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On the electromagnetic symmetry producing fields charges at four bosons association

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Abstract

Physics would like to know what electric charge is. As a matter property it generates EM fields, coupling constant, conserved current. Nevertheless Maxwell is uncomplete. It requires to be extended. An approach is supported by electric charge transfer phenomenology. Consider on three flavours charges $\{+, 0, -\}$ transmission.

A generic electric charge is defined by the triad $\{+, 0, -\}$. It provides an exchange charge physics through the quadruplet $\{A_\mu, U_\mu, V_\mu^\pm\}$. An electromagnetic symmetry is constituted. It associates the four vectorial bosons. The EM completeness of particles carrying three electric charges is found. A four photons EM is derived. It includes, A_μ as the usual photon, U_μ massive photon, $V_\mu^\pm$ massive charged photons.

A new electromagnetic physics is expressed through an enlarged abelian symmetry, $U_q(1)$. Maxwell relationships between charge and fields are extended. Fields charges are more primitive than electric charge. Noether theorem improves the attributes on electric charge conservation, symmetry equation and constraint. The symmetry equation which govern the electric charge dynamics shows a charge behaviour beyond matter, as fields flux. EM interaction is extended from fine structure constant to modulated and neutral charges.

The four bosons electromagnetism introduces a non-univoque electromagnetic symmetry. A pluriformity of EM models is performed under similar abelian group, $U_q(1)$. Opportunities for different EM models are constituted preserving charge conservation law and sharing a common Lagrangian. Physical varieties on Noether theorem, fields strengths, Lagrangian coefficients, equations of motion, fields charges are expressed. Electric charge is englobed by fields charges.

The simplest four bosons model is selected. That one which fields strengths are gauge invariants. Propitiating measurable granular and collective fields strenghts. Four kinds of charges are expressed through equations of motion. Electric, modulate, neutral and Bianchi. Allowing to include new EM sectors. Extend Maxwell for nonintegers charges, nonlinearity, neutral EM, spintronics, weak interactions, photonics. A new EM energy emerges.

Keywords: Electromagnetism Nonlinear; Gauge theory studies; self-interactions photons; collective fields strengths.

1 Introduction and Contextualization

Electric charge has been studied as a property of objects and particles. Macroscopically, in 1600 in the book De Magnete, Gilbert described the existence of two electric charges [1]. Later, these charges were denominated as positive and negative, in 1745 by Leyden jar and in 1748 by Benjamin Franklin [2]. And, at 19^{th} century as currents by Volta, Ohm, Bio-Savart, Ampère, others [3]. Microscopically, since 1874 George Stoney have been suspecting on an electric charge atom, discovered in 1897 by Thompson as the electron [4]. At 20^{th} century the electric charge presence was spread in the zoo of elementary particles [5].

Electromagnetism become the theory of electric charge. However, besides of the original charged matter manifestation, Faraday discovered the existence of magnetic fields (1831), electric fields (1836) and light as EM wave (1846) [6]. Faraday induction law and Maxwell displacement current showed how EM fields are inextricably connected. More than acting as a source, electric charge joined electricity and magnetism through its conservation law.

Four equations were derived housing electric charge [7]. EM fields became the variables and electric charge the source. The new rule was Maxwell rewritten under symmetry. The original empiricism replaced by rationalism. A synthesis where electric charge source, conservation, interactions and Lorentz force were described by two symmetries. Light metric and electric charge conservation.

Thus, a first aspect beyond Maxwell is to consider on electric charge behaviour. Maxwell elevated electric charge to an universal nature entity. In 1913, Millikan measured its value $e = 1.6 \cdot 10^{-19}C$ [8]. Later, it was rewritten by Bohr atom, quantum mechanics and QED in terms of fine structure constant. In the ensuing years, another values were found. Showing that, it is not a fixed number. It provides other magnitudes through runing coupling constant, quarks fractionaries, electroweak modulations, millicharges [9]. Indicating that, the classical EM based on e value does not satisfy anymore. Their differents values should be treated under a new perspective. It also contains an internal structure given by the Gell-Mann-Nishijima expression [10].

The Maxwell second aspect is on EM fields. Discuss on Maxwell limitations. Diverse physical phenomena are requering an extension for non-linearity, origin for polarization and magnetization vectors, potential fields physicality, selfinteracting photons, spin formalism, others. Actually, there are 57 models beyond Maxwell [11]. A fundamental nonlinear EM is expected.

Our research is to look for an EM beyond Maxwell through the microscopic electric charge behaviour. Between 1927-1934 Dirac, Fermi, Majorana, Pauli, Weisskopf understood that electrons and photons are created and destroyed [12]. However, a missing aspect was not explored. It is on the electric charge mutation. A physics interchanging positive, negative, zero charges. Consider these three types of electric charges transforming on each other. Observe that electromagnetism is more than positive and negative charges. Understand on the generalized electric charge flavour $\{+, 0, -\}$.

In 1930 physics already knew the electron, proton and photon. Three particles to consider over these three charges interplay. After, in 1938 during the Warsaw conference, there were 14 particles with recognized subatomic reactions interchanging three electric charges flavours [13]. Propitious moment to introduce the electric charge set $\{+, 0, -\}$ and corresponding electromagnetic symmetry. But, guided by Oskar Klein, physicists preferred discuss on theory of everything than display on electric charge flavours.

Thus, we are first compelled to understand why the physicists omitted the charge transfer as the next significance to Maxwell. Consider that there is an EM lost story. An original generic electric charge $\{+, 0, -\}$ to be exploited. Strangeless this investigation was outline. A justification would be that, at 1940s quantum field theory was near to disappear due to problems with Lorentz covariance and divergence. Then, after being solved by Tomonaga, Feynman, Schwinger, Dyson [14], and with a notable QED theoretical-experimental result to the magnetic moment of the electron given by Lamb, Bethe, Kausch and others [15], a jubilant success was incorporated. Feyman called QED the jewel of physics. And so, the initiative for including the zero charge EM energy as participating in the EM process became secondary, although being registered at the photon. Interestingly, a massive photon was considered at that epoch by London (1930) and Proca (1936) equations [16]. And, in 1940 Schwinger introduced spin-1 charged particles called mesotrons [17]. A perspective extended in 1960 by Komar, Salam, Ward, Lee, Yang [18].

We would retreat that from 1930 to 1950s decade physics was mature to discuss about an electromagnetism under four bosons intermediations. However, although the quadruplet was there, it was not recognized as the EM enlargement. The unification between these four spin-1 fields was not a theme to express physics. They came together at 1950s with weak interaction, but, without enlarging QED to four bosons. Their unification came along in 1968 with the electroweak theory. It englobes them through the spontaneous symmetry breaking $SU(2)_L \times U_Y \stackrel{Higgs}{\rightarrow} U_{em}(1)$. Coincidentelly, it finished under an abelian symmetry. However, EW omits the quadruplet as EM symmetry unification.

Nevertheless, the charge transfer contains a realism registered at elementary particles physics reactions. At microscopic level is inevitable the electric charge exchange between positive, negative, zero charges. A triad where each one is transformed on each other. Yielding an EM where the photon transmission is enlarged to a quadruplet. Elevating the electric charge set $\{+, 0, -\}$ to the status of a generic electric charge.

An EM symmetry is introduced. Originated by such generic electric charge, it interrelates the quadruplet $\{A_\mu, U_\mu, V_\mu^\pm\}$. The EM completeness is achieved by a four bosons electromagnetism [19]. A new EM energy is formed. An electromagnetism under A_μ as the usual photon, U_μ massive photon and $V_\mu^\pm$ massive charged photons. A clue already noticed at Maxwell and electroweak. Maxwell provides a zero charge physics with light as an EM wave and with neutrino spin interaction. Electroweak with four intermediate bosons $\gamma, Z_0, W^\pm$.

There is an EM symmetry to be investigated. The quadruplet gets together by an abelian group, $U_q(1)$. The correspondent electromagnetic symmetry introduces new aspects for electric charge. Noether theorem provides three electric charge properties which are current, conservation and interaction. However, while in Maxwell they converge for the same physics, a diverse structure is generated. Three new aspects appear. The first one is that, electric charge is more than the standard external source and the only one conserved charge. The quadruplet provides electric charge with relationships beyond electric charge as matter. A dynamics where the corresponding densities and currents are written in terms of fields. The second one, is EM interactions beyond usual electric charge coupling. By last, the $U_q(1)$ symmetry is not univoque. By preserving the electric charge conservation law, there are different ways to express the quadruplet associations under abelian symmetry.

The objective of this work is to study on such diverse possibilities to manifest the four bosons physics. The relationship between conserved charge and EM features is not more univoque. There is a pluralism constituted by a common Lagrangian under different abelian symmetries. Diverse four bosons models are viable. Different physical properties are manifested preserving the electric charge conservation principle.

The research is to compare such different electric charge conservations models through their physical implications on Noether theorem, fields strengths, Lagrangian, equations of motion, fields charges. Introduce a physical choice. Consider the most adequate four bosons model in terms of experimental contact. More than consider on Lagrangian gauge invariance procedure [20], explore that one, providing the largest number of measurable granular and collective fields strengths. This is the theme at this work. Select between the four bosons EM models that one with a significant number of gauge invariants fields strengths. Make a physics where the variables at equations of motion are physical entities.

2 Electromagnetic symmetries

An electromagnetism completeness is found. A perspective beyond Maxwell given by a bosons quadruplet. Supported phenomenologically, due to the triad $\{+, 0, -\}$ mutations, it extends the electric charge physics. The QED opposite charges transmitted by the photon coupling under fine structure constant coupling is enlarged to the abelian extended $U_q(1)$ symmetry. A fields charges physics is produced. Electric charge is established by Noether theorem. However the fields dynamics includes another charges. An electromagnetism beyond electric charge has to be studied.

Electromagnetism is unrolled by the quadruplet $\{A_\mu, U_\mu, V_\pm^\pm\}$ associated by the electromagnetic symmetry $U_q(1)$. The novelty of charge transfer phenomenology through the triad $\{+, 0, -\}$ is that the EM symmetry enlarges the electric charge symmetry and is not univoquely defined. There are different possibilities to interrelate the quadruplet. A pluriformity emerges. The four bosons EM develops a commom Lagrangian under different symmetries.

An electromagnetic variety is propitiated. Different EM models may be expressed under a same Lagrangian. At this work we are going to study their diverse physicalities on Noether theorem, EM fields strengths, Lagrangian coefficients, equations of motion, fields charges. Compare their instances under various electromagnetic symmetries. Prioritize on EM fields strengths measurability.

2.1 Type I - $U_{q_1}(1) \equiv U_c(1) \times SO(2)$

The first type of electromagnetic symmetry relies on the following gauge transformation:

$$A'_\mu = A_\mu + k_1 \partial_\mu \alpha \tag{1}$$

$$U'_\mu = U_\mu + k_2 \partial_\mu \alpha \tag{2}$$

$$V_\mu^{+'} = e^{iq\alpha(x)} \left(V_\mu^+ + k_+ \partial_\mu \alpha\right) \tag{3}$$

$$V_\mu^{-'} = e^{-iq\alpha(x)} \left(V_\mu^- + k_- \partial_\mu \alpha\right) \tag{4}$$

The above transformations consider all fields transforming under a complete gauge fields set, $U_c(1)$, and also, include two charged fields under $SO(2)$. Constituing the abelian extended symmetry $U_{q_1}(1)$, the union between the symmetries $U_c(1)$ and $SO(2)$. It yields all fields evolving under the fields same parameter α, the fields electromagnetic charge embedded in the symmetry $U_{q_1}(1)$ and the electric charge physics reobtained under Noether theorem.

Eqs. (3 - 4) can be rewritten as

$$V_\mu^{\pm'} = e^{\pm iq\alpha} V_\mu^\pm + k_\pm \partial_\mu (e^{\pm iq\alpha}) \tag{5}$$

which shows a highly nonlinear dependence on the gauge parameter α

2.2 Type II - $U_{q_2} \equiv U(1) \times SO(2)$

A second symmetry is given by the following gauge transformation:

$$A'_\mu = A_\mu + k_1 \partial_\mu \alpha \tag{6}$$

$$U'_\mu = U_\mu + k_2 \partial_\mu \alpha \tag{7}$$

$$V_\mu^{+'} = e^{iq\alpha(x)} V_\mu^+ \tag{8}$$

$$V_\mu^{-'} = e^{-iq\alpha(x)} V_\mu^- \tag{9}$$

where the charged fields behaviour act just as matter fields.

2.3 Type III - $U_{q_3} \equiv U(1) \times SO(2)$

A next possibility is to include a second gauge parameter. It gives,

$$A'_\mu = A_\mu + k_1 \partial_\mu \alpha \tag{10}$$

$$U'_\mu = U_\mu + k_2 \partial_\mu \alpha \tag{11}$$

$$V_\mu^{+'} = e^{iq\beta(x)} \left(V_\mu^+ + k_+ \partial_\mu \alpha\right) \tag{12}$$

$$V_\mu^{-'} = e^{-iq\beta(x)} \left(V_\mu^- + k_+ \partial_\mu \alpha\right) \tag{13}$$

In this transformation, the charge fields are also linked to the parameter $\beta(x)$

2.4 Tipo IV - $U_{q_4} \equiv U(1) \times SO(2)$

A fourth kind of transformation is the gauge and charged fields separated by different gauge parameters.

$$A'_\mu = A_\mu + k_1 \partial_\mu \alpha \tag{14}$$

$$U'_\mu = U_\mu + k_2 \partial_\mu \alpha \tag{15}$$

$$V_\mu^{+'} = e^{iq\beta(x)} V_\mu^+ \tag{16}$$

$$V_\mu^{-'} = e^{-iq\beta(x)} V_\mu^- \tag{17}$$

Thus, the above four types and the corresponding global symmetries at Apendice A, are showing cases involving the four fields interconnections. Introducing an EM beyond Maxwell with a common Lagrangian under distinct symmetries. New EM physicalities to be investigated.

3 Noether theorem

The four symmetries should first be viewed under Noether theorem. The three Noether equations will explore their consequences. New properties on electric charge behaviour are derived. They will retreat about what electric charge is. A meaning based on electric charge conservation law.

