On the relation between short-range forces and the concept of neutrality in Hidrino and Widom-Larsen theories

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Abstract
A unified theory **[1]** details the relation between the strong-nuclear force and nuclear reactions, nuclear fusion included. The asymmetry between electron and nucleon sustains the primary concept of electrical neutrality through a weak nuclear force mechanism.

Key-words: *strong-nuclear force, weak interaction, two-body problem, Newton's third principle, neutron stars.*

I. INTRODUCTION

A. Preliminary remarks

If quantum mechanics can provide quantitative expressions of forces in conformity with the work of Erhenfest and the principle of correspondence **[2]**, recognized quantitative expressions for nuclear and weak forces do not currently exist **[3].** In addition, the four basic forces do not depend on temperature, since measured in vacuum between particles.

In one of his books **[4]**, Abraham Pais recalled a comment by Rutherford during the 1914-1919 period**:** "the Coulomb forces dominate if v (speed of alpha particles) is sufficiently small", evidencing by these words the velocity-dependence of the strong-nuclear force. However, since Rutherford did not apparently refer to temperature, optimal conditions for nuclear fusion do not necessarily arise in disordered configurations characterized by extremely high temperatures, such as those encountered in stars like the sun. Even compared with galaxy formation, hot fusion in many stars seems the slowest and most inefficient physical phenomenon in the universe, because the sun's ten billion year lifetime has an order of magnitude similar to the age of the universe, this circumstance having been highly beneficial for the life on earth.

Although not based on equations, Rutherford's conclusion constitutes the essence of the "cold" approach to nuclear fusion and reactions starting from moderate energy levels, instead of extreme temperatures hardly controlling with precision the physical parameters ruling nuclear phenomena. In this view, a better theoretical understanding of these parameters will help nuclear technologies.

B. Theoretical antecedents

Eddington mentioned the concept of asymmetric affine connection in 1921 and pointed out applications in microphysics, but he did not pursue this idea **[5]**. In 1922, Elie Cartan introduced geometric torsion, as the antisymmetric part of an asymmetric affine connection. In May 1929, Cartan wrote a letter to Einstein **[5]** in which he recommended the use of the differential formalism he developed, but Einstein did not follow Cartan's advice.

Between 1944 and 1950, J. Mariani published four papers dealing with astrophysical magnetism **[6]** and introduced an "ansatz" structurally similar to that used in the present theory. The German word "ansatz", used by Ernst Schmutzer (correspondence), refers to a supposed relationship between fields of distinct origin, for example geometric contrasting with physical. Einstein also used an ansatz when he identified gravitation with the 4-space metric, but he did not put it in the form of an equation, presumably because being trivial.

The organization of the paper is the following**:** Section II details the Lagrangian formulation and the calculus of variations. Section III is about field equations and quantitative expressions of forces. Section IV introduces the short-range force between charged particles, first referred to as strong-nuclear between nucleons. Section V is on Yukawa and complexity. Section VI details the short-range forces in both systems electron-proton and electron-neutron, evidencing a weak nuclear mechanism in LENR technologies.

When not stated otherwise, mathematical conventions are those of reference **[1]**.

II. THE THEORY AND ITS METHOD

Following Einstein's program, the field Lagrangian of this theory **[1] is** essentially gravitational and electromagnetic, with five fields and a new constant. This Lagrangian retrieves Einstein's equation for gravitation, and Maxwell's linear electromagnetism in a first approximation. The torsion structure of this Lagrangian is part of an extended (4-dimensional) Einstein-Hilbert Lagrangian, whose full affine connection includes the torsion T schematically introduced by the ansatz T = FJ (without indices), where F is the electromagnetic field and J is the electric current density. Torsion produces three quadratic Lagrangian terms evidencing quadratic electromagnetic couplings subsequently describing short-range forces, besides magnetic moments coupled with electromagnetism.

A second Lagrangian, in simpler reduced form for motion, produces the forces acting on massive matter, through coordinate variation. These forces include short-range forces Interpreted as strong-nuclear and weak, besides spin forces **[7]** not calculated so far. A third quantum Lagrangian is also part of the theory but does not include yet the specific quadratic field couplings relative to the short-range forces, which might lead (?) to strong-nuclear and weak forces expressed in terms of probability packets **[2]**.

