

Whole Gauge Physicality

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Abstract- Considering that nature also has a systemic behaviour, there is still space for a whole physics to be derived from gauge symmetry. Therefore, by observing such nature systemic behaviour, a systemic symmetry is introduced. It originates the so-called whole gauge theory. It is a model based on the meaning that to a given Lorentz group representation should be associated with a field family. So, given the representation $\{\frac{1}{2}, \frac{1}{2}\}$, it provides a dynamics with N-potential fields rotating under a same symmetry group. It develops a new possibility for gauge invariance to be explored which is to work as building maker of a group of fields.

Thus, given that nature work as a group, one moves from the usual physics given by just one field G_μ to a physics where this field is inserted in a group $\{G_\mu^I\}$. New properties are developed. At this work, one studies on such new features which are the fields non-linearity, granular and collective, connectivity, global interactivity, directive and circumstance, gauge organization, complexity.

Our framework for this investigation is the abelian fields set $\{G_\mu^I\}$. By analyzing the corresponding gauge invariant Lagrangian these new properties are deduced. They are showing a new physicality for the quanta. They are consequence from the parts to be enfolded in the whole given by the Lorentz group representation.

Keywords- Whole Abelian Model; Non-linearity; Connectivity; Gauge Organization; Complexity

I. INTRODUCTION

Our effort here is to consider on the wholeness principle. Its origin is that there is a nature general tendency to build up wholeness [1]. Similar to entropy, nature moves in direction of possible whole structures as atoms, bodies, solar systems. Therefore, in terms of field theory, we think that one should take a compromise with a whole gauge theory. This means to move from the usual gauge approach [2] and to assume as a beginning a fields set $\{G_\mu^I\}$.

It turns out that there is a systemic physics to be derived from gauge symmetry. Different from the reductionistic approach organized by the usual gauge theory, it does not take more parts isolated, then, assuming such wholeness principle a fields set $\{G_\mu^I\}$ must be considered as origin. The corresponding quanta will be associated to a given whole.

Under this viewpoint, we can see potential applications in discussing some physics for a whole family of self-interacting vector bosons. It provides the following antireductionistic abelian symmetries possibilities [3]:

$$\begin{aligned} G_\mu^I &\rightarrow G_\mu^{I'} = G_\mu^I + (\Omega^{-1})_I^J \partial_\mu \alpha \text{ (linear),} \\ G_\mu^I &\rightarrow G_\mu^{I'} = G_\mu^I + (\Omega^{-1})_I^J P_J \partial_\mu \alpha \text{ (polynomial),} \\ G_\mu^I &\rightarrow G_\mu^{I'} = a_K^I G_\mu^K + b_L^I P_L \partial_\mu \alpha \text{ (systemic),} \end{aligned} \quad (1)$$

where I means a diversity index which varies from 1 to N , Ω is a matrix depending on Lagrangian parameters with the invertibility property, $\Omega_K^I (\Omega^{-1})_I^J = \delta_{KJ}$, and $P_I(\alpha)$ means a generic polynomial expression $P_I(\alpha) = \sum a_{Im} \alpha^m$. Different proofs based on Kaluza-Klein [4], supersymmetry [5], fibre bundles [6], σ -model formulations [7] have already been studied for sustaining Eq. (1).

Thus, in order to explore such systemic nature possibility we are going to study the simplest case which is the whole abelian case [8]. Based on Eq. (1), one gets the following gauge invariant Lagrangian which transverse sector is diagonalized

$$\mathcal{L}(G) = Z_{[\mu\nu]} Z^{[\mu\nu]} + Z_{(\mu\nu)} Z^{(\mu\nu)} + \frac{1}{2} m_{II}^2 G_\mu^I G^{\mu I}, \quad (2)$$

where

$$Z_{[\mu\nu]} = b_I G_{\mu\nu}^I + Z_{[\mu\nu]}, \quad Z_{(\mu\nu)} = \beta_I S_{\mu\nu}^I + z_{(\mu\nu)} + \rho_I g_{\mu\nu} S_\alpha^{aI} + g_{\mu\nu} \omega_\alpha^a, \quad (3)$$

with

$$G_{\mu\nu}^I = \partial_\mu G_\nu^I - \partial_\nu G_\mu^I, \quad S_{\mu\nu}^I = \partial_\mu G_\nu^I + \partial_\nu G_\mu^I, \quad z_{[\mu\nu]} = \gamma_{[IJ]} G_\mu^I G_\nu^J, \quad z_{(\mu\nu)} = \gamma_{(IJ)} G_\mu^I G_\nu^J, \quad \omega_\alpha^a = \tau_{(IJ)} G_\alpha^I G^{aJ}. \quad (4)$$

Considering the definition of a physical particle in perturbation theory is that one which is the pole of the two point Green functions, one notices that G_μ^I 's are identified as the physical fields. This means that the corresponding Green's functions are those associated to the poles corresponding to spin-1 particles.

Our investigation here is to study this gauge theory that contains fields under a same Lorentz group representation $\{\frac{1}{2}, \frac{1}{2}\}$. Previous work has established Eqs. (2), (3) and (4) gauge invariances [9]. It can be seen directly from the constructor basis $\{D_\mu, X_\mu^I\}$ at Appendix A and Ω matrix invertibility. So such systemic behaviour gauge invariance, where fields are associated in

a group, now one wishes to understand which new physical properties are provided. Understand that when one assumes a field set $\{G_\mu^I\}$, instead of just propagating and interacting fields isolatedly, it appears new physical properties as non-linearity, granular and collective fields strengths, fields connectivity, global interactivity, set determinism based on directive and circumstance, model modeling through gauge organization, complexity. To establish these new properties is the trend of this work.

II. NON-LINEARITY

Considering that nature is non-linear, a major program in field theory is with respect to non-linearity. Non-linearity leads us to understand nature creative potency. Nevertheless gauge theory stipulates that the abelian case is necessarily linear and a non-linear approach is just for non-abelian case [10]. This means that fields work as their own sources just in special cases in gauge theories.

However, as a new fact, new physical and mathematical possibilities are introduced when a gauge theory for a Lorentz representation $\{\frac{1}{2}, \frac{1}{2}\}$ fields family is introduced. Eq. (2) is showing that even in abelian case this whole abelian model provides tri- and quadrilinear vertices. Also, the corresponding N -equations of motion for GI_- fields given by

$$b_I \partial_\mu Z^{[\mu\nu]} + \frac{1}{2} m_I^2 G^{\nu I} = J^{\nu I}(G),$$

with

$$\begin{aligned} J^{\nu I}(G) = & \gamma_{[IJ]} G_\mu^J Z^{[\mu\nu]} + \gamma_{(IJ)} G_\mu^J Z^{(\mu\nu)} + \tau_{(IJ)} G^{\nu J} Z_{(\mu}^{\mu)} - \beta_I \partial_\mu Z^{(\mu\nu)} \\ & - \rho_I \partial^\nu Z_{(\mu}^{\mu)} + b_I \varepsilon^{\nu\mu\rho\sigma} \partial_\mu Z_{[\rho\sigma]} + \eta \gamma_{[IJ]} \varepsilon^{\nu\mu\rho\sigma} G_\mu^J Z_{[\rho\sigma]}, \end{aligned} \quad (5)$$

are providing fields carrying their own charges.

