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CHARGE IN QUANTUM THEORY

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Abstract: **It is introduced the concept of quantum particle, characterized by its charge as a fundamental magnitude, since the relativistic mass appears as a quantity derived from it and other electromagnetic quantities; these particles correspond to the many-particle representation in Quantum Field Theory, so their characteristics are different from the "inertial" masses that obey the laws of Chemistry and Classical Mechanics.**

Quantum particles set up an "inner" space, induced by charges and represented by fields, which can be arranged in three levels, according to their energies: a) strong, as the origin of the real or inertial mass corresponding to hadrons; b) weak, for formation of atomic nuclei; c) electromagnetic, responsible of electronic structure of atoms and molecules.

Physical quantities, that is, the quantum numbers, appear as a result of the transformations produced by Lie Group on the fields, which conform to the conditions imposed by Lie Algebra, in line with Gauge Symmetry.

Keywords: **Quantum particle, coupling constant, electromagnetic mass.**

1. INTRODUCTION

The confused and ambiguous world of physical phenomena becomes an extended family of "disorder", that is, the chaos that arises from thae variability and the chance, which dominates the real world; the purpose of Physics is to turn them into certainties thanks to the determinism implicit in the theories, which is achieved from space and time coordinates by newtonian laws of Mechanics and Gravitation on the one hand and Electromagnetism on the other.

On the other hand, the disorder acquires great relevance when those laws have to be apply to a very high number of particles, in which case, you have to build a new branch, Statistical Physics, where on trying to establish a certain order, that is, to build appropiate deterministic laws, we shall have to introduce new physical variables, like heat (Q) and temperature (T); but the "disorder" is converted in a physical law, thanks to entropia, $\Delta S = \Delta Q/T$, which increases in a natural way to get a greater uniformity (variability).

It is noteworthy that every time a a topic or issues of difficult understanding quantum phenomena appear as an example of such qualification; this is due, that apparently the disorder dominates the microworld in the form of uncertainty, inherent to Quantum Theory, whose formulation becomes a true Principle, according to which Momentum and Energy, as well as the space traveled and the elapsed time, will not bew able to have defined values.

Thus, in the field of subatomic particles there will not be a kinematics, since it is not possible a defined path; in that case, we have to find the appropiate physical "quantities", outside the space-time coordinates, as it happens with Statistical Physics.

In order to establish such magnitudes we must use electromagnetic radiation, which by itself appears completely deterministic, according to Maxwell's equations, but its interaction with "matter" or its production as blackbody radiation, forced to introduce the energy "quanta", that requires a statistical treatment.

The origin of quantization it is found in the charge, "quantified" by itself, and whithout which would not be possible the existence of radiation (electromagnetic waves); from this fact it is possible to handle the physical quantities (observables) of Quantum Theory.

2. CHARGES: COUPLING CONSTANTS (SCALING)

Coupling constant, g, contributes to the interaction force of fields, so that in the simple electrostatic case, g ≡ *e*, which together with the electric field, ***E*,** allows to obtain the force

F = *e**E***; besides, if we take into account that the electric field is given by $\boldsymbol{E} = \nabla V$, where V is the electrostatic potential, we may have the energy involved, E = *eV*.

In a general way, one may get the interaction by $J_\mu A^\mu$, where J_μ = (g, ***j***) is the current and $A^\mu = (A^o, \boldsymbol{A})$, where $A^o = V$ is the escalar potential and $\boldsymbol{A} = \boldsymbol{V}$ the vector one; in the electromagnetic case, g = *e*, ***j*** = *e**v*,** namely, the electric current so that the interaction will be given by $J_\mu A^\mu = (e.V, \boldsymbol{j}.\boldsymbol{V}) = e.V = E$ (1), where $\boldsymbol{j}.\boldsymbol{V} = 0$, since the vector potential is related to magnetic field through $\boldsymbol{B} = \nabla \wedge \boldsymbol{V}$ and this is always acting orthogonally over the current, ***j.***

Therefore, the interaction's strength is reduced to the Energy, that it will be considered as an exchange of energy "quanta" (photons), as we can see later.

With this approach, it appears logical that "interactions" are reduced to the search for the coupling constants and the corresponding potentials; its relationship with mass is taking place in a relativistic context through the mas-energy equavalence, which imply the use of electron-volt (eV), as unit of mass (energy)

This will be in consonance with the involved symmetry in the arbitrary transformation of the "phases" over electromagnetic field by the uniparametric and abelian Group U(1) = $e^{i\alpha}$, where α is the angle as a variable in the phase space and the normal derivative ∂_μ becomes the covariant Derivative: $D_\mu = \partial_\mu + ieA_\mu$; so, we see that electromagnetic interaction, eA_o = E is contained in the timelike of the relativistic potential four-vector A_μ.

On the other hand, it is usually to find in the works about strong and weak interactions, as an exchange of energy quanta, due to momentum transfer, *p*, which would be the variable that determines the coupling constant, g(*p*); so, for greater *p*, we will have higher g and consequently a big intensitity in the interaction.

