PROCEEDINGS OF THE THIRD INTERNATIONAL CONFERENCE ON LIE-ADMISSIBLE TREATMENT OF IRREVERSIBLE PROCESSES (ICLATIP - 3)
Kathmandu University, Nepal, April (2011) pages 583-640

NONUNITARY LIE-ISOTOPIC AND LIE-ADMISSIBLE SCATTERING THEORIES OF HADRONIC MECHANICS, V: Foundations of the Genoscattering Theory for Irreversible Processes

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Abstract

In four previous papers of this series, we presented the foundations of a nonunitary-isounitary generalization of the unitary relativistic scattering theory as characterized by Santilli's Lie-isotopic theory. The generalized theory was called *isoscattering theory* due to the use of the underlying isomathematics. Even too time-reflection noninvariance can be accommodated via a time-dependence of the isounit, the axioms of the isoscattering theory have no "arrow of time" and, therefore, are essentially applicable to reversible scattering events, such as Coulomb scattering without collisions. In view of these limitations, in this paper we present, apparently for the first time, an irreversible covering of the isoscattering their as characterized by Santilli's Lie-admissible covering of the Lie-isotopic theory. The latter theory is presented under the name of *genoscattering theory* due to the use of the underlying genomathematics, and it is specifically intended for irreversible scattering processes, such as deep inelastic scattering. Besides a number of divergences between the data interpretation via the genoscattering and the conventional scattering theory, a significant result identified in this paper is that the irreversible treatment of inelastic processes among extended particles or wavepackets implies numerical values of the masses of intermediate states, such as that of the Higgs boson, largely different than those predicted by the conventional reversible scattering theory among point-like particles.

Key words scattering theories, nonunitary theories, isounitary theories
PACS 03.65.Nk, 11.30.Cp, 03.65.-w

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1. INTRODUCTION

1.1. Brief Outline of Preceding Papers

An important property of quantum mechanics, which is at the foundation of its physical relevance when applicable, is its *invariance over time,* **namely, the capability of predicting the same numerical values under the same conditions at different times. As it is well known, this property originates from the fact that the time evolution of quantum mechanics characterizes a** *unitary transformation* **on a Hilbert space over a field.**

However, quantum mechanics was conceived and verified for closed-isolated systems of point particles in vacuum (exterior dynamical problems), such as the atomic structures, that are *reversible over time,* **namely, their time reversal images verify causality and conservation laws. This feature is reflected in the fact that the basic mathematical and physical axioms of quantum mechanics have no "time arrow," namely, they are as reversible as the systems intended for representation.**

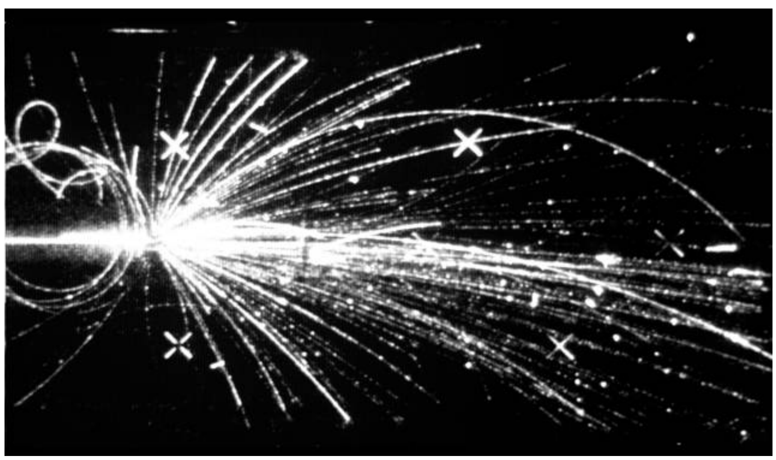

Figure 1: *A view of inelastic scattering events studied in this paper to illustrate their irreversible character.*

In the first paper of this series [1], we recalled the historical legacy by Lagrange, Hamilton and Jacobi according to which the irreversibility of natural processes originates from contact nonpotential interactions represented with the external terms in the analytic equations (interior dynamical systems); we recalled the *No Reduction Theorems* **prohibiting the reduction of macroscopic irreversible systems to a finite number of elementary particles all in reversible conditions, thus establishing the origin of nonpotential/non-Hamiltonian forces at the most elementary level of na-**

ture; and we recalled that the covering *hadronic mechanics* **was built for the specific purpose of achieving an invariant representation of systems with conventional potential Hamiltonian as well as contact non-Hamiltonian interactions, the latter demanding a time evolution which is necessarily** *nonunitary* **from the non-Hamiltonian character of the forces.**

In the preceding Papers I, II and III of this series [1], w reviewed the *Theorems of Catastrophic Mathematical and Physical Inconsistencies of Noncanonical and Nonunitary Theories* **when treated with the mathematics of canonical and unitary theories, respectively. Along these lines, we pointed out that nonunitary time evolutions violate causality when formulated on a conventional Hilbert space over a conventional field. We then reviewed** *Santilli Lie-isotopic mathematics.* **or** *isomathematics* **for short, which provides the only known method capable of resolving said catastrophic inconsistencies, by regaining invariance over time and causality. In the same Papers I, II, III, we then reviewed the** *Lie-isotopic branch of hadronic mechanics,* **or** *isomechanics* **for short, and specialized it to the scattering problem.**

It may be useful to recall that Santilli's Lie-isotopic formulations are achieved at both, the mathematical and the physical levels, by using a nonunitary transformation of a generic quantum mechanical quantity Q

$$UU^{\dagger} \neq I, \tag{1,1a}$$

$$Q \rightarrow \hat{Q} = UQU^{\dagger}, \tag{1.1b}$$

applied to the *totality of quantum mechanical, mathematical and physical quantities and their operations* **with no known exception, thus including the isotopic lifting of basic units, numbers, functions, differentials, etc. Invariance over time and causality are achieved indeed, but under the condition of elaborating isotopic theories with isomathematics, since elaborations of isotopic theories with conventional mathematics, or elaborations of conventional theories with isomathematics, are evidently inconsistent.**

In Paper IV of this series [1], we then presented in operational details the *Lie-isotopic scattering theory,* **or** *isoscattering theory* **for short, including all necessary foundations, such as the Dirac-Santilli equation, the Feynman-Animalu diagrams, and related procedure. The resulting theory emerges as a significant covering of the conventional unitary scattering theory since it possesses an essential nonunitary structure, yet it is as invariant and causal as the conventional theory. The nonunitary character permits significant advances in the representation of scattering processes, such as the representation of particles as being extended, resulting in a scattering region no longer constituted by ideal points, but consisting of a hyperdense**

medium with Hamiltonian and non-Hamiltonian internal interactions verifying the laws of hadronic mechanics, while quantum mechanics is recovered uniquely identically in the exterior of the scattering region under the limit $LimUU^\dagger = I$.

Despite these advances, *the Lie-isotopic scattering theory remains as reversible over time as the conventional scattering theory.* **This feature was expected** *ab initio* **since the formulation was constructed via the use of** *Santilli isotopies* **that are known to be** *axiom-preserving* **by conception and technical realization.**

Despite this limitation, in Paper IV we showed that the isoscattering theory is non-trivial because it allows the inclusion of scattering processes that are prohibited by the conventional theory due to its unitarity. As an illustration, we provided the representation via the isoscattering theory of the following events

$$e^- + e^+ \to \pi^0 \to e^- + e^+ \tag{1.2a}$$

$$e^- + p \to n + \nu \ \to p + e^- + \nu + \bar{\nu}, \tag{1.2b}$$

which are manifestly reversible over time, yet requiring a nonunitary scattering theory because: the rest energy of the synthesized hadron is bigger than the sum of the rest energies of the original particles; the missing energy cannot be provided by the relative kinetic energy due to the related excessively small cross section and ensuing inability to achieve the indicated syntheses of hadrons; and the only known consistent dynamical equations is the *Schrödinger-Santilli equation,* **namely, a nonunitary image of the Schrödinger equation proposed by Santilli since his original memoir of 1978 to build hadronic mechanics [2].**

1.2. The Role of the Isodual Theory for Antimatter

As it is well known, during the 20th century matter was treated at all level of study, from Newtonian Mechanics to second quantization, while antimatter was solely treated at the level of second quantization, due to the lack of technical means in Einstein's special and general relativities to provide any distinction between *neutral* **matter and antimatter. This resulted in the lack of scientific democracy in the treatment of matter and antimatter with deep implications at all levels of study.**

Santilli (see general review [5] and original papers quoted therein) resolved the above imbalance via the construction of a new mathematics, today known as *Santilli isodual mathematics,* **the related** *isodual mechanics and relativity* **and the resulting** *isodual theory of antimatter.* **The main idea of these studies can be outlined as follows. Recall that the conventional** *charge conjugation* **is defined on a Hilbert space** $\mathcal{H}$ **with states** $\psi(x)$ **over the field of**

complex numbers $\mathcal{C}$ and can be characterized by expressions of the type

$$C\ \psi(x) = -\ \psi^{\dagger}(x), \tag{1.3}$$

where x is the coordinate of the representation space, such as the Minkowski spacetine.

Santilli [28] constructed the isodual mathematics, mechanics and relativity are via an anti-Hermitean conjugation, called *isoduality* and denoted with the upper index d, applied to the totality of the mathematics and physics used for matter with no known exception to avoid catastrophic inconsistencies when mixing conventional and isodual formulations. Therefore, the isodual conjugation of an arbitrary classical or operator quantity $A(x, p, ...)$ depending on coordinates x, momenta p, and any other needed variable is given by

$$A(x, p, ...) \ \rightarrow \ A^d(x^d, p^d, ...) = A(-x^{\dagger}, -p^{\dagger}, ...). \tag{1.4}$$

This conjugation characterizes the novel *isodual unit* $1^d = -1^{\dagger}$, *isodual real, complex or quaternionic numbers* $n^d = -n^{\dagger}$, *isodual product* $n^d \times^d m^d = n^s \times (1^d)^{-1} \times m^d$, *isodual functional analysis*, isodual differential calculus, etc. (see Ref. [2] for brevity). In particular, the reader should keep in mind that isoduality is the only known consistent procedure for the differentiation between *neutral* as well as charged matter and antimatter at all levels of treatment.

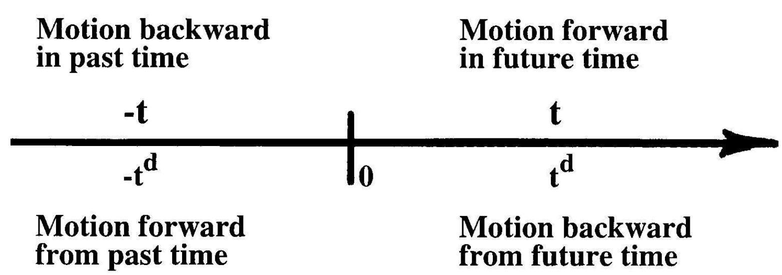

Figure 2: *An illustration of the four different directions of time and the consequential need of the isodual conjugation in addition to the conventional time inversion for the representation of all four directions.*

Even though charge and isodual conjugations are both anti-Hermitean, their differences are not trivial. From a physical viewpoint, charge conjugation conjugates states in a Hilbert space, but does not conjugate the

local coordinates x. This implies that, for 20th century theories, antimatter exists in the same spacetime of matter. At any rate, the relegation of antimatter at the level of second quantization, e.g., via Dirac's "hole theory," leaves the Minkowski spacetime unique, thus entirely characterized by the fundamental Poincaré symmetry and special relativity.

By contrast, the isodual conjugation additionally maps spacetime coordinates x into the novel *isodual coordinates* $x^d = -x^\dagger$ **that are defined on the** *Minkowski-Santilli isodual spacetime* $M^d(x^d, \eta^d, 1^d)$, **where η is the usual Minkowski metric. Therefore, under isoduality, the** *Poincaré-Santilli isodual symmetry,* **and the** *isodual special relativity,* **antimatter is predicted to exist in a new spacetime which is distinct from, yet coexisting with our spacetime. In particular, the differences of conventional and isodual spacetimes are not trivial. e.g., because the isodual conjugation of coordinates is different than inversions [2].**

It should be stressed to prevent possible scientific misrepresentations that *the isodual theory verifies all available experimental data on antimatter at both the classical and operator levels.* **In fact, the** *Newton-Santilli isodual equations* **for antiparticles verifies all available data for charged particles and antiparticles, while isoduality is equivalent to charge conjugation at the operator level by conception and construction, as recalled via Eqs. (1) and (2) (see Ref. [2] for details).**

As expected, *the isodual theory of antimatter suggested a re-interpretation of Dirac's equation with deep implications for the scattering theory.* **Recall that Dirac was forced to voice the "hole theory" for the consistent representation of antiparticles due to the unphysical character of negative energy solutions.**

The isodual theory of antimatter resolved the latter issue since negative energies are referred to negative units, thus being as causal as positive energies referred to positive units. In any case, the isodual theory of antimatter achieves a consistent representation of antiparticles at the Newtonian level, let alone that in first quantization. Consequently, the conventional Dirac equation

$$[\gamma^\mu \times (p_\mu - e \times A_\mu/c) + i \times m] \times \Psi(x) = 0, \tag{1.6a}$$

$$\gamma_k = \begin{pmatrix} 0 & -\sigma_k \\ \sigma_k & 0 \end{pmatrix}, \quad \gamma^4 = i \times \begin{pmatrix} I_{2\times2} & 0, \\ 0 & -I_{2\times2} \end{pmatrix}, \tag{1.6bb}$$

$$\{\gamma_\mu, \tilde{\gamma}_\nu\} \ = \ 2\times\eta_{\mu\nu}, \quad \Psi = i \times \begin{pmatrix} \Phi \\ -\Phi^\dagger \end{pmatrix} \tag{1.6c}$$

has been subjected to the following re-interpretation solely permitted by

the isodual theory [5]

$$[\tilde{\gamma}^\mu \times (p_\mu - e \times A_\mu/c) + i \times m] \times \tilde{\Psi}(x) = 0, \qquad (1.7a)$$

$$\tilde{\gamma}_k = \begin{pmatrix} 0 & \sigma_k^d \\ \sigma_k & 0 \end{pmatrix}, \quad \tilde{\gamma}^4 = i \begin{pmatrix} I_{2\times 2} & 0, \\ 0 & I_{2\times 2}^d \end{pmatrix}, \qquad (1.7b)$$

$$\{\tilde{\gamma}_\mu, \tilde{\gamma}_\nu\} = 2^d \times^d \eta_{\mu\nu}^d, \quad \tilde{\Psi} = -\tilde{\gamma}_4 \times \Psi = i \times \begin{pmatrix} \Phi \\ \Phi^d \end{pmatrix} \qquad (1.7c)$$

in which the electron and the positron are both treated in first quantization without any need for the "hole theory."

The main conclusion of re-interpretation (1.xxx) is that *the Dirac equation directly represents the Kronecker product of an electron and its antiparticle.* **This conclusion is equally reached, rather forcefully, on algebraic grounds. Santilli [28] first noted that there exists no** *irreducible* **four-dimensional representation of the SU(2) symmetry for spin 1/2, and there exists no** *reducible* **four-dimensional representation of SU(2) with the structure of Dirac's gamma matrices. Therefore, the sole known algebraically consistent meaning of the gamma matrices is that they characterize an** *irreducible* **representation for spin 1/2 of the Kronecker product $SU(2) \times SU(2)^d$, thus representing a Kronecker product of an electron and its antiparticle as indicated above.**

Since Feynman's diagrams for electrons and positrons are centrally dependent on Dirac's equation, it is evident that the above reformulation of the latter equation requires a necessary re-inspection of the former. In fact, the annihilation process in Feynman's diagrams

$$e^- + e^+ \ \rightarrow \ 2\ \gamma, \qquad (1.8)$$

exhibits a number of asymmetries, such as: the l.h.s. is isoselfdual (invariant under isoduality), but the r.h.s is not; the annihilation process is assumed to occur via the exchange of a particle (an electron or a photon)which is not isoselfdual; and others.

One of the major implications of the isodual conjugation which is not possible for charge conjugation is the prediction that *antimatter emits a new light with experimentally verifiable physical differences with the ordinary light emitted by matter.* **In fact, charge conjugation is evidently inapplicable to the photon, while isoduality predicts the isodual photon γ^d with energy $E^d = \hbar^d \times^d \nu^d = -E$ referred to the unit $MeV^d = -MeV$ which is predicted as being repelled by the gravitational field of matter, thus being physically distinguishable from the ordinary photon γ with g energy $E = \hbar \times \nu$ referred**

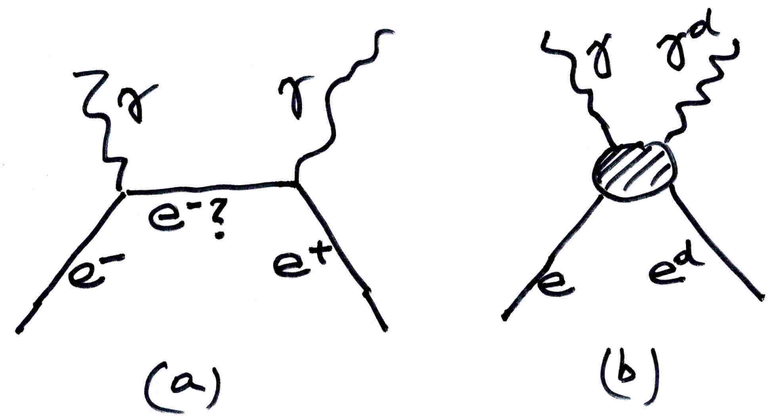

Figure 3: *A view of the electron-positron annihilation according to Dirac-Feynman theories (l.h.s) and the same annihilation as predicted by Santilli's isodual theories (r.h.s). Note the verification for the latter of all isodual laws, as well as the absence of the isoselfduality violating exchange of the former, since annihilation requires actual physical contact of particles antiparticles that cannot be triggered by particle exchanges at a distance as represented by the Feynman-Animalu diagrams.*

to the unit MeV. Consequently, the isodual theory requires the following re-interpretation of Feynman's diagram for annihilation ()1.8) [5]

$$e + e^d \equiv (e + e^d)^d \ \rightarrow \ \gamma + \gamma^d \equiv (\gamma + \gamma^d)^d, \quad e = e^-, \quad e^d = e^+, \tag{1.9}$$

that provides an evident resolution of all ambiguities and asymmetries of annihilation (1.8). Moreover, in the latter case, there is no exchange of particles, since annihilation is predicted to occur under actual physical contact or mutual penetration of the wavepackets of particles and antiparticles in accordance with *Feynman-Animalu diagrams* **(see Fig. 3).**

The insidious character of the lack of full democracy in the treatment of matter and antimatter is illustrated by comparing reactions (1.8) and (1.9). Reaction (1.8) is rather universally treated in first quantization, resulting in clear inconsistencies since, at that level, the electron and the photons can indeed be fully treated, yet the positron has negative energy in first quantization, thus prohibiting such a treatment for the sole consistent treatment in second quantization. by comparison, Reaction (1.9) can be consistently treated at the level of first quantization, its treatment at the level of second quantization being under study by V. de Haan (private communication).

