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RECENT THEORETICAL AND EXPERIMENTAL EVIDENCE ON THE COLD FUSION OF ELEMENTARY PARTICLES

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1. STATEMENT OF THE PROBLEM

In recent papers, Kadeisvili [1] reviews the nonlinear-nonlocal-noncanonical *isotopies* of Lie's theory, and Lopez [2] reviews the axiom-preserving isotopies of quantum mechanics (*QM*), called *hadronic mechanics (HM)* (originally submitted in [3], see refs. [4] for details), and their axiomatization of *Q*-operator-deformations, here called *Q-isodeformations.*

In this note we shall apply isosymmetries/*Q*-isodeformations to a speculative, yet intriguing novel problem, the *cold fusion (or chemical synthesis*) of elementary particles*, defined as the apparent tendency of massive particles to form a bound state at short distances (< 1 fm) in singlet state which is enhanced at low temperature (or very low energies).

According to these novel views, we expect that unstable elementary particles can be artificially produced via the chemical synthesis of lighter massive particles suitably selected in their spontaneous decays. Such a chemical synthesis occurs for *each individual particle* in our space-time only, without any unitary interior space and, thus, without the possibility of defining a quark. Nevertheless, compatibility with quark theories is apparently achieved by considering *families* of particles via the addition of unitary internal spaces. This aspect is studied elsewhere [5] via the isotopies $S\tilde{U}_Q(3) \approx SU(3)$ characterizing *isoquarks*, which have all conventional quantum numbers, yet more general nonlinear-nonlocal-nonhamiltonian interactions.

A central problem in the achievement of the above cold fusions/chemical syntheses is the need for *new renormalizations of the intrinsic characteristics of particles* as characterzed by *QM*: rest energy, spin, charge, magnetic moments, etc. In fact if particle preserve their conventionally renormalized intrinsic characteristics, no cold fusion is possible (see below).

The physical origin of these novel renormalizations is seen in the nonlinear-nonlocal-nonhamiltonian interactions expected in the total mutual penetration of wavepackets-wavelengths-charge distributions of particles one inside the other, and represented with the isotopic operator $Q = Q(s, x, \dot{x}, \ddot{x}, \psi, \partial\psi, \partial\partial\psi, \ldots)$ [1—5]. By recalling that all interactions must produce renormalizations, and all

*The author would like to thank A.N.Sissakian of the JINR for suggesting that name.

conventional renormalizations are Lagrangian — Hamiltonian, the novelty of the renormalizations follows from their nonlagrangian-nonhamiltonian character.

Among all possible deformations, we select the isotopies $\hat{O}_Q(3.1)$ and $\hat{P}_Q(3.1)$ of the Lorents $O(3.1)$ and Poincaré $P(3.1)$ symmetries first introduced by the author back in 1983 [6]*, which are constructed with respect to the isounit $\hat{I} = Q^{-1}$, and imply a generalization of the very notion of *particle* into the covering notion of *isoparticle* possessing precisely the generalized characteristic needed for the cold fusion.

In this note we shall denote all ordinary particles characterized by $P(3.1)$ with the familiar symbols $e^{\pm}, \mu^{\pm}, p^{\pm}$, etc. and use the symbols $\hat{e}^{\pm}, \hat{\mu}^{\pm}, \hat{p}^{\pm}$, etc. for their isotopic conditions characterized by $\hat{P}_Q(3.1)$, which represent their immersion within the hyperdense media in the interior of hadrons, called *hadronic media* [3].

A first understanding is that all Q-operators are selected in such a way to recover the tirival unit $I = \text{diag.}\ (1, 1, 1, 1)$ for distances > 1 fm, when motion returns to be in vacuum, in which case HM recovers QM identically and in its totality. Also, in the transition from interior motion within a hadronic medium to exterior motion in vacuum, isoparticles reacquire their conventional $P(3.1)$-invariance, plus possible secondary emissions (e.g., of γ and ν) due to the original excitations.

Quantitative representations of the following cold fusions are now available [3,4], here expressed in self-explanatory notations (see later for secondary emissions)

$$\text{Electron pairs} = (e^-, e^-)_{QM} \Rightarrow \text{Cooper Pair} = (\hat{e}^-, \hat{e}^-)_{HM}, \quad (1.1a)$$

$$\text{Positronium} = (e^-, e^+)_{QM} \Rightarrow \pi^0 = (\hat{e}^-, \hat{e}^+)_{HM}, \quad (1.1b)$$

$$\text{Muonium} = (\mu^-, \mu^+)_{QM} \Rightarrow \eta = (\hat{\mu}^-, \hat{\mu}^+)_{HM}, \quad (1.1c)$$

$$\text{Pionium} = (\pi^-, \pi^+)_{QM} \Rightarrow K^0_S = (\hat{\pi}^-, \hat{\pi}^+)_{HM}, \quad (1.1d)$$

$$\text{Hydrogen atom} = (p^+, e^-)_{QM} \Rightarrow n = (\hat{p}^+, \hat{e}^-)_{HM}. \quad (1.1e)$$

Numerous other chemical syntheses are then consequential, such as $\Lambda = (\hat{n}, \pi^0)_{HM}$, $\Sigma^{\pm} = (\hat{n}, \hat{\pi}^{\pm})_{HM}$, etc. A primary objective of the isosymmetry $\hat{P}_Q(3.1)$ is therefore *the reduction of all massive elementary particles to electrons and protons*, for which purpose the construction of hadronic mechanic was

*In all preceding works the isotopic element is indicated with the symbol T rather than Q.

suggested [3]. In this approach isoquarks emerge as being suitable HM bound states of electrons and/or protons resulting in fractional charges which are notoriously extraneous to $P(3.1)$, but rather natural for $\hat{P}_Q(3.1)$-invariance under generalized interactions.

The first and most fundamental cold fusion (1.1a) is fully established experimentally, and it is given by the Cooper Pair (CP) in superconductivity (see, e.g., [7] and quoted references). Its interpretation via conventional quantum mechanics is manifestly problematic owing to the highly repulsive Coulomb interactions at short distances under $P(3.1)$-invariance. However, $\hat{P}_Q(3.1)$-isoinvariance with a particular selection of the isounit $\hat{I}$ [8] does permit a consistent interpretation of the CP.

Once the experimental evidence of the (e^-, e^-) cold fusion is admitted, one has the inevitability of the (e^-, e^+) cold fusion (also called *compressed positronium*). In fact, as shown since 1978 (see [3], Sect.5), under the use of the same isounit of isotopy (1.1a), the charge radius of 1 fm and the meanlife of $0.83 \cdot 10^{-16}$ sec, the state $(\hat{e}^-, \hat{e}^+)_{HM}$ represents all characteristics of the π^0, such as rest energy (134.96 MeV), spin charge, meanlife, electric and magnetic moments, etc., as well as the decay with *lowest* mode $\pi^0 \rightarrow e^+, e^-$ $(< 2 \cdot 10^{-6})$ as a *tunnel effect* of the constituent.

Once the mechanism of the cold fusion is understood at the level of electrons, its extension to the remaining mesons is straightforward. In fact, the compression of the muonic (1.1c) and of the pionic (1.1d) atoms follows the same rules as those of the electrons. The identification of the states with the η and K^0_S particles, respectively, is rendered inevitable by the uniqueness of the total characteristics, as it was inevitable for identification (1.1b) (see Sect.2). The isopoincare symmetry $\hat{P}_Q(3.1)$ then permits the interpretation of all remaining mesons as cold fusion of lighter (massive) particles suitably selected in their spontaneous decays [4].

In the transition to baryons new fundamental problems expectedly emerge whose solution required systematic studies on the isotopies $S\hat{U}_Q(2)$ of the $SU(2)$-spin symmetry [4,9] (see also the review in [1]). The origin of the cold fusions here considered can then be traced back to Rutherford's [10] historical conception of the neutron as a *compressed hydrogen atom*. The *existence* of the neutron was subsequently confirmed by Chadwick [11], but Rutherford's *conception* of the neutron was abandoned because contrary to QM on numerous counts (impossibility to represent the total rest energy of the neutron because of the need of a «positive binding energy», inability to represent the total spin, mean life, size and other characteristics of the neutron). As well known, these difficulties lead to the conception of the isospin $SU(2)$ which subsequently leads to the $SU(3)$ theories.

