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THE NOVEL "CONTROLLED INTERMEDIATE NUCLEAR FUSION" AND A REPORT ON ITS INDUSTRIAL REALIZATION AS PREDICTED BY HADRONIC MECHANICS[1]

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[1]This paper had been accepted for publication in 2003 by the *Journal of Applied Sciences* and the publication charges were paid via credit card, but the author has been unable to receive any additional information on that journal since that time. The paper herein printed is the original version except for upgrades in references and other details. It should be also noted that versions of this paper released by the IBR office prior to this publication should be discarded because they were yet uncontrolled drafts.

Abstract

In this paper, we propose apparently for the first time a new type of controlled nuclear fusion called "intermediate" because occurring at energies intermediate between those of the "cold" and "hot" fusions to attempt the resolution of their known insufficiencies. The paper then presents a progress report on the industrial realizations going on to enhance the net energy output that, currently, is already of the order of five times the used electric energy at relatively low operating power, pressure and temperature, as verifiable in the IBR laboratory in Florida.

For this purpose: 1) We show that known limitations of quantum mechanics, quantum chemistry and special relativity, such as their reversibility in time compared to the irreversibility of all energy releasing processes, cause excessive insufficiencies for all controlled nuclear fusions; 2) We outline the structurally irreversible coverings of quantum mechanics, quantum chemistry and special relativity, collectively known as specifically conceived and verified during the past three decades for all energy releasing processes; 3) We identify seven physical laws predicted by the latter disciplines that have to be verified by all controlled nuclear fusions to occur in a systematic way; 4) We review the industrial research that can be disclosed at the moment in the most promising engineering realization and optimization of said seven laws; and 5) We review in construction details a number of reactors currently under industrial development for the possible realization of the novel controlled intermediate nuclear fusions with particular reference to reactors capable of producing large, industrially relevant heat for nuclear synthesis among light, natural and stable isotopes predicted by said covering theories *without* the emission of neutrons, protons and alphas and *without* the release of radioactive waste.

Available reactors already produce several millions of *BTU* per hour over the used electric energy, although this excess heat could be due to carbon combustion and other non-nuclear events. Hence, current industrial efforts aim at the increase of the efficiency and the net production of heat beyond the capabilities of orthodox interpretations. The results of these efforts, whether positive or negative, are expected to be published at some future time.

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1. Insufficiencies of ongoing "cold" and "hot" fusion research.

Following the pioneering research by Fleishmann, Pons and Hawkins [1a] of 1989, vast research has been conducted on *Low Energy Nuclear Syntheses* (LENS) popularly called "Cold Fusion" (CF) (see, e.g. [1a-1d] or the general review [1e] with large literature). A rather widespread view is that there is no sufficient evidence to conclude at this writing that LESNS did ot did not occur due to insufficient precision of available calorimeters, the lack of consistent reproduction of the results, and other reasons.

The view expressed by the author, following extensive theoretical, experimental and industrial research in the field, is that LENS have indeed occurred in numerous (but not all) tests, although the syntheses occurred at random, thus without hope of achieving scientific or industrial relevance. This view is expressed not only on ground of measurements conducted by the author, but also because LENS denials have at time occurred on essentially false grounds, such as: absence of "cold" fusions on grounds of incompatibilities with pre-existing theories, when the latter were not conceived for the former and more adequate covering theories have been available for a while; denial of "cold fusion on grounds of lack of emission of neutrons, while fusions without any emission of neutrons are indeed possible; and other equivocal arguments.

In any case, the achievement of clear experimental verification of "cold" fusions, let alone of industrially relevant energy output, has remained elusive, and none are in sight at this writing (June 2008) on strict scientific grounds. In the most recent experiments (that we do not quote here to prevent discriminatory listings due to their number) we merely have apparent confirmations of the synthesis of new nuclei, but without any industrially appreciable energy output.

Additional research supported by a collective international investment of about one billion dollars over the past fifty years has shown that the *High Energy Nuclear Syntheses* (HENS), popularly called "Hot Fusion" (HF), can indeed be attained in laboratory, although this research too has not achieved results of industrial significance, and none is in sight at this writing, due to uncontrollable instabilities at the initiation of the fusion process, and other reasons.

Following all these decades of failure to achieve clear scientific results and industrial value under the expenditure of so vast a sum of public and private money, it is time to re-examine the foundations of fusion research, beginning with a re-examination of the *basic theories* used for all nuclear fusions, with particular references to quantum mechanics, quantum chemistry and special relativity.

By keeping in mind the need by our society for new clean energies, and the fact that these disciplines were conceived and verified for dramatically different conditions, it is unethical to assume aprioristically and without serious scrutiny said disciplines for fusion processes.

Quantum mechanics, quantum chemistry and special relativity were conceived, constructed and verified for *reversible processes,* namely, processes whose time reversal images are causal, such as electron orbits in atomic structures, particles moving in accelerators, and many other systems. By contrast, all nuclear synthesis constitute strictly *irreversible processes,* namely, processes whose time reversal images violate causality laws.

As experts are expected to know to qualify as such, the quantum mechanical probability amplitude for a Hermitean Hamiltonian is time reversal invariant. Consequently, quantum mechanics does predict a finite probability for two nuclei $N_1,\ N_2$ to fuse into a third nucleus N_3 with the consequential release of energy ΔE given by the differences between the initial and final rest energies

$$N_1 + N_2 \ \rightarrow\ N_3 + \Delta E, \tag{1.1a}$$

$$\Delta E = E_3 - (E_1 + E_2). \tag{1.1b}$$

However, in view of said time reversal invariance, quantum mechanics also predicts a finite probability for the spontaneous occurrence of the time reversal decomposition of the third nucleus into the original two,

$$N_3 \ \rightarrow\ N_1 + N_2, \tag{1.2}$$

in gross violation of the principle of conservation of the energy, causality, and other basic laws.

Consequently, any posture that strictly reversible theories, such as quantum mechanics, quantum chemistry and special relativity are *exactly* valid for irreversible processes such as nuclear fusions, is ascientific, asocial and amoral because the selection of appropriate irreversible covering theories is indeed open to scientific debate, but not their need.

2. The main idea of the proposed controlled intermediate nuclear fusions.

In view of the above protracted insufficiencies at high and low energies, in this paper we propose, apparently for the first time, a new type of nuclear synthesis under the name of *Controlled Intermediate Nuclear Fusions* (CINF), or "Intermediate Fusion" (IF) for short.

Recall that atoms are normally protected by their electron clouds and that nuclei have to be systematically exposed out of such clouds in a controlled way for their fusion to occur. A main shortcoming of the "cold fusion" is that the available energy is insufficient to control atomic electron clouds to expose nuclei, in which case no fusion is evidently possible. For the case of the "hot fusion" we have the opposite occurrence in which atoms are completely stripped out of their electron clouds, but the energies are simply excessive thus preventing the possibility of a real control of the nuclear fusion, as well known in elementary scattering processes in which excessive collision energies prevent absorption. The name "intermediate" is here proposed to denote that the available energy is indeed intermediate between those of the "cold" and "hot" fusions for the specific intent of avoiding the shortcomings of both.

More particularly, the available energy for the proposed intermediate fusion is set to a value sufficient for the control of atomic clouds and other aspects in order to expose nuclei in and control their synthesis, as it is the case for a plasma created by an electric arc. Such a plasma is typically at about $10,000^o F$, thus having an energy that cannot be credibly qualified as belonging to either the "cold or the "hot" fusion. The energy is then carefully selected to have a threshold value for fusion so as to avoid the indicated impossibility for fusions under excessive collision energies. Priority is then given to the identification of the physical laws to be verified for all systematic, industrially viable fusions, and their engineering realizations.