Needless to say, there exists a large number of experiments in electron-positron annihilation and the emitted two photons. However, a deep inspection reveals that available experiments have provided no consideration on the possible differences between the two emitted photons, trivially, because no such difference was provided by the uses basic theories. Specific experiments for the resolution whether the two photons of reaction (1.9) are identical or physically different has been proposed in Ref. [29].

All in all, it is hoped the reader can see that *a reinspection of the 20th century scattering theory is necessary for the sole advances in antimatter, let alone because of its reversible structure compared to the general irreversibility of scattering events.*

1.3. Main Objectives of this Paper

In this paper, we present, apparently for the first time, the foundation of the *Lie-admissible scattering theory* **as a covering of the conventional or the isoscattering theory for the specific purpose of representing** *deep inelastic scattering processes involving particles and antiparticles* **that are notoriously irreversible over time (see Fig. 1). In fact, in the latter processes, we have the lack of rigorous applicability of the conventional scattering theory due to its reversibility since the selection of the appropriate scattering theory for irreversible scattering events is indeed open to scientific debates, but not its need.**

The main difficulties of this paper are numerous. First, it is essential to achieve a formulation which is truly irreversible in both its mathematical and physical formulations. This objective is implemented via *Santilli's forward and backward maps* **characterized by** *two* **nonunitary transformations of each quantum mechanical quantity Q**

$$ZZ^{\dagger} \neq I \quad WW^{\dagger} \neq I, \quad ZW^{\dagger} \neq I, \tag{1.10a}$$

$$Q \rightarrow \hat{Q}^{>} = ZQW^{\dagger}, \quad Q \rightarrow^{<} \hat{Q} = WQZ^{\dagger}. \tag{1.10b}$$

The above liftings essentially set the "time arrow" in all mathematical and physical structures and their operations. Irreversibility is then assured by the inequivalence of the forward and backward processes.

The second major difficulty is in the achievement of invariance over time not only for nonunitary theories, but also of their realization in an irreversible form. This task cannot any longer be achieved via the isomathematics, thus mandating the use of a yet broader *Santilli Lie-admissible mathematics,* **also known as***genomathematics,* **the resulting scattering theory being also proposed under the shorter name of** *genoscattering theory.*

The final difficulty is the verification that the ensuing Lie-admissible scattering theory is indeed physically valid and carries nontrivial implications in the data elaboration of deep inelastic scattering events. By remembering that the conventional scattering theory was established only following about half a century of research, the authors hope that this initiating paper will essentially set up the foundation of the new scattering theory for irreversible scattering process for a collegial future finalization.

The results of this paper are largely dependent on Santilli's lifelong studies on Lie-admissible algebras with particular reference to the latest memoir [4], as well as on Animalu's first isotopies of Feynman's diagrams [**30**].

2. SANTILLI LIE-ADMISSIBLE GENOMATHEMATICS

2.1 Genounits, Genoproducts and their Isoduals

The most fundamental notion of Santilli's genomathematics from which the entire formulation is build via compatibility arguments, is a dual generalization of the basic unit of quantum mechanics $\hbar = 1$ into two non-Hemitean (nonsingular) generalized units, called *genounits,* one used to represent motion forward in time and the other for motion backward in time, but having a nonsingular, but otherwise arbitrary dependence on time t, coordinates r, the density μ of the region considered (e.g. the scattering region), wavefunctions ψ, their derivatives $\partial\psi$, etc. [**3**]

$$\hat{I}^{>}(t, r, \mu, \psi, \partial\psi, ...) = 1/\hat{T}^{>}, \quad {}^{<}\hat{I}(t, r, \mu, \psi, \partial\psi, ...) = 1/{}^{<}\hat{T}, \tag{2.1a}$$

$$\hat{I}^{>} \neq^{<} \hat{I}, \quad \hat{I}^{>}(t, ...) \neq^{>} (-t, ...), \quad {}^{<}\hat{I}(t, ...) \neq^{<} \hat{I}(-t, ...(, \quad \hat{I}^{>} = ({}^{<}\hat{I})^{\dagger}, \tag{2.1b}$$

with two additional *isodual genounits* for the description of antimatter

$$(\hat{I}^{>})^{d} = -(\hat{I}^{>})^{\dagger} = -{}^{<}\hat{I} = -1/{}^{<}\hat{T}, \quad ({}^{<}\hat{I})^{d} = -\hat{I}^{>} = -1/\hat{T}^{>}. \tag{2.2}$$

Santilli selected since the original memoirs [**2**] of 1978 the "genotopic" from the Greek meaning of "inducing new structures and to have a differentiation with the word "isotopic" used in the preceding papers that stands for preserving the original; structures.

Jointly, all conventional and/or isotopic products $A\hat{\times}B$ among generic quantities (numbers, vector fields, operators, etc.) are lifted in such a form to admit the genounits as the correct left and right units at all levels, i.e.,

$$A > B = A \times \hat{T}^{>} \times B, \quad A > \hat{I}^{>} = \hat{I}^{>} > A = A, \tag{2.3a}$$

$$A < B = A \times^< \hat{T} \times B, \quad A <^< \hat{I} =^< \hat{I} < A = A, \tag{2.3b}$$

$$A >^d B = A \times \hat{T}^{>d} \times B, \quad A >^d \hat{I}^{>d} = \hat{I}^{>d} >^d A = A, \tag{2.3c}$$

$$A <^d B = A \times^< \hat{T}^d \times B, \quad A <^{d\ <}\hat{I}^d = {}^<\hat{I}^d <^d A = A, \tag{2.3d}$$

for all elements A, B of the set considered.

In different words, the central idea in the Lie-admissible representation of irreversible processes is to lift the conventional associative product of quantum mechanics $A \times B$ into *two* products, one for the product to the right $A > B$ and one for the product to the left $A < B$. Irreversibility is then solely guaranteed under the condition of their nonequivalent, that is, $A > B \neq A < B$. In turn, this inequivalence is impossible under the conventional associative product $A \times B$, thus mandating inequivalent genotopies $A > B = A \times \hat{T}^> \times B$ and $A < B = A \times^< \hat{T} \times B$. In the next section we shall then show that the quantity $\hat{T}^>$ precisely represents the external forces of Lagrange and Hamilton equations for motion forward in time and ${}^<\hat{T}$ represents the inequivalent time reversal image.

The assumption of all *ordered product to the right* $>$ permits the representation of matter systems moving forward in time, the assumption of all *ordered products to the left* $<$ can represent matter systems in the scattering region moving backward in time, with corresponding antimatter systems represented by the respective isodual ordered products $>^d = - >^\dagger$ and $<^d = - <^\dagger$. Irreversibility is represented *ab initio* by the inequality $A > B \neq A < B$ for matter and $>^d \neq <^d$ for antimatter.

We recall here that the simpler isotopic subclass are given by $\hat{I}^> =^< \hat{I} = \hat{I} = \hat{I}^\dagger > 0$ for matter and $\hat{I}^{>d} =^< \hat{I}^d = \hat{I}^d = \hat{I}^{d\dagger} < 0$ for antimatter.

The reader should be aware (by looking at Fig. 2) that *Santilli's genomathematics consists of four branches, namely the forward and backward genomathematics for matter and their isoduals for antimatter,* each pair being interconnected by time reversal, and the two pairs being interconnected by isodual map

$$\begin{aligned} Q(t, r, \psi, \partial\psi, ...) &\to Q^d(t^d, r^d, \psi^d, \partial^d\psi^d, ...) \\ &= -Q^\dagger(-t^\dagger, -r^\dagger, -\psi^\dagger, -\partial^\dagger(-\psi^\dagger), ...) \end{aligned} \tag{2.4}$$

that, as it is well known [5], is equivalent to charge conjugation.

2.2. Genonumbers, Genofunctional Analysis and their Isoduals

Genomathematics began with Santilli's discovery in paper [3] of 1993, that *the axioms of a field still hold under the ordering of all products to the right or, independently, to the left.* This property permitted the formulation of *new* *numbers* **that can be best introduced as a generalization of the isonumbers, although they can also be independently presented as follows:**

DEFINITION : Let $F = F(a, +, \times)$ *be a field of characteristic zero. Santilli's forward genofields are rings* $\hat{F}^> = \hat{F}(\hat{a}^>, \hat{+}^>, \hat{\times}^>)$ *with: elements*

$$\hat{a}^> = a \times \hat{I}^>, \tag{2.5}$$

where $a \in F$, $\hat{I}^> = 1/\hat{T}^>$ *is a non singular non-Hermitean quantity (number, matrix or operator) generally outside* F *and* $\times$ *is the ordinary product of* F*; the genosum* $\hat{+}^>$ *coincides with the ordinary sum* $+$,

$$\hat{a}^> \hat{+}^> \hat{b}^> \equiv \hat{a}^> + \hat{b}^>, \;\; \forall \hat{a}^>, \; \hat{b}^> \in \hat{F}^>, \tag{2.6}$$

consequently, the additive forward genounit $\hat{0}^> \in \hat{F}$ *coincides with the ordinary* $0 \in F$*; and the forward genoproduct* $>$ *is such that* $\hat{I}^>$ *is the right and left isounit of* $\hat{F}^>$,

$$\hat{I}^> \hat{\times} \hat{a}^> = \hat{a}^> > \hat{I}^> \equiv \hat{a}^>, \;\; \forall \hat{a}^> \in \hat{F}^>. \tag{2.7}$$

Santilli's forward genofields verify the following properties:

1) For each element $\hat{a}^> \in \hat{F}^>$ *there is an element* $\hat{a}^{>-\hat{1}^>}$, *called forward genoinverse, for which*

$$\hat{a}^> > \hat{a}^{>-\hat{I}^>} = \hat{I}^>, \;\; \forall \hat{a}^> \in \hat{F}^>; \tag{2.8}$$

2) The genosum is commutative

$$\hat{a}^> \hat{+}^> \hat{b}^> = \hat{b}^> \hat{+}^> \hat{a}^>, \tag{2.9}$$

and associative

$$(\hat{a}^> \hat{+}^> \hat{b}^>) +^> \hat{c}^> = \hat{a}^> \hat{+}^> (\hat{b}^> \hat{+}^> \hat{c}^>), \;\; \forall \hat{a}, \hat{b}, \hat{c} \in \hat{F}; \tag{2.10}$$

3) The forward genoproduct is associative

$$\hat{a}^> > (\hat{b}^> > \hat{c}^>) = (\hat{a}^> > \hat{b}^>) > \hat{c}^>, \quad \forall \hat{a}^>, \hat{b}^>, \hat{c}^> \in \hat{F}^>; \tag{2.11}$$

but not necessarily commutative

$$\hat{a}^> > \hat{b}^> \neq \hat{b}^> > \hat{a}^>, \tag{2.12}$$

4) The set $\hat{F}^>$ *is closed under the genosum,*

$$\hat{a}^> \hat{+}^> \hat{b}^> = \hat{c}^> \in \hat{F}^>, \tag{2.13}$$

the forward genoproduct,

$$\hat{a}^> > \hat{b}^> = \hat{c}^> \in \hat{F}^>, \tag{2.14}$$

and right and left genodistributive compositions,

$$\hat{a}^> > (\hat{b}^> \hat{+}^> \hat{c}^>) = \hat{d}^> \in \hat{F}^>, \tag{2.15a}$$

$$(\hat{a}^> \hat{+}^> \hat{b}^>) > \hat{c}^> = \hat{d}^> \in \hat{F}^> \quad \forall \hat{a}^>, \hat{b}^>, \hat{c}^>, \hat{d}^> \in \hat{F}^>; \tag{2.15b}$$

5) The set $\hat{F}^>$ verifies the right and left genodistributive law

$$\hat{a}^> > (\hat{b}^> \hat{+}^> \hat{c}^>) = (\hat{a}^> \hat{+}^> \hat{b}^>) > \hat{c}^> = \hat{d}^>, \ \forall \hat{a}^>, \hat{b}^>, \hat{c}^>, \in \hat{F}^>. \tag{2.16}$$

In this way we have the forward genoreal numbers $\hat{R}^>$, the forward genocomplex numbers $\hat{C}^>$ and the forward genoquaternionic numbers $\hat{Q}C^>$ while the forward genooctonions $\hat{O}^>$ can indeed be formulated but they do not constitute genofields [6].

The backward genofields and the isodual forward and backward genofields are defined accordingly. Santilli's genofields are called of the first (second) kind when the genounit is (is not) an element of F.

The basic axiom-preserving character of genofields is illustrated by the following:

LEMMA: Genofields of first and second kind are fields (namely, they verify all axioms of a field).

Note that the conventional product "2 multiplied by 3" is not necessarily equal to 6 because, for isodual numbers with unit -1 it is given by -6. The same product "2 multiplied by 3" is not necessarily equal to +6 or -6 because, for the case of isonumbers, it can also be equal to an arbitrary number, or a matrix or an integrodifferential operator depending on the assumed isounit [3].

In this section we point out that "2 multiplied by 3" can be ordered to the right or to the left, and the result is not only arbitrary, but yielding different numerical results for different orderings, $2 > 3 \neq 2 < 3$, all this by continuing to verify the axioms of a field per each order [3].

Once the forward and backward genofields have been identified, the various branches of genomathematics can be constructed via simple compatibility arguments.

For specific applications to irreversible processes there is first the need to construct the *genofunctional analysis,* **studied in Refs. [6,7] that we shall not review here for brevity. It should, however, be clear to the reader**

that any elaboration of irreversible processes via Lie-admissible formulations based on conventional or isotopic functional analysis leads to catastrophic inconsistencies because it would be the same as elaborating quantum mechanical calculations with genomathematics. Recall the theorem of catastrophic inconsistencies[8] which states that:

All theories with a non-unitary time evolution, $W(t)W^{+}(t) \neq I$ when formulated with mathematical methods of unitary theories (conventional fields, spaces, functional analysis, differential calculus, etc) do not preserve the said mathematical methods over time thus being afflicted by catastrophic mathematical inconsistencies and do not preserve over time the basic units of measurements, Hermiticity-observability, numerical predictions and causality, thus suffering catastrophic physical inconsistencies.

And observe that this theorem is activated unless one uses the ordinary differential calculus is lifted, for ordinary motion in time of matter, into the following *forward genodifferentials and genoderivatives*

$$\hat{d}^{>}x = \hat{T}_x^{>} \times dx, \quad \frac{\hat{\partial}^{>}}{\hat{\partial}^{>}x} = \hat{I}_x^{>} \times \frac{\partial}{\partial x}, \text{ etc.} \tag{2.16}$$

with corresponding backward and isodual expressions here ignored,

Similarly, all conventional functions and isofunctions, such as isosinus, isocosinus, isolog, etc., have to be lifted in the genoform

$$\hat{f}^{>}(x^{>}) = f(\hat{x}^{>}) \times \hat{I}^{>}, \tag{2.17}$$

where one should note the necessity of the multiplication by the genounit as a condition for the result to be in $\hat{R}^{>}$, $\hat{C}^{>}$, or $\hat{O}^{>}$.

2.3. Genogeometries and Their Isoduals

Particularly intriguing are *Santilli's genogeometries* **which are characterized by a step-by-step genotopy of isogeometries, Consider the Minkowski isospacetime (see Paper III [1])**

$$\hat{M}(\hat{c}, \hat{\eta}, \hat{I}): \quad \hat{x} = x\hat{I}, \quad \hat{\eta} = \hat{T}(x, ...) \times \eta, \quad \hat{I}(x, ...) = \hat{I}^{\dagger}(x, ...) = 1/\hat{T} > 0, \tag{2.18}$$

and introduce two nonunitary four-dimensional matrices C, D. Then the *Minkowski-Santilli genospacetime* **is given by [4]**

$$\hat{M}^{>}(\hat{x}^{>}, \hat{\eta}^{>}, \hat{I}^{>}): \quad \hat{x}^{>} = C \times \hat{x} \times D^{\dagger} = x \times \hat{I}>, \tag{2.19a}$$

$$\hat{\eta}^{>} = C \times \hat{\eta} \times D^{\dagger}, = \hat{T}^{>} \times \eta, \quad \eta = Diag.(1, 1, 1, -1), \tag{19b}$$

$$I^{>} = CD^{\dagger} = 1/T^{>}, \qquad CC^{\dagger} \neq I, \quad DD^{\dagger} \neq I, \quad CD^{\dagger} \neq I. \tag{2.19c}$$

Genospaces and related geogeometries can also be independently defined, based on one of the fundamental axiomatic principles of hadronic mechanics, namely, that *irreversibility is directly represented with the background geometry and, more specifically, with its nonsymmetric metric.*

In fact, a central feature of genospacetime p2.19) is that its geometric $\hat{\eta}^{>}$ **is** *nonsymmetric* **by conception and construction. Alternatively, it is easy to prove that a geometry with a symmetric metric cannot possible characterize irreversible processes. In this way, Santilli has initiated a new chapter in geometry, the first known to the authors with a realistic capability of achieving the much needed compatibility of geometries and thermodynamical laws, the latter being strictly irreversible over time.**

Since the Minkowski-Santilli genospacetime is the ultimate and fundamental method for our relativistic representation of high energy inelastic scattering events, a simple illustration appears recommendable. Consider the following realization of the C, D **matrices**

$$C = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ p & 0 & 0 & 1 \end{pmatrix}; \; D = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ q & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, \tag{2.20}$$

where $p \neq q$ **are non-null real numbers, under which we have the following forward and backward genotopy of the Minkowskian line element**

$$x^2 \rightarrow x^{>2>} = Cx^2D^\dagger = C(x^t\eta x)D^\dagger =$$

$$= (C^tx^tD^{t\dagger})(CD^\dagger)^{-1}(C\eta D^\dagger)(CD^\dagger)^{-1}(CxD^\dagger) =$$

$$= (x^tI^>)T^>\eta^>T^>(I^>x) = x^\mu\eta^>_{\mu\nu}x^\nu =$$

$$= (x^1x^1 + x^1qx^3 + x^2x^2 + x^3x^3 + x^1px^4 - x^4x^4), \tag{2.21a}$$

$$Dx^2C^\dagger = D(x^t\eta x)C^\dagger =$$

$$= (x^{t^<}I)^<T^<\eta^<T(^<Ix) = x^{\mu^<}\eta_{\mu\nu}x^\nu =$$

$$= (x^1x^1 + x^1px^3 + x^2x^2 + x^3x^3 + x^1qx^4 - x^4x^4), \tag{2.21b}$$

resulting in the forward and backward nonsymmetric genometrics

$$\eta^> = T^>\eta T^> = \begin{pmatrix} 1 & 0 & q & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ p & 0 & 0 & -1 \end{pmatrix}, \quad ^<\eta =^< T\eta^<T = \begin{pmatrix} 1 & 0 & 0 & p \\ 0 & 1 & 0 & 0 \\ q & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}, \tag{2.22}$$

exactly as desired. That is, the first expression of the genoinvariant is on genospaces while the second is its projection in our spacetime.