This explanation is due to a mechanical point of view of the relativistic mass, but such an interpretation may be questioned, as it will be discussed in what follows.

3. THE AMBIGUITY OF RELATIVITY

The confusión comes from the fact the in trying to overcome the Newtonian concepción of times and space as absolute physical magnitudes, it seems to have been forgotten that in reality the only "absolute" is the constancy of the speed of light (radiation) in vacuum, *c*, so that the physical quantities linked to it, such as the "proper" time and the mass "at rest", can not be constant, because in that case they would become absolute; therefore, they should be variable.

Por that reason, the analysis carried out by Relativity is adequated in its approach, but "false" in its pretension of **Unifying** Electromagnetism and Classical Mechanics, as we shall see below and we have made with our previous article: *"Relativity: The Real Meaning".* International Journal of Mathematics and Physical Sciences Research. Vol.4, Issue 2, pp:(105-114), Month: October 2016-March 2017. Available at: www.research publish.com.

3.1 Relative time and mass: the identities

To begin with, the problem lies in the treatment of parameters or variables such as time, space, mass, etc., which are indeterminate in the microworld of subatomic particles, while from a mechanical point of view they are well defined.

Also, the name of Quantum "Mechanics" does not seems consistent with the uncertainty principle, but this may be assumed by Quantum Field Theory in consonance with Relativity, where thanks to the velocity, v, (given a priori) we may get the so-called time "dilation" formula: $dt = dt'/\sqrt{(1-v^2/c^2)}$ (2), according to which, the elapsed times, *dt* and *dt'* are estimated from the fixed (O) and the moving frames (O'), respectively.

This formula is equivalent to $c^2dt^2 - v^2dt^2 = c^2dt'^2$ (3), which represents the geometric construction, where *vdt* is perpendicular to *cdt';* then it is introduced the concept of Interval: $ds = cdt' = cd\tau$ = const, and (3) becomes the equation: $c^2dt^2 - v^2dt^2$ = const,

How is it possible to admit an elapsed time, dt' (dτ), constant, while the other, dt , variable?

It turns out a postulate or axioma that is justified by the existence of two observers placed in the fixed frames (O) and the moving (O') one, without realizing that these reference systems only makes sense in relation to the coordinates (x,t) and (x',t'), but when it had been reduced to the elapsed times, dt, dt', the coordinates, x', disappears, so the moving frame (O') is "redundant".

For this reason, the relationship between both times, $dt/dt' = cdt/cdt'$, must be fulfilled whatever the velocity, v**,** so that both dt and dt' must be variable and the constancy of dt' is not admissible, because when v= 0, ==> $dt = 0$, that is, the elapsed times, dt, disappears.

In any case, due to the optional feature of the velocity, v, both the elapsed time dt and the space, $dx = vdt$, shall be "indetermined", so the only certainty is $dt > dt'$, with what we may interpret the formula $dt' = dt\sqrt{(1-v^2/c^2)}$, in the sense that the velocity, v, also affects to the value of dt'.

All this shows that the formula of time dilation or its equivalent (3) is really a mathematical **identity**, which explain why it is not possible to test it experimentally ("thoughts" experiences), something that whould not be surprising, since the same happens with the Energy "equation": $E^2 - c^2p^2 \equiv (m_oc^2)^2$ (4).

Indeed, if we take into account that the introduction of mass m_o, had the main purpose of getting the relativistic mass, $m = m_o/\sqrt{(1-v^2/c^2)}$ (5), which in turn allows to get the formulas for Energy: $E = mc^2 = m_oc^2/\sqrt{(1-v^2/c^2)}$ (6) and Momentum: $\boldsymbol{p} = m\boldsymbol{v} = m_o\boldsymbol{v}/\sqrt{(1-v^2/c^2)}$ (7); then, it is easy to see that if we introduce both formulas in (4), the quantity $(m_oc^2)^2$ is obtained by a simple algebraic operation, disappearing E^2 and $(c\boldsymbol{p})^2$.

For this reason, both physical quantities shall be mutually "exclusive" of m_oc^2, that is, the latter should not be used simultaneously than E and $c\boldsymbol{p}$; with other words, the final state, m_oc^2, coincides with the one given initially, in consonance with the mathematical "identity", which in Philosophy is called "tautology".

The result is that the use of the mass, m_o as mass of the particles is not correct; indeed:

1) The mass, m_o, should not be considered a "rest" mass, because the very identity claims that for v = 0, the mass, m disappears, and m_o would be irrelevant.

