligned}\tag{11}$$

Each term in (11) corresponds to the diagram in Fig. 5, left to right. The requirement of gauge symmetry for the amplitude is performed automatically. Practical receive regular expressions for the amplitude with a heuristic approach to the expression (11) when the expression is strictly fixed pole component, by multiplying the total amplitude at the 4-momentum of the photon polarization vector, instead of its instantaneous restores the missing factors in the contact term due to the pole and the requirements reduction.

3. Gauge symmetries and the process of disintegrating with virtual photons

The conventional understanding is that the processes of disintegrating of atomic nuclei on electrons are less critical to ensure the requirements of gauge symmetry. The basis of this assertion uses the fact of conservation of the lepton current $j^{\nu}_{lepton}q_\nu=0$. That leads to the exclusion of the longitudinal component of the propagator of the virtual photon regardless of whether the remains at the same hadrons current $q_\mu J^{\mu}_{hadron}\begin{cases}\neq 0\\ =0\end{cases}$.

Features of the gauge symmetry are that its realization should be provided accurately, because it reflects the strict law of conservation of charge. In the amplitude of the implementation of the law of conservation of charge associated with the statement: photons with polarization vectors ε_μ and $\varepsilon_\mu+\lambda\cdot q_\mu$ with $\lambda\in(-\infty,\infty)$ give indistinguishable results were observed only in the case of the universal nature of interactions in the form of minimal communication $e\varepsilon_\mu J^{\mu}$, and only for the remaining current $q_\nu J^{\nu}=0$. In processes with virtual photons ($q^2\neq 0$), formed a strong opinion that the gauge arbitrariness of the virtual photon propagator in the form of the tensor structure $\frac{q_\nu q_\mu}{q^2}$ of the matrix element

$\mathfrak{M} \sim j^{\nu}_{lepton} \cdot (-g_{\nu\mu} + \frac{q_\nu q_\mu}{q^2}) \cdot J^{\mu}_{hadron}$, is eliminated unrelenting lepton current $j^{\nu}_{lepton} q_\nu = 0$ even when not saving the hadrons' $q_\mu J^{\mu}_{hadron} \neq 0$.

This situation persists until the square of the 4-momentum virtual photon begins to come up to zero, i.e. to go in the amplitude of the virtual photon to a real photon. This condition in the plane of variables $q_\mu(\nu;0,0,q_3)$ determines the lines $q^2 = 0, \Rightarrow |\nu| = |q_3|$. In the matrix element appears uncertain of the form $\frac{j^{\nu}_{lepton} q_\nu \cdot q_\mu J^{\mu}_{hadron}}{q^2} \to \left\| \frac{0}{0} \right\|$.

We will show that resolve this uncertainty is only possible if both the current stored. To do this, select the components of the currents in the form $j_\mu(j_0;\vec{j}_\perp, j_3)$, $J_\mu(J_0;\vec{J}_\perp, J_3)$. As a result of substitution in the matrix element $\mathfrak{M} \sim j^{\nu}_{lepton} \cdot (-g_{\nu\mu} + \frac{q_\nu q_\mu}{q^2}) \cdot J^{\mu}_{hadron}$ we obtain $\mathfrak{M} \sim \left(\vec{j}_\perp \vec{J}_\perp\right) - \frac{(1-x^2) j_0 J_0 - (1-x^2) j_3 J_3}{(1-x^2)}$, where $x^2 = \left(\frac{q_3}{\nu}\right)^2$, at $q^2 \to 0$, then $x^2 \to 1$. Using the conditions for conserving the currents, which in this coordinate system take the form $j_0 = x \cdot j_3$, $J_0 = x \cdot J_3$, to obtain the amplitude $\mathfrak{M} \sim \left(\vec{j}_\perp \vec{J}_\perp\right) + \frac{(1-x^2)^2 j_3 J_3}{(1-x^2)}$. In the limit $x^2 \to 1$, we obtain $\mathfrak{M} \sim \left(\vec{j}_\perp \vec{J}_\perp\right)$, i.e. amplitude is determined by the transverse components of conserved currents, at the same time get rid of their non-physical contributions of temporal and longitudinal components.

The condition of conservation of both currents is the criterion that the amplitude of the process with a virtual photon would adequately describe the real physical situation is not distorted theoretical approach. The criterion for the correct construction of the nonlocal hadrons' EM current and its use in theoretical analysis of the processes of disintegrating of atomic nuclei is the possibility of a smooth transition in the amplitude of the 4-momentum of the virtual photon from the space-like region at the time such an area.

The analysis yields the following conclusions.

- ✓ Conserved leptonic current removes the gauge arbitrariness propagator of a virtual photon.
- ✓ Conserving hadrons' current leads to the fact that the amplitude is determined only by the contributions of the transverse components of the two currents.
- ✓ In the amplitude of the process electro disintegration provided a limit of photon point in the squared 4-momentum transfer

$$\lim_{\substack{q^2 \to 0 \\ (|\nu| \to |\vec{q}|)}} \mathfrak{M}\left(\{e, e'\}; q^2\right)\Bigg|_{\substack{I^{lepton}_{\mu} q^{\mu} = 0 \\ J^{hadron}_{\rho} q^{\rho} = 0}} = \mathfrak{M}\left(\{\gamma\}; q^2 = 0\right).$$

This provides the conditions for the study of the role of the same mechanisms of reaction in the processes with electrons and photons simultaneously, at the same time excluding from consideration the contributions of non-physical states.

Conclusions

Additional use of a set of axiomatic requirements of the local QED, can consistently introduce the nonlocal field of matter, without involving the methods of constructing the interaction Lagrangian. Objective third set of requirements is the result of an adequate description of the picture of interaction of EM fields with nonlocal field. Structure of a generalized configuration space has allowed for harmonization of displacements in the correct description of the redistribution of charge and mass of the nonlocal field between its fragments in the region of structure-forming interactions. Additional limitations in negotiating broadcast properties relate to the concept of the inseparability of charge from the concept of mass and compliance with the principle of indifference EM forces in relation to other types of interactions. It is shown that all the necessary information to describe the interaction of EM fields with fundamental matter fields with their statistics in a compact form is contained in the 2-point gauge-invariant GF. Non-local 3-point gauge-invariant GF in which the structure of Heisenberg field operators agreed with the structure of a generalized configuration space lead to the definition of a generalized pole amplitude, which dynamically coordinated action of the laws of conservation of energy-momentum and charge.

In the generalized amplitude automatically saved initially present the properties of the gauge symmetry irrespective of the type of structure-strength non-local field. This fact allows us to consider the vertices of the strong interaction in the EM process of disintegrating as the *free functional* parameters depending on the translation-invariant argument, the explicit form of which is defined as making the structure forming the equations for each available for research-scale structure of matter. The resulting amplitude has the important property of invariance under *a hierarchical structure-*

evolution forces nonlocal field and set its components, provided an accurate gauge preserving properties of EM fields. This property makes it possible to find the vertex function in the form of solutions of the exact Bethe - Salpeter's equation or its quasi potential analogs on each available for research-scale structure of matter and test these solutions in the research of EM processes of disintegrating. As a result, unable to separate the EM aspect of the research on the structural and keep intact the structure of the group U(1) gauge symmetry, ensuring the implementation of the *universal* property of EM interactions in the *minimal* form for the nonlocal fields.

The advantages of this approach is the fact that it significantly extends the possibilities of QED for the study of non-local fields on a clear idea, but it does not change the single result obtained earlier in a local quantum-field approach.

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