It should be indicated that numerous plasmas have been used in the "cold fusion" research [1b,1c,1d]. Nevertheless, dramatic differences will soon emerge between the "intermediate fusion" proposed in this paper and existing plasma fusion research due to irreconcilable differences in the assumed basic disciplines.

Another objective of this paper is to propose specific reactors, called for technical reasons explained below *hadronic reactors* for the possible industrial utilization of the clean energy expected from "intermediate fusions." To achieve this task we shall: 1) Identify the basic disciplines that are applicable to all controlled fusions, whether "cold," "intermediate" or "hot"; 2) Identify the basic laws that have to be verified for any controlled fusion to occur; and 3) Propose with construction details that can be exposed at this writing a specific hadronic reactor based on the realization and optimization of said physical laws.

3. Insufficiencies of quantum mechanics, quantum chemistry and special relativity for all controlled fusions.

When the "cold fusion" was first announced in 1989 [1a], the author was conducting research in Cambridge, Massachusetts, and he vividly remembers the objection by authoritative voices such as that by Herman Feshback of MIT stating that *cold fusions are not predicted by quantum mechanics.*

Subsequently, the existence of "cold fusion" was submitted to very extensive tests [1d]. Yet, with the passing of time, said authoritative doubts have been ignored and the CF has been essentially studied up to this day via the use of quantum mechanics. In this paper we shall show that the lack of achievement by the "cold fusion" of industrial validity is primarily due to the dismissal of said authoritative voices on their incompatibility with quantum mechanics.

Let us recall the basic dynamical equations of quantum mechanics on a Hilbert space over the field of complex numbers, such as the familiar *Scrödinger equations*

$$i \times \frac{\partial}{\partial t}|\psi >= H(r,p)\times|\psi >, \tag{3.1a}$$

$$p_k \times |\psi> = -i \times \partial_k |\psi>, \quad H = \frac{p^2}{2 \times m} + V(r), \tag{3.1b}$$

and the equivalent *Heisenberg equations* for a (Hermitean) observable A, expressible in their finite and infinitesimal forms

$$U \times U^\dagger = U^\dagger \times U = I, \tag{3.2a}$$

$$A(t) = U(t) \times A(0) \times U^\dagger(t) = e^{H \times t \times i} \times A(0) \times e^{-i \times t \times H}, \tag{3.2b}$$

$$i \times \frac{dA}{dt} = [A, H] = A \times H - H \times A, \tag{3.2c}$$

with related *canonical commutation rules*

$$[r^i, p_j] = i \times \delta^i_j, \quad [r^i, r^j] = [p_i, p_j] = 0. \tag{3.3}$$

where $\hbar = 1$ and we have used the symbol $\times$ to denote the conventional associative product of quantum mechanics in order to distinguish it from other products needed later on.

Recall that limitations on the universal validity of quantum mechanics, quantum, chemistry and special relativity were fully known by the middle of the past century. As an example, this author became a theoretical physicist because of the doubts in the "lack of completion" of quantum mechanics expressed by Einstein, Podolsky and Rosen [2a], or Fermi's doubt "as to whether the usual concepts of geometry hold for such small region of space" (Ref. [2b], p. 111 when Fermi treats the structure of nuclei), and other authoritative doubts.

With the passing of the decades, debates on these authoritative doubts have been suppressed. However, increasingly cataclysmic environmental problems have rendered mandatory the search for new clean energies and fuels. In turn, said need forced the conduction in the last part of the 20-th century of systematic studies [3] on the *insufficiencies, limitations, or sheer inapplicability* of quantum mechanics, quantum chemistry and special relativity, that is, the identification of the conditions under which said disciplines are exactly valid, and the different conditions under which said disciplines are only approximately valid or inapplicable (rather than violated because not intended for the conditions considered).

The latter studies [3] (see also independent monographs [4] and comprehensive 90-pages long literature covering three decades of research in Ref. [3n]), have confirmed that quantum mechanics, quantum chemistry and special relativity can indeed be assumed to be *exactly valid* under the conditions of their original conception, construction and verification, namely, *for systems of point-like particles and electromagnetic waves propagating in vacuum (empty space).*

Typical examples of exact validity of quantum mechanics and special relativity are the structure of the hydrogen atom, particles moving in high energy accelerators, the structure of crystals and various other structures for which the indicated conditions of applicability are met.

However, studies [3,4] have identified precise conditions under which quantum mechanics and special relativity are *approximately valid or inapplicable,* among which we note (see [3o] for an extensive treatment):

1) In **particle physics,** there exist various cases in which the fit of experimental data requires the introduction of arbitrary parameters, as it is the case for the Bose-Einstein correlation that requires *four* arbitrary parameters. In reality, these parameters constitute a direct measure of the *deviations* of the Bose-Einstein correlation from the unadulterated axioms of quantum mechanics and special relativity (for detailed proofs, see monograph [3q]. As an example, the two point correlation function of the Bose-Einstein correlation requires off-diagonal terms that are incompatible with the quantum axiom of expectation values of operators that, to be observables, must be Hermitean, thus diagonal (see monographs [3i,3k] for details).

2) In **atomic physics,** quantum mechanics and special relativity have not permitted an exact representation of all spectral data of the helium, with embarrassing deviations from the experimental data of heavy atoms such as the zirconium, let alone the historical inability in about one century to understand the spectral emission of the Sun (see, again, refs. [3i,3k] for details).

3) In **nuclear physics,** quantum mechanics and special relativity have been unable to represent the experimental data of the simplest possible

nucleus, the deuteron, because of the inability to explain the spin 1 of its ground state (since quantum axioms require that the ground state of two particles with spin 1/2 should be 0, while the ground state of the deuteron has spin 1), the lack of an exact representation of the deuteron magnetic moment despite all possible relativistic corrections, the historical inability to understand the stability of the neutron in the deuteron, and other basic insufficiencies, with truly embarrassing deviations from experimental data of heavy nuclei [3i,3k,3q].

4) In **superconductivity,** quantum mechanics, quantum chemistry and special relativity have created a condition similar to that of atomic physics prior to the representation of the structure of atoms, since said disciplines cannot explain the bond of the two identical electrons in the Cooper pair (evidently because electrons repel each other according to quantum mechanics), thus resulting in a description of an *ensemble* of Cooper pairs without a true description of their structure [3l,3r].

5) In **chemistry,** quantum mechanics, quantum chemistry and special relativity have been unable to provide an exact representation of the binding energy of the simplest molecule, the hydrogen molecule (due to the historical 2% missing when using unadulterated quantum axioms), with larger deviations when passing to more complex molecules such as water (for which, e.g., electric and magnetic moments are predicted with the wrong sign, let alone large numerical deviations), not to forget the embarrassing prediction by quantum chemistry that all molecules are paramagnetic (a direct consequence of the independence of the electrons in valence bonds, thus permitting the polarization of their orbits under an external magnetic field). At the same time, adulterations of quantum axioms now vastly used to improve the approximation, such as the so-called "screenings of the Coulomb law," imply the abandonment of the very quantum of energy (because no longer admitted for potentials of the type $\frac{q_1 q_2}{r} e^{f(r)}$), while the same screenings can only be achieved via structural departures from quantum axioms (because the transition from the Coulomb to screened potentials requires *nonunitary transforms,* thus exiting from the classes of equivalence of quantum mechanics and, in any case, the notion of quantum of energy cannot be remotely conceived for screened Coulomb potentials) (see [3l,3r] for details).

6) In **biology,** any claims of exact validity of quantum mechanics, quantum chemistry and special relativity constitute scientific deceptions because, as experts are expected to know to qualify as such, quantum treatments imply that biological structures are perfectly rigid, perfectly reversible in time and perfectly eternal, as it is typically the case for crystals (see monograph [3j] for details).