Due to the local character of physical forces, implied by the presence of the current J and the non-vanishing of torsion in massive matter, the first and second Lagrangians only define field equations and forces inside massive matter, here synonymous to electrically charged particles such as electrons and quarks. This is so because forces act on massive matter at its precise location, not close to it in vacuum if one accepts that massive particles are not singularities of fields in vacuum. Nevertheless, this formalism is easily extended to the usual description of forces in vacuum, together with cosmology **[1]**.

Somewhat summarizing the nuclear problem, a coupling of torsion to massive matter, via electrodynamics, evidences the quadratic structure of torsion in an enlarged Einstein-Maxwell theory implying squared electromagnetism covering short-range forces such as nuclear and weak.

About equations, attempting to extract all interactions from a system of field equations is not applicable in this theory, because one derives field equations by varying separately all fields representing variable entities in a field Lagrangian. From a second Lagrangian for motion, one obtains a unique equation of motion, containing all interactions, by varying the 4-coordinates of one massive (charged) particle. There is therefore no reason to confuse both processes, apart from their common field Lagrangian. Moreover, the same Lagrangian field couplings were introduced in a third quantum Lagrangian that includes Schrödinger's field, which produces a wave equation retrieving Schrödinger's equation in a non-relativistic weak field approximation. This operation leads to energy definition through Hamiltonian wave-solutions of Schrödinger's time-dependent equation (of evolution) **[1]**.

In conclusion, these three Lagrangians describe the fields inside matter and the forces acting on this massive matter, all massive particles being electrically charged. Moreover, these forces are naturally extended in vacuum. In relation with this, physics appears quite far from a unique theoretical model, besides the Standard Model and a long list covering classical mechanics, thermodynamics, large number of quantum approaches, etc...

III. THE EQUATIONS

In general relativity, the trajectories of matter are geodesics. This is the consequence of the variational postulate $\delta S = 0$, whose action S is defined by the line-integral implying the gravitational force **[8]** in a curved 4-space in general relativity**:**

$$S = \int - mcds = \int p_k dx^k, \qquad (1a)$$

where p_k is the 4-momentum defined by

$$p_k \equiv mcdx_k/ds \ ; \ (ds^2 \equiv - dx_k dx^k). \qquad (1b)$$

For other interactions, gravity is switched off **[5]** and the formalism of special relativity is used. Such interactions are derivable from the action **[8]**

$$S = \int (p_k + eN_k)dx^k, \qquad (2)$$

where e is the electric charge and N_k is the enlarged vector potential constructed from the Lagrangian densities containing the electric current density. An ensuing equation of motion, encompassing all interactions besides gravity, is derived from (2) by the sole variation of coordinates. One verifies

$$\delta(ds^2) = 2ds(\delta ds) = - 2dx_k \delta dx^k. \qquad (3)$$

Eq. (3) implies

$$(\delta p_k)dx^k \equiv 0, \qquad (4)$$

obtained by replacing p_k with its expression (1b). For the variation of (2), one uses $\delta dx^k = d\delta x^k$ and $\delta N_k = \partial_i N_k \delta x^i$, integrating by parts according to the known procedure **[8]** and finds

$$\delta S = \big| (p_k + eN_k)\delta x^k \big| - \int [dp_k - e(\partial_k N_i - \partial_i N_k)dx^i]\delta x^k \qquad (5)$$

(from points A fo B).

In accordance with usual limit conditions, the null-variation of S ($\delta S = 0$) implies the equation of motion

$$F_k \equiv dp_k/dt = e(\partial_k N_n - \partial_n N_k)dx^n/dt, \qquad (6)$$

where F_k is the generalization of the Newtonian force in special relativity. Since dt is not an invariant, F_k is not a vector.