3.1 Type I

The three Noether's identities are

$$\alpha \partial_\mu J_N^\mu + \partial_\nu \alpha \{\partial_\mu K^{\mu\nu} + J_N^\nu\} + \partial_\mu \partial_\nu \alpha K^{\mu\nu} = 0 \tag{18}$$

Eq.(18) contains three independent equations. The first one is the conservation of electrical charge:

$$\partial_\mu J_N^\mu = 0 \tag{19}$$

where the current is given by

$$J_N^\mu = iq\left\{\left[V_\nu^+ \frac{\partial L}{\partial\left(\partial_\nu V_\mu^+\right)}\right] - \left[V_\nu^- \frac{\partial L}{\partial\left(\partial_\nu V_\mu^-\right)}\right]\right\} \tag{20}$$

The second is the symmetry equation, entitled as the electric charge equation. It yields,

$$\partial_\nu K^{\nu\mu} + J_N^\mu = 0 \tag{21}$$

where the term $K^{\nu\mu}$ is

$$K^{\nu\mu} = k_1 \frac{\partial L}{\partial\left(\partial_\nu A_\mu\right)} + k_2 \frac{\partial L}{\partial\left(\partial_\nu U_\mu\right)} + k_+ \frac{\partial L}{\partial\left(\partial_\nu V_\mu^+\right)} + k_- \frac{\partial L}{\partial\left(\partial_\nu V_\mu^-\right)} \tag{22}$$

The third equation is the constraint:

$$\partial_\mu \partial_\nu K^{\nu\mu} = 0 \tag{23}$$

which means that $K^{\nu\mu}$ is an antisymmetric tensor.

3.2 Type II

The corresponding Noether identities are the conserved charge

$$\partial_\mu J_N^\mu = 0 \tag{24}$$

where the current is given by

$$J_N^\mu = iq\left\{\left[V_\nu^+ \frac{\partial L}{\partial\left(\partial_\nu V_\mu^+\right)}\right] - \left[V_\nu^- \frac{\partial L}{\partial\left(\partial_\nu V_\mu^-\right)}\right]\right\} \tag{25}$$

Formally eqs. (20) and (21) are producing the same expression.

The symmetry equation is

$$\partial_\nu K^{\nu\mu} + J_N^\mu = 0 \tag{26}$$

with the term $K^{\mu\nu}$ as

$$K^{\nu\mu} = k_1 \frac{\partial L}{\partial\left(\partial_\nu A_\mu\right)} + k_2 \frac{\partial L}{\partial\left(\partial_\nu U_\mu\right)} \tag{27}$$

Eq. (26) is similar to QED. Only uncharged fields are dynamical. The constraint equation takes the usual form as eq.(23).

3.3 Type III

In terms of two gauge parameters the Noether's identities are written as

$$\partial_\nu \alpha \partial_\mu K^{\mu\nu} + \partial_\mu \partial_\nu \alpha K^{\mu\nu} + \beta \partial_\mu J_N^\mu + \partial_\mu \beta J_N^\mu = 0 \tag{28}$$

The charge at α conservation is given by:

$$\partial_\mu J_N^\mu = 0 \tag{29}$$

where

$$J_N^\mu = iq\left\{\left[V_\nu^+ \frac{\partial L}{\partial\left(\partial_\nu V_\mu^+\right)}\right] - \left[V_\nu^- \frac{\partial L}{\partial\left(\partial_\nu V_\mu^-\right)}\right]\right\} \tag{30}$$

However, the β invariance introduces that

$$J_N^\mu = 0 \tag{31}$$

Symmetry equation

$$\partial_\mu K^{\mu\nu} = 0 \tag{32}$$

with

$$K^{\nu\mu} = k_1 \frac{\partial L}{\partial\left(\partial_\nu A_\mu\right)} + k_2 \frac{\partial L}{\partial\left(\partial_\nu U_\mu\right)} + k_+ \frac{\partial L}{\partial\left(\partial_\nu V_\mu^+\right)} + k_- \frac{\partial L}{\partial\left(\partial_\nu V_\mu^-\right)} \tag{33}$$

Constraint equation

$$\partial_\mu \partial_\nu K^{\mu\nu} = 0 \tag{34}$$

The introduction of β symmetry cancels the electric charge formed at eq. (30). It yields on electric charge dynamics without source.

3.4 Type IV

Noether's theorem equations are

$$\partial_\nu \alpha \partial_\mu K^{\mu\nu} + \partial_\mu \partial_\nu \alpha K^{\mu\nu} + \beta \partial_\mu J_N^\mu + \partial_\mu \beta J_N^\mu = 0 \tag{35}$$

Charge conservation

$$\partial_\mu J_N^\mu = 0 \tag{36}$$

where

$$J_N^\mu = iq\left\{\left[V_\nu^+ \frac{\partial L}{\partial\left(\partial_\nu V_\mu^+\right)}\right] - \left[V_\nu^- \frac{\partial L}{\partial\left(\partial_\nu V_\mu^-\right)}\right]\right\} \tag{37}$$

and

$$J_N^\mu = 0 \tag{38}$$

Symmetry equation

$$\partial_\mu K^{\mu\nu} = 0 \tag{39}$$

where

$$K^{\nu\mu} = k_1 \frac{\partial L}{\partial\left(\partial_\nu A_\mu\right)} + k_2 \frac{\partial L}{\partial\left(\partial_\nu U_\mu\right)} \tag{40}$$

with

$$\partial_\mu \partial_\nu K^{\mu\nu} = 0 \tag{41}$$

Notice that symmetries III and IV work similarly. Only eqs. (33) and eq. (40) are different

Thus, different symmetries are expressed by Noether theorem. The Maxwell principle of electric charge conservation is preserved, however, introducing diverse possibilities for deriving electric charge properties. The EM symmetry allows to introduce different electric charge behaviours under its conservation law.

4 Electromagnetic fields

Originated from the fundamental quadruplet $\{A_\mu, U_\mu, V_\mu^{\pm}\}$ diverse fields strengths are constituted. They are under constraints according to their corresponding symmetries.

4.1 Symmetry I

This case was already studied in [20]. It shows that although the model is gauge invariant under the Lagrangian, individually each field strength is not necessarily. The physicality depend on conditions imposed by free coefficients. For instance, the collective antisymmetric tensor $\mathbf{e}_{[\mu\nu]}^{[12]}$ is gauge invariant under constraints depending on adjusting the theory free coefficients [19-20].

4.2 Symmetry II

It is the most physical case. The corresponding fields strengths are directly gauge invariants. For granular antisymmetric fields strengths, one gets:

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu, \quad F'_{\mu\nu} = F_{\mu\nu} \tag{42}$$

$$U_{\mu\nu} = \partial_\mu U_\nu - \partial_\nu U_\mu, \quad U'_{\mu\nu} = U_{\mu\nu} \tag{43}$$

$$V_{\mu\nu}^{\pm} = D_\mu V_\nu^{\pm} - D_\nu V_\mu^{\pm}, \quad V_{\mu\nu}^{\pm\prime} = e^{\pm iq\alpha} V_{\mu\nu}^{\pm} \tag{44}$$

with the covariant derivative

$$D_\mu = \partial_\mu + i\left(q_1 A_\mu + q_2 U_\mu\right) \tag{45}$$

where q_1 and q_2 are modulated electric charge given by $q_1 = a \cdot q; \& q_2 = b \cdot q$, where $ak_1 + bk_2 = -1$.

For antisymmetric collective fields:

$$\mathbf{e}_{[\mu\nu]}^{[12]} = \frac{1}{2}\mathbf{e}_{[12]}\left(A_\mu U_\mu - U_\mu A_\mu\right) \tag{46}$$

$$\mathbf{e}_{[\mu\nu]}^{[+-]} = i\mathbf{e}_{[34]}\left(V_\mu^+ V_\nu^- - V_\mu^- V_\nu^+\right) \tag{47}$$

where each of them is invariant under $U(1)$ and $SO(2)$, respectivaly. The free coefficients $\mathbf{e}_{ij}$ associated to collective fields are defined in [21].

The terms below

$$\mathbf{e}_{[\mu\nu]}^{[12+]} = \frac{1}{2}\mathbf{e}_{[12]}\left[\left(A_\mu - U_\mu\right)V_\nu^+ + \left(A_\nu - U_\nu\right)V_\mu^+\right] \tag{48}$$

$$\mathbf{e}_{[\mu\nu]}^{[12-]} = \frac{1}{2}\mathbf{e}_{[12]}\left[\left(A_\mu - U_\mu\right)V_\nu^- + \left(A_\nu - U_\nu\right)V_\mu^-\right] \tag{49}$$

are covariant

$$\mathbf{e}_{[\mu\nu]}^{[12+]'} = e^{iq\alpha(x)}\mathbf{e}_{[\mu\nu]}^{[12+]} \tag{50}$$

$$\mathbf{e}^{[12-]'} = e^{-iq\alpha(x)}\mathbf{e}_{[\mu\nu]}^{[12-]} \tag{51}$$

For the symmetric sector:

$$S_{\mu\nu 1} = \partial_\mu A_\nu + \partial_\nu A_\mu, \tag{52}$$

$$S_{\mu\nu 2} = \partial_\mu U_\nu + \partial_\nu U_\mu. \tag{53}$$

the invariance is under the condition

$$S_{\mu\nu}^{1'} + S_{\mu\nu}^{2'} = S_{\mu\nu}^{1} + S_{\mu\nu}^{2} \tag{54}$$

Charged fields are transforming as

$$S_{\mu\nu}^{\pm} = D_\mu V_\nu^{\pm} + D_\nu V_\mu^{\pm}, \quad S_{\mu\nu}^{\pm'} = e^{\pm iq\alpha}S_{\mu\nu}^{\pm} \tag{55}$$

and

$$S_{\alpha 1}^{\alpha} = 2\partial_\alpha A^\alpha, \tag{56}$$

$$S_{\alpha 2}^{\alpha} = \partial_\alpha U^\alpha. \tag{57}$$

with

$$S_\alpha^{\alpha 1'} + S_\alpha^{\alpha 2'} = S_\alpha^{\alpha 1} + S_\alpha^{\alpha 2} \tag{58}$$

Longitudinal terms are written as

$$S_\alpha^{\alpha\pm} = D_\alpha V^{\alpha\pm}, \quad S_\alpha^{\alpha\pm'} = e^{\pm iq\alpha}S_\alpha^{\alpha\pm} \tag{59}$$

The collective symmetric fields strengths are invariant as

$$\begin{aligned}\mathbf{e}_{(\mu\nu)} &= \mathbf{e}_{(11)}A_\mu A^\nu + \mathbf{e}_{(12)}\left(A_\mu U_\nu + U_\mu A_\nu\right) + \mathbf{e}_{(22)}U_\mu U_\nu = \mathbf{e}'_{(\mu\nu)}\\ \mathbf{e}_{(\mu\nu)}^{(+-)} &= \mathbf{e}_{(34)}V_\mu^+ V_\nu^- = \mathbf{e}_{(\mu\nu)}^{(+-)'}\end{aligned} \tag{60}$$

and

$$\mathbf{e}_\alpha^\alpha = \mathbf{e}_{(11)}A_\alpha A^\alpha + 2\mathbf{e}_{(12)}A_\alpha U^\alpha + \mathbf{e}_{(22)}U_\alpha U^\alpha = \mathbf{e}_\alpha^{\alpha'} \tag{61}$$

$$\mathbf{e}_\alpha^{(+-)\alpha} = \mathbf{e}_{(34)}V_\alpha^+ V^{-\alpha} = \mathbf{e}_\alpha^{(+-)\alpha'} \tag{62}$$

The collective fields strengths below

$$\mathbf{e}_{(\mu\nu)}^{(12+)} = \left[\mathbf{e}_{(11)}A_\mu + \mathbf{e}_{(12)}\left(A_\mu + U_\mu\right) + \mathbf{e}_{(22)}U_\mu\right]V_\nu^+ \tag{63}$$

$$\mathbf{e}_{(\mu\nu)}^{(12-)} = \left[\mathbf{e}_{(11)}A_\mu + \mathbf{e}_{(12)}\left(A_\mu + U_\mu\right) + \mathbf{e}_{(22)}U_\mu\right]V_\nu^- \tag{64}$$

$$\mathbf{e}_{(\mu\nu)}^{(++)} = \frac{1}{2}\left(\mathbf{e}_{(33)} - \mathbf{e}_{(44)}\right)V_\mu^+ V_\nu^+ \tag{65}$$

$$\mathbf{e}_{(\mu\nu)}^{(--)} = \frac{1}{2}\left(\mathbf{e}_{(33)} - \mathbf{e}_{(44)}\right)V_\mu^- V_\nu^- \tag{66}$$

are transforming as

$$\mathbf{e}_{(\mu\nu)}^{(12+)'} = e^{iq\alpha(x)}\mathbf{e}_{(\mu\nu)}^{(12+)} \tag{67}$$
$$\mathbf{e}_{(\mu\nu)}^{(12-)'} = e^{-iq\alpha}\mathbf{e}_{(\mu\nu)}^{(12-)} \tag{68}$$
$$\mathbf{e}_{(\mu\nu)}^{(++)'} = e^{2iq\alpha(x)}\mathbf{e}_{(\mu\nu)}^{(++)'} \tag{69}$$
$$\mathbf{e}_{(\mu\nu)}^{(--)'} = e^{-2iq\alpha(x)}\mathbf{e}_{(\mu\nu)}^{(--)'} \tag{70}$$

Similarly,

$$\mathbf{e}_{\alpha}^{(12+)\alpha} = \left[\mathbf{e}_{(11)}A_\alpha + \mathbf{e}_{(12)}\left(A_\alpha + U_\alpha\right) + \mathbf{e}_{(22)}U_\alpha\right]V^{+\alpha} \tag{71}$$
$$\mathbf{e}_{\alpha}^{(12-)\alpha} = \left[\mathbf{e}_{(11)}A_\alpha + \mathbf{e}_{(12)}\left(A_\alpha + U_\alpha\right) + \mathbf{e}_{(22)}U_\alpha\right]V^{-\alpha} \tag{72}$$
$$\mathbf{e}_{\alpha}^{(++)\alpha} = \frac{1}{2}\left(\mathbf{e}_{(33)} - \mathbf{e}_{(44)}\right)V_\alpha^{+}V^{\alpha+} \tag{73}$$
$$\mathbf{e}_{\alpha}^{(--)\alpha} = \frac{1}{2}\left(\mathbf{e}_{(33)} - \mathbf{e}_{(44)}\right)V_\alpha^{-}V^{\alpha-} \tag{74}$$

$$\mathbf{e}_{\alpha}^{(12+)\alpha} = e^{iq_2\alpha(x)}\mathbf{e}_{\alpha}^{(12+)\alpha} \tag{75}$$
$$\mathbf{e}_{\alpha}^{(12-)\alpha} = e^{-iq_2\alpha(x)}\mathbf{e}_{\alpha}^{(12-)\alpha} \tag{76}$$
$$\mathbf{e}_{\alpha}^{(++)\alpha} = e^{2iq_2\alpha(x)}\mathbf{e}_{\alpha}^{(++)\alpha} \tag{77}$$
$$\mathbf{e}_{\alpha}^{(--)\alpha} = e^{-2iq_2\alpha}\mathbf{e}_{\alpha}^{(--)\alpha} \tag{78}$$

Although the gauge covariant terms are not directly measurable they will contribute to the Lagrangian.