However, the above QM difficulties were inconclusive, because of the unplausibility of the underlying assumptions such as: the electron freely orbits within the densest medium measurd in laboratory; the treatment deals with a tiny atom inside the proton; etc. As a result of such inconclusive character, studies on Rutherford's historical conception of the neutron were continued by various authors.

The most salient recent results are the following. The first representation of all characteristics of the neutron via HM, including spin via the use of the $S\hat{U}_Q(2)$ symmetry, was reached in ref. [12] of 1990. However, the problem of the total spin of the neutron (which requires a null total angular momentum for Rutherford's isoelectron $\hat{e}^-$ when compressed inside the proton) was first solved by Dirac (without his knowledge) in two of his last (and little known) papers of 1971—1972 [13,14], where he introduced a generalization of his equation, which subsequently emerged as possessing an essential isotopic structure.

The first preliminary, yet direct and impressive experimental verifications of the cold fusion of protons and electrons into neutrons via the reaction at low energy $p^+ + e^- \rightarrow n + \nu$ have been achieved by an experimental team headed by the (late) don Borghi [15], reviewed in Sect.8 with a number of indirect experimental confirmations.

Under these authoritative theoretical and experimental results, the role of hadronic mechanics is then essentially reduced to the identification of their appropriate theoretical framework (see the more detailed presentation [16] and [4]).

It is hoped the reader can see the intriguing implications of cold fusion (1.1e). In fact, if confirmed, it will imply the possibility not only of producing unstable particles via chemical synthesis, but also their artificial disintegration. By recalling that currently available technologies are based on mechanisms in the structure of molecules, atoms and nuclei, the studies of this paper are motivated by the possibility of resulting in a new technology, called *hadronic technology* [12], which is based on mechanisms, this time, in the interior of hadrons*.

*Quark theories are known to have no practical application of any nature. Under isotopic $S\hat{U}_Q(3)$ symmetries the situation is different. Isoquarks are perennially confined in a strict sense (with identically null transition probabilities for free quarks due to the total incoherence of the interior isohilbert and the exterior Hilbert space), while their *isoconstituents* are ordinary massive particles which can be freely produced in spontaneous or stimulated decays. Practical applications are then conceivable [12].

2. NONRELATIVISTIC TREATMENT

The radial nonrelativistic treatment of the cold fusion of particles has been known since 1978 [3] (see [4,16] for recent accounts). The central hypothesis is the generalization of Planck's constant $\hbar = 1$ into the isounit $\hat{I} = Q^{-1} = \hat{I}(t, p, \dot{p}, \hat{\psi}, \partial\hat{\psi}, \partial\partial\hat{\psi}, \ldots) > 0$ which represents nonlinear-nonlocal-nonhamiltonian interactions, although $\hat{I} \equiv \hbar$ for mutual distances $r > 1$ fm.

The isotopy of the unit then implies corresponding compatible isotopies of the totality of the structure of QM into that of HM [4] (see the outline [2]), including: isotopy of field $F(n, +, \times) \Rightarrow \hat{F}_Q(\hat{n}, +, *)$, $\hat{I} = Q^{-1}$, $* = \times Q \times$, $Q =$ fixed (in this note $\hat{F} = \hat{R}_q$ or $\hat{C}_q$), with *isonumbers* $\hat{n} = n\hat{I}$, conventional sum $+$, and isotopic product $\hat{n}*\hat{m} := \hat{n}Q\hat{m}$, Q fixed, $\hat{I}*\hat{m} \equiv \hat{n}*\hat{I} \equiv \hat{n}, \forall\ \hat{n} \in \hat{R}$, and consequential generalization of all operations [1—5]; isotopy of the conventional Euclidean space $E(r, \delta, R) \Rightarrow \hat{E}_Q(r, \hat{\delta}, \hat{R})$, $\hat{\delta} = Q\delta$; isotopy of Hilbert spaces $\mathcal{H}: \langle\psi|\phi\rangle \in C \Rightarrow \hat{\mathcal{H}}_Q: \langle\hat{\psi}\hat{|}\hat{\phi}\rangle = \langle\hat{\psi}|Q|\hat{\phi}\rangle\hat{I} \in \hat{C}_Q$; isotopy of eigenvalue equations $H|\psi\rangle = \overset{\circ}{E}|\psi\rangle \Rightarrow H*|\hat{\psi}\rangle = HQ|\hat{\psi}\rangle = \hat{E}*|\hat{\psi}\rangle \equiv E|\hat{\psi}\rangle$, $E \neq \overset{\circ}{E}$; isotopy of enveloping operator algebras, Lie algebras, Lie groups, etc.

The Q-isodeformation operator is then selected to yield the isotopy [3]

$$\left[-\frac{d}{2mr^2dr}r^2\frac{d}{dr} \pm \frac{e^2}{r}\right]\psi = \overset{\circ}{E}\psi \Rightarrow \left[-\frac{d}{2mr^2dr}r^2\frac{d}{dr} \pm \frac{\hat{e^2}}{r}\right]*\hat{\psi} = E\hat{\psi} \approx$$

$$\approx \left[-\frac{Q^{\circ -1}}{2m}\frac{1}{r^2}\frac{d}{dr}r^2\frac{d}{dr} \pm \frac{e^2}{r} - V_0\frac{e^{-R^\circ r}}{1 - e^{-R^\circ r}}\right]\hat{\psi}(r) = E\hat{\psi}(r), \qquad (2.1)$$

where $\overset{\circ}{Q}$ and $\overset{\circ}{R}$ are positive constants. By recalling that the Hulten potential behaves at small distances like the Coulomb one, isotopy (2.1) can then be reduced to

$$\left[-\frac{d}{2mr^2dr}r^2\frac{d}{dr} \pm \frac{e^2}{r}\right]\psi =$$

$$= \overset{\circ}{E}\psi \Rightarrow \left[-\frac{Q^{\circ -1}d}{2mr^2dr}r^2\frac{d}{dr} - V\frac{e^{-R^\circ r}}{1 - e^{-R^\circ r}}\right]\hat{\psi} = E\hat{\psi}, \qquad (2.2)$$

where $V = \overset{\circ}{V} - (\pm e^2\overset{\circ}{R})$. The radial structure equations of the cold fusion submitted in ref. [3], Eq. (5.1.14), p. 836, are then given by ($\hbar = 1$)

$$\left[- \frac{\overset{o-1}{Q}}{2m} \frac{1}{r^2} \frac{d}{dr} r^2 \frac{d}{dr} - V \frac{e^{-R^0 r}}{1 - e^{-R^0 r}} \right] \hat{\psi}(r) = E \hat{\psi}(r), \tag{2.3a}$$

$$E^{tot} = \sum_{k=1,2} E_{k,\,const.} - E(\mathrm{MeV}), \quad \tau^{-1} = 4\pi \lambda\!\!\!^{-} |\hat{\psi}(0)|^2 \alpha E^{kin} (\mathrm{sec}^{-1}), \quad R^0 (\mathrm{cm}), \tag{2.3b}$$

where E^{tot}, τ^{-1} and R^0 are the total energy, meanlife and charge radius, respectively, of the isobound state.