2) The constancy of m_o seems to work through the "tricky way" of dispensing with the relativistic mass, m, so that all the (mathematical) arguments are based on recourse directly to the formula (4), where the only quantities are E and $\boldsymbol{p}$; but, the "identity" is already inserted in the formula (5), so this should be written: $m \equiv m_o/\sqrt{(1-v^2/c^2)}$ ===> $(mc^2)^2 - c^2\boldsymbol{p}^2 \equiv (m_oc^2)^2$, from which it is easy to demonstrate that $m_o \neq const$:

Indeed, if we consider two velocities, $v_2 > v_1$ ==> $m_2 > m_1$, so the energy variation will be greater than that of momentum, that is, $(m_2^2 - m_1^2)c^2 > c^2(m_2^2v_2^2 - m_1^2v_1^2)$ ===>

$(m_2c^2)^2 - c^2(m_2v_2)^2 > (m_1c^2)^2 - c^2(m_1v)^2$ ===> $E_2^2 - c^2p_2^2 > E_1^2 - c^2p_1^2$; for this reason, the relativistic, m, must be the only one that should be used, in the same way that happens with the times; with other words, m, replaces to m_o, on account of the dilation coefficient, $1/\sqrt{(1-v^2/c^2)}$, which is the mathematical meaning of the "identity".

3) As it will be discussed below, m_o, may be associated to "vacuum", that is, it is like an empty mass, from which may be produced the relativistic mass, m, corresponding to elementary particles, either fermions or bosons.

3.2 Electromagnetic mass:

The formula of the energy (4) is usually expressed by Four-momentum: $p^2 = E^2 - c^2\mathbf{p}^2$ = const, but such constant is just eventual, that is, it is only valid for a certain value of the velocity, v, which indicates that this physical quantity is actually, variable, as we have shown above.

Then, Relativistic Dynamics is reduced to the the formulas of Energy, $E = mc^2$ and Momentum, $\boldsymbol{p} = m\boldsymbol{v}$**,** whose relationship is rather peculiar, since it takes place through the relativistic mass that, in turn depends on any value of velocity, v, producing an "indetermination" in both physical magnitudes, that can be interpreted in a statistical way, that allows to connect them with the equations of Planck: $E = \hbar w$ (8) on radiation and De Broglie, $\boldsymbol{p} = \hbar\boldsymbol{k}$ (9), on the wave-corpuscle duality.

It also happens with the time interval, dt, and the corresponding space, $dx = vdt$, with which these physical quantities may be adjusted to the **quantization**, through the so-called Uncertainty Principle: $\Delta E.\Delta t \geq \hbar$; $\Delta x.\Delta p \geq \hbar$ ==> $\Delta E.dt \geq \hbar$; $dx.\Delta\boldsymbol{p} \geq \hbar$, (10).

The statistical behaviour implies that we have a many-particles system and then comes into play the Quantum Field Theory, where the continuous space-time fails.

How such kind of mass may characterize a particle?.

It seems evident that the only way to accept this sort of **mass** is being of **electromagnetic** nature and **virtual** because it is linked to the velocity, *c*, that no corporeal (inertial) mass can assume; as for momentum, $\boldsymbol{p} = m\boldsymbol{v}$, it should not be accepted by newtonian dynamics, because it depends doubly on velocity, v, not allowing the existence of any force, since in Special Relativity no acceleration is possible and the so-called Minkowski force is just a mathematical device, since it is defined from $m_o\boldsymbol{v}$, instead of $m\boldsymbol{v}$.

Further, the electromagnetic nature of the mass is in line with the unit chosen, electron-Volt (eV) , under the equivalence $eV \equiv mc^2$, with which the status of particle given to mass is really due to the **charge**, *e*, in consonance with Thompson's experiment about the mass of electron, *m*, that could not be obtained without the prior knowledge of the charge (Millikan's experiment) and other electromagnetic magnitudes.

Where the velocity is coming from?.

In a formal way, Lorentz Group shows us that it is introduced by the so called, "boost" and then we will have the Momentum, $\boldsymbol{p} = m\boldsymbol{v}$, which is equivalent to the production of the current, $\boldsymbol{j} = e\boldsymbol{v}$ when it is applied a difference of potencial.

But that transformation does not allow "displacement", having to be increased by the so-called Poincaré Group, where the rotation is implicit; so, we have the key to start with the adecuated physical quantity or "observable": Angular Momentum.

4. ANGULAR MOMENTUM

Angular momentum in a given volumen is coming by $l = \int \rho_m (r \wedge v) dV$, which it appears to be equivalent to magnetic momentum, $\mu = 1/2 \int \rho (r \wedge \mathrm{v}) \mathrm{dV} = 1/2 \int r \wedge j) dV$, where ρ_m is mass density, while ρ charge density.

The relationship between the two variables is a constant, $\Gamma = \frac{\mu}{l}$, called "gyromagnetic ratio"; for a proton or neutron it is usually introduced a form factor, *G*, so that $\Gamma = Ge/2m$, but for an elementary particle like electron, $G = 2$ and $\Gamma = e/m$ (11).

The magnetic momentum definition is just "kinematic", as it is the dielectric moment of a polarized molecule, $p = \int \rho r dV$, which is merely an alignment of charges; but, in the special case of a closed stationary current, the magnetic momentum will be, $\mu = jS$.

The angular momentum's quantization can only be verified experimentally by a magnetic field, which acts as usual on a moving charge, through the formula $\mathbf{F} = e\mathrm{v}\mathrm{x}\boldsymbol{B}$. But if we use the magnetic momentum, this expression becomes $\mathbf{F} = \nabla(\mu.\boldsymbol{B}) = \mu.\nabla\boldsymbol{B}$, (12), where μ is constant that may be corresponding to any component of angular moment, l_a or spin, s_a, with which the interaction will be possible.