Thus such whole abelian approach opens a new phenomenon for physics to be done. It moves beyond Born-Infeld non-linearity [11]. Firstly, it introduces fields as their own sources. Then, it introduces self-interacting photons [12]. As we know, although different proposals have been developed for non-linear electrodynamics as Born-Infeld case, it preserves the photon field linear behaviour. Thirdly, differently from Yang-Mills where the three and four vertices are connected by gauge invariance, here they can be treated separately. So, it yields a weaken non-linearity, which is more easy to be treated mathematically. It appears possible to treat gauge fields non-linearity solutions without the usual Yang-Mills difficulties.

III. GRANULAR AND COLLECTIVE FIELDS

Another feature is on the appearance of granular and collective fields strengths. From Eq. (1), one derives the following gauge invariant tensors fields $G_{\mu\nu}^I, \beta_I S_{\mu\nu}^I, z_{[\mu\nu]}, z_{(\mu\nu)}$, as defined at Eq. (4), where the first two have a granular nature and $z_{\mu\nu}$ a collective nature.

As granular we understand a one-to-one relationship between the potential field G_μ^I and the corresponding field strength, while as collective the case where these fields agglomerate in a group, like $z_{\mu\nu}$ tensors are showing. These collective fields are a new aspect being introduced by the whole concept. Then, notice from Eq. (5), that $z_{\mu\nu}$ collective fields not only act as source but also propagate on space and time. This makes them dynamics variables as that ones in the granular sector. Consequently, Eq. (5) contains for every involved field a new physical interpretation which is the granular-collective complementarity.

Analyzing vectorially by taking $G_\mu^I \equiv (\Phi_I, \vec{G}_I)$, one derives granular and collective electromagnetic fields as shown in [12]. There the granular fields $(\vec{E}_I - \vec{B}_I)$ originated from G_μ^I appear associated with collective fields $(\vec{e} - \vec{b})$ defined from $z_{[\mu\nu]}$ and also with $(\Phi_I, \vec{G}_I, \vec{E}_I, \vec{B}_I)$ clusters. As a result it provides an answer for $\vec{P}$ and $\vec{M}$ origins coming from Eq. (2). It shows that the collective fields $(\vec{e} - \vec{b})$ derived from $z_{[\mu\nu]}$ correspond to the polarization and magnetization vectors established by Maxwell constitutive equations.

Thus this whole theory provides an interrelationship between the granular and collective aspects. By calculating from Eq. (5) the corresponding potential fields one realizes such granular-collective behaviour. It will show a domain where a given whole is expressed by its individual and collective regimes.

IV. CONNECTED FIELDS

Given a fields set $\{G_\mu^I\}$, there is a new fact which is on the whole interdependence. It yields two kinds of dependence between fields. They are fields connectivity and interactivity. By connectivity, one means that one whose corresponding G_μ^I fields keep interdependence between themselves without interaction switched on. By interactivity, it means the usual case where the Lagrangian interaction sector is developed.

From this systemic gauge symmetry one gets a property which means fields correlations. It says that before performing the usual interactions, these fields keep correlations which are derived due to being associated together. It is understood as

correlations properties which are not deducted from the minimum action principle.

These correlations are classified in six types. They are derived from the global free coefficients, gauge parameter, charges, gauge fixing term, mixing propagators, inductive laws. They will be identified as the whole associations. They are showing a sector where this systemic approach manifests its physics without considering the minimum action principle.

The first correlation originates from the fact that the variables and parameters have a global nature. At Appendix A, one relates on the global free coefficients and on physical fields derived as a constructor fields linear combination. The expression $G_\mu^I = \Omega_{I1}^{-1} D_\mu + \Omega_{Ii}^{-1} X_\mu^i$ shows how G_μ^I fields are globalized. This means that they are intrinsically connected. They are correlated as two vectors in a same plane. G_μ^I and G_μ^{I+1} fields are depending on $\{D_\mu, X_\mu^i\}$ basis and common Ω_{IJ} parameters. The second interlacing comes directly from gauge transformations. Eq. (1) develops the following general expression for fields joining

$$\delta G_\mu^I = h(\alpha) G_\mu^{I+1}, \quad (6)$$

which correlates them through a coefficient $h(\alpha)$. Notice that this coefficient can depend on the gauge parameter or not. It contains three possibilities which are the linear, polynomial and systemic gauge transformations as expressed in Eq. (1). While the first case is not, for the other two the corresponding fields variations will be depending on the gauge parameter.

Thus fields can be directly or indirectly correlated through the gauge transformations. Similarly to mathematical functions which can be linearly independent or not, one obtains two possibilities under this group whole rotation. For instance, taking the case with just two fields transforming as $A'_\mu = A_\mu + \partial_\mu P(\alpha)$, $B'_\mu = B_\mu + \partial_\mu Q(\alpha)$, one gets $\delta A_\mu = \frac{P'(\alpha)}{Q'(\alpha)} \delta B_\mu$. Then, notice that this expression is showing how much fields rotations are related to each other, saying that one variation is not necessarily followed by the other. Consider a point x_0 where $\delta A_\mu = P'(\alpha(x_0)) \partial_\mu \alpha|_{x_0} \neq 0$ and $Q'(\alpha(x_0)) = 0$, $\delta B_\mu|_{x_0} = 0$, one gets independent field rotations but is connected by a common gauge parameter.

In this way, while in the traditional gauge approach the presence of two fields A_μ and B_μ is associated to a group $U(1) \otimes U(1)$ with two independent gauge parameters, Eq. (1) shows connected situations as $P(\alpha) = kQ(\alpha)$ given $\delta A_\mu = h(\alpha) \delta B_\mu$ and $P(\alpha) \neq kQ(\alpha)$ given $\delta A_\mu = h(\alpha) \delta B_\mu$. However, different from the usual case $U(1) \otimes U(1)$, this whole approach writes $U(1)_A \times U(1)_B$ where the common gauge parameter symmetry can provide direct and indirect rotations [13].