Note that irreversibility selects a mutation of the line elements along a pre-selected direction of space and time.

Note also that the quantities p and q can be functions of the local spacetime variables, in which case the resulting *Minkowskian genogeometry* can be equipped by a suitable lifting of the machinery of the Riemannian geometry (see Ref. [7] for the isotopic case). Moreover, because Minkowski-Santilli genospace has such an explicit dependence on spacetime coordinates, it is equipped with the entire formalism of the conventional Riemannian spaces covariant derivative, Christoffel's symbols, Bianchi identity, etc. only lifted from the isotopic form into the genotopic form.

The central property of genospaces, their lack of symmetric character, is evidently expressed by

$$\hat{\eta}^{>}_{\mu\nu} \quad \neq \quad \hat{\eta}^{>}_{\nu\mu}. \tag{2.23}$$

Consequently, *genotopies permit the lifting of conventional symmetric metrics into nonsymmetric forms,*

$$\eta^{Minkow.}_{Symm} \quad \rightarrow \quad \hat{\eta}^{>Minkow.-Sant.}_{NonSymm} \tag{2.24}$$

We note in particular the following *invariance under genotopy*

$$(x^{\mu} \times \eta_{\mu\nu} \times x^{\nu}) \times I \equiv [x^{\mu} \times (\hat{T}^{>} \times \eta_{\mu\nu}) \times x^{\nu}] \times T^{>-1} \equiv$$
$$\equiv (x^{\mu} \times \hat{\eta}^{>}_{\mu\nu} \times x^{\nu}) \times \hat{I}^{>}, \tag{2.25}$$

that evidently occurs for the particular case in which $\hat{T}^{>}$ is a complex number, with the understanding that such an invariance does not hold in general.

2.4. Santilli Lie-Admissible Theory and its Isodual

As it is well known, the methodological pillar of the entire 20th century physics is *Lie's theory.* In full awareness of this feature, Santilli first introduced in the original memoirs [2] of 1978 in rather large details the *Lie-isotopic theory* which is at the foundation of the isoscattering theory of the preceding Paper IV [1]. In the same original memoirs [2], Santilli introduced the yet broader *Lie-admissible theory* for the specific intent of characterizing open irreversible systems, and the latter theory is at the foundation of the genoscattering theory of this paper.

It should be noted that, except for the achievement of invariance, that was achieved only in the late 2000 (and studied in the next section), the

Santilli's Lie-admissible theory, also called *Lie-Santilli genotheory,* has remained essentially that of the original formulation [2]. The main advances has been the formulation of the theory on genospaces over genofields.

In accordance with the original proposal of 1978, the lie-admissible theory is characterized by the structural broadening of the following main branches of Lie's theory widely used in physics (See monographs [7] for the most general formulation to date):

GENOTOPIES OF ENVELOPING ALGEBRAS: They are characterized by the *forward and backward universal enveloping genoassociative algebra* $\hat{\xi}^>$, $^<\hat{\xi}$, with infinite-dimensional basis characterizing the *Poincaré-Birkhoff-Witt-Santilli genotheorem*

$$\hat{\xi}^> : \hat{I}^>,\ \hat{X}_i,\ \hat{X}_i > \hat{X}_j,\ \hat{X}_i > \hat{X}_j > \hat{X}_k,\ \ldots,\ i \leq j \leq k, \tag{2.26a}$$

$$^<\hat{\xi} : \hat{I},\ ^<\hat{X}_i,\ \hat{X}_i < \hat{X}_j,\ \hat{X}_i < \hat{X}_j < \hat{X}_k,\ \ldots,\ i \leq j \leq k; \tag{2.26b}$$

where the "hat" on the generators denotes their formulation on genospaces over genofields and their Hermiticity implies that $\hat{X}^> =^< \hat{X} = \hat{X}$;

GENOTOPIES OF LIE ALGEBRAS: They are characterized by the *Lie-Santilli genoalgebras* characterized by the universal, jointly Lie- and Jordan-admissible brackets,

$$^<\hat{L}^> : (\hat{X}_i \hat{,} \hat{X}_j) = \hat{X}_i < \hat{X}_j - \hat{X}_j > \hat{X}_i = C_{ij}^k \times \hat{X}_k, \tag{2.27}$$

here formulated formulated in an invariant form (see below);

GENOTOPIES OF LIE GROUPS: They are characterized by the *Lie-Santilli genotransformation groups*

$$^<\hat{G}^> : \hat{A}(\hat{w}) = (\hat{e}^{\hat{i}\hat{\times}\hat{X}\hat{\times}\hat{w}})^> > \hat{A}(\hat{0}) <^< (\hat{e}^{-\hat{i}\hat{\times}\hat{w}\hat{\times}\hat{X}}) =$$

$$= (e^{i\times\hat{X}\times\hat{T}^>\times w}) \times A(0) \times (e^{-i\times w\times ^<\hat{T}\times\hat{X}}), \tag{2.28}$$

where $\hat{w}^> \in \hat{R}^>$ are the *genoparameters;* the *genorepresentation theory,* etc.

the most salient mathematical aspect of Santilli's Lie-admissible theory is that its representation requires the necessary use of a *genobymodules,* referred to conventional modules whose action to the right and that to the left remain indeed associative, but in order to be different they have to be genoassociatives, e.g.

$$H > |\hat{a}^> >= H \times \hat{T}^> \times |\hat{a}^> >, \quad <^< \hat{b}| < H =<^< \hat{b}| \times^< \hat{T} \times H. \tag{2.29}$$

Consequently, the representation theory of Lie algebras for the conventional scattering theory is done on a conventional module with the conventional associative composition law. The representation theory of the

isoscattering theory is done on an isomodule, that is a module with isoassociative composition law. Finally, the representation theory of the genoscattering theory of this paper is done on a genobymodules, as indicated above, consisting of the necessary use of a module for the product to the right and one for the product to the left whose composition law is still associative, but it is characterized by two different isotopic elements as a necessary condition to represent irreversibility./

3. ELEMENTS OF LIE-ADMISSIBLE HADRONIC MECHANICS

3.1. Basic Dynamical Equations

The *Lie-admissible branch of hadronic mechanics* **comprises four different formulations, the** *forward and backward genomechanics for matter and their isoduals for antimatter* [**4.7**]**.The forward genomechanics for matter is characterized by the following main structures:**

1) The nowhere singular (thus everywhere invertible) non-Hermitean *forward genounit* **for the representation of all effects causing irreversibility, such as contact nonpotential interactions among extended particles,**

$$\hat{I}^{>} = 1/\hat{T}^{>} \neq (\hat{I}^{>})^{\dagger}, \tag{3.1}$$

with all corresponding ordered product to the right, forward genoreal $\hat{R}^{>}$ and forward genocomplex $\hat{C}^{>}$ genofields;

2) *Hilbert-Santilli forward genospace* $\hat{\mathcal{H}}^{>}$ **with** *forward genostates* $|\hat{\psi}^{>}>$, *forward genoinner product*

$$<^{<}\hat{\psi}| > |\hat{\psi}^{>}> \times \hat{I}^{>} =<^{<}\hat{\psi}| \times \hat{T}^{>} \times |\hat{\psi}^{>}> \times \hat{I}^{>} \in \hat{C}^{>}, \tag{3.2}$$

and fundamental property

$$\hat{I}^{>} > |\hat{\psi}^{>}> = |\hat{\psi}^{>}>, \tag{3.3}$$

establishing that $\hat{I}^{>}$ is indeed the correct unit for motion forward in time, and *forward genounitary transforms*

$$\hat{U}^{>} > (\hat{U}^{>})^{\dagger} = (\hat{U}^{>})^{\dagger} > \hat{U}^{>} = \hat{I}^{>}; \tag{3.4}$$

3) Santilli's Lie-admissible equations, first proposed in the original proposal [2] of 1978, formulated on genospaces and genodifferential calculus on genofields, today known as *Heisenberg-Santilli genoequations,* **which can be written in the finite form**

$$\hat{A}(\hat{t}) = \hat{U}^{>} > \hat{A}(0) <^{<}\hat{U} = (\hat{e}_{>}^{\hat{i}\hat{\times}\hat{H}\hat{\times}\hat{t}}) > \hat{A}(\hat{0}) < ({}_{<}\hat{e}^{-\hat{i}\hat{\times}\hat{t}\hat{\times}\hat{H}}) =$$

$$= (e^{i\times\hat{H}\times\hat{T}^{>}\times t}) \times A(0) \times (e^{-i\times t\times {}^{<}\hat{T}\times\hat{H}}), \tag{3.5}$$

with corresponding infinitesimal version

$$\hat{i}\hat{\times}\frac{\hat{d}\hat{A}}{\hat{d}\hat{t}} = (\hat{A}\hat{,}\hat{H}) = \hat{A} < \hat{H} - \hat{H} > \hat{A} =$$

$$= \hat{A} \times^{<} \hat{T}(\hat{t}, \hat{r}, \hat{p}, \hat{\psi}, \ldots.) \times \hat{H} - \hat{H} \times \hat{T}^{>}(\hat{t}, \hat{r}, \hat{p}, \hat{\psi}, \ldots) \times \hat{A}, \tag{3.6}$$

where there is no time arrow, since Heisenberg's equations are computed at a fixed time.

4) The equivalent *Schrödinger-Santilli genoequations*, **can be written as**

$$\hat{i}^{>} > \frac{\hat{\partial}^{>}}{\hat{\partial}^{>}\hat{t}^{>}}|\hat{\psi}^{>} >= \hat{H}^{>} > |\hat{\psi}^{>} >=$$

$$= \hat{H}(\hat{r}, \hat{v}) \times \hat{T}^{>}(\hat{t}, \hat{r}, \hat{p}, \hat{\psi}, \hat{\partial}\hat{\psi} \ldots) \times |\hat{\psi}^{>} >= E^{>} > |\psi^{>} >, \tag{3.7}$$

where the time orderings in the second term are ignored for simplicity of notation;

5) The *forward genomomentum*

$$\hat{p}^{>}_{k} > |\hat{\psi}^{>} >= -\hat{i}^{>} > \hat{\partial}^{>}_{k}|\hat{\psi}^{>} >= -i \times \hat{I}^{>i}_{k} \times \partial_{i}|\hat{\psi}^{>} >, \tag{3.8}$$

6) The *fundamental genocommutation rules*

$$(\hat{r}^{i}\hat{,}\hat{p}_{j}) = i \times \delta^{i}_{j} \times \hat{I}^{>}, \ \ (\hat{r}^{i}\hat{,}\hat{r}^{j}) = (\hat{p}_{i}\hat{,}\hat{p}_{j}) = 0, \tag{3.9}$$

7) The *genoexpectation values* **of an observable for the forward motion** $\hat{A}^{>}$

$$\frac{<^{<} \hat{\psi}| > \hat{A}^{>} > |\hat{\psi}^{>} >}{<^{<} \hat{\psi}| > |\hat{\psi}^{>} >} \times \hat{I}^{>} \in \hat{C}^{>}, \tag{3.10}$$

under which the genoexpectation values of the genounit recovers the conventional Planck's unit as in the isotopic case,

$$\frac{< \hat{\psi}| > \hat{I}^{>} > |\hat{\psi} >}{< \hat{\psi}| > |\hat{\psi} >} = I. \tag{3.11}$$

Note that, unlike conventional quantum mechanics, physical quantities are generally *nonconserved,* **as it must be the case for the energy,**

$$\hat{i}^{>} > \frac{\hat{d}^{>}\hat{H}^{>}}{\hat{d}^{>}\hat{t}^{>}} = \hat{H} \times ({}^{<}\hat{T} - \hat{T}^{>}) \times \hat{H} \neq 0. \tag{3.12}$$

Therefore, *the genotopic branch of hadronic mechanics is the only known operator formulation permitting nonconserved quantities to be Hermitean as a necessary condition to be observability.* **Other formulations attempt to represent nonconservation, e.g., by adding an "imaginary potential" to the Hamiltonian, as it is often done in nuclear physics. In this case the Hamiltonian is non-Hermitean and, consequently, the nonconservation of the energy cannot be an observable. Moreover, since the said "nonconservative models" with non-Hermitean Hamiltonians are nonunitary and are formulated on conventional spaces over conventional fields, they are plagued by all the catastrophic inconsistencies cited earlier. However, we should stress that the representation of irreversibility and nonconservation beginning with the most primitive quantity, the unit and related product.** *Closed irreversible systems* **are characterized by the Lie-isotopic subcase in which**

$$\hat{i}\hat{\times}\frac{\hat{d}\hat{A}}{\hat{d}\hat{t}} = [\hat{A}\hat{,}\hat{H}] = \hat{A} \times \hat{T}(t,\ldots) \times \hat{H} - \hat{H} \times \hat{T}(t,\ldots) \times \hat{A}, \qquad 3.13a)$$

$$^{<}\hat{T}(t,\ldots) = \hat{T}^{>}(t,\ldots) = \hat{T}(t,\ldots) = \hat{T}^{\dagger}(t,\ldots) \neq \hat{T}(-t,\ldots), \qquad (3.13b)$$

for which the Hamiltonian is manifestly conserved. Nevertheless the system is manifestly irreversible. Note also the first and only known observability of the Hamiltonian (due to its iso-Hermiticity) under irreversibility.

The above formulation must be completed with three additional Lie-admissible formulations, the backward formulation for matter under time reversal and the two additional isodual formulations for antimatter. For brevity, their study is left to the interested reader.

3.2. Simple Construction of Lie-Admissible Theories

As it was the case for the isotopies, a simple method for the construction of Lie-admissible (geno-) theories from any given conventional, classical or quantum formulation consists in *identifying the genounits as the product of two different nonunitary transforms,*

$$\hat{I}^{>} = (^{<}\hat{I})^{\dagger} = U \times W^{\dagger}, \quad ^{<}\hat{I} = W \times U^{\dagger}, \qquad (3.15a)$$

$$U \times U^{\dagger} \neq 1, \quad W \times W^{\dagger} \neq 1, \quad U \times W^{\dagger} = \hat{I}^{>}, \qquad (3.15b)$$

and subjecting the totality of quantities and their operations of conventional models to said dual transforms,

$$I \rightarrow \hat{I}^{>} = U \times I \times W^{\dagger}, \quad I \rightarrow^{<} \hat{I} = W \times I \times U^{\dagger}, \qquad (3.16a)$$

$$a \rightarrow \hat{a}^{>} = U \times a \times W^{\dagger} = a \times \hat{I}^{>}, \qquad (3.16b)$$

$$a \rightarrow^< \hat{a} = W \times a \times U^\dagger =^< \hat{I} \times a, \quad (3.16c)$$

$$a \times b \rightarrow \hat{a}^> > \hat{b}^> = U \times (a \times b) \times W^> =$$

$$= (U \times a \times W^\dagger) \times (U \times W^\dagger)^{-1} \times (U \times b \times W^\dagger), \quad (3.16d)$$

$$\partial/\partial x \rightarrow \hat{\partial}^> / \hat{\partial}^> \hat{x}^> = U \times (\partial/\partial x) \times W^\dagger = \hat{I}^> \times (\partial/\partial x), \quad (3.16e)$$

$$< \psi| \times |\psi > \rightarrow <^< \psi| > |\psi^> >= U \times (< \psi| \times |\psi >) \times W^\dagger, \quad (3.16f)$$

$$H \times |\psi > \rightarrow \hat{H}^> > |\psi^> >=$$

$$= (U \times H \times W^\dagger) \times (U \times W^\dagger)^{-1} \times (U \times \psi > W^\dagger), \text{ etc.} \quad (3.16g)$$

As a result, any given conventional, classical or quantum model can be easily lifted into the genotopic form. Note that the above construction implies that *all conventional physical quantities acquire a well defined direction of time.* **For instance, the correct genotopic formulation of energy, linear momentum, etc., is given by**

$$\hat{H}^> = U \times H \times W^\dagger, \;\; \hat{p}^> = U \times p \times W^>, \text{ etc.} \quad (3.17)$$

In fact, under irreversibility, the value of a nonconserved energy at a given time t for motion forward in time is generally different from the corresponding value of the energy for $-t$ for motion backward in past times. This explains the reason for having represented in this section energy, momentum and other quantities with their arrow of time $>$. Such an arrow can indeed be omitted for notational simplicity, but only after the understanding of its existence.