Since (2) avoids the summation symbol for various particles, the equation of motion (6) is restricted to a system formed by different fields and only one particle, at the approximation that one moving body does not affect the fields. The aim is to delimit the general problem of interactions in the simplest case, being aware that this technique is apparently limited to a 2-body problem. This method is now applied to the field Lagrangian £ **[1]** defined by

$$£/\sqrt{g} \equiv (1/2K)[R + T^{a,bc}(T_{a,bc} + \Phi J_{(a}F_{bc)})] + A_iJ^i$$

$$- (1/4\mu_o)F_{ik}F^{ik} + \alpha\Phi J_iJ^i, \qquad (7)$$

where g_{ab} is the symmetric metric tensor with $g \equiv - \det(g_{ab})$. $T_{a,bc}$ is the torsion tensor and parentheses around three indices mean their cyclic permutation. J_k is the electric current density, A_k is the 4-vector potential, F_{ik} is the electromagnetic tensor. R is Riemann's scalar, K is Einstein's constant of gravitation and μ_o is the magnetic permeability of vacuum. Φ is a scalar field and α is a (new) constant. Furthermore, agreeing with Poincaré's definition of science as a system of relations **[9]**, only the relation between torsion and physical fields is meaningful regarding the relation between geometry and physics.

In line with the next equations (16) to (18), the line-integral (2) for motion will arise as a 4-volume integration of the Lagrangian terms, which in (7) include the electric current density J^i containing the 4-velocity $c(dx^i/ds)$ for coordinate variation. For motion, one therefore discards the terms not containing J^i**.**

In special relativity (gravitation switched off **[5]**), this procedure thus leads to the second reduced Lagrangian scalar L for motion, given by

$$L \equiv (1/2K)T^{a,bc}\Phi J_{(a}F_{bc)} + A_iJ^i + \alpha\Phi J_iJ^i, \qquad (8)$$

where

$$T_{a,bc} = - (\Phi/2)J_{(a}F_{bc)} \qquad (9)$$

is the equation-definition for torsion **[1].** One details

$$J_k \equiv \rho_o u_k = \rho_o c(dx_k/ds) = = \rho(dx_k/dt) \qquad (10)$$

(u_k is the 4-velocity), where ρ_o is the rest electric charge density and ρ is this charge density in the referential of the observer, so that (10) implies

$$\rho = \rho_o / (1 - v^2/c^2)^{1/2}. \qquad (11)$$

Using (9), one puts (8) in the form

$L = N_i J^i + \alpha\Phi J_i J^i$,   (12)

with

$N_a \equiv A_a - (3\Phi^2 / 4K) J_{(a}F_{ik)}F^{ik}$,   (13)

due to the substitution of torsion by the right member of (9) and the identity

$J_{(a}F_{bc)}.J^{(a}F^{bc)} = 3J_a F_{bc} J^{(a}F^{bc)}$.   (14)

One first shows that the second "nuclear" term including $J_i J^i$ in the right member of (12) produces the line-integral (1a) after 4-volume integration, according to the mass condition **[1]**

$m = \alpha\Phi\rho_o e$,   (15)

where the Φ-field plays a key-role in next equations (16) to (18). Φ originally came from solutions of Einstein's equation for gravitation in a static, spherically symmetric space-time inside matter **[1]**. Such solutions would not exist if αΦ were a constant. The Φ-field was therefore introduced as a variable physical quantity.

Using (15) and the notation $u_k \equiv J_k/\rho_o$ for relativist 4-velocity, one writes

$$\int dt(\alpha\Phi J_k J^k)d^3x = \int dt(\alpha\Phi\rho_o u_k \rho)(dx^k/dt)d^3x = \int (m/e)u_k \rho dx^k d^3x$$

$$= (1/e)\int p_k \rho d^3x dx^k = \int p_k dx^k \qquad (16)$$

($\Phi\rho_o$ is constant). One follows the same procedure with $N_i J^i$ in (12)**:**

$$\int dt(N_k J^k)d^3x = \int dt(N_k \rho dx^k/dt)d^3x = \int e N_k dx^k, \qquad (17)$$

and gets

$$S \equiv \int (L.d^3x)dt = \int (p_k + eN_k)dx^k. \qquad (18)$$

Field equations and equations of motion are distinct objects. From the first field Lagrangian £, one gets field equations by varying the fields. From the second matter Lagrangian L, simplified for motion, one derives an equation of motion by varying the coordinates representing the location of matter.