For exploring more on these gauge transformations interweaving, a next step should be to explore them through the Noether theorem. Taking

$$\begin{aligned} \Phi_I &\rightarrow \Phi'_I = e^{igq_I P_I(\alpha)} \Phi_I, \\ G_\mu^I &\rightarrow G_\mu^{I'} = G_\mu^I + P_I'(\alpha) \partial_\mu \alpha, \end{aligned} \quad (7)$$

one derives the following three Noether identities

$$(\partial_\mu J^{\mu I}) P_I(\alpha) = 0, \quad J^{\mu I} = \frac{\partial \mathcal{L}}{\partial \partial_\mu \Phi_I} igq_I \Phi_I + cc, \quad (8)$$

$$\left(\frac{\partial \mathcal{L}}{\partial G_\mu^I} + J^{\mu I} \right) \partial_\mu P_I(\alpha) = 0, \quad (9)$$

$$\frac{\partial \mathcal{L}}{\partial \partial_\mu G_\nu^I} P_I' \partial_\mu \partial_\nu \alpha = 0, \quad \frac{\partial \mathcal{L}}{\partial \partial_\mu G_\nu^I} P_I'' \partial_\mu \alpha \cdot \partial_\nu \alpha = 0. \quad (10)$$

Thus the number of Noether identities will depend on the number of independent $P_I(\alpha)$'s and $P_I'(\alpha)$'s. For instance, analyzing Eq. (8) one observes that depending on the polynomials proportionality relations, one gets independent conserved currents even under the same group. It yields a model with independent connected conserved currents $\{\partial_\mu J^{\mu I}\}$.

Another group connectivity comes from the fields relationship established through the gauge fixing term. Given that this systemic model contains just one gauge parameter associated to different potential fields, it yields that just one gauge can be fixed, for instance, in terms of a linear combination between fields. Taking the Lorentz gauge, one has the combination $g[G_\mu^I] = \sigma_I \partial_\mu G^{\mu I}$ where σ_I are just parameters. It gives the expression $\alpha(x) = - \int d^4 y G(x-y) \sigma_I \partial_\mu G^{\mu I}$ where $G(x-y)$ is the corresponding Green's function. Consequently, it introduces a kind of fields connection through the gauge fixing term.

A fifth connectivity is through the mixing propagators. Although the transverse sector is diagonalized as Eq. (2) shows, the longitudinal sector is not. This produces the longitudinal sector the presence of propagator $\langle G_\mu^I G_\nu^J \rangle_L$ out of diagonal. Consequently, the longitudinal creation and annihilation operators are intertwined.

As a sixth connectivity category is the inductive laws derived from the Bianchi identities. The difference from the standard reductionistic way is that when the $\{G_\mu^I\}$ systemic gauge symmetry is considered, one gets antisymmetric and symmetric Bianchi identities. They are given respectively by the relationships

$$\partial_\mu G_{\nu\rho}^I + \partial_\nu G_{\rho\mu}^I + \partial_\rho G_{\mu\nu}^I = 0, \quad (11)$$

$$\partial_\mu z_{[\nu\rho]} + \partial_\nu z_{[\rho\mu]} + \partial_\rho z_{[\mu\nu]} = \gamma_{[IJ]} G_\nu^I G_{\nu\mu}^J + \gamma_{[IJ]} G_\rho^I G_{\rho\mu}^J + \gamma_{[IJ]} G_\mu^I G_{\rho\nu}^J, \quad (12)$$

$$\partial_\mu z_{(\nu\rho)} + \partial_\nu z_{(\rho\mu)} + \partial_\rho z_{(\mu\nu)} = \gamma_{[IJ]} G_\mu^I S_{\nu\rho}^J + \gamma_{[IJ]} G_\nu^I S_{\rho\mu}^J + \gamma_{[IJ]} G_\rho^I S_{\mu\nu}^J, \quad (13)$$

$$\partial_\mu \omega_{(\nu}^{)} + 2\partial_\nu \omega_{(\mu}^{)} = \tau_{[IJ]} G_\mu^I S_\nu^{J]} + 2\tau_{[IJ]} G_\nu^I S_\mu^{J]}. \quad (14)$$

where the above equations are developing $N + 3$ inductive laws between the corresponding electric and magnetic fields with granular and collective, antisymmetric and symmetric natures.

Thus six interconnectivity types are based on this fields set $\{G_\mu^I\}$. They are derived from the gauge parameter and the free coefficients that theory develops. They are showing that before interactively be turned on there is a connectivity physics to be considered. It provides an entangled physics to be explored.

V. GLOBAL INTERACTIVITY

Another aspect from this whole physics is on the global meaning. It yields a global model where its energy and transmission are associated with a global interactivity.

The corresponding equations are derived from a common gauge parameter and the variables and parameters associated with these equations have a global nature. As previously discussed, they are built up in terms of physical fields G_μ^I and global free coefficients as Appendices A and B are showing. They are saying that the model is built up by global equations. Also, even at tree level, the coupling constants corresponding to tri-and-quadri linear vertices and matter couplings show a global nature.

A qualitative change happens relatively to the usual gauge theories. Fields nature and behaviour are globalized by a systemic symmetry. Relationships are not more individual but inside of global structure. Nothing more acts in an isolated way but in whole terms. The corresponding interactions are not more individualized but under a global character. Taking, for instance, the non-linear partial differential equations of motion, Eq. (5), one notices that beside one field is correlated to each other in the $\{G_\mu^I\}$ set, their relationships do not act individually but globally. Equations of motion are relating a global interactivity. The same will happen when Feynman graphs vertices are considered from Eq. (2).

VI. SET DETERMINISM

This whole approach produces a determinism where only from one gauge parameter one derives $2N + 7$ classical equations. They are N equations of motion, $N + 3$ Bianchi identities, 3 Noether identities and 1 Ward identity. We should investigate on its meaning. For this, one has to examine the involved symmetries.

These $2N + 7$ integral equations contain two kinds of symmetry. They are the directive symmetry and the circumstantial symmetry. Their qualitative difference is that while the director symmetry appears as a direct instruction from the gauge parameter, the circumstantial symmetry will depend on relationships between the so-called global free coefficients described at Appendix A. It means that, while the first one comes directly from Eq. (1), the second one is associated with the volume of circumstances considered at Appendix C.

Thus, these $2N + 7$ whole equations expressed in the last sections, are now understood as a conglomerated of fields under a set determinism based on directive and circumstance. A new shape of global equation is expressed. It yields a global time evolution based on a global orientation and individual circumstances.

The notion of directive is introduced. The gauge parameter is transformed from compensating fields to an instrument for set orientation. It provides a gauge directive for establishing state equations for the fields set $\{G_\mu^I\}$. It builds up N -equations of motion written at Eq. (5), Eqs. (8-10) Noether relationships, Ward identity given by Eq. (15).

The notion of circumstance emerges. It is a consequence of the possibility of interfering on symmetry. For analyzing this new possibility of interference a so-called volume of circumstances or symmetry environment is defined. It means the number of free coefficients that a given model provides. In Appendix C it shows that $\mathcal{L}$ at Eq. (2) generates a volume equal to $\frac{1}{4}[3N^4 - 8N^3 + 13N^2 - 12N + 8]$ where N is the number of fields in the $\{G_\mu^I\}$ set. Therefore any whole gauge model contains a strategy of circumstances which says that different properties can be derived without gauge invariance being violated.

Directive and circumstantial symmetries become properties of such a whole gauge physics. The equations evolution depends on both aspects. Thus for systematizing the whole dynamics one has to read off its directive and circumstantial laws. The former means a guideline of an overall plan while the latter establishes gauge strategies. They are respectively a natural consequence of sharing a common gauge parameter (Ward and Noether information) and stem from possibilities given by global free parameters relationships (symmetry environment).