Wheb applied to cold fusion (1.1b), the above model permitted the representation to the totality of the characteristics of the π^0, beginning with the suppression of the original spectrum of the positronium into one, single, admissible energy level: 134.896 MeV [3]. Similar results hold for all other cold fusions (1.1). A realization of the isotopic element Q verifying (2.1) has been identified by Animalu [8] in the expression $Q = Q^0 \exp \{it | E^0 | \langle \psi | \hat{\psi} \rangle \}$. A comprehensive study is provided in [4]. We then have the following *isopostulates of the cold fusion of particles* [3,4,16]:

2.1. Isorenormalizations. *The intrinsic characteristics of the constituents of cold fusions (1.1) are isorenormalized («mutated» in the language of [3]) because of the nonlinear-nonlocal-nonhamiltonian interactions expected in the total mutual penetration of the wavepackets-wavelengths-charge distributions.*

2.2. Energy Balance. *Conventional QM bound states have a "negative binding energy" because $E_T < 2E_{const}$. All cold fusions (1.1) instead, if QM treated would require a «positive binding energy» because $E_T > 2E_{const.}$ thus resulting in inconsistent indicial equaions [3,4,16]. A necessary condition to resolve this problem is the renormalization of the rest energy of the constituents given in Eqs.(2.1) by $mc_0^2 \Rightarrow mc_0^2 Q^0$, under which binding energies can return to be negative. While conventional fusion processes «release» energy, cold fusions (1.1) «require» energy*.*

2.3. Suppresion of Triplet States. *Only singlet isobound states of spinning particles are stable, because triplet couplings under total mutual penetration imply highly repulsive nonlinear-nonlocal-nonhamiltonian forces due to the spinning of each particle inside and against that of the other (this occurrence was represented in [3] via the so-called «gear model»).*

2.4. Charge Independence. *The mechanism of cold fusions (1.1) is the dominance of nonlinear-nonlocal-nonhamiltonian forces at distances < 1 fm which are attractive in singlet couplings and absorb the Coulomb interactions resulting in attractive total interactions irrespective of the attractive or repulsive character of the original Coulomb interactions.*

*However, novel forms of energy from cold fusions (1.1) should not be ruled out, because they are conceivable via mechanisms different than conventional ones

in attractive total interactions irrespective of the attractive or repulsive character of the original Coulomb interactions.

2.5. Constancy of Size. *Another difference between bound states in QM and HM is that the size of the former increases with mass, as established in nuclear and atomic structures, while the size of the latter remains approximately constant with the increase of the mass, as established for hadrons. This occurrence is quantitatively interpreted by HM via the unification of the seemingly disparate occurrences: 1) the range of the nonlinear-nonlocal-nonhamiltonian interactions due to total mutual penetration; 2) the range of the strong interactions and 3) the minimal hole needed to activate Hulten's potential. The addition to an isobound state of a further constituent does then increases its rest energy (and density, thus increasing the isorenormalizations), but leaves the size essentially unaffected.*

2.6. Suppression of Atomic Energy Spectrum. *Yet another difference between QM and HM bound states is that the former generally have a spectrum of energy, while the latter admit only one, single, energy level (this occurrence was called «specturm suppression» in [3]). Each given cold fusion (1.1) therefore has no excited isostates at distances < 1 fm, because all excited states imply greater distances, thus recovering conventional QM energy levels at distances > 1 fm. In fact, the Hulten potential has a finite spectrum of energy levels, as well known. When all conditions of systems (2.3) are imposed, this finite spectrum reduces to only one level (see [3,4,15,16]).*

2.7. Nearly Free Constituents. *The notion of potential energy has no mathematical or physical meaning for the contact nonhamiltonian interactions responsible for cold fusions (1.1). The binding energies are then generally small, $E_{bind} \approx 0$ an occurrence which is reminiscent of «asymptotic freedom» in quark theories [5].*

3. ISOTOPIES AND ISODUALITIES OF POINCARE SYMMETRY

We now outline results which are rather old in isotopies, but which do not appear to have propagated as yet to the literature on their direct applicability, that on q-deformations.

Consider the Minkowski space $M(x, \eta, R)$ with local coordinates $x = \{x, x^4\}$, $x^4 = c_0 t$, c_0 = speed of light in vacuum, metric η = diag. (1, 1, 1, -1), separation $x^\mu \eta_{\mu\nu} x$ and invariant measure $ds^2 = - dx^\mu \eta_{\mu\nu} dx^\nu$. Its group of linear-local-canonical isometries is the ten-dimensional Poincare group $P(3.1)$ characterized by the (ordered sets of) parameters $w = \{\theta, v, a\}$ (Euler's angles

θ_k, speed parameter v_k and translation parameters a), and generators, say, for a system of two particles with non-null masses m_a, $X = \{X_k\} = \{M_{\mu\nu} = \sum_a (x_{a\mu} p_{a\nu} - x_{a\nu} p_{a\mu}), P_\mu = \sum_a p_{a\mu}\}$, $\mu, \nu = 1, 2, 3, 4$, $a = 1,2$, in their known fundamental representation (see, e.g., [17], p.40).

Three realizations of the ten-dimensional isotopic covering $\hat{P}_Q(3.1)$ of $P(3.1)$ have been constructed via the Lie-isotopic theory, the classical [18], operator [4,19] and abstract [6] ones. The latter can be readily constructed by following the space-time version of steps 1—5 for the isorotational symmetry [1], Sect.3.E. Step 1 is the identification of the fundamental isotopic element Q here interpreted as a 4×4 matrix generalization of q-number-deformations. The identification is done via its most fundamental implication, the deformation of the Minkowski metric η into the most general known metric $\hat{g}$ which is nonlinear, nonlocal-integral, and noncanonical in all variables, wavefunctions and their derivatives,

$$\hat{g} = \hat{g}(s, x, \dot{x}, \ddot{x}, \psi, \partial\psi, \partial\partial\psi, \ldots) = Q(s, x, \dot{x}, \ddot{x}, \psi, \partial\psi, \partial\partial\psi, \ldots)\eta, \quad (3.1)$$

under the condition of being of Kadeisvili Class III [1] (smooth, bounded, nowhere singular and Hermitean, but not necessarily positive or negative-definite). Under the assumed conditions, the Q-matrix can always (although not necessarily) be diagonalized into the form

$$Q = \text{diag.}\,(\hat{g}_{11}, \hat{g}_{22}, \hat{g}_{33}, \hat{g}_{44}) = Q^\dagger, \quad \det Q \neq 0. \quad (3.2)$$

The isosymmetry $\hat{P}_Q(3.1)$ is then constructed with respect to the isounit $\hat{I} = Q^{-1}$.

Step 2 is the lifting of the conventional field $R(n, +, \times)$ of real numbers n into the isofield $\hat{R}_Q(\hat{n}, +, *)$ of isoreal numbers $\hat{n} = n\hat{I}$, $\hat{I} = q^{-1}$.

Step 3 is the lifting (necessary for the consistency) of space $M(x, \eta, R)$ on the field R into the *isominkowski space* $\hat{M}_Q(x, \hat{g}, \hat{R})$ on the isofield $\hat{R}$ with isoseparation [6]

$$(x - y)^{\hat{2}} = [(x^\mu - y^\mu)\hat{g}_{\mu\nu}(s, x, \dot{x}, \ddot{x}, \psi, \partial\psi, \partial\partial\psi, \ldots)(x^\nu - y^\nu)]\hat{I} \in \hat{R}. \quad (3.3)$$

Step 4 identifies the basic isotransformations leaving invariant (3.3)

$$x' = \hat{\Lambda}(w) * x, \quad \hat{\Lambda}^\dagger \hat{g} \hat{\Lambda} = \hat{\Lambda} \hat{g} \hat{\Lambda}^\dagger = \hat{I} \hat{g} \hat{I},$$

$$\hat{\text{Det}}\, \hat{\Lambda} = [\text{Det}\,(\hat{\Lambda} Q)] = \pm \hat{I}, \; x' = x + A, \quad (3.4)$$

where the quantity A will be identified shortly. The connected component $\hat{P}^0_Q(3.1) = S\hat{O}_Q(3.1) \times \hat{T}_Q(3.1)$ is characterized by $\hat{\text{Det}}\, \hat{\Lambda} = +\hat{I}$ with structure [4,6,18,19]

$$\hat{Q}_Q(3.1) : \hat{\Lambda}(w) * x = \{\prod_k{}^{*} e_{\xi_Q}^{iX_k * \hat{w}_k}\} Q x = \{\prod_k e^{iX_k Q w_k}\} x, \quad (3.5a)$$

$$\hat{T}_Q(3.1) : \{e_{\xi_Q}^{iP\eta a}\} * x = \{e^{iP\hat{g}a}\} x, \quad \{e_\xi^{iP\eta a}\} * p \equiv 0, \quad (3.5b)$$

where w_k and X_k are conventional [17] and Q is given by (3.2) The isocommutation rules of $\hat{P}^0_Q(3.1)$ are given by [loc. cit.]