4.3 Symmetry III

This case is similar to type I, where we have invariants fields strengths under conditions. For example, the collective field $\mathbf{e}_{[\mu\nu]}^{[12]}$ is gauge invariant under the free parameters conditions.

4.4 Symmetry IV

This case is similar to type II where the same tensors are formed, but, under SO(2) the transformation

$$\mathbf{e}_{[\mu\nu]}^{[12+]'} = e^{iq\beta(x)}\mathbf{e}_{[\mu\nu]}^{[12+]} \tag{79}$$
$$\mathbf{e}^{[12-]'} = e^{-iq\beta(x)}\mathbf{e}_{[\mu\nu]}^{[12-]} \tag{80}$$

It replies the format of the model II.

5 Common Lagrangian

The electromagnetic symmetry proposes different manifestations as in section 4 and Appendix A. The physical background is that these diverse electromagnetic symmetries converge to a common Lagrangian under different parameters. It gives,

$$L = L_A + L_S + L_M \tag{81}$$

where the antisymmetric sector is

$$L_K^A = a_1 F_{\mu\nu} F^{\mu\nu} + U_{\mu\nu} U^{\mu\nu} + a_3 V_{\mu\nu} V^{\mu\nu}, \tag{82}$$

$$L_3^A = (a_1 F_{\mu\nu} + a_2 U_{\mu\nu}) \left(\mathbf{e}^{[12][\mu\nu]} + \mathbf{e}^{[+-][\mu\nu]} \right) + \\ + a_3 V_{\mu\nu}^{+} \mathbf{e}^{[12-][\mu\nu]} + a_3 V_{\mu\nu}^{-} \mathbf{e}^{[12+][\mu\nu]}, \tag{83}$$

$$L_4^A = \left(\mathbf{e}_{[\mu\nu]}^{[12]} + \mathbf{e}_{[\mu\nu]}^{[+-]} \right)^2 + \mathbf{e}^{[12+][\mu\nu]} \mathbf{e}^{[12-][\mu\nu]}, \tag{84}$$

The symmetric sector

$$L_K^S = (S_{\mu\nu 1} + S_{\mu\nu 2} + g_{\mu\nu} S_{\alpha 1}^{\alpha} + g_{\mu\nu} S_{\alpha 2}^{\alpha})^2 + \beta_3 S_{\mu\nu} S_{\mu\nu}^{+} S^{\mu\nu -} \\ 4\rho_3 S_{\alpha}^{\alpha +} S_{\beta}^{\beta -} + \beta_+ \rho_- S_{\alpha}^{\alpha +} S_{\beta}^{\beta -} + \beta_- \rho_+ S_{\alpha}^{\alpha -} S_{\beta}^{\beta +}, \tag{85}$$

$$L_3^S = (S_{\mu\nu 1} + S_{\mu\nu 2} + g_{\mu\nu} S_{\alpha 1}^{\alpha} + g_{\mu\nu} S_{\alpha 2}^{\alpha}) \, (\mathbf{e}^{(11)(\mu\nu)} + \mathbf{e}_{(\mu\nu)}^{(12)} + \\ \mathbf{e}^{(22)(\mu\nu)} + \mathbf{e}^{(+-)(\mu\nu)} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(11)\alpha} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(12)\alpha} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(22)\alpha} \\ + g^{\mu\nu} \mathbf{e}_{\alpha}^{(+-)\alpha}) + (\beta_+ S_{\mu\nu}^{+} + \rho_+ g_{\mu\nu} S_{\alpha}^{\alpha +})(\mathbf{e}^{(12-)(\mu\nu)} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(12-)\alpha}) \\ + (\beta_- S_{\mu\nu}^{-} + \rho_- g_{\mu\nu} S_{\alpha}^{\alpha -})(\mathbf{e}^{(12+)(\mu\nu)} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(12+)\alpha}), \tag{86}$$

$$L_4^S = (\mathbf{e}^{(11)(\mu\nu)} + \mathbf{e}_{(\mu\nu)}^{(12)} + \mathbf{e}^{(22)(\mu\nu)} + \mathbf{e}^{(+-)(\mu\nu)} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(11)\alpha} \\ + g^{\mu\nu} \mathbf{e}_{\alpha}^{(12)\alpha} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(22)\alpha} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(+-)\alpha})^2 + (\mathbf{e}^{(12-)(\mu\nu)} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(12-)\alpha}) \\ (\mathbf{e}^{(12+)(\mu\nu)} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(12+)\alpha}) + (\mathbf{e}_{(\mu\nu)}^{(++)} + g_{\mu\nu} \mathbf{e}_{\alpha}^{(++)\alpha})(\mathbf{e}^{(--)(\mu\nu)} + g^{\mu\nu} \mathbf{e}_{\alpha}^{(--)\alpha}). \tag{87}$$

Mass sector

$$L_M = \mathbf{m}_U^2 U_\mu U^\mu + \mathbf{m}_V^2 V_\mu^{+} V^{\mu -} \tag{88}$$

The above Lagrangian underneath four local and global symmetries. It is composed by various gauge invariants sectors under different coefficients. It contains a nonlinearity that, diversely to usual Yang-Mills, trilinear and quadrilinear antisymmetric and symmetric terms are independently gauge invariants. Under symmetry II view, the Lagrangian invariance is expressed more directly in terms of fields strengths.

6 Physical Choice: Symmetry II

Although sharing a common Lagrangian, these symmetries develop differents physicalities. Noether equations, fields strengths gauge invariances, equations of motions, fields charges are expressing their differences. Symmetry I based on Lagrangian invariance was already considered at previous papers [19-21]. Supported on the fields strengths measurability, we are going to privilege the symmetry II. Symmetries III, IV are just complementarities. Symmetry II is the simplest case to be explored.

6.1 Noether II

Noether differentiate the electric charge behaviour for spin-1 and spin-0 sectors [21]. For spin-1 fields, the corresponding Noether equation related to symmertry II is

$$\partial_\nu K_T^{\nu\mu} + J_{NT}^\mu = 0 \tag{89}$$

with

$$K_T^{\mu\nu} = k_1[4a_1F^{\nu\mu} + 2a_2(\mathbf{e}^{[12][\mu\nu]} + \mathbf{e}^{[+-][\mu\nu]})k_2[4u_1U^{\mu\nu} + 2u_2(\mathbf{e}^{[12][\mu\nu]} + \mathbf{e}^{[+-][\mu\nu]})] \tag{90}$$

and the transversal conserved electric charge current

$$J_{NT}^\mu \equiv iq\{V_\nu^+[v_1V^{\mu\nu-} + v_2\mathbf{e}^{[12-][\mu\nu]}] - V_\nu^-[v_1V^{\mu\nu+} + v_2\mathbf{e}^{[12+][\mu\nu]}]\} \tag{91}$$

Eq. (91) includes the presence of neutral fields at electric charge current.

For the longitudinal sector

$$\partial^\mu K_{\alpha L}^\alpha + J_{NL}^\mu = 0 \tag{92}$$

with

$$K_{\alpha L}^\alpha \equiv k_1[s_1S_\alpha^{\alpha 1} + c_1\mathbf{e}_\alpha^\alpha] + k_2[s_2S_\alpha^\alpha + c_2\mathbf{e}_\alpha^\alpha] \tag{93}$$

and the corresponding longitudinal electric charge current

$$\begin{aligned} J_{NL}^\mu \equiv\ & iq\{V_\nu^+[2\beta_3S^{\mu\nu-} + 2\beta_+\mathbf{e}^{(12-)(\mu\nu)} + \\ & (8\rho_3 + 4\beta_3\rho_3 + 4\beta_4\rho_4)\, g^{\mu\nu}S_\alpha^{\alpha-} + 2\,(\beta_+ + 5\rho_+)\, g^{\mu\nu}\mathbf{e}_\alpha^{(12-)\alpha}] + \\ & -V_\nu^-[\beta_3S^{\mu\nu+} + (8\rho_3 + 4\beta_3\rho_3 + \beta_4\rho_4)\, g^{\mu\nu}S_\alpha^{\alpha+} + \\ & +2\beta_-\mathbf{e}^{(12+)(\mu\nu)} + 2\,(\beta_- + 5\rho_-)\, g^{\mu\nu}\mathbf{e}_\alpha^{(12+)\alpha}]\} \end{aligned} \tag{94}$$

Diversely from Maxwell eqs. (89) and (92) are showing that theory embeds two different electric charges according to spin sector. Each one with densities and currents depending on different fields. However, while the transverse current is conserved, the longitudinal acts just as a source.

6.2 Constitutive Equations of Motion II

The quadruplet $\{A_\mu, U_\mu, V_\mu^\pm\}$ interrelations express constitutive equations of motion. They are composed by the Euler-Lagrange equations, algebric identities and Noether relationships. For case II, we will study the corresponding constitutive equations of motion for each field in the quadruplet.

For A_T^μ constitutive:

$$\partial_\nu \left\{4a_1F^{\nu\mu} + a_2\left(\mathbf{e}^{[12][\nu\mu]} + \mathbf{e}^{[+-][\nu\mu]}\right)\right\} = 2a_3\mathbf{m}_U^2U^\mu + J_{AT}^\mu \tag{95}$$

The Maxwell photon equation is enlarged. At LHS the usual Maxwell EM fields are complemented by collective fields corresponding to polarization and magnetization fields. The RHS source includes the massive photon and the following abelian currents

$$J^{\mu}_{AT} \equiv j^{\mu}_{AT} + a_3 j^{\mu}_{UT} + j^{\mu}_{NT} \tag{96}$$

where j^{μ}_{AT} is the source of the Euler-Lagrange equation for A_{μ}, given by

$$\begin{aligned} j^{\mu}_{AT} \equiv \mathbf{e}_{[12]}[(a_1 F^{\mu\nu} + u_1 U^{\mu\nu})\, U_{\nu} + 2\left(V^{\mu\nu+}V^{-}_{\nu} + V^{\mu\nu-}V^{+}_{\nu}\right) \\ 4\left(\mathbf{e}^{[12][\mu\nu]} + \mathbf{e}^{[+-][\mu\nu]}\right) U_{\nu} + \left(\mathbf{e}^{[12-][\mu\nu]}V^{+}_{\nu} + \mathbf{e}^{[12+][\mu\nu]}V^{-}_{\nu}\right)] \\ 2iq_1\left(\partial^{\mu}V^{+}_{\nu}V^{\nu-} - \partial_{\nu}V^{\mu+}V^{\nu-} + \partial^{\mu}V^{\nu-}V^{+}_{\nu} - \partial_{\nu}V^{\mu-}V^{\nu+}\right) \\ -2q_1q_2(V^{+}_{\nu}V^{\nu-}U^{\mu} - V^{\mu-}V_{\nu+}U^{\nu}) - q_1^2(2V^{+}_{\nu}V^{\nu-}A^{\mu} \\ -V^{+}_{\nu}A^{\nu}V^{\mu-} - V^{-}_{\nu}A^{\nu}V^{\mu+}), \end{aligned} \tag{97}$$

j^{μ}_{UT} the source of the Euler-Lagrange equation for U_{μ}, given by

$$\begin{aligned} j^{\mu}_{UT} \equiv \mathbf{e}_{[12]}[(a_1 F^{\mu\nu} + u_1 U^{\mu\nu})\, A_{\nu} + 2\left(V^{\mu\nu+}V^{-}_{\nu} + V^{\mu\nu-}V^{+}_{\nu}\right) \\ 4\left(\mathbf{e}^{[12][\mu\nu]} + \mathbf{e}^{[+-][\mu\nu]}\right) A_{\nu} + \left(\mathbf{e}^{[12-][\mu\nu]}V^{+}_{\nu} + \mathbf{e}^{[12+][\mu\nu]}V^{-}_{\nu}\right)] \\ 2iq_2(\partial^{\mu}V^{+}_{\nu}V^{\nu-} - \partial_{\nu}V^{\mu+}V^{\nu-} + \partial^{\mu}V^{\nu-}V^{+}_{\nu} - \partial_{\nu}V^{\mu-}V^{\nu+}) \\ -2q_1q_2(V^{+}_{\nu}V^{\nu-}A^{\mu} - V^{\mu-}V_{\nu+}A^{\nu}) - q_2^2(2V^{+}_{\nu}V^{\nu-}U^{\mu} \\ -V^{+}_{\nu}U^{\nu}V^{\mu-} - V^{-}_{\nu}U^{\nu}V^{\mu+}), \end{aligned} \tag{98}$$

and j^{μ}_{NT} at eq. (91).