Therefore, in the study of bound electron to the atomic structure, it is plausible and convenient to transfer the relevant properties of spin, *s*, and angular momentum, *l*, to magnetic moment, where charge must be the essential parameter instead of mass, since this appears as derivative of that, as can be deduced from (11).

Thus, the equivalence of momentum, $\boldsymbol{p} = m\boldsymbol{v}$ and $\boldsymbol{j} = e\boldsymbol{v}$, as was stated before, appears in a consistent manner; anyway, their purpose are to obtain both angular and magnetic momentum, for establishing the quantum numbers. Also, being the angular momentum, *l*, the physical magnitude, it must be admittted that relativistic mass should be derived from **charge,** in line with what is obtained experimentally, where velocity is implicit and its dependence of electromagnetic parameters is undoubted.

Finally, we can point out that with the magnetic momentum, μ, apart from being in agreement with the experimental requirement, it turns out much more appropiate to understand the issue about "orbitals" in the electronic structure, which may be carried out by Lie Group and Lie Algebra.

4.1 Lie Group:

Rotations form a "vector space" which physically correspond to angular momentum, l, as we have seen. In the macroscopic world this is expressed like a well defined orbit (circular or elliptical) of a movement around an axis, which has a vector direction, $\boldsymbol{l} = \mathbf{r} \wedge m\mathbf{v}$ and where the coordinates (x,y,z) allows any value of **r, v** and $\boldsymbol{l}$.

In the microcosm of subatomic particles, rotations arise when considering the phase, *(wt-kx)*, that define electromagnetic waves through the function exp*(wt-kx)*, where is easy to see that the angle, as a geometric variable is contained in the same.

In the same way that the charge, responsibles for electromagnetic waves, are related to the mass, the momentum magnetic, μ, must do so with the momentum angular, l, with which the quantization of both physical quantities arise like "constrains" over the rotations themselves.

The mathematical relationship that set up angular momentum is generated by rotations acting on a escalar field, $\phi(x)$, according to the expression $\phi(x') = U(\theta_a)\phi(x)U^{-1}(\theta_a)$, where $U(\theta_a) = \exp(\theta_a l_a)$ (13), where l_a is the angular momentum whose components in the rotational (angular) space is given by $l_a = \partial/\partial\theta_a$, which is equivalent to those corresponding to coordinates space (x,y,z), $l_k = \epsilon_{ijk} x_i \partial_j$.

Such transformation corresponds to the Group SO(3), which acts in the functions space or vector fields, ϕ^i: $U(\theta_a)\phi(x)^i U^{-1}(\theta_a) = \phi^{ij}(-\theta_a)\phi^j(x')$ (14).

It is the so-called Lie Group, that it makes the configuration of an "inner" space, which together with its corresponding Lie Algebra, describes pretty well the physical situation.

4.2 Lie Algebra:

Let's see more accurately what have been said before: the mapping (homomorphism) of the Lie group, SO(3), over the phase, completes the "inner" space, through $so_{(3)}$, that set up the Lie Algebra; this arises from the expression (13), which now it becomes $U = \exp(\varepsilon_a t_a)$, where $\varepsilon_a \equiv \theta_a$ are the real parameters and t_a the generators.

These are associated with the directions (rotation axis), whose unit vectors correspond to angular momentum, ie, $t_a = l_a$ and then, Lie Algebra is given by $[l_a, l_b] = \epsilon_{abc} l_c$ (15) , where the so-called structure constant, ϵ_{abc} is antisymmetrical: $\epsilon_{abc} = -\epsilon_{bac}$.

This characteristic determines the structure of the Algebra itself, that provided us the values of l_a connected with each rotating axis of the system; thus, focusing on l_c, we will have $+l_c$ if the order is *ab*, but $-l_c$ for the order *ba*, while for $l_a = l_b$ ==> $l_c = 0$.

Adjusting to such criteria, we can get the possible values the angular momentum, which shall be asigned to electrons distributed around the "charges" (protons) of atomic nucleous, which by virtue of **quantization** gives rise to the electronic structure of atoms:

- 3 dimensions (axis)) -->angular momentum of orbitals "p" (-1, 0, +1)
- 5 axis ---> angular momentum of electrons "d" (-2, -1, 0, +1, +2)
- 7 axis ---> angular momentum of electrons "f" (-3, -2, -1, 0, +1, +2, +3).

As we have previously indicated, **r** and **v** are implicit, so that the corresponding orbits do not exist, but the so-called orbital, and its spacial distribution or probability is assigned to each axis separately, like $p_x(l_a)$, $p_y(l_b)$, $p_z(l_c)$.

To complete the picture of quantum numbers associated with rotations, we have to add the intrinsec angular momentum or **spin**, which should be established around a single axis that is impossible, since in that case, $l_a = l_b$ ==> $l_c = 0$, that is, there will be no rotation, but a spherical symmetry corresponding to orbital "s".