7) In **engineering,** various equipment show sizable deviations from quantum mechanics, quantum chemistry and special relativity. As an illustration important for the reactors to be proposed in this note, the use of Maxwell's equations and quantum chemistry for underwater electric arcs between graphite electrodes is afflicted by a *ten fold error in excess* in the prediction of the produced carbon monoxide, a *ten-fold error in defect* in the production of carbon dioxide in the combustion exhaust, a *fourteen-fold error in defect* in the amount of oxygen present in the combustion exhaust, and other deviations simply too big to be accommodated via the usual *ad hoc* parameters or other manipulations to adapt reality to preferred theories.

All the above limitations exist for *matter.* Additional large insufficiencies exist for *antimatter* as presented in details in monograph [3n], such as the inability by Einsteinian theories to provide a consistent *classical* treatment of antiparticles because, after quantization, one obtains a "particle," rather than a charge conjugated "antiparticle" with the wrong sign of the charge, the impossibility for Einsteinian theories to provide a distinction between classical neutral bodies made up of matter and antimatter, and other serious problems. These insufficiencies are ignored hereon because we shall evidently deal with nuclei made up of *matter.* Nevertheless, the insufficiencies for antimatter establish, alone, the nonscientific nature of any claim of terminal character of quantum mechanics, quantum chemistry and special relativity.

Independently from these studies, a mere confrontation of reality with the basic axioms of quantum mechanics, quantum chemistry and special relativity is sufficient to establish their limits of exact applicability.

As an example, a confrontation of the pillar of special relativity, the Poincaré symmetry, and the structure of hadrons, nuclei, molecules and stars is sufficient to see the *impossibility* for special relativity to be exactly valid for the structures considered.

A necessary condition for the validity of the Poincaré symmetry, well known to experts to qualify as such, is to have a *Keplerian structure* as occurring in the atomic and planetary structures, while *hadrons, nuclei, molecules, stars and other systems do not have a Keplerian structure because, e.g., nuclei do not have nuclei.* The modification of the Poincaré symmetry to account for the absence of Keplerian nuclei, no matter how small, causes its evident breaking, with consequential *impossibility* beyond scientific doubt for special relativity to be exactly valid for the structures considered (collectively called *interior dynamical systems*, while atomic and planetary systems are examples of *exterior dynamical systems* [3a,3b]).

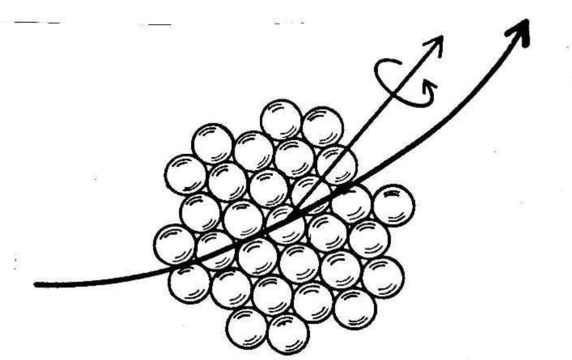

Figure 1: *A view presented by the author various times in his works to show the impossibility for the Poincaré symmetry to be exactly valid for the nuclear structure, since said symmetry is only valid for Keplerian systems with a nucleus, while nuclei do not admit nuclei, thus requiring a breaking of the Poincaré symmetry. The impossibility for special relativity and quantum mechanics to be exact for the nuclear structure then follows.*

Similarly, an inspection of the basic dynamical equations of quantum mechanics and quantum chemistry is sufficient to see their *impossibility* to be exactly valid in *interior dynamical systems,* such as the interior of hadrons, nuclei and stars.

Inspection of the above equations confirms their exact validity for systems of point-like particles moving in vacuum, but also identifies the impossibility to represent, e.g., the hyperdense fireball of the Bose-Einstein correlation, or the deep overlapping of electrons in valence bonds or chemical reactions at large due to the strictly linear, local, potential and reversible character of the equations, while said fireball or chemical reactions are expected to be dominated by nonlinear, nonlocal, nonpotential and irreversible effects.

Alternatively and equivalently, the impossibility for equations (3.1)-(3.3) to be exactly valid for conditions 1)-7) above can be derived from their basic Euclidean topology, since the latter solely admit the treatment of a finite set of isolated points.

Consequently, any claim of exact validity of Eqs. (3.1)-(3.3) for the Bose-Einstein correlation, chemical reactions and other processes is nonscientific, since the only scientifically debatable issue is the identification of the applicable *generalization* of quantum mechanics and special relativity.

When passing to the study of controlled nuclear fusions, the *impossibility* of quantum mechanics, quantum chemistry and special relativity to be exactly valid becomes dramatic (see [3k] for details). Besides limitations 1)-7), we here restrict ourself to the indication that *quantum mechanics, quantum chemistry and special relativity are strictly invariant under time reversal, trivially, because all known potentials are reversible in time. Consequently, said disciplines can only predict the synthesis of nuclei in a form that is time reversal invariant, that is, by equally admitting as causal their disintegration. This feature alone, let alone numerous other technical inconsistencies [3i,3k], is sufficient to establish that quantum mechanics, quantum chemistry and special relativity are not suited for quantitative treatments of any controlled nuclear fusion, whether cold, intermediate or hot.*

In closing this section it should be indicated that the use of the word "violation" of quantum mechanics, quantum chemistry and special relativity would not be scientifically appropriate because said disciplines were not conceived and constructed for the conditions considered (e.g., antimatter had yet to be discovered when Einstein formulated special and general relativities). This illustrates the reason for the use of the word "inapplicable."

4. Incompatibilities of quark and neutrino conjectures with nuclear fusions.

It should be indicated for completeness that, contrary to ongoing theoretical theologies, the insufficiencies of quantum mechanics, quantum chemistry and special relativity are *multiplied,* rather than resolved or even decreased, under the assumption that the hypothetical quarks are physical constituents of hadrons existing in our spacetime. Said problematic aspects are even multiplied by the assumption that neutrinos are *emitted* as physical particles at the time of the neutron synthesis (for comprehensive studies, see monograph [3n] or recent paper [7k]).

To begin, quarks cannot be technically defined in our spacetime, since they can be solely defined, on serious technical grounds outside theologies, as a purely mathematical representation of a purely mathematical internal symmetry defined on a purely mathematical complex-valued space. As a consequence, we have their theological assumption as being physical particles, although without any serious foundations. On the contrary, quarks are afflicted by the impossibility of experiencing gravity (since the latter can notoriously be solely defined in our spacetime as stated by Einstein himself). Hence, to separate serious science from academic theologies, quark believers should levitate in space in the event their nuclei had been made up of the hypothetical quarks.

Even assuming that quarks exist as physical particular, we have very serious insufficiencies. For instance, the reduction of the deuteron to quarks *increases* the deviations in representing the magnetic moment, trivially, because the hypothetical orbits of the hypothetical quarks are too small to yield polarizations sufficient to fit experimental data, while the problem of the spin of the deuteron is equally multiplied, trivially, because of difficulties for quark conjectures to represent the spin of individual protons and neutrons, let alone their bond, not to mention lack of achievement of a true confinement that bypasses the prediction from Heisenberg's uncertainty principle of a finite probability that quarks are free, in dramatic disagreement with available experimental evidence.

Any study of controlled nuclear fusions via quark conjecture is dismissed in this paper as purely nonscientific because of the indicated impossibility for a serious definition of gravity for nuclei made up of quarks and other irreconcilable inconsistencies.