Note finally that a conventional, one dimensional, unitary Lie transformation group with Hermitean generator X and parameter w can be transformed into a covering Lie-admissible group via the following nonunitary transform [4]

$$Q(w) \times Q^\dagger(w) = Q^\dagger(w) \times Q(w) = I, \; w \in R, \quad (3.18a)$$

$$U \times U^\dagger \neq I, \quad W \times W^\dagger \neq 1, \quad (3.18b)$$

$$A(w) = Q(w) \times A(0) \times Q^\dagger(w) = e^{X \times w \times i} \times A(0) \times e^{-i \times w \times X} \rightarrow$$

$$\rightarrow U \times (e^{X \times w \times i} \times A(0) \times e^{-i \times w \times X}) \times U^\dagger =$$

$$\equiv [U \times (e^{X \times w \times i}) \times W^\dagger \times (U \times W^\dagger)^{-1} \times A \times A(0) \times$$

$$\times U^\dagger \times (W \times U^\dagger)^{-1} \times [W \times (e^{-i \times w \times X}) \times U^\dagger] =$$

$$= (e^{i \times X \times X})^> > A(0) <^< (e^{-1 \times w \times X}) = \hat{U}^> > A(0) <^< \hat{U}, \quad (3.18c)$$

which equations confirm the property that under the necessary mathematics *the Lie-admissible theory is indeed admitted by the abstract Lie axioms, and it is a realization of the latter being broader than the isotopic form.*

3.3. Invariance of Lie-Admissible Theories

It is easy to see that Lie-admissible formulations are not invariant under noniunitary transformations, in which case they verify the Theorems of catastrophic Inconsistencies of Nonunitary. Theores reviewed in Paper I [1]. The crucial invariance permitting the prediction of the same numbers under the same conditions at different times was first achieved by Santilli in Ref. [28] of 1997 and can be reviewed as follows.

Invariance of Lie-admissible formualtions is provided by reformulating any given nonunitary transform in the *genounitary form*

$$U = \hat{U} \times \hat{T}^{>1/2}, W = \hat{W} \times \hat{T}^{>1/2}, \tag{3.19a}$$

$$U \times W^{\dagger} = \hat{U} > \hat{W}^{\dagger} = \hat{W}^{\dagger} > \hat{U} = \hat{I}^{>} = 1/\hat{T}^{>}, \tag{3.19b}$$

and then showing that genounits, genoproducts, genoexponentiation, etc., are indeed invariant under the above genounitary transform in exactly the same way as conventional units, products, exponentiations, etc., are invariant under unitary transforms,

$$\hat{I}^{>} \rightarrow \hat{I}^{>\prime} = \hat{U} > \hat{I}^{>} > \hat{W}^{\dagger} = \hat{I}^{>}, \tag{3.20a}$$

$$\begin{gathered} \hat{A} > \hat{B} \rightarrow \hat{U} > (A > B) > \hat{W}^{\dagger} = \\ = (\hat{U} \times \hat{T}^{>} \times A \times T^{>} \times \hat{W}^{\dagger}) \times (\hat{T}^{>} \times W^{\dagger})^{-1} \times \hat{T}^{>} \times \\ \times (\hat{U} \times \hat{T}^{>})^{-1} \times (\hat{U} \times T^{>} \times \hat{A} \times T^{>} \times \hat{W}^{>}) = \\ = \hat{A}' \times (\hat{U} \times \hat{W}^{\dagger})^{-1} \times \hat{B} = \hat{A}' \times \hat{T}^{>} \times B' = \hat{A}' > \hat{B}', \text{ etc.} \end{gathered} \tag{3.20b}$$

from which all remaining invariances follow, thus resolving the catastrophic inconsistencies.

Note that the *numerical invariances of the genounit* $\hat{I}^{>} \rightarrow \hat{I}^{>\prime} \equiv \hat{I}^{>}$, *of the genotopic element* $\hat{T}^{>} \rightarrow \hat{T}^{>\prime} \equiv \hat{T}^{>}$, *and of the genoproduct* $> \rightarrow >' \equiv >$ **are necessary to have invariant numerical predictions.**

3.4. Genotopy of Pauli-Santilli Isomatrices

We now proceed to define the genotopy of the Pauli spin matrices and of the Dirac equation, which will be required for constructing genoscattering

theory in Sec. 4. We begin by defining the Pauli-Santilli iso-spin matrices, without spin mutation (see Papers II and III):

$$\hat{\sigma}_1 = \begin{pmatrix} 0 & n_1 \times n_2 \\ n_1 \times n_2 & 0 \end{pmatrix}, \hat{\sigma}_2 = \begin{pmatrix} 0 & -i \times n_1 \times n_2 \\ i \times n_1 \times n_2 & 0 \end{pmatrix},$$

$$\hat{\sigma}_3 = \begin{pmatrix} n_1^2 & 0 \\ 0 & n_2^2 \end{pmatrix}, \hat{T} = \begin{pmatrix} n_1^{-2} & 0 \\ 0 & n_2^{-2} \end{pmatrix} \qquad (3.21a)$$

where $n_k^{-2} = b_k^2 (k = 1, 2, 3), (b_1^2 \times b_2^2 \times b_3^2) = 1$ **for an ellipsoidal deformation of a spherical scattering region; and, with spin mutation:**

$$\hat{\sigma}_1 = \begin{pmatrix} 0 & n_1^2 \\ n_2^2 & 0 \end{pmatrix}, \hat{\sigma}_2 = \begin{pmatrix} 0 & -i \times n_1^2 \\ i \times n_2^2 & 0 \end{pmatrix}, \hat{\sigma}_3 = \begin{pmatrix} w \times n_1^2 & 0 \\ 0 & w \times n_2^2 \end{pmatrix} \qquad (3.21b)$$

Consequently, the isotopies provide five additional quantities [the four ($b_k, k = 1, ...4$**) for spacetime mutation and one (**w **) for the spin] for the representation of experimentally measureable features of the scattering region in isoscattering theory, such as shape, deformation, scaling, density, anisotropy, etc . The construction of the genotopies is most conveniently done by subjecting the conventional Pauli's matrices to two different nonunitary transforms. To avoid un-necessary complexity, one may select the following two matrices**

$$A = \begin{pmatrix} 1 & 0 \\ a & 1 \end{pmatrix}, \quad B = \begin{pmatrix} 1 & 0 \\ b & 1 \end{pmatrix}, \quad AA^\dagger \neq I, \ \ ] \ BB^\dagger \neq I, \qquad (3.22)$$

where a **and** b **are non-null real numbers, and observe that if** Q, P **are idempotent (creation and annihilation) matrices, then one may write** $A = I + aQ \equiv exp(a \times Q), B = I + bP \equiv exp(b \times P)$**. Accordingly, one has the following forward and backward genounits and related genotopic elements**

$$I^> = AB^\dagger = \begin{pmatrix} 1 & b \\ a & 1 \end{pmatrix}, \quad T^> = \frac{1}{(1 - ab)} \begin{pmatrix} 1 & -b \\ -a & 1 \end{pmatrix}, \qquad (3.23a)$$

$$^<I = BA^\dagger = \begin{pmatrix} 1 & a \\ b & 1 \end{pmatrix}, \quad ^<T = \frac{1}{(1 - ab} \begin{pmatrix} 1 & -a \\ -b & 1 \end{pmatrix}, \qquad (3.23b)$$

The *forward and backward Pauli-Santilli genomatrices* **are then given respectively by**

$$\sigma_1^> = A\sigma_1 B^\dagger = \begin{pmatrix} 0 & 1 \\ 1 & (a+b) \end{pmatrix}, \quad \sigma_2^> = A\sigma_2 B^\dagger = \begin{pmatrix} 0 & -i \\ i & (a+b) \end{pmatrix}, \qquad (3.24a)$$

$$\sigma_3^> = A\sigma_3 B^\dagger = \begin{pmatrix} 1 & b \\ a & -1 \end{pmatrix}, \quad {}^<\sigma_1 = B\sigma_1 A^\dagger = \begin{pmatrix} 0 & 1 \\ 1 & (a+b) \end{pmatrix}, , \tag{3.24b}$$

$$^<\sigma_2 = B\sigma_2 A^\dagger = \begin{pmatrix} 0 & -i \\ i & (a+b) \end{pmatrix}, \quad {}^<\sigma_3 = A\sigma_3 B^\dagger = \begin{pmatrix} 1 & a \\ b & -1 \end{pmatrix}, \tag{3.24c}$$

in which the direction of time is embedded in the structure of the matrices.

It is an instructive exercise for any interested reader to verify that *conventional commutation rules and eigenvalues of Pauli's matrices are preserved under forward and backward genotopies,*

$$\sigma_i^> > \sigma_j^> - \sigma_j^> > \sigma_i^> = 2i\epsilon_{ijk}\sigma_k^> \tag{3.25a}$$

$$\sigma_3^> > | >= \pm 1| >, \quad \sigma^{>2>} > | >= 2(2+1)| >, \tag{3.25b}$$

$$^<\sigma_i >^< \sigma_j -^< \sigma_j >^< \sigma_i = 2i\epsilon_{ijk}^<\sigma_k \tag{3.25c}$$

$$< | <^< \sigma_3 =< | \pm 1, \; ; < | <^< \sigma^{2>} =< |(2(2+1). \tag{3.25d}$$

We can, therefore, conclude by stating that *Pauli's matrices can indeed be lifted in such an irreversible form to represent the direction of time in their very structure.*

3.5. Genotopy of Dirac-Santilli isoequation

The Dirac-Santilli isomatrices ($\hat{\gamma}_\mu$) are defined as follows (see Papers II and III):

$$\hat{\gamma}_k = b_k \times \begin{pmatrix} 0 & \hat{\sigma}_k \\ -\hat{\sigma}_k & 0 \end{pmatrix}, \hat{\gamma}_4 = i \times b_k \times \begin{pmatrix} I_{2\times 2} & 0 \\ 0 & -I_{2\times 2} \end{pmatrix} \tag{3.26a}$$

$$[\hat{\gamma}_\mu \hat{,} \hat{\gamma}_\nu] \equiv \hat{\gamma}_\mu \times T \times \hat{\gamma}_\nu + \hat{\gamma}_\nu \times T \times \hat{\gamma}_\mu = 2 \times \hat{\eta}_{\mu\nu}.$$

To construct the simplest possible genotopy of Dirac's equation via the genotopies of the Pauli-spin matrices and space-time structure, we shall use Dirac's equation in its isodual re-interpretation representing a direct product of one electron and one positron, the latter without any need of second quantization. We note, however, that the latter re-interpretation requires the use of the *isodual transform* $A \to A^d = -A^\dagger$) **as being distinct from Hermitean conjugation. Under this clarifications, the** *forward Dirac genoequation* **can be written**

$$(\eta^{>\mu\nu}\gamma_\mu^> T^> p_\nu^> - im)T^>|\psi^> >= 0 \tag{3.27a}$$

$$p_\nu^> T^>|\psi^> >= -i\frac{\partial^>}{\partial^> x^{>\nu}}|\psi^> >= -iI^>\frac{\partial}{\partial x^>}|\psi^> >, \tag{3.27b}$$

with *forward genogamma matrices*

$$\gamma_4^> = \begin{pmatrix} A & 0 \\ 0 & B^d \end{pmatrix} \begin{pmatrix} I_{2\times 2} & 0 \\ 0 & -I_{2\times 2} \end{pmatrix} \begin{pmatrix} A^d & 0 \\ 0 & B \end{pmatrix} = \begin{pmatrix} AA^d & 0 \\ 0 & -B^d B \end{pmatrix} \quad (3.28a)$$

$$\gamma_k^> = \begin{pmatrix} A & 0 \\ 0 & B^d \end{pmatrix} \begin{pmatrix} 0 & \sigma_k \\ \sigma_k^d & 0 \end{pmatrix} \begin{pmatrix} A^d & 0 \\ 0 & B \end{pmatrix} = \quad (3.28b)$$

$$= \begin{pmatrix} 0 & A\sigma_k B^\dagger \\ B\sigma_k^d A^d & 0 \end{pmatrix} \begin{pmatrix} 0 & \sigma_k \\ \sigma_k^d & 0 \end{pmatrix} = \begin{pmatrix} 0 & \sigma_k^> \\ {}^<\sigma_k^d & 0 \end{pmatrix}. \quad (3.28c)$$

$$\{\gamma_\mu^>\hat{,}\gamma_\nu^>\} = \gamma_\mu^> T^> \gamma_\nu^> + \gamma_\nu^> T^> \gamma_\mu^> = 2\eta_{\mu\nu}^>, \quad (3.28d)$$

where $\eta_{\mu\nu}^>$ **is given by the same genotopy of Eqs. (3.26a). The backward genoequation may be constructed similarly.**

For additional insight into the mathematical structure of the genotopy of the spin matrices, it should be noted, at this juncture, that in terms of the larger group O(4,2), considered as a set of linear transformations in a six-dimensional linear vector space which leave the quadratic form, $g_{IJ}X^I X^J$ **with** $I, J = 1, 2, 3, 4, 0 = 5, 6; g_{IJ} = (- - - - ++)$ **invariant, it is well known that the O(4,2) group generators can be explicitly written in terms of creation and annihilation operators of a spin-**$\frac{1}{2}$ **field as follows:**

$$L_{ij} = L_k = \frac{1}{2}[a^+\sigma_k a + b^+\sigma_k b]; L_{44} = A_i = -\frac{1}{2}[a^+\sigma_i a - b^+\sigma_i b];$$

$$L_{i5} = M_i = -\frac{1}{2}[a^+\sigma_i C b^+ - aC\sigma_i b]; L_{i6} = \Gamma_i = -\frac{i}{2}[a^+ C b^+ - aCb];$$

$$L_{45} = T = -\frac{i}{2}[a^+ C b^+ - aCb]; L_{46} = S = \frac{1}{2}[a^+ C b^+ + aCb];$$

$$L_{56} = \Gamma_5 = \frac{1}{2}[a^+ a + b^+ b + 2] \quad (3.29)$$

where $i, j, k = 1, 2, 3$

$$a = \begin{pmatrix} a_1 \\ a_2 \end{pmatrix}; b = \begin{pmatrix} b_1 \\ b_2 \end{pmatrix};$$

and $C = i\sigma_2$**, where the matrices** $\sigma_1, \sigma_2, \sigma_3$ **are the Pauli spin matrices. The group operators given in Eq.(2.29) are readily shown to satisfy the commutation relation for the 15 generators of the group considered as an antisymmetric tensor** $L_{IJ} = -L_{JI}$

$$[L_{IJ}, L_{KL}] = -i[g_{IK}L_{JL} - g_{JL}L_{IK} - g_{JK}L_{IL} - g_{IL}L_{JK}] \quad (3.30)$$

One can then see in this way the implicvations of the transition from the conventional to the genotopic scattering theory.

4. LIE-ADMISSIBLE INVARIANT GENOSCATTERING THEORY

4.1. The Fundamental Lie-Admissible Scattering Matrix

As it is well known, the conventional (relativistic scattering theory is based on the *scattering matrix* S for the connection of initial (i) and final (f)states

$$S = (S_{if}), \tag{4.1}$$

whose central feature is that of being *unitary* on the base Hilbert space $\mathcal{H}$ over the field of complex numbers $\mathcal{C}$,

$$S \times S^{\dagger} = S^{\dagger} \times S = I. \tag{4.2}$$

The latter feature then assures the verification of *causality,* the predictions of the same numerical values under the same conditions at different times (*invariance*), and the remaining axiomatic features of relativistic quantum mechanics, including the characterization of symmetries via the fundamental *Lie theory.*

Despite historical advances, the above conception of the scattering matrix has the same insufficiencies as those of the underlying disciplines, namely, the theory is based on the necessary reduction of scattering processes to dimensionless points. As indicated in the preceding Papers I-IV [1], this abstraction of reality is effective for a number of scattering events, such as Coulomb scattering without collisions, but it is manifestly insufficient for the characterization of high energy scattering processes, e.g., because of the inability to characterize the hyperdense scattering region and the consequential expected non-hamiltonian internal effects.

To initiate the process toward a more accurate description of high energy scattering processes, in Paper IV [1] we have reviewed and expanded the notion of the *isoscattering matrix*

$$\hat{S} = (\hat{S}_{if}), \tag{4.3}$$

whose primary feature is that of being *nonunitary* when formulated on $\mathcal{H}$ over $\mathcal{C}$,

$$\hat{S} \times \hat{S}^{\dagger} \neq I, \tag{4.4}$$

but of being *unitary,* namely, of verifying the conditions of unitarity on the Hilbert-Myung-Santilli isospace $\hat{\mathcal{H}}$ over Santilli isofield $\hat{\mathcal{C}}$

$$\hat{S} \hat{\times} \hat{S}^{\dagger} = \hat{S} \times \hat{T} \times \hat{S}^{\dagger} = \hat{S}^{\dagger} \hat{\times} \hat{S} = \hat{S}^{\dagger} \times \hat{T} \times \hat{S} \equiv \hat{I} 1/\hat{T} > 0, \tag{4.5}$$

which property resolves the historical inconsistencies of nonunitary scattering theories by achieving full causality and invariance when properly elaborated, that is, treated over $\hat{\mathcal{H}}$ over $\hat{\mathcal{C}}$, by allowing the use of the axiomatically consistent formulations of the isotopic branch of hadronic mechanics, including the fundamental use of the *Lie-Santilli isotheory* **for all symmetry needs.**

The main advantage of the transition from the scattering to the isoscattering theory is that of achieving a more realistic representation of the scattering region at distances of $1\ fm$, while recovering the conventional scattering matrix at bigger distances. This is possible because the isounit $\hat{I}$ and, therefore, the isoscattering matrix $\hat{S}$, have a completely unrestricted functional dependence on all needed variables and quantities, including local coordinates x, momenta p, density d, wavefunctions ψ, their derivatives $\partial\psi$, etc.

$$\hat{S} = \hat{S}(x, p, d, \psi, \partial\psi, ...). \tag{4.6a}$$

$$Lim_{r\ >\ 1\ fm}\hat{S}\ \equiv\ S. \tag{4.6b}$$

The above feature permits, for the first time in the field, a quantitative, causal and invariant representation of nonlinear, nonlocal and nonpotential effects that are inevitable in the scattering of particles at high energy.