Eq. (95) is consistent with the three conservation laws,

$$\partial_{\mu} j^{\mu}_{NT} = 0 \tag{99}$$

$$\partial_{\mu} j^{\mu}_{AT} = 0 \tag{100}$$

$$\partial_{\mu}(j^{\mu}_{UT} + 2\mathbf{m}^2_{U}U^{\mu}) = 0 \tag{101}$$

A photon dynamics with a step forward to Maxwell and electric charge is expressed. The photon is no more passive but generating its own EM fields. Differently from Maxwell the above equations are including three types of charges at the photon equation. Besides the electric conservation, the photon constitutive dynamics provides two other charges. The modulated and neutral charges. These three types of charge is that are joining the quadruplet and not only the electric charge.

Thus, the photon field contains three kinds of charges derived from the electromagnetic symmetry. Spliting in terms of modulate and neutral charges, one gets

$$\partial_{\mu}\left(j^{\mu}_{AT} + j^{\mu}_{UT}\right) \quad = \partial_{\mu} J^{\mu}_{neutT} + \partial_{\mu} j^{\mu}_{modT} = 0 \tag{102}$$

where the neutral current is given by

$$\begin{aligned} j^{\mu}_{neutT} &= \mathbf{e}_{[12]}\left(a_1 F^{\mu\nu} + u_1 U^{\mu\nu}\right)\left(U_{\nu} + a_3 A_{\nu}\right) + \\ & 2(1+a_3)[(\partial^{\mu}V^{\nu+} - \partial^{\nu}V^{\mu+})V^{-}_{\nu} + (\partial^{\mu}V^{\nu-} - \partial^{\nu}V\mu-)V^{\mu+}] \\ & +4\mathbf{e}_{[12]}(\mathbf{e}^{[12][\mu\nu]} + \mathbf{e}^{[+-][\mu\nu]})\left(U_{\nu} + a_3 A_{\nu}\right) \\ & +2(1+a_3)\mathbf{e}_{[12]}(\mathbf{e}^{[12-][\mu\nu]}V^{+}_{\nu} + \mathbf{e}^{[12+][\mu\nu]}V^{-}_{\nu}) \end{aligned} \tag{103}$$

Eq. (103) shows a neutral current. It contains relationships between photon-photon and photon-Z^0 which are not included in the Standard Model. Also the presence of charged fields under a chargeless coupling constant.

The electric charge modulated current is given by

$$\begin{aligned} & j_{modT} \equiv 2(1+a_3)[q_1(A^{\mu}V^{\nu+} - \partial^{\nu}V\mu+)V^{-}_{\nu} + q_2(U^{\mu}V^{\nu-} - U^{\nu}V\mu-)V^{\mu+}] \\ & -2q_1q_2(V^{+}_{\nu}V^{\nu-}U^{\mu} - V^{\mu-}V_{\nu+}U^{\nu} + a_3V^{+}_{\nu}V^{\nu-}A^{\mu} - V^{\mu-}V_{\nu+}A^{\nu}) \\ & -q_1^2(2V^{+}_{\nu}V^{\nu-}A^{\mu} - V^{+}_{\nu}A^{\nu}V^{\mu-} - V^{-}_{\nu}A^{\nu}V^{\mu+}) \\ & -a_3q_2^2(2V^{+}_{\nu}V^{\nu-}U^{\mu} - V^{+}_{\nu}U^{\nu}V^{\mu-} - V^{-}_{\nu}U^{\nu}V^{\mu+}) \end{aligned} \tag{104}$$

A relationship allowing to incorporate the couplings between $W^{+}W^{-}\gamma$ and $W^{+}W^{-}Z^{0}$ with modulated electric charge similar to the electroweak. However, eqs (103) and (104) are not conserved isolatedly.

For U^{μ}_{T}:

$$\partial_{\nu}\left\{4u_1U^{\nu\mu} + u_2\left(\mathbf{e}^{[12][\nu\mu]} + \mathbf{e}^{[+-][\nu\mu]}\right)\right\} - 2\mathbf{m}^2_U U^{\mu} = J^{\mu}_{UT} \tag{105}$$

where

$$J^{\mu}_{UT} \equiv j^{\mu}_{U} + u_3 j^{\mu}_{AT} + J^{\mu}_{NT} \tag{106}$$

The corresponding neutral and charged current are

$$\begin{aligned} j^{\mu}_{neutT} &= \mathbf{e}_{[12]}[\left(a_1F^{\mu\nu} + u_1U^{\mu\nu}\right)\left(A_{\nu} + u_3U_{\nu}\right) + \\ & 2(1+u_3)[(\partial^{\mu}V^{\nu+} - \partial^{\nu}V\mu+)V^{-}_{\nu} + (\partial^{\mu}V^{\nu-} - \partial^{\nu}V\mu-)V^{\mu+}] \\ & +4(\mathbf{e}^{[12][\mu\nu]} + \mathbf{e}^{[+-][\mu\nu]})(A_{\nu} + u_3U_{\nu}) \\ & +2(1+u_3)(\mathbf{e}^{[12-][\mu\nu]}V^{+}_{\nu} + \mathbf{e}^{[12+][\mu\nu]}V^{-}_{\nu})] \end{aligned} \tag{107}$$

and

$$\begin{aligned} & j_{modT} \equiv 2(1+u_3)[q_1(A^{\mu}V^{\nu+} - \partial^{\nu}V^{\mu+})V^{-}_{\nu} + q_2(U^{\mu}V^{\nu-} - U^{\nu}V^{\mu-})V^{\mu+}] \\ & -2q_1q_2(V^{+}_{\nu}V^{\nu-}A^{\mu} - V^{\mu-}V_{\nu+}A^{\nu} + u_3V^{+}_{\nu}V^{\nu-}U^{\mu} - u_3V^{\mu-}V_{\nu+}U^{\nu}) \\ & -u_3q_2^2(2V^{+}_{\nu}V^{\nu-}U^{\mu} - V^{+}_{\nu}U^{\nu}V^{\mu-} - V^{-}_{\nu}U^{\nu}V^{\mu+}) \\ & -q_1^2(2V^{+}_{\nu}V^{\nu-}A^{\mu} - V^{+}_{\nu}A^{\nu}V^{\mu-} - V^{-}_{\nu}A^{\nu}V^{\mu+}) \end{aligned}$$

For $V^{\mu\pm}_{T}$:

$$\partial_{\mu}\{2\left(v_1 + \beta_3\right)V^{\nu\mu\pm} + 2v_2\mathbf{e}^{[12\pm][\nu\mu]}\} - \mathbf{m}^2_V V^{\mu\pm} = J^{\mu\pm}_{VT}$$

one gets,

$$\begin{aligned}
&J_T^{\mu\pm} \equiv 2v_1 V^{\mu\nu\pm}(A_\nu + U_\nu) - q_1^2\left(V^{\mu\pm}A_\nu A^\nu - V_\nu^\pm A_\nu A^\mu\right) - q_2^2\left(V^{\mu\pm}U_\nu U^\nu - V_\nu^\pm U_\nu U^\mu\right)\\
&-i[4\mathbf{e}_{[34]}\left(\mathbf{e}^{[+-][\mu\nu]} + \mathbf{e}^{[+-][\mu\nu]}\right)V_\nu^\pm + 2q_1\left(\partial_\nu V^{\mu\pm}A^\nu + \partial^\mu V^{\nu\pm}A_\nu\right)\\
&2q_2\left(\partial_\nu V^{\mu\pm}U^\nu - \partial^\mu V^{\nu\pm}U_\nu\right)]\}
\end{aligned} \tag{108}$$

Charged photons have only neutral and modulated currents. The neutral current is

$$j_{neutT}^{\mu\pm} \equiv 2v_1\left(\partial^\mu V^{\nu\pm} - \partial^\nu V^{\mu\pm}\right)(A_\nu + U_\nu) - i4\mathbf{e}_{[34]}\mathbf{e}^{[12\mp][\mu\nu]}V_\nu^\pm \tag{109}$$

and the modulate

$$\begin{aligned}
&j_{modT}^{\mu\pm} \equiv [q_1\left(A^\mu V^{\nu\pm} - A^\nu V^{\mu\pm}\right) + q_2\left(U^\mu V^{\nu\pm} - U^\nu V^{\mu\pm}\right)](A_\nu + U_\nu)\\
&-2iq_1\left(\partial_\nu V^{\mu\pm}A^\nu + \partial^\mu V^{\nu\pm}A_\nu\right) - i2q_2\left(\partial_\nu V^{\mu\pm}U^\nu - \partial^\mu V^{\nu\pm}U_\nu\right) +\\
&+q_1^2\left(V^{\mu\pm}A_\nu A^\nu - V_\nu^\pm A_\nu A^\mu\right) - q_2^2\left(V^{\mu\pm}U_\nu U^\nu - V_\nu^\pm U_\nu U^\mu\right)
\end{aligned} \tag{110}$$

A comparision with the $U_{em}(1)$ Standard Model symmetry is propitious. The symmetry II quadruplet unification reproduces the EW relationships and produce more plenitude for the spin-1. It shows that the above equations include more terms between the four fields.

Longitudinal sector:

For A_L^μ constitutive:

$$\partial^\mu\left\{s_1 S_\alpha^{\alpha 1} + c_1\mathbf{e}_\alpha^\alpha\right\} = 2t_1\mathbf{m}_U^2 U^\mu + j_{AL}^\mu + t_1 j_{UL}^\mu - (t_1+1)j_{NL}^\mu \tag{111}$$

where, j_{AL}^μ and j_{UL}^μ are sources of the Euler-Lagrange equations. The current j_{AL}^μ it is given by

$$\begin{aligned}
&j_{AL}^\mu \equiv 2\left(\beta_1 S^{\mu\nu 1} + \beta_2 S^{\mu\nu 2} + \rho_1 g^{\mu\nu} + \rho_2 g^{\mu\nu}S_\alpha^{\alpha 2}\right)\left(\mathbf{e}_{(11)}A_\nu + \mathbf{e}_{(12)}U_\nu\right) +\\
&+2[(\beta_1 + 4\rho_1)S_\alpha^{\alpha 1} + (\beta_2 + 4\rho_2)S_\alpha^{\alpha 2}]\left(\mathbf{e}_{(12)}A^\mu + \mathbf{e}_{(12)}U^\mu\right)\\
&\left(\mathbf{e}_{(11)} + \mathbf{e}_{(12)}\right)[\left(\beta_+ S^{\mu\nu +} + \rho_+ g^{\mu\nu}S_\alpha^{\alpha +}\right)V_\nu^- + \left(\beta_- S^{\mu\nu -} + \rho_- g^{\mu\nu}S_\alpha^{\alpha -}\right)V_\nu^+\\
&\left(4\mathbf{e}_{(11)}\mathbf{e}_{(11)(\mu\nu)} + 2\mathbf{e}_{(12)}\mathbf{e}^{(12)(\mu\nu)} + 2\mathbf{e}_{(11)}\mathbf{e}(22)(\mu\nu) + 2\mathbf{e}_{(11)}\mathbf{e}^{(22)(\mu\nu)}\right)A_\nu\\
&\left(16\mathbf{e}_{(11)}\mathbf{e}_\alpha^{(11)\alpha} + 8\mathbf{e}_{12}\mathbf{e}_\alpha^{(12)\alpha} + 16\mathbf{e}_\alpha^{(12)\alpha} + 16\mathbf{e}_{(11)}\mathbf{e}_\alpha^{(22)\alpha} + 16\mathbf{e}_\alpha^{(+-)\alpha}\right)A^\mu\\
&\left(2\mathbf{e}_{(12)}\mathbf{e}^{(12)(\mu\nu)} + 2\mathbf{e}_{(12)} + 4\mathbf{e}_{(12)}\mathbf{e}^{(11)(\mu\nu)} + 2\mathbf{e}_{(12)}\mathbf{e}^{(22)(\mu\nu)} + 2\mathbf{e}_{(12)}\mathbf{e}^{(+-)(\mu\nu)}\right)U_\nu\\
&\left(2\mathbf{e}_{(12)}\mathbf{e}_\alpha^{(12)\alpha} + 2\mathbf{e}_{(12)} + 4\mathbf{e}_{(12)}\mathbf{e}_\alpha^{(11)\alpha} + 2\mathbf{e}_{(12)}\mathbf{e}_\alpha^{(22)\alpha} + 2\mathbf{e}_{(12)}\mathbf{e}_\alpha^{(+-)\alpha}\right)U^\mu\\
&+2\left(\mathbf{e}_{(11)} + \mathbf{e}_{(12)}\right)\left(\mathbf{e}^{(12+)(\mu\nu)}V_\nu^- + \mathbf{e}^{(12-)(\mu\nu)}V_\nu^+\right)\\
&+12\left(\mathbf{e}_{(11)} + \mathbf{e}_{(12)}\right)\left(\mathbf{e}_\alpha^{(12+)\alpha}V^{\mu -} + \mathbf{e}_\alpha^{(12-)\alpha}V^{\mu +}\right) +\\
&iq_1(\partial^\mu V_\nu^+ V^{\nu -} + \partial^\mu V^{\mu +}V^{\nu -} + \partial_\nu V^{\mu +}V^{\nu -} + \partial_\nu V^{\mu -}V^{\nu +} + \partial_\alpha V^{\alpha +}V^{\mu -}\\
&+\partial_\alpha V^{\alpha -}V^{\mu +}) - q_1 q_2(2V_\nu^+ V^{\nu -}U^\mu + V_\nu^+ V^{\mu -}U^\nu + U_\nu V^{\nu -}V^{\mu +}
\end{aligned}$$

$$
\begin{aligned}
&+U\nu V^{\nu-}V^{\mu+}+U\nu V^{\nu+}V^{\mu-})-q_1^2[2\left(V_\nu^+V^{\nu-}A^\mu+V^{\mu-}V_\nu^+A^\nu\right)]\\
&A_\alpha V^{\alpha+}V^{\mu-}]+-\beta_1\{\mathbf{e}_{(11)}(S_\alpha^{\alpha1}A^\mu+2S^{\nu\mu1}A_\nu)+\mathbf{e}_{(22)}S_\alpha^{\alpha2}U^\mu+2S^{\mu\nu2}U_\nu)\\
&\mathbf{e}_{(12)}(S_{\alpha1}^\alpha U^\mu+S_{\alpha2}^\alpha A^\mu+2S^{\nu\mu1}U_\nu)+2S^{\nu\mu2}U_\nu)]+\mathbf{e}_{(34)}(S_\alpha^{\alpha+}V^{\mu+}\\
&+S_\alpha^{\alpha-}V^{\mu+}+S^{\mu\nu+}V_\nu^-S^{\mu\nu-}V_\nu^+)\}
\end{aligned}
\tag{112}
$$