In this paper, we shall assume that:*the SU(3)-color symmetry provides the final Mendeleev-type classification of hadrons into families; quarks are indeed necessary for the elaboration of SU(3)-color symmetries in the only way they can be technically defined, as mathematical representations of a mathematical internal symmetry defined on a mathematical complex-valued unitary space without any possible quantitative representation in our spacetime as needed for physical particles; and the physical constituents of hadrons are basically unknown at this writing. Hence, the author dismisses any study of any nuclear fusions based on quark conjectures.*

By recalling that the historical contributions to civilization produced by molecules, atoms and nuclei were based on the capability *to extract the constituents free,* the assumption of the hypothetical quark as physical particles permanently bound inside hadrons is considered nowadays one of the biggest obstructions against new clean energies so much needed by mankind [3k,3m].

The hypothesis on the existence of the neutrino as a physical particle in our spacetime is perhaps more controversial than that of quarks due to the impossibility of quantitative treatment of the historical synthesis of neutrons from protons and electrons as occurring in stars (see Ref.]7k,9ℓ] for details)

$$p^+ + e^- \ \rightarrow \ n + \nu, \tag{4.1}$$

In fact, the neutron is 0.782 MeV *heavier* than the sum of the rest energies of the proton and the electron, thus eliminating any possibility of a quantitative representation of the *emission* of the neutrino in said synthesis. In addition, reaction (4.1) requires a *positive binding energy* under which Schrödinger's equations (3.1) become physically inconsistent (all consistent quantum bound states, such as nuclei, atoms and molecules, must have a *negative binding energy* under which we have the known "mass defect", rather than the "mass excess" occurring in the neutron synthesis). Additionally, there is no credible explanation of the "missing energy" if assumed to originate from the kinetic energy of the proton and electron since their scattering cross section is essentially null at about 1 MeV.

In order to achieve a scientific, that is, quantitative representation of the synthesis of the neutron beyond the level of academic theologies, there is the need for the *absorption,* rather than the emission of a particle carrying the missing energy, spin and other quantities. However, the conjugate expression

$$p^+ + \bar{\nu} + e^- \;\rightarrow\; n, \tag{4.2}$$

leads to irreconcilable catastrophic inconsistencies, such as: antineutrinos have a practically null cross sections with protons and electrons, thus preventing any possible synthesis; antineutrinos have recently emerged to have *negative energy referred to a negative unit in a new dual spacetime* [3m], rather than the needed positive energy in our spacetime; and other inconsistencies.

Following studies of the problem for three decades, the author can safely state that a necessary condition to achieve a quantitative representation of the synthesis of the neutron is the abandonment of quantum mechanics in favor of a nonunitary covering, since only a nonunitary map of dynamical equations (3.1)-(3.3) will admit "positive" binding energies. In turn, as shown below, hadronic mechanics is the sole nonunitary covering of quantum mechanics that is invariant over time and universal.

A comprehensive review of the numerically exact and time invariant representation of all characteristics of the neutrons from protons and electrons as permitted by hadronic mechanics has been recently provided by J. V. Kadeisvili [9k]. The laboratory synthesis of the neutron from protons and electron has been recently confirmed by Santilli [9j] following original tests by Don Borghi. These studies are at the foundation of the proposed intermediates nuclear fusion.

To initiate scientific (that is quantitative and numerical) studies toward the solution of the above problems, Santilli [7k] submitted the hypothesis that the quantities missing for the synthesis of the neutron (rest energy, spin, etc.) are provided by the synthesis environment according to the reaction

$$p^+ + a + e^- \;\rightarrow\; n, \tag{4.3}$$

where "a" *is not* a particle, but a mechanism for the transfer of said missing quantities called *aetherino* (or etherino). Since stars at their initiation synthesize an enormous number of neutrons (estimated to be of the order of 10^{50} n/s), the idea that the missing energy for the synthesis of the neutron is provided by the interior of stars, would prohibit any star from ever producing light (since it would require the use of 10^{50} MeV/s).

In view of these difficulties of solutions along old orthodox lines, Santilli [7k] submitted the hypothesis that the missing energy is provided by the ether conceived as a universal substratum with very high energy density, thus providing support to the old hypothesis of continuous creation of matter in the universe.

As we shall see in Section 9, a quantitative study of the synthesis of the neutron has truly fundamental relevance for all nuclear fusions. As a matter of fact, following decades of studies in the field, the author can safely claim that the lack of resolution of the synthesis of the neutron prevents any serious study of any nuclear fusion.

We can then state that: *the synthesis of the neutron is the first and most fundamental nuclear synthesis in nature; no serious quantitative study on nuclear fusions can be done without a quantitative representation on the synthesis of the neutron; no nuclear fusions can be conceived as being feasible unless the setting also permits the synthesis of the neutron; and all quantum mechanical studies of nuclear fusions based on reactions (4.1), (4.2), are hereon dismissed in view of their irreconcilable and catastrophic inconsistencies.*

At any rate, *how can any scientist claim that quantum mechanics is the correct discipline for the study of nuclear synthesis when it is catastrophically inapplicable to the most fundamental synthesis, that of the neutron?*

It is hoped the reader in good faith begins to understand in this way our denunciation of unethical conduct for any blind use of quantum mechanics for nuclear syntheses without a serious scrutiny on the applicability of the assumed discipline.

5. Hadronic mechanics.

Studies [3,4] have established that the basic insufficiency responsible for *all* limitations 1)-7) of the preceding section is the impossibility to represent interactions originating from deep mutual penetration and overlapping of the wavepackets and/or charge distributions of particles as illustrated in

Figure 2. We are here referring to *interactions of contact type (thus of zero-range) that are nonlinear (in the wavefunctions), nonlocal-integral (because occurring in a finite volume), and nonpotential, thus not representable with a Hamiltonian.*

This limitation is evidently due to the fact that quantum mechanics, quantum chemistry and special relativity are strictly linear, local-differential and potential theories. Consequently, the interactions depicted in Figure 1 are beyond any hope of representation.

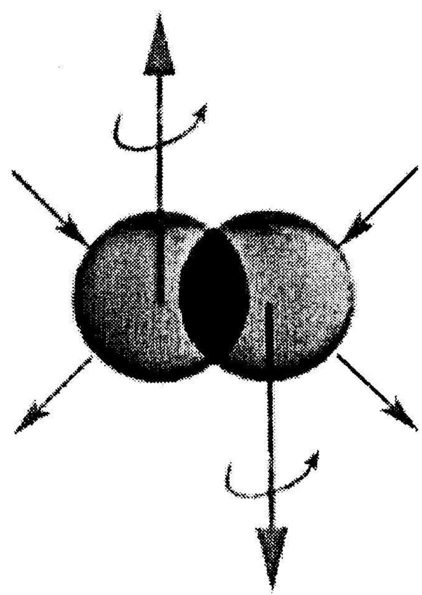

Figure 2: *A schematic view of the interactions at the foundation of hadronic mechanics, chemistry and isorelativity, those caused by deep wave-overlappings of the charge distribution as well as of the wavepackets of particles. A main purpose of this paper is to show that these interactions are crucial for industrial realizations of controlled fusions of any type.*

A typical illustration is that of valence bonds that are abstracted by quantum chemistry into two point-particles interacting at a distance. It is, of course, true that electrons have a *point-like charge.* However, the idea that electrons have a "point-like wavepacket" is outside the boundary of serious science. When this physical reality is admitted, valence bonds result to be due not only to electromagnetic interactions but also to contact nonlocal-integral and nonpotential interactions due to the mutual penetration of the wavepackets as depicted in Figure 2.

The lack of representation of deep wave-overlappings has been proved to be responsible for the lack of representation of 2% of experimental data in molecular binding energies [3l,9a,9b], the departures from spectral data in the helium (where, contrary to popular belief, the two electrons are partially in conditions of mutual overlap as in Figure 1) [3k], and other insufficiencies.