In order to establish this special "rotation", we must apply the group SU(2) on the complex field, $U = \exp(i\varepsilon_a\sigma_a)$ (16), where σ_a are the known matrices (operators) of Pauli, as a unit vectors, s_a, of the axes of rotations taking place in the abstract space or complex space, which having two components, there will be only one axis of rotation.

Now, we can make use of the preceding formula, so that its manifestation in the phase space is produced by Lie Algebra, thanks to the mapping (homomorfism): SU(2) --> $_{SU(2)}$ ==> $[\sigma_a, \sigma_b] = i\epsilon_{abc}\sigma_c$ ==> $[s_a, s_b] = i s_{abc} s_c$ (17) , like that of angular momentum, l.

Then, we may consider s_c, whose values +1/2 or -1/2, are due to the fact that in the complex field a complete rotation requires twice that in the real one, that is, 4π, so the manifestation of the spin will be half of the angular momentum, *l*. In this way, it may contribute to the total angular momentum, $J = l + s$, which determines the energy of electrons in the atom and whose conservation is required throughout subatomic process.

Finally, electronic distribution appears as a many-particle state, namely, a set of "identical" and "indistinguishable" quantum particles for electrons, which on the other hand can be considered individually, so that each one may be found in any of the multiples possibilities or "degree of freedom" indicated by angular momentum, in consonance with Pauli's Exclusion Principle.

5. ENERGY LEVELS

As we have seen, angular momenta set the criteria for the electronic distribution of atoms; such provision shall determine the different energy levels, that is its **quantization;** so, the first two electrons constitute the energy level, n = 1, with two sublevels, $s_+ = +1/2$ y $s_- = -1/2$; the next lervel, n = 2, for $l = 1$ and $s = ½$, there will be a total of eight electrons, which shall be positioned according the same number of sublevels, etc.

Once again, we may point out that the importance of the **charge** as a basic quantity as it turns out evident in the energy sublevels, in the sense that they may be discriminated by suitable magnetic fields, such as it happens with spin in the Stern-Gerlach's experiment.

On the other hand, these energy levels will be associated with **potentials**, according to $E = eV$, where *e* is the charge as an essential parameter of the particle and *V* the scalar potential of the electromagnetic field. It seems clear its similar properties to those of angular momenta, so such potential must comply with the conditions imposed by Lie Algebra and therefore quantized**,** adjusting to the relationship: $eV \equiv mc^2$.

What is the role played by *that mass?*

The energy difference which imply to move from one level to another is taking place by "electromagnetic interaction", that can be expressed: $e\Delta V \equiv \Delta mc^2 = h\nu$ (18), where

mass appears as a mere "intermediary" between the real observables quantities: *e,* (charge),

ΔV (potential difference) and ν (frequency); this mass (relativistic) is variable and as such may have any value, as it happens with the frequency, due to the quantization represented by the quantities, *e,* and, *h*, both quantized.

Finally, as this **mass** determines the energy levels, required for "quantum particles", but depending on electromagnetic magnitudes as a physical quantity, must be of **electromagnetic** nature and **virtual** (non-inertial)**,** as indicated above.

6. QUANTUM PARTICLES

In order to admit such an important conclusion, it is necessary to establish two different physical spaces: a) the "inner"**,** formed by the phase of the fields produced by a fundamental quantized constant, the **charge** and responsible for Quantum Theory's laws; b) "exterior"**,** where particles (macroscopic bodies) are characterized by another constant, **mass,** subject to the laws of Classical Mechanic and Chemistry.

Three kinds of interactions take place In the "inner" space, where waves and electromagnetic fields play a major role and are distinguished by the level of energy involved in each of them:

6.1 Electromagnetic Interaction: It is the responsible of the formation of atoms, in which the arrangement of electrons repond to rotational (gauge) symmetry, as stated above. The actual interaction is described as an "exchange" of photons, which can be reflected by the quantization of potential, A_μ; this is performed through a Fourier expansion and allows to extract the vector ε^λ (λ = 1 y 2, polarization), which is given by the transversality condition, $\boldsymbol{\varepsilon.k} = 0$, where ε have the direction of potential vector, ***V;*** This expression shall be corresponding to

$\boldsymbol{j.V} = 0$ for being $\boldsymbol{j}$ proportional to $\boldsymbol{k}$, due to the equivalence with momentum, $\boldsymbol{p}$ and the quantization of that expressed in (8) (wave-corpuscle duality).

Photons, γ, are "quantum" particles whose action is interpreted as an exchange of energy, $\hbar w$, but in the direction of potential vector, ***V,*** that is, perpendicular to the current, ***j;*** its spin is corresponding with the "circular polarization" similar the so-called "helicity": +1, -1.

With photons was introduced the "quantization" of radiation, which was soon extended to the particles (electrons) that realize atomic structure; so, when a potential acting on the charge, *e*, rises it to another energy level (activated), $e\Delta V$, which at the same time implies an increase of relativistic mass, Δm. The natural tendency is to return it to the previous (inferior) level with the "spontaneous" emission of photons, $\Delta mc^2 = \hbar w$, , with what we can give mass to photons, especially after having demonstrated that there is no mass "at rest".