$$[M_{\mu\nu} \hat{,} M_{\alpha\beta}] = i(\hat{g}_{\nu\alpha} M_{\beta\mu} - \hat{g}_{\mu\alpha} M_{\beta\nu} - \hat{g}_{\nu\beta} M_{\alpha\mu} + \hat{g}_{\mu\beta} M_{\alpha\nu}), \quad (3.6a)$$

$$[M_{\mu\nu} \hat{,} P_\alpha] = i(\hat{g}_{\mu\alpha} P_\nu - \hat{g}_{\nu\alpha} P_\nu), \quad [P_\mu \hat{,} P_\nu] = 0, \quad (3.6b)$$

where the product is the fundamental Q-isocommutator $[A \hat{,} B] := A * B - B * A = AQB - BQA$ of the Lie-isotopic theory [1,3]. The isocasimirs are then given by

$$C^{(0)} = \hat{I}, \quad C^{(1)} = P^{\hat{2}} = P * P = P_\mu \hat{g}^{\mu\nu} P_\nu, \quad (3.7a)$$

$$C^{(2)} = \hat{W}^{\hat{2}} = \hat{W}_\mu \hat{g}^{\mu\nu} \hat{W}_\nu, \quad \hat{W}_\mu = \varepsilon_{\mu\alpha\beta\rho} J^{\alpha\beta} * P^\rho. \quad (3.7b)$$

The *general isopoincare transformations* are then given by [loc. cit.]

$$x' = \hat{\Lambda} * x \text{ isolorentz transforms}, \quad (3.8a)$$

$$x' = x + A(s, x, \dot{x}, \ddot{x}, \ldots), \text{ isotranslations}, \quad (3.8b)$$

$$x' = \hat{\pi}_r * x = (-x, x^4), \quad x' = \hat{\pi}_t * x = (x, -x^4), \text{ isoinversions}, \quad (3.8c)$$

$$A_\mu = a_\mu \{\hat{g}_{\mu\mu} + a^\alpha [\hat{g}_{\mu\mu} \hat{,} P_\alpha]/1! + a^\alpha a^\beta [[\hat{g}_{\mu\mu} \hat{,} P_\alpha] \hat{,} P_\beta]/2! + \ldots\}. \quad (3.8d)$$

The *general isolorentz transformations* are given by the isorotations reviewed in [1], and the *isoboosts* first constructed in [6].

$$x'^1 = x^1, \quad x'^2 = x^2, \quad (3.9a)$$

$$x'^3 = x^3 \cosh [v(\hat{g}_{33}\hat{g}_{44})^{\frac{1}{2}}] - x^4\hat{g}_{44}(\hat{g}_{33}\hat{g}_{44})^{-\frac{1}{2}} \sinh [v(\hat{g}_{11}\hat{g}_{22})^{\frac{1}{2}}] = = \hat{\gamma}(x^3 - \beta x^4), \tag{3.9b}$$

$$x'^4 = - x^3\hat{g}_{33}(\hat{g}_{33}\hat{g}_{44})^{-\frac{1}{2}} \sinh [v(\hat{g}_{11}\hat{g}_{22})^{\frac{1}{2}}] + x^4 \cosh [v(\hat{g}_{33}\hat{g}_{44})^{\frac{1}{2}}] = = \hat{\gamma}(x^4 - \hat{\beta} x^3), \tag{3.9c}$$

where

$$\beta = v/c_0, \quad \hat{\beta} = v^k g_{kk} v^k / c_0 g_{44} c_0, \tag{3.10a}$$

$$\cosh [v(\hat{g}_{11}\hat{g}_{22})^{\frac{1}{2}}] = \hat{\gamma} = |1 - \beta^2|^{-\frac{1}{2}}, \quad \sinh [v(\hat{g}_{11}\hat{g}_{22})^{\frac{1}{2}}] = \hat{\beta}\hat{\gamma}. \tag{3.10b}$$

A few comments are in order. It is easy to prove the local isomorphisms $\hat{P}_Q(3.1) \approx P(3.1)$ for all $Q > 0$ (but not so for Q of generic Class III). This illustrates that the Lorentz *transformations* are necessarily inapplicable (and not «violated») under isotopies, but the Poincaré symmetry is preserved in an exact form, only realized in its most general possible (rather than simplest possible) form.

The «direct universality» of the isopoincare symmetry should be noted, i.e., its applicability for all infinitely possible isoseparations (3.3) (universality), directly in the x-frame of the experimenter (direct universality).

Despite their apparent simplicity, isotransformations (3.9) are highly nonlinear-nonlocal-noncanonical owing to the unrestricted functional dependence of the Q-matrix (or elements $\hat{g}_{\mu\mu}$). The simplicity of the final invariance should also be noted. In fact, the invariance of all infinitely possible isoseparations (3.3) is merely given by plotting the given $\hat{g}_{\mu\mu}$ elements in Eqs. (3.9).

This brings us to a first application of Q-isodeformations which has not yet propagated to the literature on q-deformations. It is given by the capabilities of the Q-isotopies [18]: a) to represent the transition from the Minkowskian to the Riemannian geometry; b) to provide the universal invariance of general relativity and c) to achieve a geometric unification of the special and general relativities. All these results are achieved by merely assuming the particular nonlinear, yet local and Lagrangian realization $\hat{g} \equiv g(x) = \text{Riemann} = Q(x)\,\eta$, and then the construction of the $\hat{P}_Q(3.1)$ isosymmetries with respect to the gravitational isounit $\hat{I} = [Q(x)]^{-1}$.

Note that all Riemannian metrics admit the above Q-decomposition with $Q > 0$ (trivially, from their locally Minkowskian character). Our isopoincare symmetry $\hat{P}_Q(3.1)$ then ensures: 1) the invariance of all Riemannian line elements*; 2) the crucial isomorphisms $\hat{P}_Q(3.1) \approx P(3.1)$; and 3) the isomorphisms among the underlying spaces $\hat{R}(x, g, \hat{R}) \approx M(x, \eta, R)$, where the Riemannian space $R(x, g, R)$ is reinterpreted as the isominkowskian space $\hat{R}(x, g, \hat{R})$, $g = Q\eta$, $\hat{I} = Q^{-1}$. The isotopic unification of the special and general relativities then follows via the embedding of curvature $Q(x)$ in the isounit $\hat{I}$ of the theory.

The *isodual isopoincaré symmetry* $\hat{P}^d_Q(3.1)$ is characterized by the antiautomorphic conjugation $Q \to Q^d = - Q^d (\hat{I} \to \hat{I}^d = - \hat{I})$ leading to isodual isofield $\hat{F}^d_Q(\hat{n}^d, +, *^d)$, isodual isospaces $\hat{M}^d_Q(x, \hat{g}^d, \hat{R}^d)$, $\hat{g}^d = - \hat{g}$, $\hat{R}^d \approx - \hat{R}$, etc. They characterize negative-definite energies, motion flowing backward in time, etc., thus permitting an intriguing (and novel) characterization of antiparticles [1,4,18,19]. Note the *isodual Poincaré symmetry* $P^d(3.1)$, whose identification requires the isotopic theory (owing to the need of a *bona fide* generalized unit $I^d = (-I)$).

For physical applications the isotopies are restricted to preserve the signature $(+, +, +, -)$ of $M(x, \eta, R)$, called of Kadeisvili Class I [1], with realization

$$\hat{g} = Q\,\eta,\ Q = \text{diag.}\,(b_1^2, b_2^2, b_3^2, b_4^2) \equiv \text{diag.}\,(n_1^{-2}, n_2^{-2}, n_3^{-2}, n_4^{-2}),$$

$$b_\mu,\ n_\mu > 0, \tag{3.11}$$

where the b's are called *characteristic functions* of the medium considered. The use of the quantity $Q^d = - Q$ then characterizes the isodual symmetry.

The unifying powers of the isopoincare symmetry should be finally noted. On mathematical grounds, the single abstract isotope $\hat{\mathcal{P}}_Q(3.1)$ of Class III outlined above unifies all possible inhomogeneous ten-dimensional groups, such as $O(4)\times T(4)$, $O(3.1)\times T(3.1)$, $O(2.2)\times T(2.2)$ all their isoduals and all their infinite isotopes [4,18].