When at the Department of Mathematics of Harvard University in the late 1970s, R. M. Santilli initiated comprehensive research toward a solution of the insufficiencies of conventional doctrines outlined in Section 1.

The central problem was *to identify a broadening-generalization of quantum mechanics, quantum chemistry and special relativity in such a way to represent linear, local and potential interactions, as well as additional, contact, nonlinear, nonlocal-integral and nonpotential interactions.*

Since the Hamiltonian can only represent conventional interactions, the above condition requested the identification of a *new quantity* capable of representing interactions that, by conception, are outside the capability of a Hamiltonian. Another necessary condition was the exiting from the class of equivalence of quantum mechanics, as a consequence of which the broader theory had to be *nonunitary,* namely, its time evolution has to violate the unitarity condition (3.2a). The third and most insidious condition was the *invariance,* namely, the broader theories had to represent the new nonpotential interactions in a way as invariant as that of conventional interactions, so as to predict the same numerical values under the same conditions at different times. We assume that experts are aware of the *theorems of catastrophic inconsistencies of noncanonical and nonunitary theories* [5j], which theorems mandate the achievement of invariance for any theory to have physical value.

It was evident that a solution verifying the above conditions required *new mathematics, e.g. new numbers, new spaces, new geometries, new symmetries, etc.* A detailed search in advanced mathematics libraries of the Cantabridgean area revealed that the needed new mathematics simply did not exist.

Following additional (unpublished) trials and errors, Santilli [5a,5b] proposed in 1978 the solution consisting in the representation of said contact, nonlinear, nonlocal and nonpotential interactions via a *generalization (called lifting) of the basic unit* $+1$ of conventional theories into a function, a matrix or an operator $\hat{I}$ that is positive-definite like $+1$, but otherwise has an arbitrary functional dependence on all needed quantities, such as time t, coordinates r, momenta p, energy E, density μ, frequency ω, wavefunctions ψ, their derivatives $\partial\psi$, etc.

$$+1 \quad \rightarrow \quad \hat{I}(t, r, p, E, \mu, \omega, \psi, \partial\psi, ...) = 1/\hat{T} > 0, \tag{5.1}$$

while jointly lifting the conventional associative product $\times$ between two generic quantities A, B (numbers, vector fields, matrices, operators, etc.) into the form admitting $\hat{I}$, and *no longer* $+1$, as the correct left and right unit

$$A \times B \quad \rightarrow \quad A \hat{\times} B = A \times \hat{T} \times B, \tag{5.2a}$$

$$1 \times A = A \times 1 = A \quad \rightarrow \quad \hat{I} \hat{\times} A = A \hat{\times} \hat{I} = A, \tag{5.2b}$$

for all elements A, B of the set considered.

The selection of the basic unit resulted to be unique for the verification of the above three conditions. As an illustration, whether generalized or not, the unit is the basic invariant of any theory. The representation of non-Hamiltonian interactions with the basic unit permitted the crucial by-passing of the theorems of catastrophic inconsistencies of nonunitary theories [5j] (skeptic readers are encouraged to try alternative solutions).

Since the unit is the ultimate pillar of all mathematical, physical and chemical formulations, liftings (5.2a) and (5.2b) requested a corresponding, compatible lifting of the *totality* of the mathematical, physical and chemical formulations used by conventional theories, resulting indeed into new numbers, new fields, new spaces, new algebras, new geometries, new symmetries, etc, [3,4]. This explains the dimension and time requested by the research. Following the original proposal of 1978 to build hadronic mechanics [5a,5b], mathematical maturity in the formulation of the new numbers was reached in memoir [5c] of 1993 and general mathematical maturity was reached in memoir [5d] of 1996. Physical maturity was then quickly achieved in papers [5e,5f,5g].

In honor of Einstein's vision on the lack of completion of quantum mechanics, Santilli submitted in the original proposal [5a,5b] the name of *isotopies* for the above liftings, a word used in the Greek meaning of "preserving the original axioms." In fact, $\hat{I}$ preserves all topological properties of $+1$, $A\hat{\times}B$ is as associative as the conventional product $A \times B$ and the preservation of the original axioms holds at all subsequent levels to such an extent that, in the event any original axiom is not preserved under isotopies, the lifting is incorrect. Nowadays, the resulting new mathematics is known as *Santilli isomathematics* [4], $\hat{I}$ is called *Santilli's isounit*, $A\hat{\times}B$ is called the *isoproduct,* etc.

The fundamental dynamical equations of hadronic Mechanics were submitted by Santilli in the original proposal [5a], are today called *Heisenberg-Santilli isoequations,* and can be written in the finite form

$$\hat{U}\hat{\times}\hat{U}^{\dagger} = \hat{U}\hat{\times}\hat{U} = \hat{I} \neq 1, \tag{5.3a}$$

$$\begin{aligned} \hat{A}(\hat{t}) &= \hat{U}(\hat{t})\hat{\times}\hat{A}(\hat{0})\hat{\times}\hat{U}^{\dagger}(\hat{t}) = (\hat{e}^{\hat{H}\hat{\times}\hat{t}\hat{\times}\hat{i}})\hat{\times}\hat{A}(\hat{0})\hat{\times}(\hat{e}^{-\hat{i}\hat{\times}\hat{t}\hat{\times}\hat{H}}) = \\ &= [(e^{H\times\hat{T}\times t\times i}) \times \hat{I}] \times \hat{T} \times A(0) \times \hat{T} \times [\hat{I} \times (e^{-i\times t\times\hat{T}\times H})] = \\ &= (e^{H\times\hat{T}\times t\times i}) \times \hat{A}(\hat{0}) \times (e^{-i\times t\times\hat{T}\times H}), \end{aligned} \tag{5.3b}$$

and infinitesimal form [5a,5g]

$$\hat{i}\hat{\times}\frac{\hat{d}\hat{A}}{\hat{d}\hat{t}} = i \times \hat{I}_t \times \frac{d\hat{A}}{d\hat{t}} = [\hat{A}\hat{,}\hat{H}] = \hat{A}\hat{\times}\hat{H}\hat{-}\hat{H}\hat{\times}\hat{A} =$$

$$= \hat{A} \times \hat{T}(\hat{t}, \hat{r}, \hat{p}, E, \hat{\psi}, \hat{\partial}\hat{\psi}, ...) \times \hat{H} - \hat{H} \times \hat{T}(\hat{t}, \hat{r}, \hat{p}, E, \hat{\psi}, \hat{\partial}\hat{\psi}, ...) \times \hat{A}, \tag{5.4}$$

where: Eq. (5.3a) represent the crucial *isounitary property,* namely, the reconstruction of unitarity on *iso-Hilbert spaces* over isofields with inner product $< \hat{\psi}|\hat{\times}|\hat{\psi} >$; all quantities have a "hat" to denote their formulation on isospaces over isofields with isocomplex numbers $\hat{c} = c \times \hat{I}$, $c \in C$; and one should note the *isodifferential calculus* with expressions of the type $\hat{d}/\hat{d}\hat{t} = \hat{I}_t \times d/d\hat{t}$ first achieved in memoir [5d] (see below).