Despite the above advances, the isoscattering theory has "no arrow of time" in its axioms and technical realization, thus being solely applicable to *high energy reversible scattering processes requiring a nonunitary-isounitary structure* **as indicated in Section 1.**

The latter insufficiency has mandated the studies presented in this paper, that are centered in the notion of *forward and backward genoscattering matrices*

$$\hat{S}^{>} = (\hat{S}^{>}_{if}), \tag{4.7a}$$

$$^{<}\hat{S} = (^{<}\hat{S}_{if}), \tag{4.7b}$$

whose primary feature is that of being *nonunitary* **as well as** *non-isounitary,* **yet being** *genounitary,* **namely, verifying the conditions of unitarity on the forward and backward genospaces over genofields, respectively,**

$$\hat{S}^{>}\hat{\times}\hat{S}^{>\dagger} = \hat{S}^{>} \times \hat{T}^{>} \times \hat{S}^{>\dagger} =$$

$$= \hat{S}^{>\dagger}\hat{\times}^{>}\hat{S}^{>} = \hat{S}^{>\dagger} \times \hat{T}^{>} \times \hat{S}^{>}\ \equiv\ \hat{I}^{>}1/\hat{T}^{>}\ >\ 0, \tag{4.8a}$$

$$^{<}\hat{S}^{<}\hat{\times}^{<\dagger}\hat{S} =^{<} \hat{S} \times^{<} \hat{T} \times^{<\dagger} \hat{S} =^{<\dagger} \hat{S}^{<}\hat{\times}^{<}\hat{S} =$$

$$=^{<} \hat{S}^{\dagger} \times^{<} \hat{T} \times^{<} \hat{S}\ \equiv\ ^{<}\hat{I}1/^{<}\hat{T} > 0, \tag{4.8b}$$

which can be constructed from the isoscattering or conventional scattering theory via the rule (1.10) formulated on genospaces over genofields under the crucial condition of preserving limit (4.6b)

$$ZZ^{\dagger} \neq I \quad WW^{\dagger} \neq I, \quad ZW^{\dagger} \neq I, \tag{1.9a}$$

$$\hat{S} \rightarrow \hat{S}^{>} = Z \times Q \times W^{\dagger}, \tag{4.9b}$$

$$Lim_{r\ >\ 1\ fm}\hat{S}^{>} \ \equiv \ S. \tag{4.9c}$$

$$\hat{S} \rightarrow^{<} \hat{S} = W\hat{S}Z^{\dagger}. \tag{4.9d}$$

$$Lim^{<}_{r\ >\ 1\ fm}\hat{S} \ \equiv \ S. \tag{4.9e}$$

Under the latter conditions the forward and backward genoscattering matrices recover, individually, unitarity, invariance and the other features of the genotopic branch of hadronic mechanics, including its fundamental treatment via *Santilli Lie-admissible theory.*

Note that *the forward and backward genoscattering matrices are individually causal,* **because they are necessary for the consistency of the theory as well as for the treatment of antimatter requiring a backward treatment. Nevertheless,** *the Lie-admissible scattering theory is indeed irreversible over time because of the strict inequivalence between the forward and backward scattering matrix.*

We shall now pass to a more detailed the formulation of the Lie-admissible scattering theory, by restricting our attention for simplicity to the forward scattering matrix.

4.2. Genotopy of the Isoscattering Formalism

As is well known[2], the usual Feynman propagator in conventional QED of spin-$\frac{1}{2}$ particles can be characterized as follows in the O(3,1) carrier space of a relativistic quantum mechanics:

$$S_F(x) = (\gamma^{\mu}p_{\mu} + im)\Delta_F(x), \Delta_F(x) = \int \frac{d^4p}{(2\pi)^4}\frac{e^{-ipx}}{p^2 - m^2 + i\epsilon} \tag{4.10}$$

with corresponding expression in momentum 4-vector space:

$$S_F(p) = (\gamma^{\mu}p_{\mu} + im)\Delta_F(p), \Delta_F(p) = \frac{\gamma^{\mu}p_{\mu} + im}{p^2 - m^2 + i\epsilon} \tag{4.11}$$

In terms of the "isounit" ($\hat{I}$)and isotopic element ($\hat{T} = \hat{I}^{-1}$)defined in Sec.2.1, and represented as $\hat{I}_{st}$ and T_{st},the generalized Feynman (which may be called iso-Feynman) propagator in the $\hat{O}(3,1)$ carrier space of hadronic mechanics is given by the corresponding expressions as follows

$$\hat{S}_F(\hat{x}) = (\hat{\eta}^{\mu\nu}_{st} \times \hat{\gamma}^{\mu} \times \hat{p}_{\mu} + i \times \hat{m}) \times \hat{T}_{st} \times \hat{\Delta}_F(\hat{x}),$$

$$\hat{\Delta}_F(\hat{x}) = \int \frac{d^4p}{(2\pi)^4} \frac{e^{-ip\times\hat{T}_{st}\times x}}{\hat{p}^{\hat{2}} - \hat{m}^{\hat{2}} + i\times\hat{\epsilon}} \tag{4.12}$$

with corresponding expression in iso-momentum 4-vector space

$$\hat{S}_F(\hat{p}) = (\hat{\eta}_{st}^{\mu\nu} \times \hat{\gamma}^\mu \times \hat{p}_\mu + i\times\hat{m}) \times \hat{T}_{st} \times \hat{\Delta}_F(\hat{p}),$$

$$\hat{\Delta}_F(\hat{p} = \frac{(\hat{\eta}_{st}^{\mu\nu} \times \hat{\gamma}^\mu \times \hat{p}_\mu + i\times\hat{m}) \times \hat{T}_{st}}{\hat{p}^{\hat{2}} - \hat{m}^{\hat{2}} + i\times\hat{\epsilon}} \tag{4.13}$$

In terms of the "genounits" ($\hat{I}^>$, $^<\hat{I}$) genotopic elements ($\hat{T}^> = 1/\hat{I}^>$, $^<\hat{T} = 1/^<\hat{I}$) defined in Sec. 3.4 and represented as ($\hat{I}_{st}^>,^< \hat{I}_{st}$) and ($T_{st}^>$ $^<T_{st}$), the generalized Feynman (which may be called geno-Feynman) propagator in the ($\hat{O}^>(3,1)$, $^<\hat{O}(3,1)$ carrier genospaces of the Lie-admissible branch of hadronic mechanics is given by the corresponding expressions as follows

$$\hat{S}_F^>(\hat{x}) = ((\hat{\eta}_{st}^>)^{\mu\nu} \times \hat{\gamma}_\mu^> \times \hat{p}_\mu + i\times\hat{m}) \times \hat{T}_{st}^> \times \hat{\Delta}_F^>(\hat{x}),$$

$$\hat{\Delta}_F^>(\hat{x}) = \int \frac{d^4p}{(2\pi)^4} \frac{e^{-ip\times\hat{T}_{st}^>\times x}}{\hat{p}^{\hat{2}} - \hat{m}^{\hat{2}} + i\times\hat{\epsilon}} \tag{4.14a}$$

$$^<\hat{S}_F(\hat{x}) = (^<\hat{\eta}_{st}^{\mu\nu} \times^< \gamma_\mu \times \hat{p}_\mu + i\times\hat{m}) \times^< \hat{T}_{st} \times^< \hat{\Delta}_F(\hat{x}),$$

$$^<\hat{\Delta}_F(\hat{x}) = \int \frac{d^4p}{(2\pi)^4} \frac{e^{-ip\times^<\hat{T}_{st}\times x}}{\hat{p}^{\hat{2}} - \hat{m}^{\hat{2}} + i\times\hat{\epsilon}} \tag{4.14b}$$

with corresponding expression in geno-momentum 4-vector space

$$\hat{S}_F^>(\hat{p}) = ((\hat{\eta}_{st}^>)^{\mu\nu} \times \hat{\gamma}_\mu^> \times \hat{p}_\mu + i\times\hat{m}) \times \hat{T}_{st}^> \times \hat{\Delta}_F^>(\hat{p}),$$

$$\hat{\Delta}_F^>(\hat{p}^2) = \frac{((\hat{\eta}_{st}^>)^{\mu\nu} \times \hat{\gamma}_\mu^> \times \hat{p}_\mu + i\times\hat{m}) \times \hat{T}_{st}^>}{\hat{p}^{\hat{2}} - \hat{m}^{\hat{2}} + i\times\hat{\epsilon}} \tag{4.14c}$$

$$^<\hat{S}_F(\hat{p}) = (^<\hat{\eta}_{st}^{\mu\nu} \times^< \hat{\gamma}_\mu \times \hat{p}_\mu + i\times\hat{m}) \times^< \hat{T}_{st} \times^< \hat{\Delta}_F(\hat{p}),$$

$$^<\hat{\Delta}_F(\hat{p}^2) = \frac{(^<\hat{\eta}_{st}^{\mu\nu} \times^< \hat{\gamma}^\mu \times \hat{p}_\mu + i\times\hat{m}) \times^< \hat{T}_{st}}{\hat{p}^{\hat{2}} - \hat{m}^{\hat{2}} + i\times\hat{\epsilon}} \tag{4.14d}$$

In the presence of an external electromagnetic field, the solution of the (regular) Dirac-Santilli isoequation takes the form

$$\hat{\Psi} = \hat{\psi}(\hat{x}) + \hat{e}\hat{\times}\hat{\int}\hat{d}^4\hat{x}'\hat{\times}\hat{S}_f(\hat{x}-\hat{x}')\hat{\times}\hat{\gamma}\hat{.}\hat{A}(\hat{x}')\hat{\times}\hat{\Psi}(\hat{x}$$

$$= \hat{\psi}(\hat{x}) + \hat{e}\hat{\times}\hat{\int} \hat{d}^4\hat{x'}\hat{\times}\hat{S}_f(\hat{x}-\hat{x'})\hat{\times}\hat{\gamma}\hat{.}\hat{A}(\hat{x'})\hat{\times}\hat{\psi}(\hat{x})$$

$$+\hat{e}^{\hat{2}}\hat{\times}\hat{\int} \hat{d}^4\hat{x'}\hat{\int} \hat{d}^4\hat{x"}\hat{\times}\hat{S}_f(\hat{x}-\hat{x'})\hat{\times}\hat{\gamma}\hat{.}\hat{A}(\hat{x'})\hat{\times}\hat{S}_f(\hat{x'}-\hat{x"})\hat{\times}\hat{\gamma}\hat{.}\hat{A}(\hat{x"})\hat{\times}\hat{\psi}(\hat{x"}) + ... \quad (4.15)$$

This leads to a formal definition of the iso-Feynman propagator either as a series

$$\hat{S'}_f(\hat{x},\hat{x'}) = \hat{S}_f(\hat{x}-\hat{x'}) + \hat{e}\hat{\times}\hat{\int} \hat{d}^4\hat{x"}\hat{\times}\hat{S}_f(\hat{x}-\hat{x"})\hat{\times}\hat{\gamma}\hat{.}\hat{A}(\hat{x"})\hat{\times}\hat{S}_f(\hat{x'}-\hat{x"}) + ... \quad (4.16)$$

or as an integral equation

$$\hat{S'}_f(\hat{x},\hat{x'}) = \hat{S}_f(\hat{x}-\hat{x'}) + \hat{e}\hat{\times}\hat{\int} \hat{d}^4\hat{x"}\hat{\times}\hat{S}_f(\hat{x}-\hat{x"})\hat{\times}\hat{\gamma}\hat{.}\hat{A}(\hat{x"})\hat{\times}\hat{S'}_f(\hat{x'}.\hat{x"}) \quad (4.17)$$

where $\hat{\gamma}\hat{.}\hat{A}(\hat{x'}) \equiv \hat{\eta}_{st}^{\mu\nu} \times \hat{\gamma}_\mu \times \hat{A}_\nu(\hat{x'})$ **and** $\hat{A}_\nu(\hat{x'})$ **is the iso-electromagnetic four-vector potential given by the corresponding iso-gauge principle[xx]. This leads, in turn, to a formal definition of geno-Feynman propagators either as series:**

$$\hat{S'}^{>}_f(\hat{x},\hat{x'}) = \hat{S}^{>}_f(\hat{x}-\hat{x'}) + \hat{e} > \hat{\int} \hat{d}^4\hat{x"} > \hat{S}^{>}_f(\hat{x}-\hat{x"}) > \hat{\gamma}^{>}\hat{.}\hat{A}^{>}(\hat{x"}) >$$

$$\hat{S}^{>}_f(\hat{x'}-\hat{x"}) + ...$$

$$^{<}\hat{S'}_f(\hat{x},\hat{x'}) = ^{<}\hat{S}_f(\hat{x}-\hat{x'}) + \hat{e} < \hat{\int} \hat{d}^4\hat{x"} <^{<}\hat{S}_f(\hat{x}-\hat{x"}) <^{<}\hat{\gamma}\hat{.}^{<}\hat{A}(\hat{x"}) <$$

$$^{<}\hat{S}_f(\hat{x'}-\hat{x"}) + ... \quad (4.18)$$

or as an integral equation

$$\hat{S'}^{>}_f(\hat{x},\hat{x'}) = \hat{S}^{>}_f(\hat{x}-\hat{x'}) + \hat{e} > \hat{\int} \hat{d}^4\hat{x"} > \hat{S}^{>}_f(\hat{x}-\hat{x"}) >$$

$$\hat{\gamma}^{>}\hat{.}\hat{A}^{>}(\hat{x"}) > \hat{S'}^{>}_f(\hat{x'}.\hat{x"})$$

$$^{<}\hat{S'}_f(\hat{x},\hat{x'}) = ^{<}\hat{S}_f(\hat{x}-\hat{x'}) + \hat{e} < \hat{\int} \hat{d}^4\hat{x"} < \hat{S}^{>}_f(\hat{x}-\hat{x"}) <$$

$$^{<}\hat{\gamma}\hat{.}^{<}\hat{A}(\hat{x"}) <^{<}\hat{S'}_f(\hat{x'}.\hat{x"}) \quad (4.19)$$

where $\hat{\gamma}^{>}\hat{.}\hat{A}^{>}(\hat{x'}) \equiv (\hat{\eta}^{>}_{st})^{\mu\nu} \times \hat{\gamma}^{>}_\mu \times \hat{A}^{>}_\nu(\hat{x'})$ **and** $\hat{A}^{>}_\nu(\hat{x'})$**, and similarly for** $^{<}\hat{\gamma}\hat{.}^{<}\hat{A}(\hat{x"})$

Note that, in the limit of unitary transformation, we recover exactly the conventional expressions. For this reason, the primary interest of isoscattering and genoscattering theories lies in the formal relationship/differentiation of the isoscattering and genoscattering profiles (1.1) and (1.2) for interpreting the existing and future scattering experimental data. As our interest is to elaborate the basic physical concepts in terms of Feynman diagrams for electron scattering with an electromagnetic field and electroweak neutron decay, as well as remove divergences from the theory, it is useful to characterize the differences by noting that, in 1st quantization scheme, the generalized S-matrix for isoscattering theory is given by

$$\hat{S}_{f,i} = lim_{t\rightarrow \inf} \hat{\int} \hat{d}^3 \hat{x} \hat{\times} \hat{\psi}^{+\hat{s'}}_{\hat{p}} \hat{\times} \hat{\Psi}^{\hat{s}}_{\hat{p}} \tag{4.20}$$

where $\hat{\Psi}^{\hat{s}}_{\hat{p}}$ is the exact solution given by

$$\hat{\Psi}^{\hat{s}}_{\hat{p}}(\hat{x}) = \hat{\psi}^{\hat{s}}_{\hat{p}}(\hat{x}) + \hat{e} \hat{\times} \hat{\int} \hat{d}^4 \hat{x'} \hat{\times} \hat{S}_f(\hat{x} - \hat{x'}) \hat{\times} \hat{\gamma} \hat{.} \hat{A}(\hat{x'}) \times \hat{\Psi}^{\hat{s}}_{\hat{p}}(\hat{x'}) \tag{4.21}$$

with the normalization

$$\hat{\int} \hat{d}^3 \hat{x} \hat{\times} \hat{\psi}^{\hat{+s}}_{\hat{p}}(\hat{x}) \hat{\times} \hat{\psi}^{\hat{+s'}}_{\hat{p'}}(\hat{x}) = \hat{\delta}_{\hat{s}\hat{s'}} \hat{\times} \hat{\delta}^3(\hat{p} - \hat{p'}) \tag{4.22}$$

and similarly for the geno case. Consequently, as indicated in Fig. 2, the correspondence principle in 1st quantization scheme involves a lifting of the Coulomb vertex in QED into the approximate Yukawa vertex in hadronic mechanics. In 2nd quantization scheme, one has additionally the lifting from Bose-Einstein to Fermi-Dirac statistics, i.e., mutation of spin under sufficiently high energies and further differences indicated in Sec 3.4 above.

The correspondence between Feynman graphs/rules and their isotopic images for computation of contributions to the S-matrix in QED of spin-$\frac{1}{2}$ particles have been summarized in table 2 of Ref.[1, paper IV] and need not be repeated here for brevity.

4.3. $\hat{O}^{>}(4,2) \times \hat{S}U^{>}(3) \times \hat{U}^{>}(1)$ Dynamical Symmetries of the Scattering Region.