A set determinism is obtained [14]. Instead of the time evolution of a given particle, there is the dynamics of the whole system. The corresponding equations are expressing a physics which is more than a problem of fragmentation. It is coordinated by the notions of directive and circumstance. Then, given a set of fields, there is a global flow carrying granular and collective variables, coupled equations and global conservation laws expressed through a set determinism. So adding to the usual determinism cases such as classical mechanics, quantum mechanics, and catastrophe theory, it the whole gauge theory introduces a type of set determinism.

VII. GAUGE ORGANIZATION

The wholeness principle yields a new structure for gauge theories. It says that gauge theories are not restricted to establish interactions. It yields that the corresponding physical properties are not only to be derived but also organized. There is a gauge modelling to be explored.

Thus the whole concept introduces a gauge organization complementing the gauge parameter directive with the free coefficients volume of circumstances. It organizes a variety of possibilities for certain physical entities expressed without breaking gauge symmetry.

There is a symmetry management based on the corresponding directive and circumstance symmetries. For example, we are going to study the corresponding Ward identities. We are going to do modelling with it without breaking any gauge symmetry. Taking initially the constructor basis $\{D_\mu, X_\mu^i\}$ as described in Appendix A, where $\delta D_\mu = \partial_\mu \alpha$, $\delta X_\mu^i = 0$, $\delta \psi = i g \alpha \psi$ and the gauge-fixing term is $g[D_\mu, X_\mu^i] = \partial_\mu (D^\mu + \sigma_i X^{\mu i})$, one gets that the Ward identity for the generating functional of the 1-PI Green's function is given by

$$\frac{i}{\alpha} \square \partial_\mu (D^\mu + \sigma_i X^{\mu i}) + \partial_\mu \frac{\delta \Gamma}{\delta D^\mu(x)} - g \psi \frac{\delta \Gamma}{\delta \psi} + g \bar{\psi} \frac{\delta \Gamma}{\delta \bar{\psi}} = 0, \quad (15)$$

where the above equation is derived directly from the gauge parameter directive. It acts only over D_μ field, and so, one obtains on the persistence of perturbation massless of the D_μ field

$$\partial_\mu \Gamma^{\mu\nu}(x-y) = \frac{1}{\alpha} \square_x \partial^\nu \delta(x-y), \quad (16)$$

Where $\Gamma^{\mu\nu}(x-y) = \frac{\delta^2 \Gamma}{\delta D_\mu(x) \delta D_\nu(y)}$. Eq. (16) directive is the necessary ingredient for a massless D_μ field, implying $\pi^{\mu\nu} = (-\eta^{\mu\nu} p^2 + p^\mu p^\nu) \pi(p)$, and hence forbidding terms like $m^2 \eta_{\mu\nu}$ that would give rise to a mass. Consequently the $\langle D_\mu D_\nu \rangle$ propagator is given by

$$D_{\mu\nu}(p) = -\frac{(\eta^{\mu\nu} - \frac{p^\mu p^\nu}{p^2})}{p^2(1 - i\hbar\pi(p))} - \alpha \frac{p^\mu p^\nu}{p^2}, \quad (17)$$

which says that order by order in perturbation theory there is no mechanism for generating a pole at $p^2 = 0$ in $\pi(p)$. In this way the directive symmetry controls that the D_μ pole remains at $p^2 = 0$.

Nevertheless, D_μ and X_μ^i are not the physical fields. They are just expressing a constructor basis, while the physical basis is that one associated with the poles of two point Green's functions. Thus, rewriting the Ward identity in terms of physics fields, one gets $\delta G_\mu^I = \Omega_{I1}^{-1} \partial_\mu \alpha$, $\delta \psi = i \alpha \psi$, $\delta \bar{\psi} = -i \alpha \bar{\psi}$ and the gauge fixing term $g[G^{\mu I}] = \sigma_I \partial_\mu G^{\mu I}$, which yields the following W. I. state equation [16],

$$\frac{i}{\alpha} \square \partial_\mu (D^\mu + \sigma_i X^{\mu i}) + \partial_\mu \frac{\delta \Gamma}{\delta D^\mu(x)} - g \psi \frac{\delta \Gamma}{\delta \psi} + g \bar{\psi} \frac{\delta \Gamma}{\delta \bar{\psi}} = 0. \quad (18)$$

Now, working out the above expression, one derives a system with N -equations

$$\Omega_{I1} \partial^\mu \Gamma_{\mu\nu, IJ} \Delta_{\nu, J}, \quad \Delta_{\nu, J} \equiv \frac{\sigma_J}{\alpha} \square \partial_\nu \delta(x-y), \quad (19)$$

to be solved. Then, taking the circumstantial relationship where $\Omega_{I1} = 0$ for $I \neq K$, one gets that every equation in (19) contains a term $\Omega_{K1} \partial^\mu \Gamma_{\mu\nu, KI}$ (not adding in K), which yields

$$\Gamma_{\mu\nu, IK} = \frac{1}{\Omega_{KI}} \Delta_I \quad (K \text{ fixed}, 1 \leq I \leq N). \quad (20)$$

Thus through the Ward identity one can notice that when directive symmetry acts over D_μ field it shows directly that it does not suffer radiative corrections. Nevertheless, when it acts over the $\{G_\mu^I\}$ set, it says that just one spin 0 field is frozen but it does not identify which is. However this whole approach propitiates a gauge organization in the model. It allows that Eq. (19) be manipulated by free coefficients (circumstantial symmetry) in such a way that it guarantees that the longitudinal part of the

propagator does not suffer radiative corrections. So under this gauge strategy we have understood that the vector boson propagator $\langle G_\mu^K G_\nu^J \rangle_L$ longitudinal part does not suffer radiative corrections [17].

As another case, Eq. (2) contains instructions, such as the compulsory existence of one massless field together with circumstantial possibilities for decoupling the longitudinal sector.

VIII. COMPLEXITY

The wholeness principle establishes that while the $\{G_\mu^I\}$ set is controlled by directive symmetries the corresponding individual fields are complemented by circumstances. In this way the behaviour of a particular field will depend on general and particular relations. Three principles will control this whole-individual behaviour. They are the gauge, minimum action and organizational principles. They define what can be called as whole gauge complexity.

Thus another property is complexity. This symmetry extension from a single field G_μ^I to a field set $\{G_\mu^I\}$ creates a fields environment. It provides other physical principle additional to the lower laws. It generates state equations. It says that while Maxwell equations work with photons and electrons just as elementary particles, Eq. (1) provides them under the meaning of complexity.

Eq. (1) makes a bridge between the simple and the complex. As complexity here one understands a gauge physics derived from a field environment. The starting point is that Eq. (1) introduces a primordial soup of fields $G_\mu^I \equiv (\phi_I, \vec{G}_I)$ which yields a field theory based on the following elemental gauge transformations: $\phi_I \rightarrow \phi_I' = \phi_I + \Omega_{I1}^{-1} \frac{\partial}{\partial t} \alpha$, $\vec{G}_I \rightarrow \vec{G}_I' = \vec{G}_I - \Omega_{I1}^{-1} \vec{\nabla} \alpha$, that defines a gauge fields environment.