The equivalent lifting of Schrödinger's equation was suggested by Santilli [5a,6a], Myung and Santilli [6b] and by Mignani [6c], all original proposals being formulated on conventional spaces over conventional fields. The isoequation was reformulated via the isodifferential calculus by Santilli [5d], it is today called the *Schrödinger-Santilli isoequation,* and can be written

$$\hat{i}\hat{\times}\frac{\hat{\partial}}{\hat{\partial}\hat{t}}|\hat{\psi}>= i\times\hat{I}_t\times\frac{\partial}{\partial\hat{t}}|\hat{\psi}>=\hat{H}\hat{\times}|\hat{\psi}>=$$

$$=\hat{H}(\hat{t},\hat{r},\hat{p})\times\hat{T}(\hat{r},\hat{p},\hat{\psi},\hat{\partial}\hat{\psi},....)\times|\hat{\psi}>=\hat{E}\hat{\times}|\hat{\psi}>=E\times|\hat{\psi}>, \tag{5.5}$$

with *isoexpectation values*

$$<\hat{A}>=\frac{<\hat{\psi}|\hat{\times}\hat{A}\hat{\times}|\hat{\psi}>}{<\hat{\psi}|\hat{\times}|\hat{\psi}>} \tag{5.6}$$

and basic properties

$$\frac{<\hat{\psi}|\hat{\times}\hat{I}\hat{\times}|\hat{\psi}>}{<\hat{\psi}|\hat{\times}|\hat{\psi}>}=\hat{I},\quad \hat{I}\hat{\times}|\hat{\psi}>=|\hat{\psi}>, \tag{5.7a}$$

$$\hat{I}^{\hat{n}}=\hat{I}\hat{\times}\hat{I}\hat{\times}...\hat{I}\equiv\hat{I},\quad \hat{I}^{\hat{1/2}}=\hat{I}, \tag{5.7b}$$

confirming that $\hat{I}$ is indeed the isounit of hadronic mechanics (where the isoquotient $\hat{/}=/\times\hat{I}$ has been tacitly used [5d]).

By the mid 1990's, despite the isotopic lifting of all possible quantities and operations, hadronic mechanics had not yet reached an invariant formulation. In particular, hadronic mechanics still missed a consistent representation of the isotopic momentum, thus preventing systematic verifications and applications.

After extensive additional studies, the problem resulted to rest where nobody would expect it, in the ordinary differential calculus. It was popularly believed for centuries in mathematics that the differential calculus is independent from the unit of the underlying field. Such a belief is, of course, correct, for *constant units.* However, isomathematics uses isounits with an arbitrary functional dependence that does require the lifting into the *isodifferential calculus.* The latter permitted the first invariant formulation of the *isomomentum* [4d]

$$\hat{p}_k\hat{\times}|\hat{\psi}>=-\hat{i}\hat{\times}\hat{\partial}_k|\hat{\psi}>=-i\times\hat{I}^i_k\times\partial_i|\hat{\psi}>, \tag{5.8}$$

with *isocanonical commutation rules*

$$[\hat{r}^i \hat{,} \hat{p}_j] = \hat{i} \hat{\times} \hat{\delta}^i_j = i \times \delta^i_j \times \hat{I}, [\hat{r}^i, \hat{r}^j] = [\hat{p}_i, \hat{p}_j] = 0. \tag{5.9}$$

A few comments are now in order. Note the identity of Hermiticity and its isotopic image, $(< \hat{\psi}|\hat{\times}\hat{H}^{\hat{\dagger}})\hat{\times}|\hat{\psi} >\equiv< \hat{\psi}|\hat{\times}(\hat{H}\hat{\times}|\hat{\psi} >), \hat{H}^{\hat{\dagger}} \equiv \hat{H}^{\dagger}$, thus implying that all quantities that are observable for quantum mechanics remain observable for hadronic mechanics; the new mechanics is indeed isounitary, thus avoiding the theorems of catastrophic inconsistencies of nonunitary theories; hadronic mechanics preserves all conventional quantum laws, such as Heisenberg's uncertainty principle, Pauli's exclusion principle, etc.; hadronic mechanics has been proved to be "directly universal" for all possible theories with conserved energy, that is, capable of representing all infinitely possible systems of the class admitted (universality) directly in the frame of the observer without transformations (direct universality); and numerous other features one can study in Refs. [3i,3k,3l].

Note that the *representation of closed-isolated irreversible systems under the conservation of the total energy* can be easily achieved via an explicit time dependence of the isotopic element,

$$\hat{T}(t, ...) \neq T(-t, ...), \tag{5.10a}$$

$$i \times \hat{d}\hat{H}/\hat{d}\hat{t} = [\hat{H} \hat{,} \hat{H}] \equiv 0. \tag{5.10b}$$

However, nuclear syntheses are open irreversible processes, thus requiring the *irreversible branch of hadronic mechanics,* also called *Santilli genomechanics* [3p,9ℓ]. Regrettably, we cannot possibly review this irreversible covering of quantum mechanics to avoid a prohibitive length, and have to restrict ourselves to a review of the simpler isotopic branch. For our needs in this paper it is sufficient to note that the transition from the isotopic to the genotopic mechanics is achieved via the transition from the Hermitean isounit $\hat{I} = \hat{I}^{\dagger}$ to a non-Hermitean form, thus having two generalized units, one $I^{>}$ used to represent motion forward in time and the other $^{<}I$ used to represent motion backward in time with inter-relationship $I^{>} = (^{<}I)^{\dagger}$. The underlying new mathematics, called *Santilli genomathematics,* assures an invariant representation of irreversibility while prohibiting acausal time reversal images [9ℓ].

Also, one should note that *hadronic mechanics verifies the abstract axioms of quantum mechanics to such an extent that the two mechanics coincide at the abstract, realization-free level.* In reality, hadronic mechanics provides an explicit and concrete realization of the theory of "hidden variables" λ [2c], as one can see from the abstract identity of the isoeigenvalue equation $H\hat{\times}|\hat{\psi}>=\hat{E}\hat{\times}|\hat{\psi}>$ and the conventional equation $H\times|\psi>=E\times|\psi>$, by providing in this way an *operator* realization of hidden variables $\lambda=\hat{T}$ (for detailed studies on these aspects, including the *inapplicability* of Bell's inequality [2d] for hadronic mechanics due to its nonunitary structure, we refer the reader to memoir [7h]).

We should also indicate that the birth of hadronic mechanics can be seen in the following *new isosymmetry,* here expressed for a constant K for simplicity,

$$<\psi|\times|\psi>\times 1\equiv<\psi|\times K^{-1}\times|\psi>\times(K\times 1)=<\psi|\hat{\times}|\psi>\times\hat{I}. \quad (5.11)$$

The reader should not be surprised that the above isosymmetry remained unknown throughout the 20-th century, because its identification required the prior discovery of *new numbers,* Santilli's isonumbers with arbitrary units [5c].

Compatibility between hadronic and quantum mechanics is reached via the condition

$$Lim_{r>>10^{-13cm}} \quad \hat{I}\equiv 1, \quad (5.12)$$

under which hadronic mechanics recovers quantum mechanics uniquely and identically at all levels.

The name of "hadronic mechanics" was suggested [5a] to represent strong interactions as well as all possible short range interactions. The new mechanics was then constructed in such a way to coincide everywhere with quantum mechanics except inside the so-called *hadronic horizon,* namely, a sphere of radius $1F=10^{-13}cm$.