In this theory of motion, massive charged particles are not point-like. However, the framework of motion relative to such particles has no interest in a variable charge density inside matter. One therefore interprets ρ_o as the average value of rest charge density.

IV. THE SHORT-RANGE FORCE AT THE ELECTRO-NUCLEAR APPROXIMATION

To evidence short-range forces, one discards the Lorentz force engendered by A_a in the right member of (13), whose second term will produce an attractive force in $1/r^5$, of intensity proportional to the square of non-relativistic momentum multiplied by the particle volume at rest (see further). This short-range force is distance-dependent **[10, 11]**, in opposition to spin forces of greater local character.

One now calculates the components f_a of this short-range force in the approximation of electromagnetism reduced to its electric components, due to the non-relativistic neglect of the magnetic field **[2]**. Accordingly, this short-range force of electro-nuclear character reads

$$f_a \equiv dp_a/dt = e(\partial_a Q_b - \partial_b Q_a)dx^b/dt, \qquad (19)$$

with

$$Q_a = - (3\Phi^2 / 4K)J_{(a}F_{ik)}F^{ik}, \qquad (20)$$

from (13), thus without A_a implying the Lorentz force. Using (15), Eq. (20) then becomes

$$Q_a = - (3m^2 / 4K\alpha^2 e^2 \rho_o^2)J_{(a}F_{ik)}F^{ik}. \qquad (21)$$

Due to the existence of quarks, the simplest interaction between nucleons is a 6-body problem. However, one will treat the system nucleon-nucleon as a 2-body problem in a first approximation.

Rectangular coordinates characterize the referential Oxy where a first static proton is located at the origin O. A second proton moves above the x-axis, its velocity **v** being parallel to the y-axis. Using $x^o = ct$ in the approximation of point-like protons, the components E_x and E_y of the electric field produced by the proton at rest are

$$E_x = cF_{xo} = ex/r^3 \; ; \; E_y = cF_{yo} = ey/r^3 \qquad (22)$$

($r^2 \equiv x^2 + y^2$; $v_y \equiv v$), at the approximation of Maxwell's electric field in vacuum.

The electric current density reads

$J_y = \rho_o v_y / \Gamma$ **;** $J_x = 0$, (23)

where $\Gamma \equiv (1 - v^2/c^2)^{1/2}$. (24)

One calculates

$J_{(x}F_{ik)}F^{ik} = 2J_yF_{xo}F_{yo}$ **;** $J_{(y}F_{ik)}F^{ik} = - 2J_y(F_{xo})^2$, (25)

and finds

$Q_x = (-3m^2v / 2K\alpha^2\rho_o\Gamma c^2)(xy / r^6)$, (26a)

$Q_y = (3m^2v / 2K\alpha^2\rho_o\Gamma c^2)(x^2 / r^6)$, (26b)

$Q_o = 0$. (27).

The components of f_a then read

$f_x = e(\partial_x Q_y - \partial_y Q_x)v$, (28a)

$f_y = 0$. (28b)

Writing $x/r = \sin\delta$, where δ is here the angle between the straight line defined by the two proton centers and the velocity of the moving proton, Eq, (28a) gives

$f_x = (-9m^2v^2V\sin\delta \,/\, 2K\alpha^2c^2\Gamma)r^{-5}$ (29)

($f_y = 0$) where $V \equiv e/\rho_o$ is the proton volume, defined before in the approximation of a constant rest electric charge density ρ_o.