Eq. (1) does not derive just N -equations of motion corresponding to every field G_μ^I . It determines state equations for the $\{G_\mu^I\}$ set. From Eqs. (5), (11-14), (18) and from the energy-momentum tensor it derives the global Maxwell Equations, global Noether, global Ward identities and global Lorentz Equations [14]. It yields a model which physical system obeys complex laws. For instance, the interaction between two fields will depend on the number of fields inserted in the whole $\{G_\mu^I\}$. While at conventional physics there is no room for such differentiation, there is an integral physics inserted on such $\{G_\mu^I\}$ state equations [18].

Thus, physics can be seen through different objects which emerge from this field environment. Given such initial $4N$ -potential fields, one gets that elementary particles cannot work in an isolated way anymore; they may trigger physical entities with collective, cooperative and organizational aspects. It shows that the physics for one field G_μ^I alone is different from that one when it is allocated in a group $\{G_\mu^I\}$.

IX. CONCLUSION

Modern physics relies a great deal on the concept of fields. Our assumption here is that, nature works systemically, then, instead of considering fields isolatedly, one understands that they should work as a group. Therefore, we introduce the presence of a conglomerate of fields G_μ^I 's being structured through the systemic gauge parameter defined by Eq. (1). As a consequence, a whole gauge theory is generated and, in this conclusion it is necessary to differentiate it from the usual case.

Two interpretations are possible for this whole gauge theory. A first one is to characterize that it develops a model based on $(\frac{1}{2}, \frac{1}{2})$ Lorentz representation. This means that instead of associating just one field to each representation (as usual) to consider in terms of fields family. Similarly to what Gell-Mann did with the Eightfold Way for mesons and baryons to explore on photon, Z^0 and $W^\pm$ under a same $(\frac{1}{2}, \frac{1}{2})$ representation. Instead of understanding these particles under $SU(2) \otimes U(1)$ to interpret them under a $\{\gamma, Z^0, W^\pm\}$ family [19]. A second interpretation is to understand this conglomerate as a road between the simple and complex.

Independently from such possible interpretations, this work studies on seven new properties. They are non-linearity, granular and collective, connectivity, global interactivity, directive and circumstance, gauge organization, complexity. They are new features for a given field G_μ^I when it is allocated in a fields set $\{G_\mu^I\}$. They are showing on the parts new behaviour inside of the group.

A first property not usual in the abelian approach is about nonlinearity. It will allow self-interacting vector bosons to be included at $U(1)$ model [9]. Since greek times with 'aether' that people have been trying to fill the empty space. Today is with dark energy [20]. From such whole approach containing charges and currents depending just on fields, it appears another physics for justifying the non-emptiness. The space-time is fulfilled with nonlinearity.

Nonlinearity leads us to understand nature creative potency. We can interpret self-interacting equations as performing 'intelligent matter', they provide a capacity of decision in the model where the meaning of growth and reply depends on a dynamics with feedback. Thus, even at abelian level, such whole gauge theories contain such self-organizing dynamics that in principle allow the system as a whole to undergo process with spontaneous self-organization.

The second one is on the whole relationship between the granular and collective constituents. This group gauge approach opens the possibility to relate these two regimes. It defines fields and particles both under a granular-collective complementarity. It makes the corresponding granular and collective fields be dynamical variables evolving in space-time. It builds up a type of theory where the description of a given field-particle will depend on its individual and collective characters.

This granular-collective complementarity can be viewed through the nature constitutive laws. For instance, the Maxwell constitutive theory provides polarization and magnetization vectors (introduced by hand with origins on material properties), however, from Eq. (1) gauge principles ones develop a collective field $z^{[\mu\nu]}$ which vectors z^{0i} and z^{ij} are associated with the polarization and magnetization vectors as shown in [14].

A third property is connectivity. Fields under a common gauge parameter are interlaced. There is a group interconnection where fields are correlated without considering the interactions. It propitiates six correlations types. They are intertwined relationships originated from the gauge parameter, global free coefficients, charges, gauge fixing term, mixing propagators, inductive laws. It says that fields can be gathered without considering the variational principle.

Thus without considering the minimum action principle an association physics is first derived. It is a consequence from this systemic symmetry physics. It works as an extension from Faraday law connecting $\{\vec{E}, \vec{B}\}$ to a potential fields $\{G_\mu^I\}$ correlations. Physically, it expresses that primordially fields can be related between themselves through relationships which are not derived from equations of motion. It creates a field network and says that the information-energy transmissions can be processed through such correlations.

The fourth property is that a global structure is obtained. Observing the corresponding model equations, as Eqs. (2) and (5), one notices that their variables and parameters have a global nature. They are consistent with the global character that the systemic symmetry proposes where it defines that all variables and equations must be derived from a common unit given by the gauge parameter.

Then, from this fact that fields work globally, the meaning of whole appears. It is an approach where fields do not work more isolatedly but integratedly in a whole. It characterizes the so-called antireductionistic process. It says that, based on this whole meaning, and not over isolated elementary particles, this model intends to interpret physics.

Given such fields globalization a next step is to understand the corresponding dynamics. Considering a physics moved through the fields set $\{G_\mu^I\}$, it yields a dynamics written through the directive originated from the gauge parameter and circumstances from the global coefficients. This whole approach produces state equations based on the meanings of directive and circumstance. Consequently the gauge invariance instructions are complemented by a symmetry management. As a new aspect the concept of chance appears. Similar to the concept of probability there is the meaning of circumstance as Appendix C studies.

Thus as a fifth aspect there is another concept of determinism that one cannot predict the future state precisely. There is a whole dynamics defined with the notions of directive established through the gauge parameter and circumstance through global free coefficients. It brings another interpretation for the concept of causality. Like quantum mechanics and chaos, whole gauge models work with an uncertain causality.

A sixth property for this systemic behaviour is organization. There is a new fact for gauge symmetry which is symmetry management. It shows that such whole gauge symmetry provides capacity for modeling. It says that physical processes are not only ruled under fixed interactions but also under the opportunity for developing an organized activity. Physical variables are not just interacting but also being integrated through association, induction and chance. This symmetry management is able to interfere on the minimum action principle, Noether and Ward identity laws [15].

The basis for this gauge organizing principle is the volume of circumstance. It defines the meaning of chance. It is defined in Section II and Appendix C. It says that there is a freedom of circumstance offered by gauge invariance for physical processes. It means the capacity of interfering in the whole system without breaking symmetry. It also allows to manage fields with extra symmetries as

$$G_\mu^{I'} = O_J^I G_\mu^I, \quad (21)$$

where O_J^I means an organizing matrix introducing a symmetry depending on global parameters.