The current j_{UL}^μ is

$$
\begin{aligned}
&j_{UL}^\mu\equiv2\left(\beta_1S^{\mu\nu1}+\beta_2S^{\mu\nu2}+\rho_1g^{\mu\nu}+\rho_2g^{\mu\nu}S_\alpha^{\alpha2}\right)\left(\mathbf{e}_{(22)}U_\nu+\mathbf{e}_{(12)}A_\nu\right)+\\
&+2[\left(\beta_1+4\rho_1\right)S_\alpha^{\alpha1}+\left(\beta_2+4\rho_2\right)S_\alpha^{\alpha2}]\left(\mathbf{e}_{(22)}U^\mu+\mathbf{e}_{(12)}A^\mu\right)\\
&\left(\mathbf{e}_{(22)}+\mathbf{e}_{(12)}\right)[\left(\beta_+S^{\mu\nu+}+\rho_+g^{\mu\nu}S_\alpha^{\alpha+}\right)V_\nu^-+\left(\beta_-S^{\mu\nu-}+\rho_-g^{\mu\nu}S_\alpha^{\alpha-}\right)V_\nu^+\\
&\left(2\mathbf{e}_{(22)}\mathbf{e}_{(11)(\mu\nu)}+2\mathbf{e}_{(12)}\mathbf{e}^{(12)(\mu\nu)}+2\mathbf{e}_{(22)}\mathbf{e}(22)(\mu\nu)+4\mathbf{e}_{(22)}\mathbf{e}^{(22)(\mu\nu)}\right)U_\nu\\
&\left(16\mathbf{e}_{(22)}\mathbf{e}_\alpha^{(11)\alpha}+8\mathbf{e}_{(12)}\mathbf{e}_\alpha^{(12)\alpha}+16\mathbf{e}_{(22)}\mathbf{e}_\alpha^{(12)\alpha}+16\mathbf{e}_{(22)}\mathbf{e}_\alpha^{(22)\alpha}+16\mathbf{e}_{(22)}\mathbf{e}_\alpha^{(+-)\alpha}\right)U^\mu\\
&\left(2\mathbf{e}_{(12)}\mathbf{e}^{(12)(\mu\nu)}+2\mathbf{e}_{(12)}+2\mathbf{e}_{(12)}\mathbf{e}^{(11)(\mu\nu)}+4\mathbf{e}_{(12)}\mathbf{e}^{(22)(\mu\nu)}+2\mathbf{e}_{(12)}\mathbf{e}^{(+-)(\mu\nu)}\right)A_\nu\\
&\left(2\mathbf{e}_{(12)}\mathbf{e}_\alpha^{(12)\alpha}+2\mathbf{e}_{(12)}+2\mathbf{e}_{(12)}\mathbf{e}_\alpha^{(11)\alpha}+4\mathbf{e}_{(12)}\mathbf{e}_\alpha^{(22)\alpha}+2\mathbf{e}_{(12)}\mathbf{e}_\alpha^{(+-)\alpha}\right)A^\mu\\
&+2\left(\mathbf{e}_{(22)}+\mathbf{e}_{(12)}\right)\left(\mathbf{e}^{(12+)(\mu\nu)}V_\nu^-+\mathbf{e}^{(12-)(\mu\nu)}V_\nu^+\right)\\
&+12\left(\mathbf{e}_{(22)}+\mathbf{e}_{(12)}\right)\left(\mathbf{e}_\alpha^{(12+)\alpha}V^{\mu-}+\mathbf{e}_\alpha^{(12-)\alpha}V^{\mu+}\right)+\\
&iq_2(\partial^\mu V_\nu^+V^{\nu-}+\partial^\mu V^{\mu+}V^{\nu-}+\partial_\nu V^{\mu+}V^{\nu-}+\partial_\nu V^{\mu-}V^{\nu+}+\partial_\alpha V^{\alpha+}V^{\mu-}\\
&+\partial_\alpha V^{\alpha-}V^{\mu+})-q_1q_2(2V_\nu^+V^{\nu-}A^\mu+V_\nu^+V^{\mu-}A^\nu+A_\nu V^{\nu-}V^{\mu+}\\
&+A\nu V^{\nu-}V^{\mu+}+A_\nu V^{\nu+}V^{\mu-})-q_2^2[2\left(V_\nu^+V^{\nu-}U^\mu+V^{\mu-}V_\nu^+u^\nu\right)]\\
&U_\alpha V^{\alpha+}V^{\mu-}]+-\beta_2\{\mathbf{e}_{(11)}(S_\alpha^{\alpha1}A^\mu+2S^{\nu\mu1}A_\nu)+\mathbf{e}_{(22)}S_\alpha^{\alpha2}U^\mu+2S^{\mu\nu2}U_\nu)\\
&\mathbf{e}_{(12)}(S_{\alpha1}^\alpha U^\mu+S_{\alpha2}^\alpha A^\mu+2S^{\nu\mu1}U_\nu)+2S^{\nu\mu2}U_\nu)]+\mathbf{e}_{(34)}(S_\alpha^{\alpha+}V^{\mu+}\\
&+S_\alpha^{\alpha-}V^{\mu+}+S^{\mu\nu+}V_\nu^-S^{\mu\nu-}V_\nu^+)\}
\end{aligned}
\tag{113}
$$

Nevertheless the photon longitudinal current is not conserved. It is just inserted in the following equation.

$$\Box[s_1S_{\alpha1}^\alpha+c_1\mathbf{e}_\alpha^\alpha]=\partial\cdot J_{AL} \tag{114}$$

For U_L^μ:

$$\partial^\mu\{s_2S_\alpha^{\alpha2}+c_2\mathbf{e}_\alpha^\alpha\}-\mathbf{m}_U^2U^\mu=j_{UL}^\mu+t_2j_{AL}^\mu-(t_2+1)j_{NL}^\mu \tag{115}$$

For $V_L^{\mu\pm}$:

$$\partial^\mu\{2(\beta_3+2\beta_3\rho_3+2\beta_4\rho_4+4\rho_3)S_\alpha^{\alpha\pm}+(\beta_\pm+5\rho_\pm)\mathbf{e}_\alpha^{(12\pm)\alpha}\}-\mathbf{m}_V^2V^{\mu\pm}=J_{VL}^{\mu\pm} \tag{116}$$

where

$$J_{VL}^{\mu\pm}\equiv2\mathbf{e}_{(34)}\{\left(\beta_1S^{\mu\nu1}+\beta_2S^{\mu\nu2}+\rho_1g^{\mu\nu}S_\alpha^{\alpha1}+\rho_2g^{\mu\nu}S_\alpha^{\alpha2}\right)V_\nu^\pm+$$

$$[(\beta_1+4\rho_1)S_\alpha^{\alpha 1}+(\beta_2+4\rho_2)g^{\mu\nu}S_\alpha^{\alpha 2}]V^{\mu\pm}\}+[\beta_\pm+\rho_\pm g^{\mu\nu}][\mathbf{e}_{(11)}A_\nu$$
$$+\mathbf{e}_{(12)}(A_\nu+U_\nu)+\mathbf{e}_{(22)U_\nu}]+(\beta_\pm+4\rho_\pm)\,S_\alpha^{\alpha\pm}[\mathbf{e}_{(11)}A^\mu+\mathbf{e}_{(12)}(A^\mu+U^\mu)$$
$$+\mathbf{e}_{(22)}U^\mu]+\mathbf{e}_{(34)}(2\mathbf{e}^{(+-)(\mu\nu)}V_\nu^\pm+6\mathbf{e}_\alpha^{(+-)\alpha}V^{\mu\pm})+2\mathbf{e}^{(12\pm)(\mu\nu)}[\mathbf{e}_{(11)}A_\nu$$
$$+\mathbf{e}_{(12)}(A_\nu+U_\nu)+\mathbf{e}_{(22)}U_\nu]+\mathbf{e}_{(34)}[2\mathbf{e}^{(\mp+\mp)(\mu\nu)}V_\nu^\pm+\mathbf{e}_\alpha^{(\mp+\mp)\alpha}V^{\mu\pm}]$$
$$+6\mathbf{e}_\alpha^{(12-)\alpha}[(\mathbf{e}_{(11)}A^\mu+\mathbf{e}_{(12)}(A^\mu+U^\mu)+\mathbf{e}_{(22)}U^\mu]+iq_1(\partial^\nu V^{\mu\pm}A_\nu$$
$$+\partial^\mu V_\nu^\pm A^\nu+\partial_\nu V_{\nu\pm}A^\mu)+iq_2(\partial^\nu V^{\mu\pm}U_\nu+\partial^\mu V_\nu^\pm U^\nu+\partial_\nu V^{\nu\pm}U^\mu)$$
$$-q_1^2(A_\alpha A^\alpha V^{\mu\pm}+2V_\alpha^\pm A^\alpha A^\mu)-q_1q_2(2A_\alpha U^\alpha V^{\mu-}+2A_\alpha V^{\alpha\pm}U^\mu+2U_\alpha V^{\alpha\pm}A^\mu)$$
$$-q_2^2(U_\alpha U^\alpha V^{\mu\pm}+2U_\alpha V^\pm U^\mu)-\beta_\pm\{(\mathbf{e}_{(11)}S_\alpha^{\alpha\pm}A^\mu+S_\alpha^{\alpha 1}V^{\mu\pm}S^{\mu\nu\pm}A_\nu+S^{\mu\nu 1}V_\nu^\pm)\}$$
$$\mathbf{e}_{(12)}\left(S_\alpha^{\alpha\pm}A^\mu+S_\alpha^{\alpha 1}V^{\mu\pm}+S_\alpha^{\alpha\pm}V^{\mu\pm}+S_\alpha^{\alpha\pm}U^\mu+S_\alpha^{\alpha 2}V^{\mu\pm}\right)+\mathbf{e}_{(22)}(S^{\alpha\pm}U^\mu+$$
$$S_\alpha^{\alpha 2}V^{\mu\pm}+S^{\mu\nu}U_\nu+S^{\mu\nu 2}V_\nu^\pm)+\mathbf{e}_{(12)}(S^{\mu\nu\pm}A_\nu+S^{\mu\nu 1}V_\nu^\pm+S^{\mu\nu\pm}U_\nu+S^{\mu\nu 2}V_\nu^\pm)$$
$$(117)$$

Notice that at SM the four bosons unification does not include such longitudinal sector.

The above equation of motion are relating an electromagnetism beyond Maxwell. A quadruplet of messengers particles carrying EM energy is included. The EM completude is expressed. A nonlinearity appears. A dynamics with new granular and collective fields strengths. Potential fields are explicit in the equations. Reflecting the neutral charge presence in the generic charge $\{+,0,-\}$ new classes of neutral currents are proposed. There is a neutral physics beyond $Z^0-neutrino$ interaction discovered at Gargamelle detector in 1973 [22]. EM is more than the polarization between positive and negative charges. New electromagnetic sectors are envisaged. $Z_0-\gamma$ interaction and photonics with selfinteraction photons are included.

7 Constitutive equations II as fields condensates

A fields condensated physics is generated. A microscopic version for these equations is written through London, conglomerates and current terms. It gives,

For A_T^μ:

$$\partial_\nu\left\{4a_1F^{\nu\mu}+a_2\left(\mathbf{e}^{[12][\nu\mu]}+\mathbf{e}^{[+-][\nu\mu]}\right)\right\}+l_{AT}^\mu+c_{AT}^\mu=$$
$$=2a_3\mathbf{m}_U^2U^\mu+J_{AT}^\mu+J_{NT}^\mu \quad (118)$$

where the London terms is written as

$$l_{AT}^\mu=\{4\mathbf{e}_{[12]}U_\nu U^\nu-2a_3(q_2^2+q_1q_2)V_\nu^+V^{\nu-}\}A^\mu+$$
$$\{4a_3\mathbf{e}_{[12]}A_\nu A^\nu-2(q_1q_2+q_1^2)V_\nu^+V^{\nu-}\}U^\mu \quad (119)$$

Eq. (119) derives masses from fields condensations. Terms as $A_\nu A^\nu$, $U_\nu U^\nu$ are numbers with mass dimension but not identified as mass properly due to not be gauge invariant. They work as photon balls. However, the term $V_\nu^+V^{\nu-}$ are definitively mass condensates.

The condensates mixing terms are written as conglomerates

$$c_{AT}^\mu=4\mathbf{e}_{[12]}[A_\nu U^\nu U^\mu+a_3A_\nu U^\nu A^\mu+1/2(1+a_3)(\mathbf{e}^{[12-][\mu\nu]}V_\nu^+$$

$$
\begin{aligned}
&+\mathbf{e}^{[12+][\mu\nu]}V_\nu^-)] - 2q_1q_2(+V_\nu^+U^\nu V^{\mu-} + a_3V_\nu^+A^\nu V^{\mu-} + V_\nu^+U^\nu V^{\mu-}\\
&+a_3V_\nu^+A^\nu V^{\mu-}) + 2\mathbf{e}_{[12]}(1+a_3)(\mathbf{e}^{[12-][\mu\nu]}V_\nu^+ + \mathbf{e}^{[12+][\mu\nu]}V_\nu^-)\\
&-q_1^2V_\nu^+A^\nu V^{\mu-} - q_1^2V_\nu^-A^\nu V^{\mu+}\\
&-2a_3q_2^2(V_\nu^+U^\nu V^{\mu-} + V_\nu^-U^\nu V^{\mu+}) \qquad (120)
\end{aligned}
$$

where mixing terms as $A_\nu U^\nu$, $A_\nu V^{\nu\pm}$, and so on are connected photonballs contributions. Notice that terms as $\mathbf{e}^{[12-][\mu\nu]}V_\nu^+$ produce mass term

The current term is expressed as

$$
\begin{aligned}
&j_{AT}^\mu = \mathbf{e}_{[12]}[(a_1F^{\mu\nu} + u_2U^{\mu\nu})(U_\nu + a_3A_\nu)1/2\mathbf{e}_{[12]}(1+a_3)(V^{\mu\nu+}V_\nu^- + V^{\mu\nu-}V_\nu^+)]\\
&-(2iq_1 + a_3q_2)(\partial^\mu V_\nu^+V^{\nu-} - \partial_\nu V_{\mu+}V^{\nu-} + \partial^\mu V_\nu^-V^{\nu+} - \partial_\nu V^{\mu-}V^{\nu+}) \qquad (121)
\end{aligned}
$$

Eq. (121) introduces the expected relationship between EM potential fields. A property already considered by Faraday in 1841 by rotating the light polarization through an external magnetic field.