Furthermore, if that emission coincides with the absorption of photon from external radiation, but if these occur at the time the atom is already activated, a "stimulated" emission will occur, that is, two "coherent" photons give rise to laser.

Electrons, *e*, that also act as "quantum" particles because its dual nature, are the sources of electromagnetic radiation and when they are moving constitute a current, $\boldsymbol{j}$, or their equivalent momentum, $\boldsymbol{p} = \hbar \boldsymbol{k}$; hence, it will be perpendicular to vector potential, $\boldsymbol{V}$, and thus to photon.

They also participate in the emission of photons, so the energy distribution of these (blackbody radiation) coincides with that of the electrons in their promotion or jump from one level to another; but, taking into account wave-corpuscle characteristic, we may apply the Principle of Uncertainty: $e\Delta V = \Delta mc^2 = \hbar\Delta \boldsymbol{k} \equiv \hbar\Delta k \boldsymbol{v}$ (19), which it is equivalent to (18) , so but, the characteristic of the mass (Δm) is the same: as an intermediate feature between particle (e) and wave (Δk).

It turns out reasonable that photons are not emitted at very high frequency ("ultraviolet catastrophe"), since it would require the transition of electrons to non-existent levels.

6.2 ***Weak Interaction:*** The "inner space", formed by baryons (proton and neutron), is characterized by the charge $Q = t_3 + Y/2$ (19), where t_3 is the so-called isospin and

Y (hypercharge) = B (baryon number) + S (strangeness), which allows us to identify the "quantum particles" exchanged in weak interaction.

Thus, for $t_3 = +1/2$ and B = 1 (proton) ===> Q = ½ + ½ = 1, we will have W^+ particle, while, at $t_3 = -1/2$ and B = -1 (neutron) ===> Q = -1/2 – ½ = -1, it turns out W^- particle.

The "electric charge" of these particles acquieres full meaning in beta decay**,** whereby the neutron turns into a proton, spontaneously in a irreversible way, with the emission of electrons: n --> p + e^-; the energy required for this process is due to the difference of "relativistic mass" between proton and neutron, ie, $\Delta mc^2 \simeq 1.2$ MeV.

The graphical interpretation of the energy distribution of electrons, led to the inclusion of a new particle, **neutrino;** this graph is similar to that of photons in blackbody radiation, since the energy linking with electrons is total, as noted above.

Therefore, it may be objectionable the existence of "neutrino", as we have tried to demonstrate in our paper, "*Neutrino: A True Particle?".* International Journal of Scientific & Technology Research, Volume 5, Issue 12, December 2016.

Actually, Weak Interaction occurs by oscillations (reversible process) between proton and neutron, as an exchange of **gauge particles**: W^+, W^-,Z^o, due to *isospin*. So, we have "rotation" in a similar way to angular momentum, *l*, but in this case affecting to potentials (gauge), which also must be subjected to Lie Algebra $[A_\mu^1, A_\mu^2] = i\epsilon_{123}A_\mu^3$ (20)

In order to make these potentials operational, we introduce the electromagnetic one, A_μ, related to electric charge, *e*; in this way, it is obtained the coupling constants, g and g´, if we proceed to the union group: SU(2)xU(1), which consists of establishing a new "rotation" between potential A_μ^a belonging to Group SU(2) with A_μ, included in the Group U(1), getting *Z:*

$Z = -Asin\theta_W + A_3 cos\theta_W$; $\boldsymbol{A} = Acos\theta_W + A_3 sin\theta_W$ (21) , where θ_W is the weak mixing angle, experimentally determined through $sin^2\theta_W \simeq 0.222$; this angle allows to relate g and g´, according to g´= g $tg\theta_W$ and both constants are related to electron charge, *e*, as follows g = $e/sin\theta_W$ and g´ = $e/cos\theta_W$ (22).

The energies of the mentioned particles are obtained by multiplying these constants, which acts as weak charges in the "inner space", with the scalar potentials, A_o^1, A_o^2 and A_o^3, as it will be shown later. As a "quantum particles", their action occurs in a similar way than photons, that is, by exchanging them, with the difference that its spin are null (*s* = 0), since the interaction is taking place by scalar fields.

6.3 Strong Interaction: Through this interaction the "inner space" produce Hadrons, as particles composed of quarks; the mass assigned to these hadrons is due to the interaction originated by "color charges" and the fields formed by "gluons", under the symmetry group SU(3), which does not allows to **quarks** passing to "exterior" space, according to phenomena called "confinement".

In this way, Nature provides the real mass**,** where "inertia" is a consequence of the inner or internal structure of the particles, while quarks are merely "charges fraction", whose function is to supply electrical charges to leptons and hadrons.

We are, therefore, at the turning point of "inner" versus "exterior" spaces: in the first, proton may be treated as quantum particle, in which case the proton mass will be 938 MeV, but that can only be understood as a "reference" energy level.