The concern with these fields environment is the possibility of a gauge management. Different Lie groups can be added to the initial symmetry preserving the gauge symmetry, as the organizing matrix O_J^I shows [14]. Another management possibility is to interfere on the equations of motion and some conservation laws without breaking gauge invariance.

An open physics is generated from the fifth and sixth properties. It says that from a given initial field set $\{G_\mu^I\}$ various types of fields conglomerates can be derived. There are various forms of complexity stipulated from elemental fields based on the meaning of directive, chance and organization.

The seventh property corresponds to complexity. Eq. (1) favors not only interactions but also integrations. It appears an

integral physics derived from these six whole properties. It says that nature consists of elementary constituents combined into systemic systems. It yields a network model which combines elementariness and complexity.

Moving from elemental fields G_μ^I to a fields set $\{G_\mu^I\}$ there is a new aspect for a field theory to be explored. While conventional physics does not leave room for a global cooperation, it appears an integral physics. Processes go beyond just elementary interactions. Fields integral properties such as set, diversity, connectivity, directive and circumstance, environment, network and order appear. It leads from the simple to the complex.

In conclusion, we would say that Eq. (1) develops a whole physics that leads to complexity. From it, concepts from complexity as organization and growth of structure, can be studied based on the minimum action principle, Noether principle and on the gauge organizing principle. In a future work we will study laws of complexity and self-organization based on the notion of systemic symmetry.

Appendix A Global Free Coefficients

The first element on this connectivity is the so-called global free coefficients. They are parameters associated with the field strengths. In order to understand them, let us start by working with this whole symmetry at the constructor basis $\{D_\mu, X_\mu^i\}$. It is due to the fact that under this field-referential, the model gauge invariance becomes more immediate. Remember that while D_μ works as a genuine gauge field, X_μ^i correspond to fields that generate quanta but are scalar under the gauge transformation. It yields the following antisymmetric and symmetric field strengths

$$Z_{[\mu\nu]} = dD_{\mu\nu} + \alpha_i X_{\mu\nu}^i + \gamma_{[ij]} X_\mu^i X_\nu^j, \quad Z_{(\mu\nu)} = \beta_i \Sigma_{\mu\nu}^i + \rho_i g_{\mu\nu} \Sigma_\alpha^{\alpha i} + \gamma_{(ij)} X_\mu^i X_\nu^j + \tau_{(ij)} g_{\mu\nu} X_\alpha^i X^{\alpha j}, \quad (A1)$$

where the basic field strengths are $D_{\mu\nu} = \partial_\mu D_\nu - \partial_\nu D_\mu$, $X_{\mu\nu}^i = \partial_\mu X_\nu^i - \partial_\nu X_\mu^i$, $\Sigma_{\mu\nu}^i = \partial_\mu X_\nu^i + \partial_\nu X_\mu^i$. Then, the coefficients $d, \alpha_i, \gamma_{[ij]}, \beta_i, \rho_i, \gamma_{(ij)}, \tau_{(ij)}, m_{ij}$ are identified as the free coefficients of the theory because they can take any value without the involved symmetry being broken.

Diagonalizing the transverse sector, one derives the physical fields as that ones which physical masses are the poles of the two-point Green functions. So the physical basis $\{G_\mu^I\}$ is defined as $D_\mu = \Omega_{1I} G_\mu^I$, $X_\mu^i = \Omega_{iI} G_\mu^I$ where the Ω matrix is a function of these initial free gauge coefficients as Appendix B shows. It rewrites Eq. (A1) on the $\{G_\mu^I\}$ basis

$$Z_{[\mu\nu]} = b_I G_{\mu\nu}^I + z_{[\mu\nu]}, \quad Z_{(\mu\nu)} = \beta_I \Sigma_{\mu\nu}^I + \rho_I g_{\mu\nu} \Sigma_\alpha^{\alpha I} + z_{(\mu\nu)} + g_{\mu\nu} \omega_{(\alpha)}^{\alpha}, \quad (A2)$$

with $G_{\mu\nu}^I = \partial_\mu G_\nu^I - \partial_\nu G_\mu^I$, $\Sigma_{\mu\nu}^I = \partial_\mu G_\nu^I + \partial_\nu G_\mu^I$, $z_{[\mu\nu]} = \gamma_{[IJ]} G_\mu^I G_\nu^J$, $z_{(\mu\nu)} = \gamma_{(IJ)} G_\mu^I G_\nu^J$, $\omega_{(\mu\nu)} = \tau_{(IJ)} G_\mu^I G_\nu^J$. Now, the corresponding global free coefficients are

$$b_I = d\Omega_{1I} + \alpha_i \Omega_i^I, \quad \gamma_{[IJ]} = \gamma_{[ij]} \Omega_i^I \Omega_j^J, \quad \beta_I = \beta_i \Omega_i^I, \quad \rho_I = \rho_i \Omega_i^I, \quad \gamma_{(IJ)} = \gamma_{(ij)} \Omega_i^I \Omega_j^J, \quad \tau_{(IJ)} = \tau_{(ij)} \Omega_i^I \Omega_j^J. \quad (A3)$$

The new fact is that the coefficients written at Eq. (A3) are not just free coefficients but take the expression as whole free coefficients. They show a first manifestation of the existence of the totality conjecture. Their corresponding index I is expressing global coefficients.

Appendix B Global Physical Fields

Although this whole symmetry can be worked out through different fields sets, the corresponding spectroscopy is revealed when one works on the so-called physical basis $\{G_\mu^I\}$. The associated G_μ^I fields are that ones which by diagonalizing the Lagrangian transverse sector they specify the quantum numbers corresponding to the spin-1 sector. Because of this they are identified as physical fields. They are related to the constructor basis through the so-called Ω -matrix defined through the transformations $D_\mu = \Omega_{1I} G_\mu^I$, $X_\mu^i = \Omega_{iI} G_\mu^I$. To express the Ω -matrix, one has to compare the kinetic sector between $\{D, X^i\}$ -basis

$$\mathcal{L}(V) = -\frac{1}{2} V_\mu^t \{ (K \square + M^2) P_T^{\mu\nu} + (K_L \square + M^2) P_L^{\mu\nu} \} V_\nu, \quad (B1)$$

where $V^t \equiv (D, X^i)$, and the transverse diagonalized physical sector

$$\mathcal{L}(G) = -\frac{1}{2} G_\mu^t \{ (\square + m^2) P_T^{\mu\nu} + [(a_{(IJ)} + b_{(IJ)} + c_{(IJ)}) \square + m^2] P_L^{\mu\nu} \} G_\nu. \quad (B2)$$

It yields the following Ω -matrix relationships:

$$\Omega^t K \Omega = \mathbb{1}, \quad (B3)$$

$$\Omega^t M^2 \Omega = m^2 \quad (\text{diagonal}), \quad (B4)$$

with

$$\Omega = S^t \tilde{K}^{-\frac{1}{2}} R^t, \quad (B5)$$

and

$$\tilde{K} = SKS^t, \quad (B6)$$

where S and R are unitary matrices which diagonalize the kinetic and mass terms. The explicit attainment of the Ω -matrix is carried out in 3 main steps: diagonalization of the kinetic matrix through the orthogonal matrix S ; normalization of the diagonalized kinetic term (this step brings about the matrix $\tilde{K}^{-\frac{1}{2}}$) and, finally, diagonalization of $\tilde{M}^2$, which is accomplished by means of the orthogonal matrix R .