For U_T^μ:

$$
\begin{aligned}
&\partial_\nu\left\{4u_1U^{\nu\mu} + u_2\left(\mathbf{e}^{[12][\nu\mu]} + \mathbf{e}^{[+-][\nu\mu]}\right)\right\} - 2\mathbf{m}_U^2U^\mu + l_{UT}^\mu + c_{UT}^\mu =\\
&= J_{UT}^\mu + J_{NT}^\mu \qquad (122)
\end{aligned}
$$

with the following London term

$$
\begin{aligned}
&l_{UT}^\mu = 4\mathbf{e}_{[12]}(4\mathbf{e}_{[12]}A_\nu A^\nu U^\mu + u_3U_\nu U^\nu A^\mu) - 2q_1q_2(V_\nu^+V^{\nu-}A^\mu + u_3V_\nu^+V^{\nu-}U^\mu)\\
&-2q_2^2(V_\nu^+V^{\nu-}U^\mu - 2u_3q_1^2V_\nu^+V^{\nu-}A^\mu, \qquad (123)
\end{aligned}
$$

conglomerate

$$
\begin{aligned}
&c_{UT}^\mu = 4\mathbf{e}_{[12]}[A_\nu U^\nu A^\mu + u_3A_\nu U^\nu U^\mu 1/2(1+u_3)(\mathbf{e}^{[12-][\mu\nu]}V_\nu^+ + \mathbf{e}^{[12+][\mu\nu]}V_\nu^-)]\\
&-2q_1q_2(V_\nu^+A^\nu V^{\mu-} + u_3V_\nu^+U^\nu V^{\mu-} + V_\nu^+A^\nu V^{\mu-}\\
&+u_3V_\nu^+U^\nu V^{\mu-}) + 2\mathbf{e}_{[12]}(1+u_3)(\mathbf{e}^{[12-][\mu\nu]}V_\nu^+ + \mathbf{e}^{[12+][\mu\nu]}V_\nu^-)\\
&-2q_2^2(V_\nu^+U^\nu V^{\mu-} + V_\nu^-U^\nu V^{\mu+}), \qquad (124)
\end{aligned}
$$

and current

$$
\begin{aligned}
&j_{UT}^\mu = \mathbf{e}_{[12]}[(a_1F^{\mu\nu} + u_2U^{\mu\nu})(A_\nu + u_3U_\nu) + 1/2\mathbf{e}_{[12]}(1+u_3)(V^{\mu\nu+}V_\nu^- + V^{\mu\nu-}V_\nu^+)]\\
&-(2iq_1 + u_3q_2)(\partial^\mu V_\nu^+V^{\nu-} - \partial_\nu V_{\mu+}V^{\nu-} + \partial^\mu V_\nu^-V^{\nu+} - \partial_\nu V^{\mu-}V^{\nu+}). \qquad (125)
\end{aligned}
$$

For $V_T^{\mu\pm}$:

$$
\begin{aligned}
&\partial_\mu\{2(v_1+\beta_3)V^{\nu\mu\pm} + 2v_2\mathbf{e}^{[12\pm][\nu\mu]}\} - \mathbf{m}_V^2V^{\mu\pm} + l_{VT}^\pm + c_{VT}^\pm =\\
&= J_{VT}^{\mu\pm} \qquad (126)
\end{aligned}
$$

with the London term

$$
l_{VT}^{\mu\pm} = -4i\mathbf{e}_{[34]}V_\nu^\pm V^{\nu\pm}V^{\mu\mp} - q_1^2A_\nu A^\nu V^{\mu\pm} - q_2^2U_\nu U_\nu V^{\mu\pm}, \qquad (127)
$$

conglomerate

$$c^{\pm}_{VT} = -4i\mathbf{e}_{[34]}(V^{\pm}_{\nu}V^{\nu\mp}V^{\mu\pm}\mathbf{e}^{[12][\mu\nu]}V^{\pm}_{\nu}) - 2q_1q_2(A_{\nu}U^{\nu}V^{\mu\pm} - V^{\pm}_{\nu}U^{\nu}A^{\mu})$$
$$+q_1^2V^{\pm}_{\nu}A^{\nu}A^{\mu} + q_2^2V^{\pm}_{\nu}U^{\nu}U^{\mu}, \tag{128}$$

and current term

$$J^{\mu\pm}_{VT} = 2v_1V^{\mu\nu\pm}(A_{\nu} + U_{\nu}) - 2iq_1(\partial_{\nu}V^{\mu\pm}A^{\nu} - \partial^{\mu}V^{\nu\pm}A_{\nu})$$
$$-2iq_2(\partial_{\nu}V^{\mu\pm}U^{\nu} - \partial^{\mu}V^{\nu\pm}A_{\nu}). \tag{129}$$

The above equations show the quadruplet correlations physics. It generates the condensated fields physics with masses and charges depending on fields.

For longitudinal sector:

For A^{μ}_{L}:

$$\partial^{\mu}\left\{s_1S^{\alpha 1}_{\alpha} + c_1\mathbf{e}^{\alpha}_{\alpha}\right\}l^{\mu}_{AL} + c^{\mu}_{AL} = 2t_1\mathbf{m}^2_{U}U^{\mu} + J^{\mu}_{AL} + (t_1+1)j^{\mu}_{NL} \tag{130}$$

with the corresponding London term

$$l^{\mu}_{AL} = 4\mathbf{e}_{(11)}(\mathbf{e}^{(11)(\mu\nu)}A_{\nu} + 4\mathbf{e}^{(11)\alpha}_{\alpha}A^{\mu} + \mathbf{e}^{(22)\alpha}_{\alpha}A^{\mu}) + 2\mathbf{e}_{(12)}(2\mathbf{e}^{(12)(\mu\nu)}U_{\nu}$$
$$+4\mathbf{e}^{(12)(\mu\nu)}A_{\nu} + \mathbf{e}^{(11)\alpha}_{\alpha}A^{\mu} + \mathbf{e}^{(22)(\mu\nu)}U_{\nu} + \mathbf{e}^{(22)\alpha}_{\alpha}U^{\mu}) + 4t_1(\mathbf{e}^{(22)\alpha}_{\alpha}U^{\mu}$$
$$+\mathbf{e}^{(11)\alpha}_{\alpha}U^{\mu} + \mathbf{e}^{(22)(\mu\nu)}U_{\nu}) + 2t_1\mathbf{e}_{(12)}(\mathbf{e}^{(11)(\mu\nu)}A_{\nu} + \mathbf{e}^{(11)\alpha}_{\alpha}A^{\mu} + 4\mathbf{e}^{(12)(\mu\nu)}U_{\nu}$$
$$\mathbf{e}^{(22)\alpha}_{\alpha}U^{\mu} + \mathbf{e}^{(11)(\mu\nu)}A_{\nu} + \mathbf{e}^{(12)\alpha}_{\alpha}U^{\mu}) - q_1^2V^{+}_{\nu}V^{\nu-}A^{\mu} - 2q_2^2t_1V^{+}_{\nu}V^{\nu-}U^{\mu}$$
$$-2q_1q_2(V^{+}_{\nu}V^{\nu-}A^{\mu} + V^{+}_{\nu}V^{\nu-}U^{\mu}), \tag{131}$$

and conglomerate

$$c^{\mu}_{AL} = 2\mathbf{e}_{(12)}(\mathbf{e}^{(12)\alpha}_{\alpha}U^{\mu} + \mathbf{e}^{(12)\alpha}_{\alpha}A^{\mu} + \mathbf{e}^{(11)(\mu\nu)}U_{\nu} + \mathbf{e}^{(+-)(\mu\nu)}U_{\nu}$$
$$+\mathbf{e}^{(+-)\alpha}_{\alpha}U^{\alpha}) + \mathbf{e}_{(11)}(\mathbf{e}^{(22)(\mu\nu)}A_{\nu} + \mathbf{e}_{(11)}(\mathbf{e}^{(+-)(\mu\nu)}A_{\nu} + 8\mathbf{e}^{(+-)\alpha}_{\alpha}A^{\mu})$$
$$+2\mathbf{e}_{(34)}(\mathbf{e}^{(12+)(\mu\nu)}V^{-}_{\nu} + \mathbf{e}^{(12-)(\mu\nu)}V^{+}_{\nu} + 6\mathbf{e}^{(12+)\alpha}_{\alpha}V\mu- + 6\mathbf{e}^{(12-)\alpha}_{\alpha}V\mu+)$$
$$+4t_1\mathbf{e}_{(22)}(\mathbf{e}^{(11)(\mu\nu)}U_{\nu} + \mathbf{e}^{(+-)(\mu\nu)}U_{\nu} + \mathbf{e}^{(+-)\alpha}_{\alpha}U^{\mu}) + 2t_1\mathbf{e}_{(12)}(\mathbf{e}^{(12)\alpha}_{\alpha}A^{\mu}$$
$$+\mathbf{e}^{(12)\alpha}_{\alpha}U^{\mu} + \mathbf{e}^{(22)(\mu\nu)}A_{\nu} + \mathbf{e}^{(+-)(\mu\nu)}A_{\nu} + \mathbf{e}^{(+-)\alpha}_{\alpha}A^{\mu})$$
$$+2t_1\mathbf{e}_{(34)}(\mathbf{e}^{(12+)(\mu\nu)}V^{-}_{\nu} + \mathbf{e}^{(12-)(\mu\nu)}V^{+}_{\nu} + 6\mathbf{e}^{(12+)\alpha}_{\alpha}V^{\mu-} + 6\mathbf{e}^{(12-)\alpha}_{\alpha}V^{\mu+})$$
$$-t_1q_2^2(2V^{+}_{\nu}A^{\nu}V^{\mu-} + V^{-}_{\nu}A^{\nu}V^{\mu+}) - 2q_1q_2(t_1V^{+}_{\nu}A^{\nu}V^{\mu-} + t_1V^{-}_{\nu}A^{\nu}V^{\mu+}$$
$$V^{+}_{\nu}U^{\nu}V^{\mu-} + V^{-}_{\nu}U^{\nu}V^{\mu+}). \tag{132}$$

and current term

$$J^{\mu}_{AL} = 2(\beta_1S^{\mu\nu 1} + \beta_2S^{\mu\nu 2} + \rho_1g^{\mu\nu}S^{\alpha 1}_{\alpha} + \rho_2g^{\mu\nu}S^{\alpha}_{\alpha})(\mathbf{e}_{(11)}A_{\nu} +$$
$$t_1\mathbf{e}_{(12)}A_{\nu} + \mathbf{e}_{(12)}U_{\nu} + t_1\mathbf{e}_{(22)}U_{\nu}) + 2[(\beta_1 + 4\rho_1)S^{\alpha}_{\alpha}$$
$$+(\beta_2 + 4\rho_2)S^{\alpha 2}_{\alpha}](\mathbf{e}_{(11)}A^{\mu} + t_1\mathbf{e}_{(22)}U^{\mu} + \mathbf{e}_{(12)}U^{\mu} + t_1\mathbf{e}_{(12)}A^{\mu})$$
$$\mathbf{e}_{(34)}(1+t_1)[(\beta_{+}S^{\mu\nu+} + \rho_{+}g^{\mu\nu}S^{\alpha+}_{\alpha}) + (\beta_{-}S^{\mu\nu-} + \rho_{-}g^{\mu\nu}S^{\alpha}_{\alpha})V^{+}_{\nu}]$$
$$+i(q_1 + t_1q_2)(\partial^{\mu}V^{+}_{\nu}V^{\nu-} + \partial^{\mu}V^{-}_{\nu}V^{\nu+} + \partial_{\nu}V^{\mu+}V^{\nu-} + \partial_{\nu}V^{\mu-}V^{\nu+}$$
$$+\partial_{\alpha}V^{\alpha+}V^{\mu-} + \partial_{\alpha}V^{\alpha-}V^{\mu+}). \tag{133}$$