A simple method has been identified in Refs. [5f,5g] for the construction of hadronic mechanics and all its underlying new mathematics. This method is important for controlled nuclear fusions because it permit the implementation of existing conventional models into covering isomodels, thus permitting the addition of contact nonpotential interactions that will soon acquire a crucial role for controlled nuclear fusions. The method consists in:

(i) Representing all conventional interactions with a Hamiltonian H and all non-Hamiltonian interactions and effects with the isounit $\hat{I}$;

(ii) Identifying the latter interactions with a nonunitary transform

$$U \times U^{\dagger} = \hat{I} \neq I \tag{5.13}$$

and

(iii) Subjecting the *totality* of conventional mathematical, physical and chemical quantities and all their operations to the above nonunitary transform, resulting in expressions of the type

$$I \rightarrow \hat{I} = U \times I \times U^{\dagger} = 1/\hat{T}, \tag{5.14a}$$

$$a \rightarrow \hat{a} = U \times a \times U^{\dagger} = a \times \hat{I}, \tag{5.14b}$$

$$a \times b \rightarrow U \times (a \times b) \times U^{\dagger} =$$
$$= (U \times a \times U^{\dagger}) \times (U \times U^{\dagger})^{-1} \times (U \times b \times U^{\dagger}) = \hat{a} \hat{\times} \hat{b}, \tag{5.14c}$$

$$e^{A} \rightarrow U \times e^{A} \times U^{\dagger} = \hat{I} \times e^{\hat{T} \times \hat{A}} = (e^{\hat{A} \times \hat{T}}) \times \hat{I}, \tag{5.14d}$$

$$[X_i, X_j] \rightarrow U \times [X_i X_j] \times U^{\dagger} =$$
$$= [\hat{X}_i \hat{,} \hat{X}_j] = U \times (C_{ij}^{k} \times X_k) \times U^{\dagger} = \hat{C}_{ij}^{k} \hat{\times} \hat{X}_k =$$
$$= C_{ij}^{k} \times \hat{X}_k, \tag{5.14e}$$

$$< \psi | \times | \psi > \rightarrow U \times < \psi | \times | \psi > \times U^{\dagger} =$$
$$= < \psi | \times U^{\dagger} \times (U \times U^{\dagger})^{-1} \times U \times | \psi > \times (U \times U^{\dagger}) =$$
$$= < \hat{\psi} | \hat{\times} | \hat{\psi} > \times \hat{I}, \tag{5.14f}$$

$$H \times | \psi > \rightarrow U \times (H \times | \psi >) = (U \times H \times U^{\dagger}) \times (U \times U^{\dagger})^{-1} \times (U \times | \psi >) =$$
$$= \hat{H} \hat{\times} | \hat{\psi} >, etc. \tag{5.14g}$$

Note that the above simple rules permit the explicit construction of the new isoeigenvalues equations and related iso-Hilbert space over isonumbers, as well as of all needed aspects, including isoalgebras, isosymmetries and their isorepresentations [3].

Note also that *catastrophic inconsistencies emerge in the event even one single quantity or operation is not subjected to isotopies.* In the absence of comprehensive liftings, we would have a situation equivalent to the elaboration of quantum spectral data of the hydrogen atom with isomathematics, resulting of dramatic deviations from reality.

It is easy to see that the application of an additional nonunitary transform $W \times W^\dagger \neq I$ to expressions (5.14) causes the *lack of invariance,* with consequential activation of the catastrophic inconsistencies of theorems [5j]. However, any given nonunitary transform can be identically rewritten in the isounitary form,

$$W \times W^\dagger = \hat{I}, \quad W = \hat{W} \times \hat{T}^{1/2}, \tag{5.15a}$$

$$W \times W^\dagger = \hat{W} \hat{\times} \hat{W}^\dagger = \hat{W}^\dagger \hat{\times} \hat{W} = \hat{I}, \tag{2.15b}$$

under which we have the invariance of the isounit and isoproduct

$$\hat{I} \rightarrow \hat{I}' = \hat{W} \hat{\times} \hat{I} \hat{\times} \hat{W}^\dagger = \hat{I}, \tag{5.16a}$$

$$\begin{gathered} \hat{A} \hat{\times} \hat{B} \rightarrow \hat{W} \hat{\times} (\hat{A} \hat{\times} \hat{B}) \hat{\times} \hat{W}^\dagger = \\ = (\hat{W} \times \hat{T} \times \hat{A} \times \hat{T} \times \hat{W}^\dagger) \times (\hat{T} \times \hat{W}^\dagger)^{-1} \times \hat{T} \times (\hat{W} \times \\ \times \hat{T})^{-1} \times (\hat{W} \times \hat{T} \times \hat{B} \times \hat{T} \times \hat{W}^\dagger) = \\ = \hat{A}' \times (\hat{W}^\dagger \times \hat{T} \times \hat{W})^{-1} \times \hat{B}' = \hat{A}' \times \hat{T} \times \hat{B}' = \hat{A}' \hat{\times} \hat{B}', \ etc. \end{gathered} \tag{5.16b}$$

from which the invariance of the entire hadronic mechanics follows.

Note that the invariance is ensured by the *numerically invariant values of the isounit and of the isotopic element under nonunitary-isounitary transforms,*

$$\hat{I} \rightarrow \hat{I}' \equiv \hat{I}, \tag{5.17a}$$

$$A \hat{\times} B \rightarrow A' \hat{\times}' b' \equiv A' \hat{\times} B', \tag{5.17b}$$

in a way fully equivalent to the invariance of quantum mechanics, as expected to be necessarily the case due to the preservation of the abstract axioms under isotopies. The resolution of the catastrophic inconsistencies for noninvariant theories is then consequential.

One, among several realizations of Santilli's isounit for the representation of non-Hamiltonian interactions between two extended particles in conditions of mutual penetration as in Figure 1, can be written

$$\hat{I} = Diag.(n_{11}^2, n_{12}^2, n_{13}^2, n_{14}^2) \times Diag.(n_{21}^2, n_{22}^2, n_{23}^2, n_{24}^2) \times$$
$$\times e^{N \times (\hat{\psi}/\psi) \times \int d^3 r \times \psi_{\downarrow}^{\dagger}(r) \times \psi_{\uparrow}(r)} \tag{5.18}$$

where $n_{ak}^2, a = 1, 2, k = 1, 2, 3$ are the semiaxes of the ellipsoids characterizing the two particles, $n_{a4}, a = 1, 2$ represents their density, $\hat{\psi}$ represents the isowavefunctions, ψ represents the conventional function, and N is a positive constant.

Hadronic mechanics has nowadays clear experimental verifications in particle physics, nuclear physics, superconductivity, chemistry, astrophysics, cosmology and biology (see monographs [3n-3r] for details), which verifications cannot possibly be reviewed here.

6. Hadronic chemistry.

Any in depth research on nuclear synthesis requires an in depth appraisal of chemistry due to the inevitable use of chemical substances in engineering realizations, besides the need for unity of thought. Along these lines, it is easy to see that quantum chemistry is basically inapplicable to energy releasing processes because it is based on the reversible axioms of quantum mechanics, while energy releasing processes are structurally irreversible as stressed in Section 1. As an illustration, quantum chemistry does predict the familiar reaction on the synthesis of the water molecule

$$H_2 + O \ \rightarrow \ H_2O + 57 \ Kcal/mole, \tag{6.1}$$

but, from its time reversal invariance, the same theory equally predicts the *spontaneous* disintegration of the water molecule into its original constituents

$$H_2O \ \rightarrow \ H_2 + O, \tag{6.2}$$

in gross violation of basic laws. The above feature establishes the need for the *irreversible branch of hadronic chemistry,* that we cannot possibly review here (see monograph [3r] and memoir [7ℓ]).

Even for the case of structures that are reversible and closed (isolated from the universe) such as the study of the water molecule H_2O, quantum chemistry has a number of basic insufficiencies, such as the inability to represent binding energies from unadulterated first principles as indicated in Section 3, the loss of the notion of quantum of energy for the "screened Coulomb potentials", and other problems.