In the "exterior" space this mass is real (inertial), whose value is 1.67×10^{-27} kg, that after binding to **neutron,** thanks to Weak Interaction will form atomic nucleus, whose mass is measured in atomic mass unit (*amu)*, which is used in Chemistry and Classical Mechanics, where the charge is irrelevant and the eV units inapplicable.

According to Relativity, proton mass should increase in the accelerator (LHC), at least 80 times its initial mass. *How to check that*?.

The only certainty is that the particle energy rises due to potential difference acting on the charge and after collision the detected energy of 80, 90 and 125 GeV can be associated with "quantum" (gauge) particles of weak interaction; with this, we have a justification that whenever we take into account the expression: $eV \equiv mc^2$ the mass, m, should not be real, but virtual (electromagnetic) and as such may be attributed to any of the "quantum" particles.

7. EQUATIONS OF QUANTUM PARTICLES

7.1 Bosons:

The proton as a quantum particle, interacts with electron to build the atom; but, in the same way that electrons sets its quantum possibilities (quantum numbers), protons and neutrons together will have to adjust their own energy levels to constitute the atomic nucleus.

As we have seen, the association of proton-neutron is carried out through Weak Interaction and to this end it has been taken into account the relativistic Klein-Gordon equation:

$$(\partial_\mu^2 + m_o^2)\,\phi = 0 \qquad (23)$$

This equation is formulated simply by taking the energy "equation" (identity) (4) to the Quantum Theory by the transformation E ---> $i\hbar\partial/\partial t$ and p ---> $i\hbar\partial/\partial x$, considering that the derivatives, acts on the functions or fields, $\phi(t,x)$, through its argument (phase) (wt-kx), which by quantization (8) and (9), they become $\phi(iEt/\hbar - \hbar ipx/\hbar)$ and finally

$$i\hbar\partial_t\phi = E\phi; \quad -i\hbar\partial_x\phi = p\phi\ .$$

Both equations are integrated on account of the so called "proper" mass, m_o, but as we have indicated above, is just responsible for an empty mass, associated with "vacuum".

This makes sense in Quantum Field Theory, where it is working are many-particle representation, from which it is defined the "creation" and "annihilation" operators, which appear by Fourier analysis on the fields operators and are constrained by the conmutation relations, so that the quantum particles are statistically **bosons**, which means that an unlimited number of particles in the same state or situation is possible; hence, the usual name of "gregarious" particles.

Besides, we can see the relevant magnitude is the energy, w_k, where k is the momentum of each particle, contained in

In order to apply (23) to Weak Interaction, we must transform it as a Lagrangian density.

$$\mathcal{L} = \tfrac{1}{2}\,D_\mu\,\phi^*\,D^\mu\phi - \tfrac{1}{2}m_o^2\phi^2 - \lambda/4!\,\phi^4 \qquad (24),$$

where $\lambda\phi^4/4!$ corresponds to the "interaction" of fields, ϕ, necessary to constitute the potential energy:

$$V = \tfrac{1}{2}m_o^2\phi^2 + \lambda\phi^4/4!\ .$$

However, the Higgs Model is "redundant", because the potentials (gauge) determinants of the energy involved in the interaction can be obtained by the phenomenological equation introduced by Fermi, thanks to which, the Lagrangian may be reduced to $E = \left(\frac{G_F}{\sqrt{2}}\right) JxJ'$ (25), where G_F = 1.66x10^{-5}, whose value implies the reference level corresponding to proton's mas = 0.938 GeV and J and J' are the currents involved, which we can identify with g and g' , as it follows:

The energy is coming through, $E^2 = \sqrt{2}\, g^2/G_F$ ==> $E \sim 37.3$ g GeV $\sim 80\, GeV$, which corresponds to any of the W^+, W^- "particles"; as for Z, the same equation becomes:

$E^2 = \sqrt{2}$ gg'/G_F ===> E $\sim$ 37.3 $e/sin\theta_W cos\theta_W \sim$ 90 GeV.

In short, the energies are obtained by scalar potentials $A_o^1 = A_o^2 = A_o^3 \simeq 37.3\ GV$ and weak charges (coupling constants), g = $e/sin\theta_W$ for A_o^1, A_o^2 and

$\sqrt{}$gg' = $e/sin\theta_W cos\theta_W$ for A_o^3.

The enormous energies involved can be explained from the energy corresponding to the relativistic mass of proton and they are quantities that do not have to be justified by any potential energy:

Indeed, the transformation that occurs in the atomic nuclei is produced thanks to **gauge symmetry**; this actually consists in the extension of electromagnetic field with the global and abelian symmetry, U(1) in which the derivative ∂_μ becomes covariant , $D_\mu = \partial_\mu + ieA_\mu$ to the "inner" space configuration of atomic nuclei, where the corresponding symmetry will be

SU(2)xU(1), local and non-abelian and the covariant derivation, $D_\mu = \partial_\mu + igt_aA_\mu^a$, being t_a the group's generator that satisfied Lie Algebra (23).

Actually, the interaction itself is due to equation (25), which corresponds to the first term of (24), being congruent with our previous analysis about the relativistic energy "equation" (identity) (6).