We now turn to a more detailed specification of the structure of the scattering region. While the isotopy of Dirac matrices characterizes the lifting of the Lorentz group $O(3,1) \rightarrow \hat{O}(3,1)$, in terms of five additional quantities, namely the four $b_k(k = 1, ..., 4)$ for spacetime mutation and one (w)

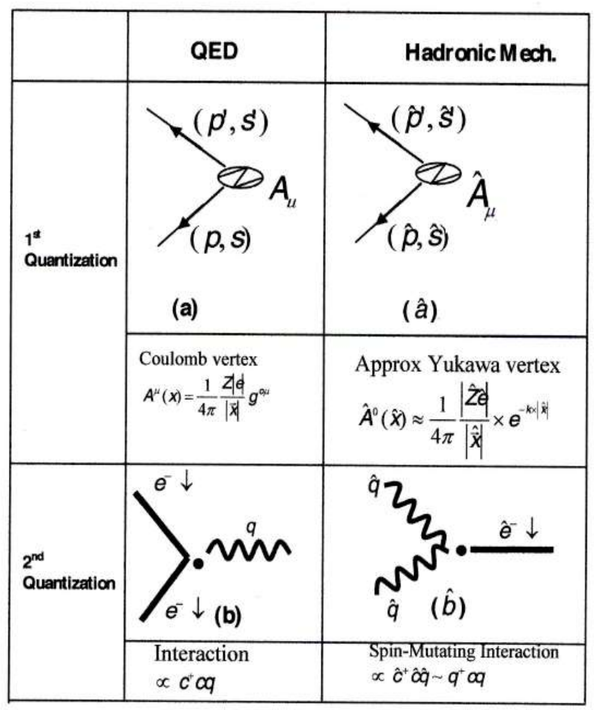

Figure 4: *Expected Modification of QED in HM*

for the spin, in regard to analyzing experimentally measureable features of the scattering region, such as its shape, deformation, anisotropy, etc, we expect the genotopy to characterize, in addition, time-irreversibility and the breaking of the associated discrete symmetry of parity by electroweak forces responsible for neutron decay in the standard (V-A, i.e. vector-axialvector) current-current interaction model.

We wish the genotopy to accommodate this feature in such a way that correlated pairs of spin-$\frac{1}{2}$ particles,e^{-}, ν and e^{-}, a^{0} , can be subsumed and long-range 1/r-potential between pairs of particles (p, e^{-}) eliminated simultaneously in the representation of the conventional O(4,2) dynamical symmetry group, in terms of the most general conserved current in the O(4,2) algebra of Dirac matrices[10] which includes not only (parity-conserving) vector current but also axial-vector (parity non-conserving) current as well as certain "convective" currents proportional to the total momentum of the particle-antiparticle system. The most important distinctive features of the scattering region for the three profiles of $e^{-}-p$ (Coulomb) action-at-a-distance between point-particles, penetration of point-like particle into an extended wave-packet, and overlap of two extended wavepackets as well as current-current interaction processes indicated in Fig. 3 are realized as indicated in Fig. 4 in terms of the progressive lifting of the larger dynamical group:

$$O(4,2) \rightarrow \hat{O}(4,2) \rightarrow \left\{ \begin{array}{c} \hat{O}^{>}(4,2) \\ . \\ {}^{>}\hat{O}(4,2) \end{array} \right\} \tag{4.23}$$

.

To elaborate the characteristics of the isoscattering region in Figs. 3 and 4, let us examine the generalized iso-current given by the isotopic lifting of the O(3,1) (Dirac) vector current into $\hat{O}(4,2)$ vector and convective currents:

$$J_{\mu} \equiv \bar{\psi}\gamma_{\mu}\psi \rightarrow \hat{\bar{\psi}} \times \hat{T} \times (\hat{\gamma}_{\mu} - i \times \kappa_{0} \times \hat{\vec{\partial}}_{\mu}) \times \hat{T} \times \hat{\psi} = \hat{J}_{\mu} \tag{4.24}$$

The generalized wave equation that conserves $\hat{J}_{\mu}$ is given by the iso-Lagrangian density

$$\hat{L} = -\frac{1}{2}\bar{\psi}(\hat{x}) \times \hat{T} \times (-i \times \hat{\gamma}^{\mu} \times \hat{\vec{\partial}}_{\mu} + \kappa_{1}) \times \hat{T} \times \hat{\psi}(\hat{x}) -$$

$$\hat{\bar{\psi}}(\hat{x}) \times \hat{T} \times \kappa_{0} \times \hat{\vec{\partial}}^{\mu}\hat{\vec{\partial}}^{\mu} \times \hat{T} \times \hat{\psi}(\hat{x}) \tag{4.25}$$

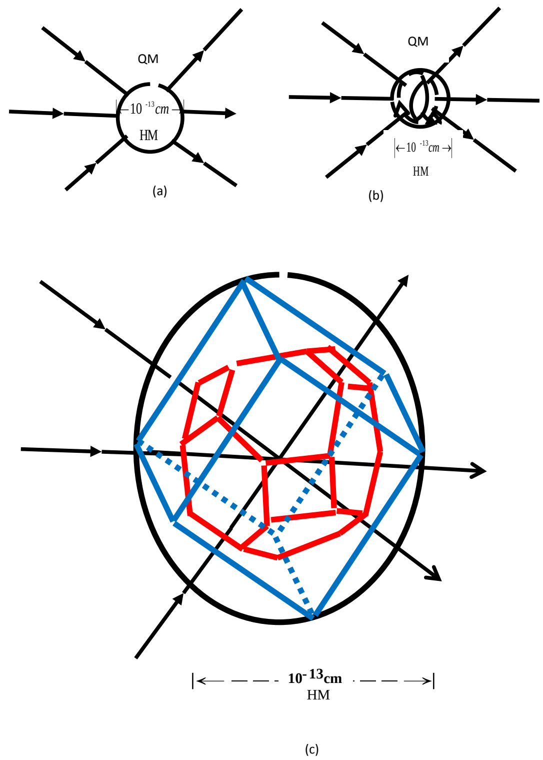

Figure 5: *A schematic view of the main assumption of (a) Lie-isotopic isoscattering theory[1] and its generalizations (b) and (c) in Lie-admissible genoscattering theory, namely, the exact validity of quantum mechanics (QM) everywhere in exterior conditions, and the validity of hadronic mechanics (HM) for the interior conditions of the scattering region of generally arbitrary shape, but represented as (a) spherical "extended" particle with radius of about* $10^{-13}cm$ *in* $\hat{O}(3,1)$ *and (b) as a deformed sphere in* $\hat{O}(4,2)$ *isoscattering theories, and as (c) overlap/penetration of a cube and its (dual) polyhedron (Wigner-Seitz unit cell) defined by the plane-coordinates representing fermion current-current interaction in genoscattering theory.*

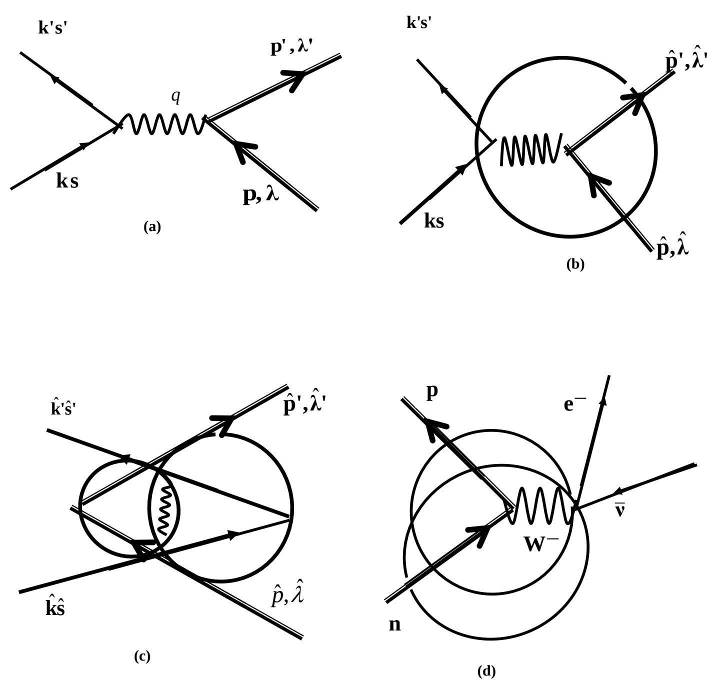

Figure 6: *Feynman diagrams for (a) conventional* $e^- - p$ *long-range Coulomb interaction via "virtual" photon exchange; (b) point-electron contact/penetration into an extended proton wave packet,*$e^- + p \to n + \nu$ *which implies* $n \sim (pe^-\bar{\nu})_{QM} \to (pe^- a^0)_{QM}$*; (c) mutual overlap of extended electron and extended proton wave packets,* $e^- + p \to n + \nu + \bar{\nu}$ *which implies* $n \equiv (\hat{e}^-, \hat{p})_{HM}$ *involving mutation of spin and in the similar scattering process* $e^+ + e^- \to \pi^0 \to e^+ + e^-$ *which implies* $\pi^0 \equiv (\hat{e}^-, \hat{e}^+)_{HM}$; and (d) electroweak decay of the neutron, $n \to p + W^- \to p + e^- + \bar{\nu}$ usually characterized by vector and axial-vector currents in unified strong and electroweak current-current interaction models.

as (cf Eq.(3.2) of Barut, Cordero and Ghirardi[10])

$$(i \times \hat{\gamma}^{\mu} \times \hat{\vec{\partial}}_{\mu} + \kappa_0 \times \hat{\vec{\partial}}^{\mu} \hat{\vec{\partial}}_{\mu} - \kappa_1) \times T \times \hat{\psi}(\hat{x}) = 0 \tag{4.26}$$

where κ_0, κ_1 are constants. It is of interest to note that the last term in Eq.(4.10) (due to convective currents) gives rise to the Pauli magnetic transitions, inasmuch as for any Dirac spinor ψ, it is easy to establish from the relation, $(\partial^{\mu}\bar{\psi})(\partial^{\mu}\psi) = (\partial^{\mu}\bar{\psi})\gamma^{\mu}\gamma^{\nu}(\partial^{\nu}\psi)$, a connection with the intrinsic Pauli-moment coupling which is tantamount to inclusion of a non-potential term,$-i\partial^{\mu}(\bar{\psi}\sigma_{\mu\nu}\partial^{\nu})\psi$, in the free Dirac Lagrangian density[11]. Thus even the ($\hat{T} \to 1$) limit of $\hat{O}(4,2)$ corresponding to the conventional $O(4,2)$ provides a simple non-trivial profile of neutron production in (e^-, p) scattering, summarized in Fig.5(Table 1), as follows.

If one puts the leptons into a triplet $l = (\nu, e^-, \mu^-)$ or (a^0, e^-, μ^-) with integral lepton number $L = Diag(1,1,1)$ and charges $Q_L = Diag(0,-1,-1)$ (in units of the proton charge) and compares with the quark tripet (u, d, s) with fractional baryon number $B = \frac{1}{3}Diag(1,1,1)$ and fractional electric charges $Q_B = \frac{1}{3}Diag(2,-1,-1)$, then one finds[12] that $L + Q_L = B + Q_B = Diag(1,0,0) \equiv F + Q_F = P$ is idempotent (i.e.,$P^2 = P$) and, therefore[13], that quarks could be obtained from the leptons by shifting 2/3 of the lepton number to the leptonic electric charge, i.e., $B \equiv L - \frac{2}{3}L, Q_B \equiv Q_L + \frac{2}{3}L$. This motivated Barut's[13] model of the neutron, and subsequently, its variant as Santilli's [14] "etherino" model.

Indeed, according to Figure 5(table 1), if in the scattering process, $e^- + p \to n + \nu$, the proton is treated as pointlike particle described by the conventional Dirac equation with $O(3,1)$ symmetry, then the electron with an associated massless neutrino may be described by the simplest (scale-invariant[15]) equation with $O(4,2)$ dynamical symmetry,

$$(i\gamma_{\mu}\partial_{\mu} - m_e^{-1}\partial_{\mu}\partial^{\mu})\psi_e = 0 \tag{4.27}$$

whose mass equation has two roots,$m = 0, m_e$, and therefore leads to Barut's model[13] of neutron production, $n \sim (pe^-\bar{\nu})_{QM}$ (which is not compatible with negative binding energy). Alternatively, if one adopts Santilli's "etherino hypothesis"[14] (for compatibility with neutron decay and negative binding energy for $n = (pe^-a^0)_{QM}$), the electron with an associated massive "etherino" may be described by the more general equation

$$[i\gamma_{\mu}\partial^{\mu} - 3m_e - (2m_e)^{-1}\partial_{\mu}\partial^{\mu}]\psi = 0, \tag{4.28}$$

whose mass equation and its two non-zero roots are respectively given by:

$$m^2 + 2m_e m - 6m_e^2 = 0, \tag{4.29}$$

Table 1: O(4,2) profile of $e^- - p$ scattering & neutron production/decay			Wave Equations	Symmetry Group
$e^- + p \to n + \nu \Rightarrow$	$n \sim (pe^-\nu_e)_{QM}$ (Barut's model[13])	p	$(i\gamma_\mu\partial_\mu - m_p)\psi_p = 0$	O(3,1)
		(e^-, ν_e)	$(i\gamma_\mu\partial_\mu - m_e^{-1}\partial_\mu\partial^\mu)\psi_e = 0$	O(4,2)
$e^- + p + a^o \to n + \nu \to e^- + p + \bar{\nu} \Rightarrow$	$n = (p, e^- a^0)_{QM}$ (Santilli's "etherino" model [14]	(e^-, a^0)	$(i\gamma_\mu\partial^\mu - 3m_e - (2m_e)^{-1}\partial_\mu\partial^\mu)\psi = 0$	O(4,2)
$n \xrightarrow[W]{} p + W \to p + e^- + \bar{\nu}$	$n \sim (p, W^-)_{QM} \Rightarrow W^- \cong \hat{e}^- \approx e^-\bar{a}0$	$(\hat{e}^-, \hat{a}^0)$	$(i\hat{\gamma}_\mu\hat{\partial}^\mu - 3\hat{m}_e - (2\hat{m}_e)^{-1}\hat{\partial}_\mu\hat{\partial}^\mu)\hat{T}\hat{\psi} = 0$	$\hat{\mathbf{O}}$(4,2)

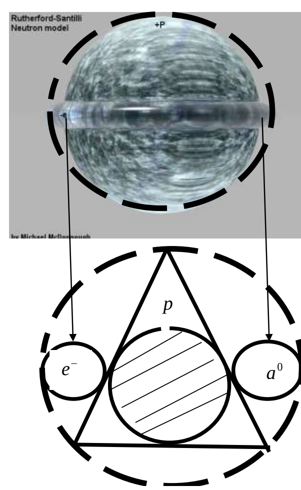

Figure 7: *Table 1: O(4,2) Profile of e-p scattering and neutron production; and 2-dimensional projection of the Macdonough representation of the Rutherford-Santilli neutron showing its relationship to Santilli's "etherino" model of the neutron.*

$$m_{\pm} = m_e(-1 \pm \sqrt{7}), i.e., \frac{m_+}{m_e} = 1,65; \frac{|m_-|}{m_e} = 3.6 \qquad (4.30)$$

Consequently, since $0.78MeV = 1.53!m_e$ **, it follows by setting** $m_{a^0} \equiv m_+ = 1.65m_e$ **that one may validly characterize a quantum mechanical bound state of** $n = (p, e^-, a^0)$ **system with negative binding energy:** $m_n - (m_p + m_e + m_{a^0}) \equiv -0.18m_e$ **.**

Intriguingly, the numerical coefficients in the wave equations (4.18) and (4.19) are uniquely related in terms of Gell-Mann SU(3) λ **- generators,**

$$\lambda_0 = \sqrt{\frac{2}{3}}\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \lambda_8 = \sqrt{\frac{1}{3}}\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -2 \end{pmatrix}, \lambda_8^{-1} = \sqrt{3}\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -\frac{1}{2} \end{pmatrix}, \qquad (4.16)$$

and a triplet field

$$\Psi = \begin{pmatrix} \psi_\nu \\ \psi_e \\ \psi_{a^0} \end{pmatrix},$$

as the components of the wave equation

$$(i\gamma_\mu \partial^\mu - m_e\sqrt{\frac{3}{2}}(\lambda_0 - \sqrt{2}\lambda_8) + (\frac{1}{m_e\sqrt{3}})\lambda_9^{-1}\partial_\mu\partial^\mu)\Psi = 0 \qquad (4.31a)$$

where

$$m_e\sqrt{\frac{1}{2}}(\lambda_0 - \sqrt{2}\lambda_8) = (3m_e)\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix};$$

$$(\frac{1}{m_e\sqrt{3}})\lambda_8^{-1} \equiv (\frac{1}{3m_e})\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -\frac{1}{2} \end{pmatrix}. \qquad (4.31b)$$

As the three equations in this system are uncoupled except insofar as there is only one characteristic mass,m_e **, for the whole triplet, Eq.(4.17a) implies that in the absence of convective currents, the apparent chiral** $SU(3) \times SU(3)$ **symmetry of the leptonic triplet (**Ψ **) is broken in the manner prescribed by Gell-Mann, Oakes and Renner[16]. This observation provides, therefore, a heuristic motivation to include both vector currents and (parity-violating) axial-vector currents in the genotopy of lepton and hadron currents in** $\hat{O}^>(4,2) \times \hat{S}^>(3) \times \hat{U}^>(1)$ **genospace suitable for a sufficiently broader genoscattering model of electroweak current-current interaction indicated in Fig.**

3 which we now proceed to elucidated further in Sec.4.3.

4.3 Genotopy of Lepton and Hadron Currents

In order for formal genoscattering theory involving strong and electroweak forces to be expressible as current-current interaction, it is necessary to construct the genotopy of the iso-current defined in Eq.(4.9) in the following broader form:

$$J_\mu \equiv \bar{\psi}\gamma_\mu\psi \rightarrow \hat{\bar{\psi}}\hat{T}(\hat{\gamma}_\mu - i\kappa_0\hat{\overleftrightarrow{\partial}}_\mu)\hat{T}\hat{\psi} \equiv \hat{J}_\mu$$

$$\rightarrow \left\{ \begin{array}{c} \hat{\bar{\Psi}}^>_F\hat{T}^>(\hat{\gamma}^>_\mu - i^>\kappa^>_0\hat{\overleftrightarrow{\partial}}^>_\mu)(\hat{I}^> + \hat{\gamma}^>_5)\hat{Q}^>_F\hat{T}^>\hat{\Psi}^>_F \equiv \hat{J}^>_\mu \\ or \\ {}^<\hat{\bar{\Psi}}_F{}^<\hat{T}({}^<\hat{\gamma}_\mu -{}^< i^<\kappa_0{}^<\hat{\overleftrightarrow{\partial}}_\mu)({}^<\hat{I} +{}^< \hat{\gamma}_5)^<\hat{Q}_F{}^<\hat{T}^<\hat{\Psi}_F \equiv^< \hat{J}_\mu \end{array} \right\} \tag{4.32}$$

where $\hat{Q}^>_F$ is the Fermion (i.e. lepton (L) or baryon (B)) charge, and $\hat{\Psi}^>_F$ is the corresponding Fermion $\hat{O}^>(4,2)\times\hat{S}U^>(3)\times\hat{U}^>(1)$ multiplet, and similarly for ${}^<\hat{Q}_F$ etc.