For U_L^{μ}:

$$\partial^{\mu}\{s_2 S_{\alpha}^{\alpha 2} + c_2 \mathbf{e}_{\alpha}^{\alpha}\} + l_{UL}^{\mu} + c_{UL}^{\mu} - \mathbf{m}_U^2 U^{\mu} = j_{UL}^{\mu} + (t_2+1) j_{NL}^{\mu} \tag{134}$$

with the London term

$$\begin{aligned} l_{UL}^{\mu} &= 4(\mathbf{e}_{\alpha}^{(22)\alpha}U^{\mu} + \mathbf{e}_{\alpha}^{(11)\alpha}U^{\mu} + \mathbf{e}^{(22)(\mu\nu)}U_{\nu}) + 2\mathbf{e}_{(12)}(\mathbf{e}^{(11)(\mu\nu)}A_{\nu} \\ &+\mathbf{e}_{\alpha}^{(11)\alpha}A^{\mu} + 4\mathbf{e}^{(12)(\mu\nu)}U_{\nu} + \mathbf{e}_{\alpha}^{(22)\alpha}U^{\mu} + \mathbf{e}^{(11)(\mu\nu)}A_{\nu} + \mathbf{e}_{\alpha}^{(12)\alpha}U^{\mu}) \\ &4t_2\mathbf{e}_{(11)}(\mathbf{e}^{(11)(\mu\nu)}A_{\nu} + 4\mathbf{e}_{\alpha}^{(11)\alpha}A^{\mu} + \mathbf{e}_{\alpha}^{(22)\alpha}A^{\mu}) + 2t_1\mathbf{e}_{(12)}(2\mathbf{e}^{(12)(\mu\nu)}U_{\nu} \\ &+4t_2\mathbf{e}^{(12)(\mu\nu)}A_{\nu} + \mathbf{e}_{\alpha}^{(11)\alpha}A^{\mu} + \mathbf{e}^{(22)(\mu\nu)}U_{\nu} + \mathbf{e}_{\alpha}^{(22)\alpha}U^{\mu}) + \\ &-t_1 q_1^2 V_{\nu}^{+}V^{\nu-}A^{\mu} - 2q_2^2 V_{\nu}^{+}V^{\nu-}U^{\mu} - 2q_1 q_2(t_2 V_{\nu}^{+}V^{\nu-}A^{\mu} \\ &+V_{\nu}^{+}V^{\nu-}U^{\mu}), \end{aligned} \tag{135}$$

conglomerate

$$\begin{aligned} c_{UL}^{\mu} &= 4\mathbf{e}_{(22)}(\mathbf{e}^{(11)(\mu\nu)}U_{\nu} + \mathbf{e}^{(+-)(\mu\nu)}U_{\nu} + \mathbf{e}_{\alpha}^{(+-)\alpha}U^{\mu}) + 2\mathbf{e}_{(12)}(\mathbf{e}_{\alpha}^{(12)\alpha}A^{\mu} \\ &+\mathbf{e}_{\alpha}^{(12)\alpha}U^{\mu} + \mathbf{e}^{(22)(\mu\nu)}A_{\nu} + \mathbf{e}^{(+-)(\mu\nu)}A_{\nu} + \mathbf{e}_{\alpha}^{(+-)\alpha}A^{\mu}) \\ &+2\mathbf{e}_{(34)}(\mathbf{e}^{(12+)(\mu\nu)}V_{\nu}^{-} + \mathbf{e}^{(12-)(\mu\nu)}V_{\nu}^{+} + 6\mathbf{e}_{\alpha}^{(12+)\alpha}V^{\mu-} + 6\mathbf{e}_{\alpha}^{(12-)\alpha}V^{\mu+}) \\ &t_2 2\mathbf{e}_{(12)}(\mathbf{e}_{\alpha}^{(12)\alpha}U^{\mu} + \mathbf{e}_{\alpha}^{(12)\alpha}A^{\mu} + \mathbf{e}^{(11)(\mu\nu)}U_{\nu} + \mathbf{e}^{(+-)(\mu\nu)}U_{\nu} \\ &+\mathbf{e}_{\alpha}^{(+-)\alpha}U^{\alpha}) + t_2\mathbf{e}_{(11)}(\mathbf{e}^{(22)(\mu\nu)}A_{\nu} + \mathbf{e}_{(11)}(\mathbf{e}^{(+-)(\mu\nu)}A_{\nu} + 8\mathbf{e}_{\alpha}^{(+-)\alpha}A^{\mu}) \\ &+2t_2\mathbf{e}_{(34)}(\mathbf{e}^{(12+)(\mu\nu)}V_{\nu}^{-} + \mathbf{e}^{(12-)(\mu\nu)}V_{\nu}^{+} + 6\mathbf{e}_{\alpha}^{(12+)\alpha}V\mu- + 6\mathbf{e}_{\alpha}^{(12-)\alpha}V\mu+) \\ &-t_1 q_2^2(2V_{\nu}^{+}A^{\nu}V^{\mu-} + V_{\nu}^{-}A^{\nu}V^{\mu+}) - 2q_1 q_2(t_1 V_{\nu}^{+}A^{\nu}V^{\mu-} + t_1 V_{\nu}^{-}A^{\nu}V^{\mu+} \\ &V_{\nu}^{+}U^{\nu}V^{\mu-} + V_{\nu}^{-}U^{\nu}V^{\mu+}) \end{aligned} \tag{136}$$

and current term

$$\begin{aligned} J_{UL}^{\mu} &= 2(\beta_1 S^{\mu\nu 1} + \beta_2 S^{\mu\nu 2} + \rho_1 g^{\mu\nu}S_{\alpha}^{\alpha 1} + \rho_2 g^{\mu\nu}S_{\alpha}^{\alpha})(t_2\mathbf{e}_{(11)}A_{\nu} + \\ &\mathbf{e}_{(12)}A_{\nu} + t_2\mathbf{e}_{(12)}U_{\nu} + t_1\mathbf{e}_{(22)}U_{\nu}) + 2[(\beta_1 + 4\rho_1)S_{\alpha}^{\alpha} \\ &+(\beta_2 + 4\rho_2)S_{\alpha}^{\alpha 2}](t_2\mathbf{e}_{(11)}A^{\mu} + \mathbf{e}_{(22)}U^{\mu} + t_2\mathbf{e}_{(12)}U^{\mu} + \mathbf{e}_{(12)}A^{\mu}) \\ &\mathbf{e}_{(34)}(1+t_2)[(\beta_+ S^{\mu\nu+} + \rho_+ g^{\mu\nu}S_{\alpha}^{\alpha+}) + (\beta_- S^{\mu\nu-} + \rho_- g^{\mu\nu}S_{\alpha}^{\alpha})V_{\nu}^{+}] \\ &+i(t_2 q_1 + q_2)(\partial^{\mu}V_{\nu}^{+}V^{\nu-} + \partial^{\mu}V_{\nu}^{-}V^{\nu+} + \partial_{\nu}V^{\mu+}V^{\nu-} + \partial_{\nu}V^{\mu-}V^{\nu+} \\ &+\partial_{\alpha}V^{\alpha+}V^{\mu-} + \partial_{\alpha}V^{\alpha-}V^{\mu+}). \end{aligned} \tag{137}$$

For $V_L^{\mu\pm}$:

$$\begin{aligned} &\partial^{\mu}\{2(\beta_3 + 2\beta_3\rho_3 + 2\beta_4\rho_4 + 4\rho_3)S_{\alpha}^{\alpha\pm} + (\beta_{\pm} + 5\rho_{\pm})\mathbf{e}_{\alpha}^{(12\pm)\alpha}\} + \\ &+l_{VL}^{\mu\pm} + c_{VL}^{\mu} - \mathbf{m}_V^2 V^{\mu\pm} = J_{VL}^{\mu\pm} \end{aligned} \tag{138}$$

London term is

$$\begin{aligned} l_{VL}^{\mu\pm} &= 2\mathbf{e}_{(34)}(\mathbf{e}^{(+-)(\mu\nu)}V_{\nu}^{\pm} + 3\mathbf{e}_{\alpha}^{(+-)\alpha}V^{\mu\pm}) + 2(\mathbf{e}_{(11)} + \mathbf{e}_{(12)})A_{\nu}A^{\nu}V^{\mu\pm} \\ &+(\mathbf{e}_{(12)} + \mathbf{e}_{(22)})U_{\nu}U^{\nu}V^{\mu\pm} + \mathbf{e}_{(34)}(\mathbf{e}^{(\pm\pm)(\mu\nu)}V_{\mu}^{\mp} + \mathbf{e}_{\alpha}^{(\pm\pm)\alpha}V^{\mu\mp}) \\ &-q_1^2 A_{\alpha}A^{\alpha}V^{\mu\pm} - q_2^2 U_{\alpha}U^{\alpha}V^{\mu\pm}, \end{aligned} \tag{139}$$

conglomerate

$$c^{\mu\pm}_{VL} = 2(\mathbf{e}_{(11)} + 2\mathbf{e}_{(12)} + \mathbf{e}_{(22)})A_\nu U^\nu V^{\mu\pm} + (\mathbf{e}_{(11)} + 2\mathbf{e}_{(12)})V^\pm_\nu A^\nu U^\mu$$
$$+(\mathbf{e}_{(12)} + \mathbf{e}_{(22)})V^\pm_\nu U^\nu A^\mu + 6\mathbf{e}^{(12\pm)\alpha}_\alpha[\mathbf{e}_{(11)}A^\mu + \mathbf{e}_{(12)}(A^\mu + U^\mu) + \mathbf{e}_{(22)}U^\mu]$$
$$-2q_1^2 V^\pm_\alpha A^\alpha A^\mu - 2q_1 q_2(A_\alpha U^\alpha V^{\mu\pm} + A_\alpha V^{\alpha\pm}U^\mu + U_\alpha V^{\alpha\pm}A^\mu)$$
$$-q_2^2 U_\alpha V^{\alpha\pm}U^\mu, \tag{140}$$

and current

$$J^{\mu\pm}_{VL} \equiv 2\mathbf{e}_{(34)}\{\left(\beta_1 S^{\mu\nu1} + \beta_2 S^{\mu\nu2} + \rho_1 g^{\mu\nu}S^{\alpha1}_\alpha + \rho_2 g^{\mu\nu}S^{\alpha2}_\alpha\right)V^\pm_\nu +$$
$$[(\beta_1 + 4\rho_1)S^{\alpha1}_\alpha + (\beta_2 + 4\rho_2)g^{\mu\nu}S^{\alpha2}_\alpha]V^{\mu\pm}\} + [\beta_\pm + \rho_\pm g^{\mu\nu}][\mathbf{e}_{(11)}A_\nu$$
$$+\mathbf{e}_{(12)}(A_\nu + U_\nu) + \mathbf{e}_{(22)U_\nu}] + (\beta_\pm + 4\rho_\pm)\, S^{\alpha\pm}_\alpha[\mathbf{e}_{(11)}A^\mu + \mathbf{e}_{(12)}(A^\mu + U^\mu)$$
$$+iq_1(\partial^\nu V^{\mu\pm}A_\nu + \partial^\mu V^\pm_\nu A^\nu + \partial_\nu V^{\nu\pm}A^\mu) + iq_2(\partial^\nu V^{\mu\pm}U_\nu + \partial^\mu V^\pm_\nu U^\nu$$
$$+\partial_\nu V^{\nu\pm}U^\mu). \tag{141}$$

The above equations are introducing another aspect on Faraday lines of force. Besides induction law they make condensates. Masses are inserted from fields condensates and coupling constants beyond electric charge are introduced.

8 Bianchi Identities II

Abelian EM monopoles are derived. Introduced through Bianchi identities. Monopoles based on fields are already stipulated in physics through spin ices [23]. It gives for antisymmetric granular sector,

$$\partial_\mu F_{\nu\rho} + \partial_\nu F_{\rho\mu} + \partial_\rho F_{\mu\nu} = 0 \tag{142}$$
$$\partial_\mu U_{\nu\rho} + \partial_\nu U_{\rho\mu} + \partial_\rho U_{\mu\nu} = 0 \tag{143}$$
$$\partial_\mu V^\pm_{\nu\rho} + \partial_\nu V^\pm_{\rho\mu} + \partial_\rho V^\pm_{\mu\nu} = iq_1(A_\mu V^\pm_{\nu\rho} + A_\nu V^\pm_{\rho\mu} + A_\rho V^\pm_{\mu\nu})$$
$$+iq_2(U_\mu V^\pm_{\nu\rho} + U_\nu V^\pm_{\rho\mu} + U_\rho V^\pm_{\mu\nu}) \tag{144}$$

For the antisymmetric collective sector

$$\partial_\mu \mathbf{e}^{[12]}_{[\nu\rho]} + \partial_\nu \mathbf{e}^{[12]}_{[\rho\mu]} + \partial_\rho \mathbf{e}^{[12]}_{[\mu\nu]} = \mathbf{e}_{[12]}\{A_\mu U_{\nu\rho} + A_\nu U_{\rho\mu} +$$
$$+A_\rho U_{\mu\nu} - U_\mu F_{\nu\rho} - U_\nu F_{\rho\mu} - U_\rho F_{\mu\nu}\}, \tag{145}$$

$$\partial_\mu \mathbf{e}^{[+-]}_{[\nu\rho]} + \partial_\nu \mathbf{e}^{[+-]}_{[\rho\mu]} + \partial_\rho \mathbf{e}^{[+-]}_{[\mu\nu]} = -i\mathbf{e}_{[34]}\{V^+_\mu V^-_{\nu\rho} + V^+_\nu V^-_\rho +$$
$$+V^+_\rho V^-_{\mu\nu} - V_\mu V^+_{\rho\mu} - V^-_\nu V^+_{\rho\mu} - V_\rho V^+_{\mu\nu}\}, \tag{146}$$

and

For the symmetric collective sector

$$\partial_\mu \mathbf{e}_{(\nu\rho)} + \partial_\nu \mathbf{e}_{(\rho\mu)} + \partial_\rho \mathbf{e}_{(\mu\nu)} = \mathbf{e}_{(11)}\{A_\mu S_{\nu\rho1} + A_\nu S_{\rho\mu1} + A_\rho S_{\mu\nu1}\}$$
$$\mathbf{e}_{(22)}\{U_\mu S_{\nu\rho2} + U_\nu S_{\rho\mu2} + U_\rho S_{\mu\nu2}\} + \mathbf{e}_{(12)}\{A_\mu S_{\nu\rho2} + A_\nu S_{\rho\mu2} + A_\rho S_{\mu\nu2}$$
$$U_\mu S_{\nu\rho1} + U_\nu S_{\rho\mu1} + U_\rho S_{\mu\nu1}\}$$

and

$$\partial_\mu \mathbf{e}^{(+-)}_{(\nu\rho)} + \partial_\nu \mathbf{e}^{(+-)}_{(\rho\mu)} + \partial_\rho \mathbf{e}^{(+-)}_{(\mu\nu)} = \mathbf{e}_{(34)}\{V^-_\mu S^+_{\nu\rho} + V^-_\nu S^+_{\rho\mu} + V^-_\rho S^+_{\mu\nu} + V^-_\mu S^+_{\nu\rho} + V^-_\nu S^+_{\rho\mu} + V^-_\rho S^+_{\mu\nu}\} \tag{147}$$

Eqs. (4.9-4.10), (4.26-4.29) also contain monopoles. The rule is that Bianchi conserved charges are just associated to antisymmetric terms. However, other Bianchi identities are derived from collective fields strengths transforming covariantly.