The "local" concept introduced in the previous equation implies that the coupling constant, *g*, is dependent on the space-time coordinates, so that $gt_aA_\mu^a$ may be a "conexion" in a curve space; in this sense, the similarity to the Relativity General Theory and the search for an Unified Theory might be plausible, but it is not possible since the physical quantities, g, g' and A_μ^a have **quantum** values in a "inner space", previously established**.**

Eventually, the Higgs Mechanism about **Symmetry** and its breaking to try to prove the origin of mass of gauge particles from "vacuum", it may be admitted, but considering that those are of **electromagnetic** and **virtual** nature and that symmetry corresponds to the conservation of the Charge.

7.2 Fermions:

The quantum treatment of electron comes from the Dirac equation, which is obtained by linearizing the quadratic energy equation: $(i\gamma^\mu\partial_\mu - m_o)\psi = 0$ (26), where γ^μ are matrices (μ=0.1.2.3) that act on the vector field, ψ, mixing its components, while ∂_μ acts on each component in the argument, that is, in the phase (*w*t-*k*x), as we have made before.

Besides, γ^μ matrices introduce the spin twice, but with opposite sign, ie, $\sigma^i - \sigma^i$, corresponding to electron an its antiparticle, positron, respectively.

This is the main contribution of this equation, that is, the existence of antiparticles; trying to explain this situation with the mass as an essential parameter, forced to create a "hole theory". But, as it has already been said, the quantum particles may be provided with mass, but this is to be "virtual", being the **charge** the essential parameter, in which case the positron may be easily understood.

In this regard it turns out significant the statements: "..It is actually a theory on a charge and not on a particle.." (Messiah: *"Mecánica Cuántica"*) and "..The Dirac theory with its inclusion of holes is not a relativistic generalization of the Schrödinger's equation of a particle.." (P.Roman: *"Advanced Quantum Theory"*).

In the same way that happens with bosons, m_o , will be an empty mass corresponding to "vacuum", so that will give meaning to "creation" and "annihilation" operators, which appear with the introduction of many-particle representation in Quantum Field Theory, where antiparticles are coming in a natural way by a Fourier expansion of fields.

The quantum behaviour of those operators and hence the fields is the same that of matrices γ^{μ} subject to the rules of anticonmutation, with which electrons obey the Fermi-Dirac Statistics, that is to say, they are **fermions**, that must also have "individuality", since only one particle may be adscribed to each state or situation, according to Pauli's Exclusion Principle.

8. CONCLUSION

We have tried to approach the "microcosm", looking for alternatives to the usual method based on treating the particles, as though they were of the same dimensions as the macroscopic world; in this sense, we think that it is inappropiate the usual treatment similar to Kinematics and Dynamics Classical, in relation to position and velocity, since it has been considered from the beginning the Uncertainty Principle.

The relativistic unifying paradigm is therefore unfeasible, since that theory is consistent with a relativistic mass (virtual), that can only be assumed by Quantum Theory, where the same is dissolved in "vibrations".

Relativity in our interpretation, give us the pattern or adquate guide in aproaching to Quantum Theory; thus, velocity is introduced suddenly (boost), appearing momentum and energy quantized and following in a similar way angular momentum thanks to rotations implicit in Poincaré Group as an extensión of the Lorentz's.

The interaction between charges or charged particles and electromagnetic radiation, originated Quantum Theory by introducing "energy quanta", which corresponds to "quantum particles". In this line, the search for the physical quantities is made using the Lie groups acting on functions or fields, according to the symmetry (gauge) implicit in the conservation's law, while the Lie algebra set up the inner space and provides the conditions to which quantum particles are subjected.

With the concept of quantum particles and the mechanism of interaction, as an exchange of energy quanta (packets), originated in the inner space, we can globalize electromagnetic, weak and strong forces. So, in the first, caused by electrons and described like exchange of photons, $\hbar\Delta w$, produced by $e\Delta V$, and thanks to Relativity are made equivalent to $\Delta m\,c^2$; all this, leads to an inseparable relationship between wave and corpuscle, since this amount of mass (virtual), Δm may be attributed to both photons and electrons.

In weak interaction, energy quanta are produced with the intervention of electromagnetic interaction and their values are given by the product of weak charges, g, g' and the corresponding potentials of Gauge Symmetry, whose particles have masses of the same nature as that of the photon, that is, virtual and a high energy is required for its appearance in "exterior" space to take place, as has been done in LHC Accelerator.

Digital images produced by Charge-Coupled-Device (CCD) is a further evidence of the essential importance of electrons' charge (current), devoid of inertia.

The real or inertial mass of particles of Classical Mechanics is obtained from strong interaction, whose energy level permits the formation of hadrons, so that its components (quarks) can not be manifested in "exterior" space; the interactive network originates the necessary structure for the existence of "inertia".

Finally, a digression from the classical wisdom: Zeus' power lies in the rule of lightning and the punishement inflicted on Prometheus for stealing god's fire, it actually was for having discovered the possibility of producing it by sparks or electric charges.

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