In order to highlight the physical content of the above generalization, it is instructive to discuss the most familiar (baryon) limit of this expression provided by Cabibbo's[17] representation of the relative strengths of the vector and axial-vector currents given in the quark triplet $q_h = (u,d,s)$ model by,

$$J^{wk}_{h\mu} = \bar{q}_h\gamma_\mu Q^{wk}_h q_h \tag{4.33}$$

where

$$Q^{wk}_h = \frac{1}{2}cos\theta(\lambda_1 + i\lambda_2) + \frac{1}{2}sin\theta(\lambda_4 + i\lambda_5) = \begin{pmatrix} 0 & cos\theta & sin\theta \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \tag{4.34}$$

and $\theta \sim 15^0$ (empirically) is the mixing (*Cabibbo*) angle. The fact that the length of the vector $(0, cos\theta, sin\theta)$ is unity expresses the so-called *lepton-hadron universality* in weak interactions. Similarly, for the lepton triplet (ν, e^-, μ^+) first introduced in 1968 by Salam[18] where ν is a 4-component neutrino $(\nu_e, \bar{\nu}_\mu)$, or more appropriately, the "Santilli" triplet, $q_l = (a^0, e^-, \mu^+)$ we have,

$$J^{wk}_{l\mu} = \bar{q}_l\gamma_\mu Q^{wk}_l q_l \tag{4.35}$$

where

$$Q^{wk}_l = \frac{1}{\sqrt{2}}(\lambda_1 - i\lambda_2) + \frac{1}{\sqrt{2}}(\lambda_4 - i\lambda_5) = \begin{pmatrix} 0 & 0 & 0 \\ cos45^0 & 0 & 0 \\ sin45^0 & 0 & 0 \end{pmatrix} \tag{4.36}$$

Thus, $Q_l^{wk} \equiv Q_h^{wk\dagger}$ apart from the difference in the numerical values of the leptonic and hadronic Cabibbo angles, in which case we may regard the hadronic Cabibbo angle θ as a "mutation" of the leptonic Cabibbo angle ϕ.

In like manner, we observe that the electric charges may be expressed in the forms

$$Q_h^\gamma \equiv \frac{1}{2}(\lambda_3 - \lambda_8/\sqrt{3})$$

$$= \begin{pmatrix} 0 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & +1 \end{pmatrix} = U\tilde{Q}_h^\gamma U^{-1} \qquad (4.37a)$$

where

$$\tilde{Q}_h^\gamma = \frac{1}{3}(\lambda_1 + \lambda_4 + \lambda_6) = \frac{1}{3}\begin{pmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{pmatrix};$$

$$U = \begin{pmatrix} 1/\sqrt{3} & 1/\sqrt{3} & 1/\sqrt{3} \\ 1/\sqrt{3} & 1/\sqrt{2} & -1/\sqrt{2} \\ 2/\sqrt{6} & -1/\sqrt{6} & -1/\sqrt{6} \end{pmatrix}; U^{-1} = U^\dagger.$$

$$Trace(U) = 1/\sqrt{3} + 1/\sqrt{2} - 1/\sqrt{6} \equiv 2cos\theta - 1 \qquad (4.37b)$$

and for the leptonic charge,

$$Q_l^\gamma \equiv \frac{1}{2}(\lambda_3 - \sqrt{3}\lambda_8) = V\tilde{Q}_l^\gamma V^{-1}$$

$$\tilde{Q}_l^\gamma = \frac{1}{3\sqrt{3}}(\lambda_2 + \lambda_5 + \lambda_7) = \frac{1}{3\sqrt{3}}\begin{pmatrix} 0 & -i & -i \\ i & 0 & -i \\ i & i & 0 \end{pmatrix} \qquad (4.2238a)$$

where

$$V = \frac{1}{\sqrt{3}}\begin{pmatrix} 1 & 1 & e^{-i\phi} \\ -1 & e^{-i\phi} & 1 \\ 1 & -e^{i\phi} & e^{i\phi} \end{pmatrix}; V^{-1} = V^\dagger, \phi = 60^0. \qquad (4.38b)$$

As a result, the lepton and hadron electromagnetic currents can be added (like Cabibbo) in terms of a single triplet,q_F such that

$$J_\mu^\gamma = \bar{q}_F \gamma_\mu \tilde{Q}_F^\gamma q_F \qquad (4.39)$$

where

$$\tilde{Q}_F^\gamma = \frac{2}{3\sqrt{3}}[cos\phi(\lambda_2 + \lambda_5 + \lambda_7] + sin\phi[\lambda_1 + \lambda_4 + \lambda_6]$$

$$= \frac{2}{3\sqrt{3}} \begin{pmatrix} 0 & e^{-i\phi} & e^{-i\phi} \\ e^{i\phi} & 0 & e^{-i\phi} \\ e^{i\phi} & e^{i\phi} & 0 \end{pmatrix} \tag{4.40}$$

Consequently, the eigenvalues of the symmetric part of $\tilde{Q}^{\gamma}_{F}$ give the eigenvalues of Q^{γ}_{l} while the eigenvalues of its antisymmetric part give the quark charges Q^{γ}_{h}. This is the unifying feature of genoscattering theory that we are after, which we now proceed to use as a framework for initiating applications of the theory to inelastic scattering involving spin-$\frac{1}{2}$ fermion (baryon+lepton) systems.

5. INITIAL APPLICATIONS

5.1 Genotopy of the S-matrix and Feynman Graphs/Rules.

In order to familiarize the reader with the use of generalized Feynman graphs/rules for computation of the S-matrix we recapitulate the Lie-isotopic elaboration of Feynman graph for reversible electron-proton Coulomb scattering shown in Fig. 6(a) which will lead to an isotopic generalization of the familiar Mott scattering cross-section, and will enable us to identify the characteristic features of inelastic scattering processes in Fig. 6(b) requiring an application of the genoscattering theory.

To write down the S-matrix for the reversible scattering process shown in Fig.6(a) using the Feynman rules, one starts in the direction of the top left arrow to right and, at each vertex, inserts all other factors between the incoming and outgoing arrows. If loop closes, one takes trace to get:

$$\hat{S}_{fi} = -4i\pi \int \frac{d^4\hat{q}}{(2\pi)^4} \times [\frac{1}{\sqrt{(2\pi)^3}}\sqrt{\frac{\hat{m}\hat{c}}{\hat{k}'_0}} \times \hat{\bar{u}}^{\hat{S}'}(\hat{k}')]\times$$

$$[-i(4\pi e)\hat{\gamma}^{\mu'}(2\pi)^4 \times \hat{\delta}^4(\hat{k}' - \hat{k} + \hat{q})] \times [\frac{1}{\sqrt{(2\pi)^3}}\sqrt{\frac{\hat{m}\hat{c}}{\hat{k}_0}} \times \hat{u}^{\hat{S}}(\hat{k})]\times$$

$$[-i\hat{g}^{\mu\nu}\hat{D}_F(\hat{q}^2)] \times [\frac{1}{\sqrt{(2\pi)^3}}\sqrt{\frac{\hat{M}\hat{c}}{\hat{P}'_0}} \times \hat{\bar{U}}^{\hat{\lambda}'}(\hat{P}')]\times$$

$$[-i(4\pi e)\hat{\gamma}^{\mu'}(2\pi)^4 \times \hat{\delta}^{(4)}(\hat{P}' + \hat{P} - \hat{q})] \times [\frac{1}{\sqrt{(2\pi)^3}}\sqrt{\frac{\hat{M}\hat{c}}{\hat{P}_0}} \times \hat{U}^{\hat{\lambda}}(\hat{P})]$$

$$= -4\pi i \int \frac{d^4\hat{q}}{(2\pi)^4}\sqrt{\frac{(\hat{m}\hat{c})^2(\hat{M}\hat{c})^2}{\hat{k}'_0\hat{k}_0\hat{P}'_0P_0}} \times \hat{\bar{u}}^{\hat{S}'}(\hat{k}')\hat{\gamma}^{\mu}\hat{u}^{\hat{S}}(\hat{k})\times$$

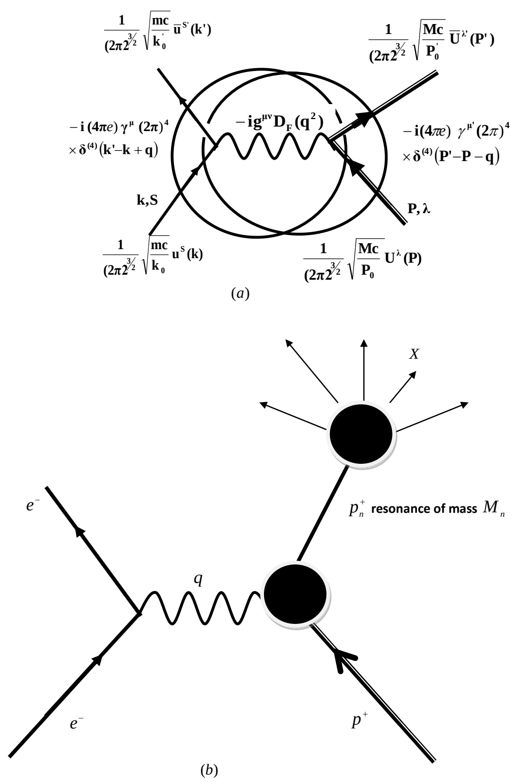

Figure 8: *generalized Feynman graphs for (a) electron-proton isoscattering and (b) resonance model of deep-inelastic* $e^- - p^+$ *genoscattering.*

$$\frac{-4\pi i\alpha}{(4\pi)^4}(2\pi)^4\hat{\delta}^{(4)}(\hat{k}'+\hat{P}'-\hat{k}-\hat{P})\times$$

$$[(\hat{k}'-\hat{k})^2+(m_\phi\hat{c})^2+i\hat{\varepsilon}]^{-2}\times\hat{\bar{U}}^{\hat{\lambda}'}(\hat{P}')\hat{\gamma}_\mu\hat{U}^{\hat{\lambda}}(\hat{P}). \quad (5.1)$$

This may be rewritten in the form of *generalized current-current interaction*:

$$\hat{S}_{fi}=-4i\pi\int\frac{d^4\hat{q}}{(2\pi)^4}\times\hat{j}^\mu(\hat{k}'\hat{k},-\hat{q})\times\frac{1}{[\hat{q}^2+(m_\phi\hat{c})^2]^2}\times\hat{J}_\mu(\hat{p}'\hat{p};\hat{q}) \quad (5.2)$$

where

$$\hat{j}^\mu(\hat{k}'\hat{k},-\hat{q})=(2\pi)^4\times\hat{\delta}(\hat{k}'-\hat{k}+\hat{q})]\times\frac{e}{(2\hat{m}\hat{c})^3}\times\sqrt{\frac{(\hat{m}\hat{c})^2}{\hat{k}'_0\hat{k}_0}}\hat{\bar{u}}^{S'}(\hat{k}')\hat{\gamma}^\mu\hat{u}^S(\hat{k}) \quad (5.3a)$$

$$\hat{A}_\mu(\hat{k}'-\hat{k})=\frac{4\pi}{(\hat{k}'-\hat{k})^2+(m_\phi\hat{c})^2+i\hat{\varepsilon}}\hat{J}_\mu(\hat{p}',\hat{p};\hat{k}'-\hat{k}) \quad (5.3b)$$

are, respectively, the generalized electromagnetic current$\hat{j}^\mu$ **and generalized Moller current**$\hat{J}_\mu$ **associated with the generalized electromagnetic vector potential,** $\hat{A}_\mu$ **.**

The differential cross section with no polarization for initial particles in the laboratory frame,$\hat{p}=(M\hat{c};0)$ **is given by**

$$d\hat{\sigma}=\frac{1}{2}\sum_{ij}\frac{1}{|\frac{\hat{k}}{\hat{k}_0}|\frac{1}{(2\pi)^3}\frac{V}{(2\pi)^3}}\frac{|\hat{S}_{if}|^2}{T}d^3\hat{p}'d^3\hat{k}' \quad (5.4)$$

We observe that, in the limit $\hat{T}\to 1$ **this leads to the standard expression of "potential scattering theory" for electron-point-proton scattering (with unpolarized initial state and no observation of final spin):**

$$\frac{d\sigma_{e-p}}{d\Omega}=\frac{\alpha^2E^2(1-\beta sin^2(\theta/2))}{4P^4sin^4(\theta/2)}=\frac{\alpha^2cos^2(\theta/2)}{E^2sin^4(\theta/2)}\equiv\frac{d\sigma_{Mott}}{d\Omega} \quad (5.5a)$$

$$\beta=\frac{|\mathbf{P}|}{E},\frac{1}{2}(\mathbf{P'}-\mathbf{P})^{\mathbf{2}}=(\mathbf{q})^{\mathbf{2}}=\mathbf{2P^2(1-cos}(\theta))=\mathbf{4P^2sin^2}(\theta/\mathbf{2}) \quad (5.5b)$$

In the isoscattering theory of reversible processes, three novel features arise: firstly, from the generalized internal photon line $\hat{D}_F(\hat{q}^2)$**, which is no longer divergent in the limit** $\hat{q}\to 0$**; secondly, from the generalized Dirac matrices** $\hat{\gamma}^\mu$**; and thirdly, from the generalized currents,**$\hat{j}^\mu$ **and** $\hat{J}_\mu$**. These features persist in genoscattering theory of irreversible processes, which**

we now proceed to explore, beginning with a review of the results of deep-inelastic electron-positron and electron-proton scattering experiments.

5.2 Deep Inelastic e-p Scattering Experimental Results

In the resonance model [19] of the 1967 SLAC-MIT experiments [20,21] on a program of inelastic electron-proton ($e^- p^+$) scattering on the 20GeV Stanford linear accelerator to study electro-production of resonances as a function of momentum transfer, the process is viewed as a generalization of the Feynman graph for electron-point-proton scattering in Fig.6(a) in which virtual space-like photon emitted by the in-coming electron violently collides with the interacting target proton and under the kinematical condition

$$M_n^2 = M^2 + 2M\nu + q^2, (M^2 \equiv P^2, \nu \equiv q.P), \tag{5.6}$$

a resonance of mass M_n is produced. Subsequently, after a short flight this resonance decays into a multitude of stable hadrons as shown in Fig.6(b).

In their rest frame, these resonances are classified under the product group, $SU(3) \times G$ where the unitary unimodular symmetry group $SU(3)$ provides the internal symmetry through quantum numbers, such as isotopic spin(I), hypercharge (Y), etc, and G represents a dynamical group, frequently chosen to be SL(2,C) and $SL(2) \times d$ or O(4,2). And in order to compare with the SLAC-MIT experimental data [19] one generalizes Eq.(5.5) to [21]:

$$\frac{d^2\sigma}{d\Omega dE} = \frac{d\sigma_{Mott}}{d\Omega}[W_2(\nu, q^2) + 2W_1(\nu, q^2)tan^2\frac{\theta}{2}] \tag{5.7a}$$

or in the form

$$\frac{d^2\sigma}{d\Omega dE} = \frac{d\hat{\sigma}_{Mott}}{d\Omega}[W_2(\nu, q^2)cos^2\frac{\theta}{2} + 2W_1(\nu, q^2)sin^2\frac{\theta}{2}]; \tag{5.7b}$$

where the structure functions, $W_1(\nu, q^2)$ and $W_2(\nu, q^2)$, depend on the properties of the target system, and $\hat{\sigma}_{Mott} \equiv \sigma_{Mott} sec^2\frac{\theta}{2}$. The fact that two such functions are required because there are two (transverse and longitudinal) polarization states of the virtual photon also lends itself to an interpretation of the scattering angle $\frac{\theta}{2}$ as a Cabibbo-like "mixing" angle envisaged in Sec.4.3.

In models that satisfy $SU(3) \times SU(3) \times O(3,1)$ current algebra, Bjorken[22] conjectured that, in the limit, $M^2 = -q^2 \to \inf, \mu = q.P \to \inf$ such that $2M\nu/q^2 = \omega$ is fixed, one should expect the following dependence on only:

$$2MW_2(\nu, q^2) = F_1(\omega), \nu W_2(\nu, q^2) = F_2(\omega) \tag{5.8a}$$

He also derived a sum-rule for inelastic electron scattering

$$\int_{q^2/2M}^{\inf} d\nu[W_2^p(\nu,q^2) + W_2^n(\nu,q^2)] \geq \frac{1}{2} \tag{5.8b}$$

where$W_2^p(\nu,q^2)$ **and** $W_2^n(\nu,q^2)$ **are the structure functions for the proton and neutron respectively. This scaling behavior in Eq.(3.4a) was subsequently found experimentally [19]; and a value over the range of MIT-SLAC data [19,20] was found for the weighted sum**

$$\int^{20} \frac{d\omega}{\omega}\nu W_2^p = 0.78 \pm 0.04 \tag{5.9}$$

It is intriguing that this is comparable to the dimensionless mass defect, $[m_n - (m_p + m_{e^-})]/(MeV) = 0.78$.