It is perhaps important to stress that, though it might seem very cumbersome, the final explicit form for Ω may be obtained in a simplified way, as far as we are able to write S in such a way that it explicitly depends on the eigenvalues of K . The trick of replacing the entities of S by the eigenvalues λ_i , rather than expressing them directly in terms of the parameters d , α_i and β_i , yield very workable expressions in the task of diagonalizing $\tilde{M}^2$ and finding the form of R .

As illustrated in what follows, we apply the procedure described above of the simplest case of 2 fields, where the difficulty of writing Ω explicitly has already felt it we do not work to simplify the entries of S . Also, this explicit example allows us to understand more directly that the Ω -matrix is sensitive to the parameters that appear in the kinetic term. The final answer for Ω and the final combinations that define the physical fields $\{G_\mu^I\}$ in terms of the constructing basis $\{D, X^i\}$ are completely set out in terms of the parameters d , α_i , β_i and m_i^2 .

Consider the kinetic matrix K :

$$\begin{bmatrix} d^2 & d\alpha_1 \\ d\alpha_1 & \alpha_1^2 + \beta_1^2 \end{bmatrix}, \quad (B7)$$

with the following eigenvalues (>0):

$$\begin{aligned} \lambda_1 &= \frac{1}{2}\alpha_1^2 + \frac{1}{2}\beta_1^2 + \frac{1}{2}d^2 + \frac{1}{2}\sqrt{\alpha_1^4 + 2\alpha_1^2\beta_1^2 + 2\alpha_1^2d^2 + \beta_1^4 - 2d^2\beta_1^2 + d^4}, \\ \lambda_2 &= \frac{1}{2}\alpha_1^2 + \frac{1}{2}\beta_1^2 + \frac{1}{2}d^2 - \frac{1}{2}\sqrt{\alpha_1^4 + 2\alpha_1^2\beta_1^2 + 2\alpha_1^2d^2 + \beta_1^4 - 2d^2\beta_1^2 + d^4}, \end{aligned} \quad (B8)$$

and normalized eigenvectors:

$$v_1 = \left[\frac{d^2 - \lambda_2}{d\alpha_1}, 1 \right], \quad v_2 = \left[\frac{d^2 - \lambda_1}{d\alpha_1}, 1 \right], \quad (B9)$$

Then diagonalizing K , one gets the following S matrix:

$$S = \begin{bmatrix} \frac{d^2 - \lambda_2}{|v_1|d\alpha_1} & \frac{1}{|v_1|} \\ \frac{d^2 - \lambda_1}{|v_2|d\alpha_1} & \frac{1}{|v_2|} \end{bmatrix}. \quad (B10)$$

Consider now the mass matrix M^2 :

$$M^2 = \begin{bmatrix} 0 & 0 \\ 0 & m_{22}^2 \end{bmatrix}, \quad (B11)$$

which express the $\tilde{M}^2$ matrix:

$$\tilde{M}^2 = SM^2S^t, \quad (B12)$$

$$\tilde{M}^2 = \begin{bmatrix} \frac{m_{22}^2}{|v_1|^2} & \frac{m_{22}^2}{|v_1||v_2|} \\ \frac{m_{22}^2}{|v_1||v_2|} & \frac{m_{22}^2}{|v_2|^2} \end{bmatrix}. \quad (B13)$$

Calculating $\tilde{K}^{-\frac{1}{2}}$:

$$\tilde{K}^{-\frac{1}{2}} = \begin{bmatrix} \frac{1}{\sqrt{\lambda_1}} & 0 \\ 0 & \frac{1}{\sqrt{\lambda_2}} \end{bmatrix}, \quad (B14)$$

one gets $\tilde{M}^2$:

$$\tilde{\tilde{M}}^2 = \tilde{K}^{-\frac{1}{2}} \tilde{M}^2 (\tilde{K}^{-\frac{1}{2}})^t, \quad (\text{B15})$$

$$\tilde{\tilde{M}}^2 = \begin{bmatrix} \frac{m_{22}^2}{\lambda_1 |v_1|^2} & \frac{m_{22}^2}{\sqrt{\lambda_1 \lambda_2} |v_1| |v_2|} \\ \frac{m_{22}^2}{\sqrt{\lambda_1 \lambda_2} |v_1| |v_2|} & \frac{m_{22}^2}{\lambda_2 |v_2|^2} \end{bmatrix}, \quad (\text{B16})$$

which eigenvalues:

$$l_1 = 0, \quad l_2 = \frac{a+a\xi^2}{\xi},$$

and eigenvectors:

$$u_1 = [1, -\xi], \quad u_2 = [\xi, 1],$$

with

$$a = \frac{m_{22}^2}{\sqrt{\lambda_1 \lambda_2} |v_1| |v_2|}, \quad \xi = \frac{\sqrt{\lambda_2} |v_2|}{\sqrt{\lambda_1} |v_1|}, \quad (\text{B17})$$

allows to build up the R matrix:

$$R = \begin{bmatrix} \frac{1}{\sqrt{1+\xi^2}} & \frac{-\xi}{\sqrt{1+\xi^2}} \\ \frac{\xi}{\sqrt{1+\xi^2}} & \frac{1}{\sqrt{1+\xi^2}} \end{bmatrix}. \quad (\text{B18})$$

Thus we can build up the Ω matrix defined in (B5)

$$\Omega = S^t \tilde{K}^{-\frac{1}{2}} R^t, \quad (\text{B19})$$

$$\begin{aligned} \Omega_{11} &= \{ |v_2| \sqrt{\lambda_2} d^2 - |v_2| \lambda_2^{3/2} - \xi |v_1| \sqrt{\lambda_1} d^2 + \xi |v_1| \lambda_1^{3/2} \} / \{ |v_1| |v_2| \sqrt{\lambda_1 \lambda_2} d \alpha_1 \sqrt{1+\xi^2} \}, \\ \Omega_{12} &= \{ \xi |v_2| \sqrt{\lambda_2} d^2 - \xi |v_2| \lambda_2^{3/2} + |v_1| \sqrt{\lambda_1} d^2 - |v_1| \lambda_1^{3/2} \} / \{ |v_1| |v_2| \sqrt{\lambda_1 \lambda_2} d \alpha_1 \sqrt{1+\xi^2} \}, \\ \Omega_{21} &= \{ |v_2| \sqrt{\lambda_2} - \xi |v_1| \sqrt{\lambda_1} \} / \{ |v_1| |v_2| \sqrt{\lambda_1 \lambda_2} \sqrt{1+\xi^2} \}, \\ \Omega_{22} &= \{ \xi |v_2| \sqrt{\lambda_2} + |v_1| \sqrt{\lambda_1} \} / \{ |v_1| |v_2| \sqrt{\lambda_1 \lambda_2} \sqrt{1+\xi^2} \}, \end{aligned} \quad (\text{B20})$$