In the more general case of two particles with respective charges e_1 and e_2, the particle 1 being at rest, (29) goes over into

$f_x = -[9(m_2)^2(v_2)^2V_2\sin\delta / 2K\alpha^2c^2\Gamma](e_1/e_2)^2r^{-5}$, (30)

where m_2, v_2, V_2, e_2 are the respective mass, velocity, volume at rest ($V_2 \equiv e_2/\rho_o$), and electric charge of the moving particle, e_1 being the charge of the particle at rest, r being the distance between them. Eqs. (28) and (30) determine the short-range force exerted by particle 1 on particle 2, which is perpendicular to the velocity of particle 2. The eventual quark structure also implies that $(e_1)^2$ and $(e_2)^2$

are sums of squared quark charges in the case of nucleons. Accordingly the expression "summed charge squared", worth 1 for a proton and 2/3 for a neutron, figures in ref **[12]**. Moreover, Eq. (30) applies to all massive particles, here built on electricity (Mie's idea, see below).

These sums of squared quark charges also relate to the equation e = Cr, unnumbered formula between Eqs. (45) and (46) in ref. **[1]** where e is the charge, C is a constant and r is the radius of a fundamental charged particle such as a quark, which presents another relation with the words "neutron mean squared intrinsic charge radius" in ref. **[13]**. The $1/r^5$ dependence of the strong interaction came out in 1926 after unsuccessful attempts with $1/r^2$ and $1/r^4$ **[4, 7]**, reference in which A. Pais recalls the discovery of a non-central component of the nuclear force, discovered by Schwinger and Bethe in 1939 **[4]**. This non-central character was confirmed in the forties **[4]**. Attractive forces are not necessarily central and the range of the strong-nuclear force is infinite, however its intensity rapidly decreases with distance, reason why this force is referred to as short-range.

There is more on the subject of fundamentals, briefly recalled now. As dynamics is an essential feature of physical theories **[2]**, Mariani's ansatz toward field unification centered on the motion of massive matter, but the problem of motion has little to do with a field theory in vacuum,where particles are singularities of the fields (see above). One thus sees that the problem of motion essentially resides inside massive matter, which implies interior solutions of field equations in matter **[1]**. In 1912, Gustav Mie introduced this idea of matter constituted by fields. Hermann Weyl detailed Mie's theory in his book *Space-Time-Matter* (Dover, NY 1952, p. 206), in which Weyl reproduced Mie's words when writing**:** *matter is "purely" electrical in nature*. Einstein and Leopold Infeld retook this idea of matter constituted by fields in *The Evolution of Physics* (Simon & Schuster, NY 1938, p. 242).

The present theory in matter reproduces field theories in torsion-free situations, Equations of motion for gravitation and electromagnetism (Lorentz's force) are also retrieved. Furthermore, one retrieves quantum mechanics for the hydrogen atom from identical field couplings, including Dirac's magnetic dipole and spin-orbit energies, by introducing additional constants such as the electron charge and mass, besides Planck's constant **[1]**. On the other hand, the quantum treatment of strong-weak couplings has been done regarding magnetic moments **[1]**, but the procedure has to be applied to short-range forces, strong-nuclear and weak, because quantum theory is over-imposed on the classical structure.

V. YUKAWA AND COMPLEXITY

Since perpendicular to velocity according to Eqs. (28), the short-range force defined by Eq. (30) does not produce energy (see below). Moreover, this force is firmly non-central, which contrasts with central forces oriented along straight lines connecting two particle centers **[11]**. A complex and chaotic kinematics, together with a rather unexpected dynamics characterize therefore strong-nuclear forces manifesting a tendency toward unpredictability and instability **[4]**, besides radioactivity opposing nuclear stability.

Apart from this stability issue, nuclear forces are velocity-dependent and complex **[4]**, so that Lev Landau's suggested to limit the study of the strong-nuclear force to binary nuclear interactions ("two by two" **[7]**). This was probably due to the Yukawa distance and the short-range character of strong-nuclear forces, to what A. Pais added "*the nuclear 2-body problem is just too complicated*" **[4]**. However, Pais' words mean that the complexity resides in the nuclear problem, not necessarily in theories describing nuclear phenomena.

About this issue of complexity, the present theory may also look complicated, example of its non-linear version of Maxwell's theory, whose approximation for the electric field in Eqs. (22) may be responsible for the vanishing work (energy) produced by the strong-nuclear force, according to Eqs. (28). From another standpoint, perpendicularity does not materialize exactly in the real world because 3-dimensional orthogonality is not an invariant in 4-dimensional relativity theory. In contrast, the attractive character of forces is an invariant according to a definite arrow of time.