Thus, collective abelian monopoles are formed through the association of different potential fields rotating in a same symmetry group. Different fields families are associated in monopoles. The terms that are sources in the equation of motion are in the monopoles constitution.

9 Concluding on electric charge.

Physics contains more than three hundred particles and billions of galaxies to be studied. Paradoxically, under few quantum numbers and universal constants. Physics provides particles and interactions with quantum numbers as spin, electric charge, mass, other charges and related through nature constants as G, h, α, c, k_B and Planck scales. These few variables are the mysteries of physics.

Our study focus on electric charge. It is the quantum number associated to electromagnetism. The fine structure constant its universal coupling. However, instead of looking to answer the Dirac question about the origin of $\alpha = \frac{e^2}{\hbar c} = \frac{1}{137}$, our search is to extend the electric charge view beyond Maxwell and QED. Enlarge the electromagnetic sense with new charges and couplings.

Electromagnetism is the theory of electric charge. It contains a delicate relationship between charge and fields. Maxwell reformulated the Coulomb law by showing that EM essence is not only electric charge but also on EM fields associations. A result supported on Faraday induction and electric charge conservation laws. Two epistemological references for promoting any subsequent model beyond Maxwell. Consider that electric charge physics is derived from fields symmetry.

Under this context, the four bosons electromagnetic symmetry is introduced. The $U_q(1)$ extended abelian symmetry interrelates the quadruplet $\{A_\mu, U_\mu, V^\pm_\mu\}$. The EM frontier is extended. It provides granular and collective fields strengths with antisymmetric and symmetric natures. New conserved charges and interactions are developed. They are showing that electric charge is not the only one magnitude with conservation and coupling at electromagnetic theory. However, its conservation law remains as the cornerstone preserved by Noether theorem.

EM with charges beyond electric charge is not an unexpected result. Nonlinear and neutral charges EM are indicating on that. Nonlinear electrodynamics develops charges from fields acting as own sources. A behaviour not strict to electric charge. Also, the presence of neutral EM phenomena with light and spin. Both are indicating that EM should exist beyond electric charge.

Physics contains at energy its primitive entity. Therefore, under a certain level of energy above to the critical fields, $E_c = \frac{m_e^2 c^3}{e h} = 1.32 \times 10^{18} V \cdot m^{-1}, B_c = \frac{m_e^2 c^2}{e\hbar} = 4.41 \times 10^9 T$, it is expected the presence of nonlinear fields. LHC and astrophysics registered cases with energy around nonlinear EM fields. LHC achieved 8T and a detected magnestar with magnetic field $1.6 \times 10^9 T$ [24]. Magnetogenesis [25] and Breit-Wheeler effect [26] are also requiring on nonlinear EM fields. Actually, literature provides 15 nonlinear models as Born-Infeld and Euler-Heisenberg [27]. However, they are just effective models.

A fundamental nonlinear EM is expected. A composition with four bosons $\{A_\mu, U_\mu, V_\mu^{\pm}\}$ intermediating three flavours charges $\{+, 0, -\}$ is proposed [19-21]. Nonlinear potentials fields associated by electromagnetic symmetry. It expresses a new perspective for what electric charge physics is. Three new electric charge properties are introduced. First, it is no more just an external source. Noether theorem introduces a conserved electric charge with an equation depending on fields. As temperature electric charge density becomes a space-time function.

Second, relationships as $g_{IJ} F_{\mu\nu I} A_I^\nu$ expressed at equations of motion where $F_{\mu\nu I} \equiv \left(F_{\mu\nu}, U_{\mu\nu}, V_{\mu\nu}^{\pm}; \mathbf{e}_{\mu\nu}\right)$ and $A_{\mu I} = \left(A_\mu, U_\mu, V_\mu^{\pm}\right)$ are stipulated by couplings constants g_{IJ} which are not necessarily the electric charge. They include modulated electric charge and neutral coupling constants as section 6 shows. This result, expands Maxwell for new EM sectors beyond the electric charge interaction. Also consider on axionic EM and the dark photon formulartions [28]. Third, the electromagnetic symmetry is not univoque. Diverse physical situations are developed with different EM properties. Revealing that, there is more than one physics sharing a common Lagrangian and electric charge conservation. A type of result that was already studied by Sakurai by including global symmetries [29].

A fundamental four bosons electromagnetism is proposed. Preserving the two Maxwell postulates, light invariance and electric charge conservation, an electromagnetic symmetry pluriformity is found. Opportunites to explore the electric charge meaning through diverse abelian symmetries, $U_{q_i}(1)$. There are different EM models beyond Maxwell to be considered. Diverse properties over electric charge conservation, transmission, mutation, interaction are derived.

The four bosons EM give an answer beyond Maxwell on what electric charge is. Fields charges are first derived from fields dynamics. And so, electric charge conservation is no more the primitive entity to define what electromagnetism is. The origin is on the quadruplet derived from EM symmetry. The nonlinear fields dynamics include charges and interactions displaying electric, modulated and neutral terms.

A new compreension on EM is obtained. Its origin is in the generic charge $\{+, 0, -\}$. It produces charges and interactions. It yields in total 32 EM fields where 12 granular and 20 collective. Four types of fields charges are produced. Electric, modulate, neutral, Bianchi. It contains one conserved electric charge, four Euler-Lagrange charges (modulated and neutral) and twelve fields monopoles (2 charged and 10 neutral). These charges are acting as fields sources. They are showing that electric charge is no more the EM fields origin and the only one conserved charge.

A travel from Maxwell to photonics is expected [30]. By preserving electric charge conservation the four bosons electromagnetism develops new fields strengths, Lagrangian, equations of motion, fields charges to expand the EM presence. Showing an electromagnetism beyond electric charge. Uncharged particles may produce electromagnetic interaction. Indicating that, there are other EM sectors to be explored. A fact that Fermi did not know, and adopted G_F, as the coupling constant of another interaction [12]. Physics has to revise this compreension. There is an enlarged electromagnetism beyond electric charge. It also relates Maxwell to photonics with selfinteracting photons at tree level [19].

Concluding, we would say that there is an EM beyond electric charge based on fields charges. While for mechanics, Newton's laws were extended by relativity; Maxwell is enlarged by the generic $\{+, 0, -\}$ charges. Preserving light invariance and charge conservation, it introduces fields charges, new fields strengths and charges. Consequently, EM is not just shaped by positive and negative electric charges. The EM phenomena is more than Maxwell and the fine structure constant. The four bosons symmetry extends the strength of electromagnetic forces beyond electric charge conservation and coupling. Modulate and neutral charges and interactions are included. Providing fractionary charges, millicharges, spintronics, weak interactions, photonics.

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10 Global symmetries

10.1 Type I - $U_q \equiv U(1) \times SO(2)_{global}$

$$A'_\mu = A_\mu + k_1 \partial_\mu \alpha \tag{148}$$
$$U'_\mu = U_\mu + k_2 \partial_\mu \alpha \tag{149}$$
$$V^{+'}_\mu = e^{iq\alpha}\left(V^+_\mu + k_+ \partial_\mu \alpha\right) \tag{150}$$
$$V^{-'}_\mu = e^{-iq\alpha}\left(V^-_\mu + k_+ \partial_\mu \alpha\right) \tag{151}$$

The objective here is to understand the physical differences between global and local symmetries through Noether theorem

the consequent three Noether laws are

$$\alpha \partial_\mu (J^G_{IN})^\mu + \partial_\nu \alpha \partial_\mu (K^G_I)^{\mu\nu} + \partial_\mu \partial_\nu \alpha (K^G_I)^{\mu\nu} = 0 \tag{152}$$

Electric charge conservation

$$\partial_\mu (J^G_{IN})^\mu = 0 \tag{153}$$

where:

$$(J_{IN}^{G})^{\mu} = iq\left\{\left[V_{\nu}^{+}\frac{\partial L}{\partial\left(\partial_{\nu}V_{\mu}^{+}\right)}\right] - \left[V_{\nu}^{-}\frac{\partial L}{\partial\left(\partial_{\nu}V_{\mu}^{-}\right)}\right]\right\} \tag{154}$$

symmetry equations

$$\partial_{\mu}(K_{I}^{G})^{\mu\nu} = 0 \tag{155}$$

where

$$(K_{I}^{G}) = k_1\frac{\partial L}{\partial\left(\partial_{\nu}A_{\mu}\right)} + k_2\frac{\partial L}{\partial\left(\partial_{\nu}U_{\mu}\right)} + k_{+}\frac{\partial L}{\partial\left(\partial_{\nu}V_{\mu}^{+}\right)} + k_{-}\frac{\partial L}{\partial\left(\partial_{\nu}V_{\mu}^{-}\right)} \tag{156}$$

constraint

$$\partial_{\mu}\partial_{\nu}(K_{I}^{G}) = 0 \tag{157}$$

10.2 Type II - $U_q \equiv U(1) \times SO(2)_{global}$

$$A'_{\mu} = A_{\mu} + k_1\partial_{\mu}\alpha \tag{158}$$

$$U'_{\mu} = U_{\mu} + k_2\partial_{\mu}\alpha \tag{159}$$

$$V_{\mu}^{\pm'} = e^{iq\alpha}V_{\mu}^{\pm} \tag{160}$$

The correspondents Noether equations

$$\alpha\partial_{\mu}(J_{IIN}^{G})^{\mu} + \partial_{\nu}\alpha\partial_{\mu}(K_{II}^{G})^{\mu\nu} + \partial_{\mu}\partial_{\nu}\alpha(K_{II}^{G})^{\mu\nu} = 0 \tag{161}$$

Electric charge conservation

$$\partial_{\mu}(J_{IIN}^{G})^{\mu} = 0 \tag{162}$$

where

$$(J_{IIN}^{G})^{\mu} = iq\left\{\left[V_{\nu}^{+}\frac{\partial L}{\partial\left(\partial_{\nu}V_{\mu}^{+}\right)}\right] - \left[V_{\nu}^{-}\frac{\partial L}{\partial\left(\partial_{\nu}V_{\mu}^{-}\right)}\right]\right\} \tag{163}$$

Symmetry equation

$$\partial_{\mu}(K_{II}^{G})^{\mu\nu} = 0 \tag{164}$$

where

$$(K_{II}^{G}) = k_1\frac{\partial L}{\partial\left(\partial_{\nu}A_{\mu}\right)} + k_2\frac{\partial L}{\partial\left(\partial_{\nu}U_{\mu}\right)} \tag{165}$$

$$\partial_{\mu}\partial_{\nu}(K_{II}^{G})^{\mu\nu} = 0 \tag{166}$$

Assim, obtemos que a simetria global remove a influência da carga elétrica na dinâmica dos campos.

10.3 Tipo III - $U_q \equiv U(1) \times SO(2)_{global}$

$$A'_\mu = A_\mu + k_1 \partial_\mu \alpha \tag{167}$$
$$U'_\mu = U_\mu + k_2 \partial_\mu \alpha \tag{168}$$
$$V_\mu^{\pm'} = e^{\pm iq\beta} \left(V_\mu^{\pm} + k_\pm \partial_\mu \alpha\right) \tag{169}$$

The correspondent Noether equations are

$$\beta \partial_\mu (J^G_{IIIN})^\mu + \partial_\nu \alpha \partial_\mu (K^G_{III})^{\mu\nu} + \partial_\mu \partial_\nu \alpha (K^G_{III})^{\mu\nu} = 0 \tag{170}$$

Electric charge conservation

$$\partial_\mu (J^G_{IIIN})^\mu = 0 \tag{171}$$

with

$$(J^G_{IIIN})^\mu = iq \left\{ \left[V_\nu^+ \frac{\partial L}{\partial \left(\partial_\nu V_\mu^+\right)} \right] - \left[V_\nu^- \frac{\partial L}{\partial \left(\partial_\nu V_\mu^-\right)} \right] \right\} \tag{172}$$

Symmetry equation

$$\partial_\mu (K^G_{III})^{\mu\nu} = 0 \tag{173}$$

where

$$(K^G_{III}) = k_1 \frac{\partial L}{\partial \left(\partial_\nu A_\mu\right)} + k_2 \frac{\partial L}{\partial \left(\partial_\nu U_\mu\right)} + k_+ \frac{\partial L}{\partial \left(\partial_\nu V_\mu^+\right)} + k_- \frac{\partial L}{\partial \left(\partial_\nu V_\mu^-\right)} \tag{174}$$

Constraint equation

$$\partial_\mu \partial_\nu (K^G_I) = 0 \tag{175}$$

10.4 Type IV - $U_q \equiv U(1) \times SO(2)_{global}$

$$A'_\mu = A_\mu + k_1 \partial_\mu \alpha \tag{176}$$
$$U'_\mu = U_\mu + k_2 \partial_\mu \alpha \tag{177}$$
$$V_\mu^{\pm'} = e^{\pm iq\beta} V_\mu^{+} \tag{178}$$

Noether equations

$$\beta \partial_\mu (J^G_{IVN})^\mu + \partial_\nu \alpha \partial_\mu (K^G_{IV})^{\mu\nu} + \partial_\mu \partial_\nu \alpha (K^G_{IV})^{\mu\nu} = 0 \tag{179}$$

charge conservations

$$\partial_\mu (J^G_{IVN})^\mu = 0 \tag{180}$$

where

$$(J_{IVN}^{G})^{\mu} = iq\left\{\left[V_{\nu}^{+}\frac{\partial L}{\partial\left(\partial_{\nu}V_{\mu}^{+}\right)}\right] - \left[V_{\nu}^{-}\frac{\partial L}{\partial\left(\partial_{\nu}V_{\mu}^{-}\right)}\right]\right\} \tag{181}$$

Electric charge dynamics

$$\partial_{\mu}(K_{IV}^{G})^{\mu\nu} = 0 \tag{182}$$

where

$$(K_{IV}^{G}) = k_1\frac{\partial L}{\partial\left(\partial_{\nu}A_{\mu}\right)} + k_2\frac{\partial L}{\partial\left(\partial_{\nu}U_{\mu}\right)} \tag{183}$$

constraint equation

$$\partial_{\mu}\partial_{\nu}(K_{IV}^{G}) = 0 \tag{184}$$