Finally, substituting ξ value, one gets

$$\begin{aligned} \Omega_{11} &= \{ -|v_2| \lambda_2^{3/2} + \lambda_1 \sqrt{\lambda_2} |v_2| \} / \{ |v_1| |v_2| d \alpha_1 \sqrt{\lambda_1 \lambda_2} \sqrt{1 + \frac{\lambda_2 |v_2|^2}{\lambda_1 |v_1|^2}} \}, \\ \Omega_{12} &= \left\{ \frac{\lambda_2 |v_2|^2 d^2}{\sqrt{\lambda_1} |v_1|} - \frac{\lambda_2^2 |v_2|^2}{\sqrt{\lambda_1} |v_1|} + |v_1| \sqrt{\lambda_1} d^2 - |v_1| \lambda_1^{3/2} \right\} / \{ |v_1| |v_2| d \alpha_1 \sqrt{\lambda_1 \lambda_2} \sqrt{1 + \frac{\lambda_2 |v_2|^2}{\lambda_1 |v_1|^2}} \}, \\ \Omega_{21} &= 0, \quad \Omega_{22} = \left\{ \frac{\lambda_2 |v_2|^2}{\sqrt{\lambda_1} |v_1|} + |v_1| \sqrt{\lambda_1} \right\} / \{ |v_1| |v_2| \sqrt{\lambda_1 \lambda_2} \sqrt{1 + \frac{\lambda_2 |v_2|^2}{\lambda_1 |v_1|^2}} \}. \end{aligned} \quad (\text{B21})$$

Given the above expressions, one confirms that this wholeness principle is expressed in the gauge transformations. Eq. (1) is showing a weight (Ω^{-1}) which is depending on the global free coefficients.

Appendix C Volume of Circumstances

A consequence from the antireductionist symmetry is the appearance of the so-called free and global coefficients. They are coefficients that can take any value without violating gauge invariance. The constructor basis, $\{D, X^i\}$, is the natural place to observe the free coefficients. And at physical basis, $\{G^I\}$, is where the global coefficients are identified.

Thus one should systematize the presence of these coefficients in the model. The free coefficients are associated with scalar terms. There are two origins: from gauge scalars given by fields strengths, and from gauge and Lorentz scalars given by the Lagrangian terms. So from Eq. (2.5) one notices that d , α_i , $\gamma_{[ij]}$, ..., $\tau_{(ij)}$ represent the gauge free coefficients. Observe that d and α_i coefficients can be absorbed through fields redefinition. At Table 1 the free coefficients are listed. It contains the so-called volume of circumstances which says that a whole model provides certain circumstances for the quanta involved on it.

TABLE 1 FREE COEFFICIENTS

Scalar	Free coefficient	Number of free coefficients
$D_{\mu\nu}D^{\mu\nu}$	d^2	1
$D_{\mu\nu}X^{\mu\nu}$	$2d\alpha_i$	$N - 1$
$D_{\mu\nu}X^{\mu i}X^{\nu j}$	$2d\gamma_{[ij]}$	$(N - 1)(N - 2)/2$
$X_{\mu\nu}^iX^{\mu\nu j}$	$\alpha_i\alpha_j$	$(N - 1)^2$
$X_{\mu\nu}^iX^{\mu k}X^{\nu j}$	$2\alpha_i\gamma_{[kj]}$	$(N - 1)^2(N - 2)/2$
$X_{\mu}^iX_{\nu}^jX^{\mu k}X^{\nu l}$	$\gamma_{[ij]}\gamma_{[kl]} + \gamma_{(ij)}\gamma_{(kl)}$	$(N - 1)^2[(N - 1)^2 + 1]/2$
$\Sigma_{\mu\nu}^i\Sigma^{\mu\nu j}$	$\beta_i\beta_j$	$(N - 1)^2$
$g^{\mu\nu}\Sigma_{\mu\nu}^i\Sigma_{\alpha}^{\alpha j}$	$2\beta_i\rho_j$	$(N - 1)^2$
$\Sigma_{\mu\nu}^iX^{\mu k}X^{\nu j}$	$2\beta_i\gamma_{(kj)}$	$N(N - 1)/2$
$g^{\mu\nu}\Sigma_{\mu\nu}^iX_{\alpha}^kX^{\alpha j}$	$2\beta_i\tau_{(kj)}$	$N(N - 1)^2/2$
$\Sigma_{\alpha}^{\alpha i}\Sigma_{\beta}^{\beta j}$	$4\rho_i\rho_j$	$(N - 1)^2$
$g^{\mu\nu}\Sigma_{\alpha}^{\alpha i}X_{\mu}^kX_{\nu}^j$	$2\rho_i\gamma_{(kj)}$	$N(N - 1)^2/2$
$\Sigma_{\alpha}^{\alpha i}X_{\beta}^kX^{\beta j}$	$8\rho_i\gamma_{(kj)}$	$N(N - 1)^2/2$
$X_{\alpha}^iX^{\alpha j}X_{\beta}^kX^{\beta l}$	$2\gamma_{(ij)}\tau_{(kl)} + 4\tau_{(ij)}\tau_{(kl)}$	$[N(N - 1)]^2/2$
$X_{\mu}^iX^{\mu j}$	$\frac{1}{2}m_{ij}^2$	$N(N - 1)/2$

Considering the contributions from antisymmetric, symmetric and mass sectors the number of free coefficients is $1 + (N - 1)(N^3 + 2N - 4)$. Adding the semitopological term we have more $(N^4 - 2N^3 + N^2 - 4N + 4)/4$. Thus the total number of free coefficients carried by the whole abelian Lagrangian is $(3N^4 - 8N^3 + 13N^2 - 12N + 8)/4$ where just $(3N^2 - 3N + 4)/2$ involves D_{μ} field.

Then from these initial coefficients plus the Ω matrix elements (which are also determined by free coefficients) one derives the global coefficients. They appear on the physical basis, $\{G^I\}$. There the global character that this whole symmetry intends to define can be explicitly understood by analyzing the equations of motion. They appear parametrized by such global coefficients.

Appendix D Circumstantial Symmetries

Two consequences from the circumstantial symmetry property developed by the global gauge model will be considered. They are the longitudinal decoupling and the new symmetries. Here circumstance on symmetry means to determine the coefficients $b_I, \beta_I, \rho_I, \gamma_{[IJ]}, \gamma_{(IJ)}, \tau_{(IJ)}$ for a certain objective without breaking gauge invariance. However, being a physical problem one has first to establish what would be the physical prescription. Thus we define by order as the model intention to have the following characteristics: antisymmetric quanta (b_I), fields environment ($\gamma_{(IJ)}$), self-interaction photons ($\gamma_{(IJ)}, \tau_{(IJ)}$), symmetric quanta (β_I, ρ_I).

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