Within a non-relativistic approximation ($\Gamma = 1$), one makes $(e_1)^2 = (e_2)^2$ and takes the absolute value of the strong-nuclear force between two protons or two neutrons from Eq. (30), equaling its right member to $mv^2/(R/2)$ for motion around the center of mass and assuming a circular motion. The factor v^2 then simplifies in both members, which gives

$$R^4 \approx 9mV / 4K\alpha^2c^2, \qquad (31)$$

($\sin\delta = 1$).

The binding of two protons, or two neutrons, consequently implies their fixed separation defining the Yukawa distance R figuring in Eq. (31) for a common particle volume (see further). R is currently valued at 1.4 fermis and allows the calculation of the constant α according to a nucleon radius of 0.7 fermis (approximation).

VI. THE WEAK NUCLEAR FORCE IN THE SYSTEM ELECTRON-NUCLEON

A. Electrons and nucleons

In ref. **[7]**, Landau wrote**:** "...quantum mechanics occupies a very original position in the range of physical theories; it contains classical mechanics as a limiting case and at the same time needs this limit to be founded" (translation). In agreement with Bohr's correspondence, one then sees the importance of a classical theory of motion and forces, before a quantum treatment evidencing probability packets **[2]**, which would bring new elements, besides reassuring the calculation of the important tunnel effect within an appropriate framework.

In this classical approach, the strong-nuclear force does not produce energy to realize nuclear fusion in a first approximation, This situation looks deceiving but leads to an apparently positive conclusion. Nuclear fusion, based on the unique role of the strong-nuclear force, still does not present a high degree of probability after many years of hot fusion experiments. Other phenomena might therefore play a significant role, if theoretically validated. In addition, LENR experiments already produce excess heat, which establishes the experimental foundation for future developments, starting from simple configurations, to improve in a second stage.

Before neutron formation with emission of a neutrino, the electron capture by a proton is a bound system electron-proton constituting a two-body system respecting Newton's principle of equality between action and reaction, in an energy conservative bound system not interfering with energy-momentum conservation of fields around it. The phenomenon of orbital electron capture from atomic levels K, L, M exists in neutron stars **[14]**, its classical description implies the presence of two short-range forces, detailed now without writing the electrostatic force between proton and electron, because this force cancels out in both members of next Eq. (33) expressing equality of action and reaction for motion around the center of mass.

Quark charges in a proton are 2/3, 2/3, -1/3, whose sum of squared charges = 1 is the same as the squared charge of the electron, which implies $(e_1)^2 = (e_2)^2$ in Eq.(30). Within a non-relativistic approximation ($\Gamma = 1$), one writes an equation whose left member is the intensity of the short-range force exerted by a proton on an electron, the right member expressing the converse. Simplifying both members by

$$9 / 2K\alpha^2c^2r^5, \qquad (32)$$

yields

$$(m_e)^2(v_e)^2V_e = (m_p)^2(v_p)^2V_{p,} \qquad (33)$$

with sinδ = 1 for both forces in opposition, in relation with round orbits of particle centers (analogy with Bohr's 1913 model). The square root of both members produces

$m_e v_e = m_p v_p (V_p / V_e)^{1/2}$. (34)

In Eq. (30), the attractive short-range force is proportional to the squared non-relativistic momentum of a particle, now retrieved in the left member of Eq. (33), whose square root gives $m_e v_e$ in the left member of Eq. (34). The time-derivative of both members then leads to

$[m(dv/dt)]_e = [m(dv/dt)]_p (V_p / V_e)^{1/2}$. (35)

whose left member is the force dp/dt figuring in Eq. (19), acting now on the electron. For consistency, therefore not only in relation with Newton's third principle, one writes

$[m(dv/dt)]_e = [m(dv/dt)]_p$, (36)

so that Eq. (35) reduces to

$V_p = V_{e,}$ (37)

the electron and the proton have therefore the same volume in this theory.