On physical grounds, the isotope $\hat{P}_Q(3.1)$ of Class I unifies: linear and nonlinear, local and nonlocal, Hamiltonian and nonhamiltonian, relativistic and gravitational, as well as exterior and interior systems, at both classical and operator levels [4,18].

*As an example, the invariance of the Schwartzschild line element is very simply achieved by plotting in Eqs. (3.8) and (3.9) the values of $g_{11} = (1 - 2M/r)^{-1}$, $g_{22} = r^2$, $g_{33} = r^2\sin^2\theta$, $g_{44} = 1 - 2M/r$. Similarly $\hat{P}_Q(3.1)$ provides the direct invariance of any arbitrarily given Riemannian metric with elements $g_{\mu\mu}$.

4. ISOTOPIES AND ISODUALITIES OF THE SPECIAL RELATIVITY

We shall now ignore gravitational profiles, and consider isotopic theories specifically build for interior relativistic dynamical problems with $Q = Q(s, \dot{x}, \ddot{x}, \psi, \partial\psi, \partial\partial\psi, \ldots)$.

The isotopies of the Poincaré symmetry $P(3.1) \Rightarrow \hat{P}_Q(3.1)$ imply necessary, corresponding liftings of the special relativity into a form called *isospecial relativity*, originally submitted in [6] and then studied in detail in [4,18,19]. The objective is a form-invariant description of extended particles and electromagnetic waves propagating within inhomogeneous and anisotropic physical media represented by isospaces $\hat{M}(x, \hat{g}, \hat{R})$. The special relativity is then identically admitted, by construction, when motion returns to the homogeneous and isotropic vacuum.

The isospecial relativity is based on the isopoincaré invariance on isospaces $\hat{M}(x, \hat{g}, \hat{R})$ of Class I, with consequential isotopies of all basic postulates of the special relativity. Those important for this note are the following isopostulates for realization (3.11) with $b\mu = b_\mu(s, \dot{x}, \ddot{x}, \hat{\psi}, \partial\hat{\psi}, \partial\partial\hat{\psi}, \ldots)$, $b_1 = b_2 = b_3 \neq b_4$:

4.1. *The invariant speed is the «maximal causal speed»*

$$V_{Max} = |dr/dt|_{Max} = c_0 b_4 / b_3. \tag{4.1}$$

4.2. *The addition of speeds u and v is given by the «isotopic addition law»*

$$v' = (u + v)/(1 + u_k b_k^2 v_k / c_0^2 b_4^2). \tag{4.2}$$

4.3. *Time intervals and lengths follow the isodilation-isocontraction laws*

$$\hat{\tau} = \hat{\gamma}\tau_0, \quad \hat{\Delta} L = \hat{\gamma}\Delta L_0. \tag{4.3}$$

4.4. *The frequency follows the «isodoppler shift law»*

$$\hat{\omega}' = \omega\hat{\gamma}(1 - \hat{\beta}\cos\alpha), \quad \cos\hat{\alpha}' = (\cos\alpha - \hat{\beta})/(1 - \hat{\beta}\cos\alpha). \tag{4.4}$$

4.5. *The energy equivalence of mass follows the «isoequivalence principle»*

$$\hat{E} = mc^2 = mc_0^2 b_4^2 = mc_0^2 / n_4^2. \tag{4.5}$$

The above generalized postulates are implicit in the preceding formulations, e.g., in isoinvariant (3.3) or in isolorentz transformations (3.9); they recover identically the conventional postulates in vacuum for which $b_\mu = 1$; and they coincide with the conventional postulate at the abstract, realization-free level,

where we lose all distinctions between $\hat{I}$ and I, $x^{\hat{2}}$ and x^2, $\hat{\beta}^2$ and β^2, $\hat{\tau}$ and τ, $\hat{\omega}$ and ω, $\hat{E}$ and E, etc.

A most visible departure from the conventional postulates is the abandonment of the speed of light as the invariant speed in favor of quantity (4.1) which is intrinsic of the isominkowski geometry and represents the maximal causal speed as characterized by an effect following a cause due to particles, fields or other means. Note that in vacuum $V_{Max} \equiv c_0$ by therefore recovering as a particular case the speed of light as the maximal causal speed.

The best way to verify Isopostulates 4.1 is in the simplest possible medium, the homogeneous and isotropic water, where the speed of light is no longer c_0, but rather the familiar value $c = c_0 / n^0 < c_0$, where n^0 is the index of refraction. The insistence in keeping the speed of light as the invariant speed leads to a number of inconsistencies, such as: the violation of both the conventional and isotopic laws of addition of speeds, none of which yields the speed of light as the sums of two light speeds $u = v = c = c_0 / n^0$; electrons can propagate in water at speeds bigger than the assumed invariant speed, as experimentally established by the Cherenkov light; and others. All these inconsistencies are resolved by the isospecial relativity [4,18,19].

Even greater inconsistencies emerge if one insists in keeping the speed of light as the invariant speed for all media more complex than water, e.g., inhomogeneous and anisotropic atmospheres. A resolution of these inconsistencies requires the separation of the invariant speed from the speed of light, and the use of their identity only for the particular case in vacuum.

Since isopostulates 1.5 are quantitatively different than the conventional ones, they are suitable for experimental verification. Intriguingly, all available experimental evidence appears to confirm the above isotopic postulates, not only for simple media such as water or atmospheres, but also for the more complex media, such as the hyperdense media inside hadrons (Sect.8,9).

Isotopic theories predict the existence of a hitherto unknown universe, called *isodual universe*, which is characterized by the isodual isominkowski (and isoriemannian) spaces $\hat{M}_Q^d(x, \hat{g}, \hat{R})$. The *isodual isospecial relativity* [4,18,19] is a $\hat{P}_Q^d(3.1)$-invariant description of antiparticles in *interior* dynamical conditions, characterized by the image of Isopostulates 1.5 on $\hat{R}_Q^d(\hat{n}^d, +, *^d)$. The *isodual special relativity* is a new image of the conventional relativity for antiparticles in *exterior* conditions characterized by the isodual Poincaré invariance $P^d(3.1)$ on $M^d(x, \eta^d, R^d)$.

5. ISORENORMALIZATION

Isominkowskian treatments with generic characteristic functions $b^2_\mu(s, \dot{x}, \ddot{x}, \psi, \partial\psi, \partial\partial\psi, \ldots)$ are valid for the local description, that is, the behaviour of a particle or an electromagnetic wave at one given point of the interior medium, such as for the value of the speed of light $c = c_0 b_4 = c_0 / n_4$ at one given point of an inhomogeneous and anisotropic medium. When «global» values are of interest, such as the average speed of light through the entire medium considered, $c = c_0 \overset{0}{b}_4 = c_0 / \overset{0}{n}_4 =$ const. The b-functions can then be effectively averaged to constants, $\overset{0}{b}_\mu =$ Aver. $(b_\mu) =$ const. > 0, $\overset{0}{n}_\mu =$ Aver. $(n_\mu) =$ const. > 0.

In this case isotransforms (3.8), called *restricted isopoincare transformations*, regain linearity and locality (thus, preserving conventional inertial frames), although they remain noncanonical. Since we are interested in the «global» treatment of cold fusions (1.1), in this section we shall consider the restricted isopoincare transformations.

A primary function of the isominkowski spaces (as well as a primary mean for their experimental verification) is the geometrization of inhomogeneous and anisotropic physical media at large, and the media in the interior of hadrons, in particular. By recalling [1,4,19] that systems are now characterized by a conventional Lagrangian or a Hamiltonian plus the isotopic element Q, the desired novel isorenormalizations are expected to originate directly from the isominkowskian geometrization.