However, from the 1990 Nobel Lecture by J. Friedman[23] entitled Deep Inelastic Scattering: Comparisons with the Quark Model, it is apparent that theoretical and practical difficulties have arisen in the analysis of the unavoidably limited experimental data from the infinities characterizing the definition of the Bjorken variable, x **(or** $\omega = 1/x$**) and its physical interpretation in Feynman's quark-parton model[24] as the fraction of proton momentum carried by point-like constituents of the proton (usually identified with free quarks) in the so-called infinite momentum frame** ($p \to \inf$) **. Also comparison of theory with limited experimental data has been largely limited to sum rule predictions (requiring integration over all** x **or** ω **). Moreover, the replacement of the electron altogether by a presumed space-like photon (traveling at superluminal speed** $V > c_0$ **) interacting with the proton (travelling at subluminal speed** $v < c_0$ **) involves the singularity in the special relativity theorem of addition of velocities, V and v, when** $vV = c_(0)^2$ **. It is not surprising, therefore, that, none of the existing models has satisfactorily explained the data, especially why scaling behavior should set in at energies as low as observed.**

It was argued by Jackiw[25] in his 1972 Physics Today review article on Scale Symmetry, that the experimental results point towards approximate O(3,1) scale symmetry (broken by non-vanishing divergence of the dilatation current density due to non-zero masses in the O(3,1) kinematical group sector of the $SU(3) \times O(3,1)$ **theory). However, as subsequently pointed out by Animalu[26] in a letter to Physics Today on Jackiw's article, scale symmetry breaking can be remedied by "lifting" the** $SU(3) \times O(3,1)$ **to** $SU(3) \times O(4,2)$ **current algebra involving fundamental length or mass scale. It was from this point of view that we have characterized the scattering region in Sec.4.2 while the basically non-unitary character of scale symmetry**

and irreversibility provide the justification for the application of genoscattering theory to the understanding of deep-inelastic electron-positron and electron-proton scattering data.

5.3 Genotopy of Bjorken Variable and Structure Functions.

In order to avoid infinites in the characterization of the Bjorken limit $M^2 = -q^2 \to \text{inf}, \mu = q.P \to \text{inf}$ **such that** $2M\nu/q^2 = \omega$**, we may define geno-Bjorken variables from the left genotopy of the "point" sphere,**$P^2 + q^2 = 0$ **into a torus in terms of the two Lorentz scalars,**$\hat{P}^2 - \hat{q}^2$ **and ,** $\hat{q}.\hat{P}$ **given by:**

$$(q,p)\begin{pmatrix} 1 & -x \\ x & 1 \end{pmatrix}\begin{pmatrix} q \\ p \end{pmatrix} \to (\hat{q},\hat{P})\begin{pmatrix} -1 & \hat{x} \\ \hat{x} & 1 \end{pmatrix}\begin{pmatrix} \hat{q} \\ \hat{P} \end{pmatrix} = 0$$

$$i.e., q^2 + P^2 \to -(\hat{q}^2 - \hat{P}^2) + 2\hat{x}\hat{q}.\hat{P} = 0 \qquad (5.10a)$$

where the underlying metrics are related as follows,

$$\eta \equiv \begin{pmatrix} 1 & -x \\ x & 1 \end{pmatrix} \to \begin{pmatrix} -1 & x \\ x & 1 \end{pmatrix} \equiv TC\eta; \qquad (5.10b)$$

and right genotopy given by:

$$(\hat{q},\hat{P})\begin{pmatrix} 1 & -\omega \\ \omega & 1 \end{pmatrix}\begin{pmatrix} \hat{q} \\ \hat{P} \end{pmatrix} \to (\hat{q},\hat{P})\begin{pmatrix} -\hat{\omega} & 1 \\ 1 & \hat{\omega} \end{pmatrix}\begin{pmatrix} \hat{q} \\ \hat{P} \end{pmatrix}$$

$$i.e., q^2 + P^2 \to -\hat{\omega}(\hat{q}^2 - \hat{P}^2) + 2\hat{q}.\hat{P} = 0 \qquad (5.10c)$$

where the underlying metrics are related as follows,

$$\eta \equiv \begin{pmatrix} 1 & -x \\ x & 1 \end{pmatrix} \to \begin{pmatrix} -x & 1 \\ 1 & x \end{pmatrix} \equiv \eta DT; \qquad (5.10d)$$

and

$$C = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \equiv \sigma_1; T = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix} \equiv -i\sigma_2; D = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \equiv -\sigma_3.$$

We observe that if $x = 1$**, then** $TC\eta - \eta DT = 0$**, with** $C \neq D^\dagger \neq I$ **is a Lie-admissible relation. From the relations on the right of Eqs.(5.10a) and (5.10c) we obtain the geno-Bjorken variables** ($\hat{x}, \hat{\omega}$ **):**

$$\hat{x} = \hat{\omega}^{-1} = (\hat{P}^2 - \hat{q}^2)/2\hat{q}.\hat{P} \qquad (5.11)$$

Consequently, following Animalu and Ekuma[27], the genotopy of the deep-inelastic structure functions, $\hat{F}_1$ **and** $\hat{F}_2$ **, can be represented (cf Myung[28]) by a pair of Riccati's equations:**

$$d\hat{F}_1/d\hat{\omega} = \hat{x}_0\hat{F}_1 - \gamma\hat{F}_1^2$$
$$d\hat{F}_2/d\hat{\omega} = -\hat{x}_0\hat{F}_2 + \gamma\hat{F}_2^2 \quad (5.9a)$$

subject to the boundary conditions, $\hat{F}(0)_1 = \hat{F}_{10}, \hat{F}(0)_2 = \hat{F}_{20}$. The solutions[23]

$$\hat{F}(\hat{\omega})_1 = \frac{\hat{x}_0/\gamma}{1 - (\hat{x}_0/\gamma\hat{F}_{10} - 1)e^{+\hat{x}_0\hat{\omega}}}$$
$$\hat{F}(\hat{\omega})_2 = \frac{\hat{x}_0/\gamma}{1 - (\hat{x}_0/\gamma\hat{F}_{20} - 1)e^{-\hat{x}_0\hat{\omega}}} \quad (5.9b)$$

have the features shown for $\hat{F}_1(0) > \hat{x}_0/\gamma$ and $\hat{F}_2(0) < \hat{x}_0/\gamma$ in Fig.7 where they are also compared with experimental data. The agreement between theory and experiment is quite good. In terms of the reciprocal Bjorken variable $\hat{\omega}$, the corresponding curve for $\hat{F}_2(\hat{x}_0)$ turns out to be an image of $\hat{F}_2(\hat{\omega})$ and has the form

$$\hat{F}_2(\hat{x}) = \frac{\hat{\omega}_0/\xi}{[1 + (\hat{\omega}_0/\xi\hat{F}_{20} - 1)e^{+\hat{x}\hat{\omega}_0}]} \quad (5.10)$$

whose feature is as shown for $\hat{F}_{20} > \hat{\omega}_0/\xi$ in Figs. 8(a) and 8(b), where it is also compared with experimental data for $\nu W_2 \equiv F_2(x)$. The agreement between theory and experiment is again quite good.

5.4. Mass Genorenormalization

In the preceding sections of this paper, we have established that an irreversible scattering theory implies rather serious differences in the data elaboration of the same inelastic scattering compared to the elaboration done with the conventional reversible scattering theory.

To complete the understanding of the implications, it is important to out;line the additional implication according to which *irreversible nonlinear, nonlocal and nonpotential effects in the interior of the scattering region cause an alteration of the numerical value of internal masses.*

This new occurrence can be seen by recalling from Paper II that nonlinear, nonlocal and nonpotential effects are representable with a general symmetric metric here expressed for simplicity in (1 + 1)-dimensions with the *light genocone* **[7b]**

$$\frac{r^2}{n_r^{2>}} - t^2\frac{c^2}{n_4^{2>}} = 0, \quad (5.11)$$

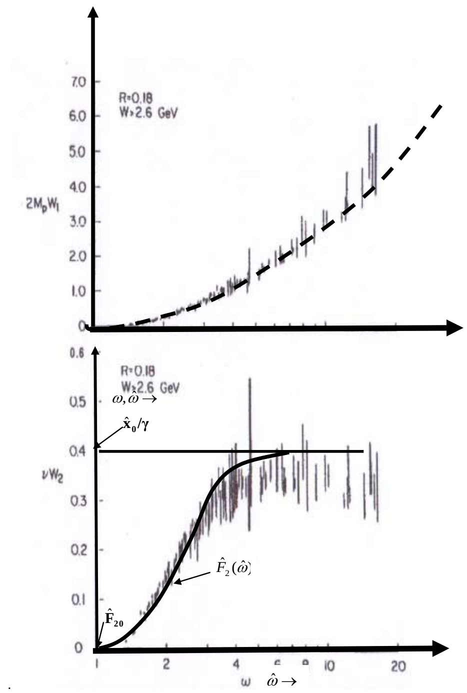

Figure 9: *Comparison of* $\hat{F}_1(\hat{\omega})$ $\hat{F}_2(\hat{\omega})$ *for* $\hat{F}_{20} < \hat{x}_0/\gamma$ *with* $2MW_1 = F_1(\omega)$ *and* $\nu W_2 = F_2(\omega)$ *where* $\omega = 2M\nu/q^2$, *for proton;* $W > 2.6GeV, q^2 > 1(GeV/c_0^2$ *and R=0.18. Data from G. Miller et al Phys. Rev.D5, 528 (1972)[19].*

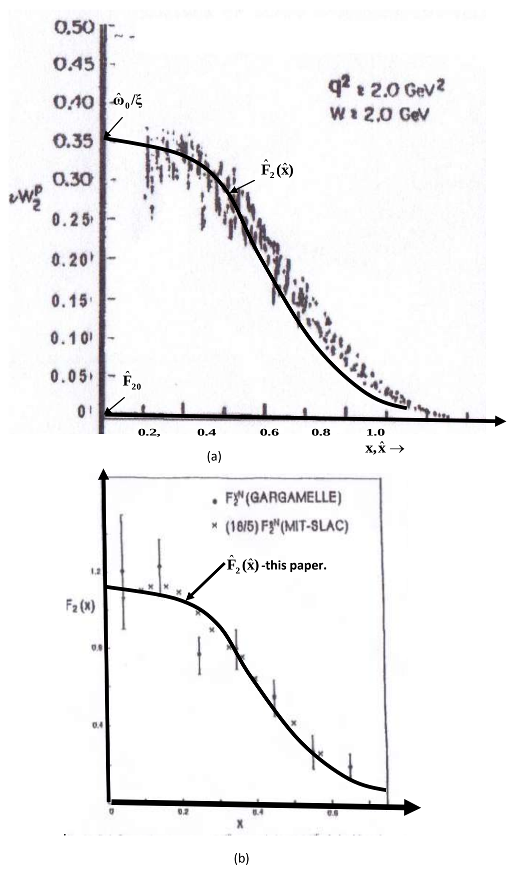

Figure 10: *(a) Comparison of* $\hat{F}_1(\hat{\omega})$ *for* $\hat{F}_{20} < \hat{\omega}_0/xi$ *(solid line) with* W_2 *versus* $x = q^2/2M\nu$ *for the proton for* $W > 2.0GeV, q^2 > 2(GeV/c_0^2$ *Data from ref.[20] : A.Bodek et al Phys. Rev .Lett. 30,1087 (1973); Phys. Lett. 51B, 417(1974); Phys. Rev. D20, 1471 (1979) . (b) Early Gargamelle measurements of* $F_2^{\nu N}$ *compared with*$(18/5)F_2^{eN}$ *calculated from the MIT-SLAC results) and with HM model* $\hat{F}_2^{\nu N}(\hat{x})$ *. (Source of data J.I. Friedman Nobel Lecture 1990, Physics 1990 p. 715 ref.[23].*

where the arrow in the characteristic quantities oi the interior medium indicates their lack of time-reversal invariance and the selection of their value for the forward motion. The preceding light genocone then characterizes the following *maximal causal genospeed*

$$V^{>}_{max} = c\frac{n^{>}_{r}}{n^{>}_{4}}. \tag{5.12}$$

The second order Casimir invariant of the Lorentz-Poincaré symmetry is then lifted from the conventional expression $p^2 - m^2c^2 = 0$ characterizing the mass m into the genotopic form

$$p^2 - m^2 V^{2>}_{max} = 0 \tag{5.13}$$

The identification from the outside of the numerical value of a mass in the interior of the scattering region, such as the mass of an exchange particle, requires the projection of the above expression in our spacetime, resulting in the *mass renormalization*

$$m \ \rightarrow \ m^{>} = m\frac{n^{>}_{r}}{n^{>}_{4}} \tag{5.14}$$

As a concrete illustration, the mass of the hypothetical;l *Higgs boson* is estimated as being between 115 and 185 GeV/c2 although it is admitted as being a model-dependent upper bound. Our genoscattering theory establishes that, for highly irreversible processes such as those of Figure 1, such a numerical prediction is additionally dependent on the energy of the scattering particles, the geometry of their collision and numerous additional features, to such a extent that the "search for the Higgs boson" is experimentally meaningless as current stated.

As illustrated in Ref., [31], the above potentially large variation of the value of the masses of extended particles is rather general and essentially due to the fact that the value c can be safely assumed as being the maximal causal speed solely for *point-like* particles. When considering *extended* particles, the value of the mass depends on the maximal causal speed in its interior that is expected to vary dependent on the density and other features, thus increasing with the mass (since hadrons have essentially the same charge distribution).

The necessity for a new renormalization of the masses for interior problems, caused by nonlinear, nonlocal and non-Lagrangian/non-Hamiltonian internal effects, was first established by Santilli in Ref. [2b] as being necessary for a quantitative representation of the synthesis of the π^o meson

from an electron and a positron, $e^+ + e^- \rightarrow \pi^o$. In this case, the total rest energy of the final state ($134\ MeV$) is much bigger than the sum of the rest energies of the two original states ($1\ MeV$), under which conditions the Schrödinger equation became inconsistent (due to the need of a "positive" binding energy which is anathema in quantum, mechanics).

Santilli (see Section 5 of paper [2b]) then established the sole known methods to achieve a quantitative representation of the considered synthesis is that of subjecting the inconsistent Schrödinger equation to a nonunitary transform. In this case, consistency of the equation is achieved via a novel renormalization of the masses of the original constituents of unitary, thus of non-Lagrangian and non-Ham,Hamiltonian type with numerical value

$$m_e = 0.5\ MeV \ \rightarrow \ m_{\hat{e}} \approx 75\ MeV, \tag{5.15}$$

which yields indeed the final value $m_{\pi^o} = 134!MeV$ in view of the mass defect caused by the Coulomb attraction between the electron and the positron.

The above novel renormalization was subsequently confirmed, also by Santilli [32], via the representation of *all* **characteristics of the neutron in its synthesis inside stars from a proton and an electron inside a star, $p^+ + e^- \rightarrow !n+?$, that also required a nonunitary lifting of the Schrödinger equation (since the rest energy of the neutron is bigger than the sum of the rest energies of the proton and the electron). This representation was first achieved in 1990 [32a] at the nonrelativistic level and then in 1993 [32b] at the relativistic level (see Kadeisvili [33] for a comprehensive review).**

Numerous additional data have independently confirmed the need for they isorenormalization of internal masses for the case of reversible interior problems and of the broader renormalization for the case of irreversible processes (see the experimental lectures in www.world-lecture-series.org).

5.5. Concluding Remarks

In this series of papers, we have shown that the so-called "experimental results" obtained in the data elaboration of inelastic scattering experiments via the conventional, quantum mechanical, scattering theory, are mere personal opinions by the issuing experimentalists, rather than incontrovertible experimental truth.

On mathematical ground, the above conclusion can be seen from the very axiomatic structure of quantum mechanics which is notoriously *local-differential,* **thus solely capable of characterizing** *a finite number of point-like particles without collisions* **(in any case, collisions are meaningless for point particles). Consequently, we can expect that the relativistic scattering**

theory can indeed provide an exact representation of scattering events without collisions, as it is the case for the Coulomb scattering. However, the local-differential mathematical foundations of the relativistic scattering theory prevents even a consistent definition of collision, let alone its quantitative treatment, under which conditions any expectation of exact results is ascientific.

On physical grounds, the very notion of collision requires the representation of particles as *extended.* **But then, the scattering/collision of extended particles implies the presence of conventionalize Hamiltonian as well as contact, zero-range, nonlinear, nonlocal-integral and nonpotential/non-Hamiltonian interactions. The insufficiency of the conventional linear, local-differential, and potential/Hamiltonian scattering theory is then beyond scientific or otherwise credible doubts.**

To state it in a nutshell, the papers of this series confirm the expectation expressed in the first lines of the first paper, namely, that time-reversal invariant theories, such as Einstein's special relativity and relativistic quantum mechanics, cannot possibly or otherwise credibly be assumed as being exactly valid for irreversible scattering events.

By looking in retrospect, the above conclusions have been known to the authors for decades. The resolution of the technical difficulties for their quantitative treatment has requested decades of research by Santilli because of the prior need to develop the new Lie-isotopic and Lie-admissible formulations for the invariant representation of the extended character of particles and/or of their wavepackets, and their most general known interactions, after which Animalu's broadening of Feynman's diagrams could be subjected to proper treatment and development.

Acknowledgments

The authors have no words to express their deepest gratitude to Larry Horwitz of Tel-Aviv University for truly invaluable critical comments and insights without which this paper would not have been possible. Additionally, the author would like to thank the participants of various meetings where the foundations of this paper were discussed in one form or another, including: the participants of the meeting of the International Association of Relativistic Dynamics (IARD) held on June 2007, in Thessaloniki, Greece; the participants to a seminar delivered at the European Laboratory in Ispra, Italy in January, 2009; and the participants of the inauguration ceremony of the Research Institute of Hypercomplex Systems in Geometry and Physics (RIHSGP) held in Moscow, Russia, on May, 2009. Finally, the second named author would like to thank the founder of the new Institute, D. G. Pavlov, its president V. Gladyshev, as well as Gh. Atanasiu, V. Balan, P. Rowlands and all other members of the new Institute for their kind invitation and hospitality in Moscow during which visit this paper was completed. The main aspects of these papers were also discussed during the recent *Third International Conference on the Lie-Admissible Treatment of Irreversible Processes* **held at the University of Kathmandu, Nepal, from January 5 to 9, 2011. The authors would like to thank all participants for invaluable comments. Additionally, special thanks are due to Dorte Zuckerman for linguistic correctsions and to Christian Corda, the Editor of the proceedings for editorial control.**

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