One repeats the same procedure, by adapting Eq. (33) to the bound system electron-neutron, taking into account the sum of squared quark charges worth 2/3 for the neutron, which gives

$(m_e)^2(v_e)^2 V_e (2/3) = (m_n)^2 (v_n)^2 V_n (3/2)$. (38)

In relation with Eq. (36), one writes

$m_e v_e = m_n v_n$, (39)

for equality of absolute values of momenta, so that Eq. (38) reduces to

$V_n = (4/9) V_e$. (40)

implying $V_n = (4/9)V_p$ in relation with Eq. (37). This result would be unphysical if the proton and neutron volumes need to be equal for defining a unique Yukawa length in Eq. (31). However, the imperfect equivalence between (p-p) and (n-n) interactions is an established fact (“very similar” in ref. **[7]).** In this view, the 18 % difference for R in Eq. (31) might be physical, and not important enough to discard this type of capture, in spite of its apparent lack of observational data. All this seems good news for the possibility of electron capture by a neutron, part of the Widom-Larsen theory **[15]** which brings forth a neutral deuteron in conformity with Eq. (38).

The spherical symmetry, fundamental in Bohr's model of the hydrogen atom and Schrödingers's equation in atomic theory, besides the statistical interpretation of the wave-function, seems typical in relation with a classically defined "weak nuclear" force mechanism in Eq. (33), referring to two distinct forces of equal intensity in the system electron-proton. The weak force acts on the electron with the same intensity as if the source were another electron, instead of a proton, and the second strong-nuclear force acts on the proton with the same intensity as if the source were another proton, instead of an electron. Short-range forces work this way because proportional to the squared mass of the particle acted upon, multiplied by the factor $(e_1/e_2)^2$ previously defined in relation with quarks.

Here, the bound system electron-proton represents the electron capture through two forces, strong-nuclear and weak, system literally characterizing a "weak nuclear" mechanism of forces, according to which proton and electron react. In relation with this, ref. **[14]** indicates that "β-decay applies to all nuclear reactions implying neutrinos or anti-neutrinos" summarized by

$$p + e^- \leftrightarrow n + v_e, \qquad (41)$$

adding that "all these reactions are ruled by the weak nuclear force", represented here by two forces, strong-nuclear and weak of equal intensity, which are Newton's inevitable action and reaction. The left member of (41) presents the electron capture explaining the neutralization of the Coulomb barrier (including eventual shielding during definite time intervals before neutron formation ?). This electron capture produces a neutron, subsequently fusing with a nucleus since being essentially acted upon by the strong-nuclear force between nucleons.

Finally, the bound system electron-proton with two distinct forces, weak and strong-nuclear of equal intensities, contrasts with the scenario of two strong-nuclear forces representing action and reaction in the usual outline of nuclear fusion between protons, as in the sun where the presence of electrons in momentary bound systems electron-proton could play a role in the fusion of hydrogen **[16]**, but this is another story. Obviously, the differentiation between short-range forces in the weak nuclear scenario of electron capture by a proton **[14]** supports the low energy approach to nuclear fusion.

B. Numbers

From Eq. (30), the coupling constant of the weak force between two electrons is $(m_e)^2$, which constitutes a first number. According to the approximation $m_n \approx m_p$, the strong nuclear force between two nucleons is characterized by the coupling constant $(m_p)^2$. Based on m_p = 1836 m_e, the coupling constant of the strong-nuclear force between nucleons is 3.37 x 10^6 times greater than the coupling constant of the weak force between electrons, this the second number.

In the bound system electron-nucleon, the weak nuclear mechanism includes the two coupling constants $(m_p)^2$ and $(m_e)^2$ because two distinct forces are present. Since the weak force acts on the electron and the strong-nuclear force acts on the nucleon, the mean value of these two coupling constants would be half the second number above, so roughly 1.69 x 10^6 because $(m_e)^2$ is negligible in regard to $(m_p)^2$. However, this third number is unrelated to relative intensities of these two forces in a bound system, where the equality between action and reaction implies the equality of both force intensities. In relation with Eq. (30), the non-central short-range force is velocity-dependent, so that relative force intensities are relative values of squared non-relativistic momenta, in opposition to relative values of coupling constants.

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