Consider the (operator) *relativistic isokinematics* on $\hat{M}(x, \hat{g}, \hat{R})$ [4,19], with basic expressions

$$p = (p^\mu) = (\hat{m} u^\mu) = (m_0 \widehat{\gamma c}\, v^k, m_0 \widehat{\gamma c}), \ \hat{m} = m_0 \hat{\gamma}, \ c = c_0 \overset{0}{b}_4, \qquad (5.1)$$

isoeigenvalue form

$$p_\mu * \hat{\psi} = - i \hat{I}^\nu_\mu \nabla_\nu \hat{\psi} = - i b_\mu^{-2} \nabla_\mu \hat{\psi}, \qquad (5.2)$$

and fundamental isoinvariant

$$p^{\hat{2}} * \hat{\psi} = \hat{\eta}^{\mu\nu} p_\mu * p_\nu * \hat{\psi} = (b^2_k p_k * p_k - c^2 p_4 * p_4) * \hat{\psi} =$$

$$= (m_0^2 \hat{\gamma}^2 c^2 v^k b^2_k v^k - m_0^2 \hat{\gamma}^2 c^4)\hat{\psi} = [- m_0^2 \hat{\gamma}^2 c^4 (1 - \beta^{\hat{2}})]\hat{\psi} = (- m_0^2 c^4)\hat{\psi}. \qquad (5.3)$$

It is then easy to see that the isorenormalization needed for the cold fusion is provided by Isopostulates 4.1/4.5 themselves. As an example, in going from motion in vacuum to motion within a physical medium with characteristics $\overset{0}{b}$-

constants, a particle experiences the following isorenormalization of the rest energy

$$E = mc_0^2 \Rightarrow E' = mc^2 = mc_0^2 b_4^{02}, \qquad (5.4)$$

which is precisely the relativistic version of the nonrelativistic isonormalization of Sect.2. A similar occurrence holds for all remaining intrinsic characteristics. This is expected from the alteration of the conventional Casimir invariants into form (3.7), as well as by the isotopies of Dirac's equation (see next section).

The predictions of the isospecial relativity for particles can be independently tested via the predictions for electromagnetic waves which, under the necessary condition of propagating within *inhomogeneous and anisotropic* media, are expressed by the *iso-plane-wave* on $\hat{M}_Q(x, \hat{g}, \hat{R})$ [4,19]

$$\hat{\psi}(x) = N\, e^{i(K^k b_k^{02} x^k - E b_4^{02} t)}. \qquad (5.5)$$

The novel predictions suitable for experimental tests (sect.9) are the *isodoppler's law* (4.4) with *isoredshift* for low density media (i.e., the prediction that electromagnetic waves lose energy within such media), and *isoblueshift* for high density media (i.e., the complementary prediction that electromagnetic waves gain energy from such media), while there is no modification of the Doppler's law in water because of its homogeneity and isotropy (i.e., electromagnetic waves preserve their energy in water).

A number of considerations here not reported for brevity (see [4,16,19]) lead to the important conlcusion that all hadrons beginning from the kaons are of the so-called *isominkowskian media of Type 9* for which $\hat{\beta} < \beta, \hat{\gamma} > \gamma$, Aver. $(\overset{0}{b}_k) < \overset{0}{b}_4$ [19], p.103. The understanding is that different hadrons have different numerical values of the characteristics $\overset{0}{b}$ quantities, e.g., because they have different densities. Intriguingly, all available experimental evidence confirmes this prediction (Sect.8).

6. ISOTOPIES AND ISODUALITIES OF DIRAC'S EQUATION

We are now sufficiently equipped to review a fundamental application of the isospecial relativity, the isotopies of Dirac's equation, here called *isodirac equation*, for the characterization of isoparticles $\hat{e}^\pm$, $\hat{p}^\pm$, etc.

The isolinearization of 2-nd order invariant (5.3) can be done by introducing the 12-dimensional isospace $\{\hat{M}_Q^{\text{Orb.}}(x, \hat{g}, \hat{R}) \times \hat{S}_Q^{\text{Intr}}(2)\} \times \{\hat{M}_Q^{d,\text{Orb.}}(x, \hat{g}^d, \hat{R}^d) \times S_Q^{d,\text{Intr.}}(2)\}$ for the characterization of the orbital and intrinsic angular momentum for particles and antiparticles, respectively. The following expression in self-explanatory notation (see [4] for details) then characterize the *isogamma matrices* $\hat\gamma$

$$(\hat g^{\mu\nu} p_\mu *^{\rm orb} p_\nu + \hat m^2) *^{\rm orb} \hat\psi(x) \equiv$$

$$\equiv (\hat g^{\mu\nu}\hat\gamma_\mu *^{\rm tot} p_\nu + i\hat m) *^{\rm tot} (\hat g^{\alpha\beta}\hat\gamma_\alpha *^{\rm tot} p_\beta - i\hat m) *^{\rm tot} \hat\psi(x), \tag{6.1a}$$

$$\{\hat\gamma_\mu, \hat{\tilde\gamma}_\nu\}^{\rm tot} = \hat\eta_\mu Q^{\rm tot}\hat\gamma_\nu + \hat\gamma_\nu Q^{\rm tot}\hat\gamma_\mu = 2\hat g_{\mu\nu}\hat I^{\rm orb}, \tag{6.1b}$$

$$\hat\gamma_\mu = \tilde\gamma_\mu \hat I^{\rm orb}, \quad \{\tilde\gamma_\mu, \tilde\gamma_\nu\}^{\rm intr} = \tilde\gamma_\mu Q^{\rm intr}\tilde\gamma_\nu + \tilde\gamma_\nu Q^{\rm intr}\tilde\gamma_\mu = 2\hat g_{\mu\nu}. \tag{6.1c}$$

The above formulation is excessively general for our needs in this note. We shall therefore assume the particularization

$$\hat I^{\rm orb} \equiv \hat I, \; Q^{\rm orb} \equiv Q, \; I^{\rm spin} = I = {\rm diag.}(1, 1), \; \hat I^d = -\,{\rm diag.}(1, 1), \tag{6.2a}$$

$$\{\hat\gamma_\mu, \hat\gamma_\nu\} = \hat\gamma_\mu Q\hat\gamma_\nu + \hat\gamma_\nu Q\hat\gamma_\mu = 2\hat g_{\mu\nu}\hat I, \quad \hat I = Q^{-1}, \tag{6.2b}$$

$$\hat\gamma^k = b^k\hat I\begin{pmatrix}0 & \sigma_k\\ -\sigma_k & 0\end{pmatrix} \gamma^4 = ib^4\hat I\begin{pmatrix}I_s & 0\\ 0 & I_s^d\end{pmatrix} I_s = {\rm diag.}\,(1, 1), \; I_s^d = -I_s, \tag{6.2c}$$

where the γ- and σ-matrices are the conventional ones, and $b_\mu = b_\mu(s, \dot x, \ddot x, \hat\psi, \partial\hat\psi, \partial\partial\hat\psi, \ldots)$. One can see the emergence of the isodual isospaces $S^d(2)$ characterized by $I^d = -\,{\rm diag.}(1, 1)$ beginning with the conventional Dirac's equation, which then persist under isotopies to $\hat S^d(2)$. The desired *isodirac equation* can then be written

$$(\hat\gamma_\mu * p^\mu + i\hat m) * \hat\psi(x) = (\hat g^{\mu\nu}\hat\gamma_\mu Q p_\nu + i\hat m)Q\hat\psi = 0, \quad \hat m = m\hat I. \tag{6.3}$$

with a simple extension to include electromagnetic potentials which, being external, are not altered by the isotopies.

The orbital and intrinsic angular momenta of particles with the lowest admissible hadronic weight are then characterized by

$$\hat O_Q(3): \hat L_k = \varepsilon_{kij} r_i p_j, \quad [\hat L_i, \hat L_j] = \varepsilon_{ijk} b_k^{-2}\hat L_k, \tag{6.4a}$$

$$\hat L^{\hat 2} * \hat\psi = (b_1^{-2}b_2^{-2} + b_2^{-2}b_3^{-2} + b_3^{-2}b_1^{-2})\hat\psi, \quad \hat L_3 * \hat\psi = b_1^{-1}b_2^{-1}\hat\psi, \tag{6.4b}$$

$$S\hat U(2): \hat S_k = \frac{1}{2}\varepsilon_{kij}\hat\gamma_i * \hat\gamma_j, \quad [\hat S_i, \hat S_j] = \varepsilon_{ijk} b_k^2\hat S_k, \tag{6.4c}$$

$$\hat S^{\hat 2} * \hat\psi = (1/4)\,(b_1^2b_2^2 + b_2^2b_3^2 + b_3^2b_1^2)\,\hat\psi, \quad \hat S_3 * \hat\psi = \frac{1}{2}\, b_1 b_2\hat\psi, \tag{6.4d}$$

which confirm the existence of the desired nontrivial isorenormalizations.

A simple isotopy of the conventional derivation, yields the *magnetic and electric isodipole moments* (assumed for simplicity along the third axis)

$$\hat\mu = \frac{b_3}{b_4}\mu, \quad \hat m = \frac{b_3}{b_4} m, \tag{6.5}$$

first derived in [3], eqs.(4.20, 16), p.803, and then isotopically reformulated in [15,4].

The full isosymmetry of (6.3) is the isotope $\hat S\hat L(2.\hat C)$ of the spinorial symmetry $SL(2.C)$ with generators $\hat S_k = \frac{1}{2}\varepsilon_{kij}\hat\gamma_i * \hat\gamma_j$, $\hat\Gamma_k = \frac{1}{2}\hat\gamma_k * \hat\gamma_4$ and isocommutation rules (3.6a). By adding isotranslations, Eqs.(6.3) therefore characterize the spinorial covering $\hat{\mathcal P}_Q(3.1)$ of the isopoincaré symmetry $\hat P_Q(3.1)$ of Sect.3. The proof that isodirac's equation transforms isocovariantly under $\hat{\mathcal P}_Q(3.1)$ is instructive [4]. Equally instructive is the proof of the *isoselfduality of Dirac's equation and of its isotopic extension* which justifies the assumed 12-dimensional isospace*.

7. ISOTOPIC CHARACTERIZATION OF THE COLD FUSION OF THE NEUTRON

We now specialize Eqs.(6.3) for the characterization of cold fusion (1.1e). Recall that Dirac's equation describes the ordinary electron e^- under the *external* field of the proton p^+. Eqs.(6.3) are therefore ideally set to describe Rutherford's electron $\hat e^-$ when immersed within the hadronic medium inside the proton considered as external.

*This proof requires the knowledge of the behaviour of all quantities under isoduality, e.g., complex number c become $c^d = -\bar c$, where bar denotes complex conjugation, etc. [4,16]

As a first step, we can therefore study the cold fusion $n = (p^+, \hat{e}^-)_{HM}$ where the proton is unperturbed owing to his much greater mass, and the isoelectron $\hat{e}^-$ is represented by (6.3) where the b_μ-functions are averaged to constants b^0_μ, thus averaging all interactions, whether Lagrangians or not*. These assumptions then permit the following remarkably simple isorenormalizations.

7.1. Isorenormalization of Rest Energy. The energies involved in cold fusion (1.1e) are: $E^0_n = 939.57$ MeV; $E^0_p = 938.28$ and $E^0_e = 0.5$ MeV. As we shall see in the next section, the binding energy is very small and can be assumed to be null in first approximation. This requires the isorenormalization via (4.5)

$$E^0_e = m^0 c_0^2 = 0.5\ \text{MeV} \Rightarrow E^0_{\hat{e}} = m^0 c_0^2 b_4^{02} \approx 1.3\ \text{MeV},\ b^0_4 \approx 1.62, \qquad (7.1)$$

first predicted in [15], p.527**.

7.2. Isorenormalization of Total Angular Momentum. The isoelectron $\hat{e}^-$ must have a null *total* angular momentum to permit a consistent cold fusion (1.1e). This result was first reached by Dirac [13,14] via his generalization of his own equaion, which results to have an essential isotopic structure with a non-diagonal Q-matrix (denoted β in [13]). The total angular momentum is then subjected to the isorenormalization $L + \frac{1}{2} \Rightarrow (n + n')/2,\ n, n' = 0, 1, 2, \ldots,$ thus being null for the ground state (see [16] for detailed review and isotopic reinterpretation).

The isotopic $\hat{SU}(2)$-spin theory [9] permits a rigorous confirmation of this result because the only allowed addition of angular momentum and spin for a particle immersed within the hyperdense medium inside the proton is that for which [12]: 1) the spin-spin coupling is a singlet; 2) the orbital angular momentum is along the spin of the heavier particle; and 3) at the limit of compression of the electron to the center of the proton, its orbital and intrinsic angular momenta must evidently coincide, thus resulting in a null total value (see also the review in [1], Sect.3.E).

*The understanding of this point requires the knowledge that conventional electromagnetic interactions can be represented via the generalized Lie tensor (the b-functions), with the Lagrangian representing only the kinetic energy [20], p.98—101. Despite its misleading appearance, Eqs.(6.3) represent, as written (i.e., *without* conventional interactions), an electron under the most general known linear and nonlinear, local and nonlocal, as well as Lagrangian and nonlagrangian interactions. Their averaging into constant b^0_μ is possible because of the stability of the cold fusion considered

**There is a clear misprint in [15], Eqs.(2.45) yielding 16.5 rather than 1.65. As we shall see in Sect.8, the experimental value is precisely 1.65 also accounting for the binding energy

Isodirac's equation (6.3) permits a quantitative interpretation of $\lim_{r\to 0} \hat{L}_{\hat{e}} \equiv S_{\hat{e}}$ via $\hat{L}_3 \equiv \hat{S}_3$ and $\hat{L}^{\hat{2}} \equiv \hat{S}^{\hat{2}}$ and from Eqs.(6.4) (for $L = 1$, $L = 0$ being unallowed for $\hat{L}_3 = \hat{S}_3 \neq 0$)

$$b_1^{-1} b_2^{-1} = \frac{1}{2} b_1 b_2,\ b_1^{-1} b_2^{-1} + b_2^{-2} b_3^{-2} + b_3^{-2} b_1^{-2} = = (1/4)(b_1^2 b_2^2 + b_2^2 b_3^2 + b_3^2 b_1^2), \qquad (7.2)$$

with numerical solution for the simple case of spherical symmetry

$$b_1^2 = b_2^2 = b_3^2 = \sqrt{2} \approx 1.415, \qquad (7.3)$$

which confirms a fundamental prediction of the isospecial relativity, that the nucleon is an isominkowskian medium of Type 9 [19], p.103 ($\hat{\beta} < \beta, \hat{\gamma} > \gamma$, Aver.$(b^0_k) < b^0_4$).

7.3. Isorenormalization of Magnetic Moments. Yet another prediction of the isospecial relativity is that, when ordinary electrons are immersed in the hyperdense medium inside protons, they experience a deformation-isorenormalization of both their orbital and intrinsic magnetic moments, first generically studied in ref. [3], p.803, and then studied, nonrelativistically, for cold fusion (1.1e) in ref. [12].

The isodirac's equation permits a quantitative, simple and direct treatment of this aspect too, via Eqs.(6.5) which yield for cold fusion (1.1e) (for $L = 1$ from (7.2), see Fig.1, p.525, of [12] for orientations)

$$\mu_n = -1.91|e|/2m_p c_0 = \mu_p + \mu_{\hat{e}}^{\text{orb}}| + \mu_{\hat{e}}^{\text{intr}}|,\ \mu_n = +2.71|e|/2m_p c_0, \qquad (7.4a)$$

$$\mu_{\hat{e}}^{\text{tot}} = -4.61|e|/2m_p c_0 = -2.4 \cdot 10^{-3}|e|/2m_e c_0, \qquad (7.4b)$$

$$\mu_{\hat{e}}^{\text{intr}} = (b^0_3/b^0_4)\,\mu_e^{\text{intr}} = (1.41/1.65)\,\mu_e^{\text{intr}} = 0.8545\,\mu_e^{\text{intr}}, \qquad (7.4c)$$

$$\mu_{\hat{e}}^{\text{orb}} = (-0.8545 + 0.0024)\,\mu_e^{\text{intr}} = -0.8521\,\mu_e^{\text{orb}}. \qquad (7.4d)$$

The latter numerical values should not be considered as final because of the need to study the general model $n = (\ddot{p}^+ \uparrow \ddot{e}^- \downarrow)_{HM}$ with isorenormalization of the electromagnetic properties of both the proton and the electron (including the charge which is not isorenormalized in this first treatment). Nevertheless, the latter study is expected to yield adjustments of numerical values (7.4).

We can therefore conclude by saying that the isospecial relativity does indeed provide a quantitative representation of the cold fusion of protons and electrons into neutrons (plus neutrinos), with all needed, specific, numerical predictions of the quantities involved in a form ready for experimental tests. The extension of the results to other cold fusions of particles is here left for brevity to the interested reader [4].

8. EXPERIMENTAL VERIFICATIONS

Even though preliminary and in need for independent re-runs, a number of direct and indirect experimental verifications are today available supporting cold fusions (1.1).

8.1. Direct Verifications. The first direct experimental verification of the isotopic origin of electron paring in superconductivity has been provided by Animalu [8] with rather impressive phenomenological agreement with data. The best verifications of cold fusions (1.1b)—(1.1d) are given by the uniqueness of the represented energy levels via model (2.7) (see Sect.9 for specific tests).

The first direct experimental verification of the cold fusion (1.1e) was done by don Borghi et al. [15]. The experiments essentially consist in forming a gas of protons and electrons inside a metallic chamber (called clystron) via the electrolytic separation of the hydrogen. Since the protons and electrons are charged, they cannot escape the metallic chamber. Nevertheless, numerous transmutations of nuclei occurred for matter put in the outside of said chamber. The measures can then be solely interpreted, in the absence of any other neutron source, by the cold fusion of the protons and electrons into neutrons which, being neutral, can escape the chamber and cause the measured transmutations.

8.2. Verifications Via the Bose-Einstein Correlation. The most important indirect verification of cold fusion (1.1e) has been recently achieved via theoretical [19] and experimental [21] studies on the Bose-Einstein's correlation. These results are important because they confirm, not only the fundamental isominkowskian *laws* underlying cold fusion (1.1e), but also their *numerical* values.

In essence, studies conducted via the full use of nonlinear-nonlocal-nonhamiltonian isominkowskian geometrization of the $p-\bar{p}$ fireball result in the two-point Boson isocorrelation function on $\hat{M}_Q(x, \hat{g}, \hat{R})$ [loc. cit.], Eq.(10.8), p.122,

$$\hat{C}_{(2)} = 1 + \frac{K^2}{3}\sum_{\mu} \hat{g}_{\mu\mu}\left(e^{-q_t^2/b_\mu^{02}}, \hat{g} = \text{Diag.}\,(b_1^{02}, b_2^{02}, b_3^{02}, -b_4^{02}\right), \qquad (8.1)$$

where q_t is the momentum thrasfer and $K = b_1^{02} + b_2^{02} + b_3^{02}$ is normalized to 3, under the sole approximation, also assumed in conventional treatments, that the longitudinal and fourth components of the momentum transfer are very small.

Phenomenological studies conducted in [21] via the *UA*1 data confirm model (8.1.) in its entirety, and identify the numerical values

$$b_1^0 = 0.267 \pm 0.054, \quad b_2^0 = 0.437 \pm 0.035,$$
$$b_3^0 = 1.661, \quad b_4^0 = 1.653 \pm 0.015. \qquad (8.2)$$

These measures have the following implications for cold fusions (1.1e): a) They first confirm the nonlinear-nonlocal-nonhamiltonian origin of the correlation, which is the expected origin of the cold fusion (1.1e); b) They confirm the isominkowskian geometrization of Type 9 ($\hat{\beta} < \beta, \hat{\gamma} > \gamma$, Aver. $(b_k^0) < b_4^0$) for the $p-\bar{p}$ fireball which, having the same density of the proton, is directly applicable to cold fusion (1.1e); c) they provide a numerical confirmation of rest energy isorenormalization (7.1) predicted in [12], beyond the best expectation by this author. Also, experimental value $b_4^0 = 1.653$ yields the isorenormalized rest energy $\hat{E}_{\hat{e}} = 1.36$ MeV, thus implying the existence of the binding energy $E = -0.072$ MeV, which is small, also as predicted.

8.3. Additional Experimental Verifications. Phenomenological calculations of deviations from the Minkowskian geometry inside pions and kaons were conducted in [22] via standard gauge models in the Higgs sector, resulting in the deformed metric $\hat{\eta} = \text{diag.}\,((1-\alpha/3), (1-\alpha/3), (1-\alpha/3), -(1-\alpha)$ which is precisely of the isominkowskian type (3.11) with numerical values

$$\text{PIONS } \pi^{\pm}: b_1^{02} = b_2^{02} = b_3^{02} \cong 1 + 1.2\cdot 10^{-3},\ b_4^{02} \cong 1 - 3.79\cdot 10^{-3}, \qquad (8.3a)$$

$$\text{KAONS } K^{\pm}: b_1^{02} = b_2^{02} = b_3^{02} \cong 1 - 2\cdot 10^{-4},\ b_4^{02} \cong 1 + 6.1\cdot 10^{-4}. \qquad (8.3b)$$

Pions $\pi^{\pm}$ are then isominkowskian media of Type 4 [19], while the heavier kaons $K^{\pm}$ are of Type 9. This confirms measures (8.2) because all hadrons heavier than $K^{\pm}$ are expected to be isominkowskian media of Type 9.

Independent phenomenological plots [23] on the behaviour of the meanlife of the K_S^0 (which, according to current experiments, is anomalous from 30 to 100 GeV and conventional from 100 to 350 GeV) via the isominkowskian geometrization yield the following characteristic values of the K_S^0

$$b_1^{02} = b_2^{02} = b_3^{02} \approx 0.909080 \pm 0.0004,\ b_4^{02} \approx 1.002 \pm 0.007, \qquad (8.4)$$

which are of the same order of magnitude of values (8.3b). Measures (8.4) therefore provide an independent confirmation that the interior of kaons is indeed an isominkowskian medium of Type 9, and an additional independent confirmation of the isogeometrization needed for cold fusion (1.1e). Plots [23] also computed the values

$$\Delta b_k^{o2} \cong 0.007, \quad \Delta b_4^{o2} \cong 0.001. \tag{8.5}$$

This confirms the prediction of the isospecial relativity in the range 30—400 GeV that the b_4^0 quantity, being an average of internal nonlocal effects, is constant for the particle considered (although varying from hadron to hadron with the density), while the dependence in the velocities rests with the b_k-quantities.

9. PROPOSED TESTS

Physics is a science with an absolute standard of value: the experiments. Experiments themselves have their own standard of value, the more fundamental the law to be tested, the more relevant the experiment. In particular, experiments such as don Borghi's verifications on the cold fusion $n = (\hat{p}^+, \hat{e}^-)_{HM}$, can only be dismissed via other experiments, and simply cannot be dismissed in a credible way via theoretical considerations or personal views.

We therefore suggest the independent verification or dismissal of experiments [15] on the fundamental and historical cold fusion (1.1e), which can nowadays be re-run via a number of independent alternatives*. Numerous, additional chemical syntheses of hadrons predicted by the isospecial relativity can then be verified or dismissed.

Similarly, we suggest the conduction of additional tests on the *stimulated decays of (unstable) hadrons* (which are the inverse of the cold fusions). The most important one at the basis of the possible hadronic technology [12] is the artificial disintegration of the neutron via the reaction $\gamma + n \rightarrow p^+ + e^- + \hat{\nu}_e$, whose cross section has been predicted [loc.cit.] to peak at the frequency of the isoelectron $\omega = 3.5 \cdot 10^{20}$ sec, rather than that of the electron $\hat{\omega} = 3.25 \cdot 10^{20}$ sec. This would permit a direct experimental test of the isorenormalizations (7.1) of the rest energy itself. Similar artificial disintegrations are possible to verify cold fusions (1.1b)—(1.1d) and their internal isorenormalizations.

Additional classical experiments have been proposed [18] for a direct test of the isominkowskian geometrization, such as, the prediction that a portion of the redshift of sun light at sunset (or a portion of quasars redshift) is due to an isodoppler shift caused by the inhomogeneity and anisotropy of Earth (quasars) atmospheres (which are media of Type 4), and numerous others.

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