Above all, the fundamental notion of quantum chemistry, that of *valence,* is a pure nomenclature without quantitative content. In fact, to be quantitative, the notion of valence should: 1) Identify explicitly the *force* between electron pairs; 2) Prove that it is *attractive;* and 3) Establish that such an explicit attractive force represents correctly experimental data. Of course, none of these features are remotely possible for the conventional notion of valence. In any case, *identical electrons must repel each other according to quantum mechanics and chemistry, and definitely cannot experience a bond.*

The latter insufficiencies are the foundation of the *reversible, isotopic, branch of hadronic chemistry* [3ℓ,3r]. In essence, the use of the isounit (5.18) permitted R. M. Santilli and D. Shillady [9a,9b] to:

A) Identify a new force between deep mutual penetration of valence electron pairs that is entirely of contact non-potential character, thus outside any dream of identification via the purely Hamiltonian quantum chemistry;

B) Prove that such a force is indeed attractive when (and only when) the electron pairs are coupled in singlet; and

C) Achieve the first exact and invariant representation on scientific records of all characteristics of the hydrogen, water and other molecules, said representation being achieved directly from first axiomatic principles without any *ad hoc* parameters, or screening adulterations of the Coulomb law. At any rate, due to its nonunitary structure, hadronic chemistry contains as a particular cases all infinitely possible screenings of the Coulomb laws (see [3ℓ] for details).

Note the admission of quantum chemistry for the atomic structure in molecular bonds and the use of a covering chemistry only in the short range valence interactions, namely, inside the "hadronic horizon." In fact, at distances sufficiently greater than 1 fm, the volume integral in the exponent of Eq. (5.18) is identically null, the actual dimensions and density of the particles are ignorable, and Santilli's isounit (5.18) verifies the crucial condition

(5.12).

We should also mention that, when the Schrödinger-Santilli isoequation is worked out in detail under isounit (5.18), there is the emergence of a strongly attractive Hulten potential that, as well known, behaves at short distances like the Coulomb potential, thus absorbing the repulsive Coulomb force between the valence electrons [9a,9b].

$$U \times [(\frac{1}{2\mu_1} p_1 \times p_1 + \frac{1}{2\mu_2} p_2 \times p_2 + \frac{e^2}{r_{12}} - \frac{e^2}{r_{1a}} - \frac{e^2}{r_{2a}} - \frac{e^2}{r_{1b}} - \frac{e^2}{r_{2b}} + \frac{e^2}{R}) \times |\psi\rangle] \times U^\dagger \approx$$

$$\approx (-\frac{\hbar^2}{2 \times \bar{\mu}_1} \times \nabla_1^2 - \frac{\hbar^2}{2 \times \bar{\mu}_2} \times \nabla_2^2 - V \times \frac{e^{-r_{12} \times b}}{1 - e^{-r_{12} \times b}}.$$
$$\left. - \frac{e^2}{r_{1a}} - \frac{e^2}{r_{2a}} - \frac{e^2}{r_{1b}} - \frac{e^2}{r_{2b}} + \frac{e^2}{R} \right) \times |\hat{\psi}\rangle, \tag{6.3}$$

where $\bar{\mu}$ denotes mutation of rest energies (see monograph [3ℓ,3p] for details). The insufficiency of quantum chemistry is now transparent because, without the hadronic lifting, the total electromagnetic force between the two hydrogen atoms is identically null. It then follows that *contact nonpotential interactions have a truly fundamental role in the very origin of molecular structure.*

Intriguingly, the Santilli-Shillady strong valence bond turns the valence electron pair into a (a generally unstable) quasi-particle called *isoelectronium.* In turn, thanks to a reduction, *the unsolvable four-body conventional structure of the hydrogen molecule is turned into a solvable three body structure,* that has indeed been solved exactly and proven to be consistent with experimental data [9ℓ].

Superficial inspections of hadronic mechanics and chemistry may tend to dismiss the relevance of the strong valence bond for controlled nuclear fusions. Recall that the conventional quantum view on valence are basically insufficient to explain how two electrons can bond to each other to form the molecular structures of our everyday life, while having identical charges that cause extreme repulsions at the distances of valence bonds. For this reason, the various valence models of quantum chemistry are mere nomenclatures, as indicated earlier.

A crucial feature established by hadronic chemistry is that *the new contact, nonlinear, nonlocal and nonpotential interactions due to wave-overlapping are strongly repulsive at short distance for triplet couplings (parallel spins) and strongly attractive in singlet coupling (antiparallel spins).*

After (and only after) the above scientific journey, the importance of hadronic mechanics and chemistry begins to emerge for the objective that motivated their construction, the prediction and quantitative treatment of basically *new* clean energies and fuels, that is, energies and fuels NOT predicted by quantum mechanics and chemistry.

7. Isorelativity.

Particles in an accelerator can be well approximated as being dimensionless points moving in vacuum under action at a distance forces, in which case special relativity applies uniquely and exactly. However, nuclear fusions deal with combining nuclei that are *extended, nonspherical, deformable and hyperdense structures,* in which case special relativity cannot be exact for various reasons such as:

1) Special relativity can only approximate nuclear fusions as occurring among point-like nuclei due to its very mathematical structure, that of local differential character, notoriously representing only points.

2) Special relativity cannot represent the actual nonspherical shape of nuclei, such as that of spheroid ellipsoids, otherwise there is the violation of its central pillar, the rotational symmetry;

3) Special relativity cannot provide any representation of the deformability, density and other nuclear features.

For physicists still politically attached to the validity of special relativity within a nucleus it is important to recall the inapplicability of the Poincaré symmetry for nuclear structure due to their lack of nuclei (Figure 1), which inapplicability mandated the construction of the covering Poincaré-Santilli isosymmetry and related isorelativity.

This paper will be useful to researchers in nuclear fusion if allows them to understand that the lack of achievement until now of a controlled "hot" or "cold" fusion of scientific or industrial relevance has been due also to the excessive limitations of special relativity for the process considered.

The *isotopic (axiom-preserving) lifting of special relativity*, today known as *Santilli's isorelativity,* was constructed to allow a more realistic representation of nuclei as they are in the physical reality. the covering isorelativity was achieved via:

A) The isotopies of the Minkowski space first presented in Ref. [7a,7b];

B) The isotopies of the rotational symmetry first reached in Ref. [7c];

C) The isotopies of the SU(2)-spin symmetry first formulated in Ref. [7d];

D) The isotopies of the Poincaré symmetry and special relativity first published in Refs. [7e];

E) The isotopies of the spinorial covering of the Poincaré symmetry first reached in Refs. [7f,7g];

F) The implications of isorelativity for local realism first reached in ref. [7h]; and

G) Comprehensive studies on the iso-Minkowskian geometry first presented in Ref. [7i] (for numerous related works, see monographs [3]).

We cannot possibly review this body of works here. We merely mention that, in accordance with general rules (5.14), isorelativity can be constructed via a noncanonical or nonunitary transform applied to the *totality* of the formalism of special relativity, and then the results formulated on isofields for invariance. Let us consider first an individual nucleus. Since the isounit is positive-definite, it can be always diagonalized to the form

$$\hat{I} = U \times U^{\dagger} = Diag.(\frac{1}{n_1^2}, \frac{1}{n_2^2}, \frac{1}{n_3^2}, \frac{1}{n_4^2}), \tag{7.1a}$$

$$n_\mu \ > \ 0, \quad \mu = 1, 2, 3, 4, \tag{7.1b}$$

under which we have the lifting of the conventional Minkowski metric into the isometric

$$m = Diag.(1, 1, 1, c_o^2) \ \rightarrow \ \hat{m} = U \times m \times U^{\dagger} =$$

$$= Diag.(\frac{1}{n_1^2}, \frac{1}{n_2^2}, \frac{1}{n_3^2}, -\frac{c_o^2}{n_4^2}), \tag{7.2}$$

that, as one can see, represents: a) the actual spheroidal share of the nucleus via the space characteristic quantities n_k^2, $k = 1, 2, 3$, representing the semiaxes; b) the deformation of such a shape expected under collision, via a functional dependence of the characteristic quantities, e.g., on the energy, $n_k^2 = n_k^2(E, ...)$; and c) the density of the nucleus considered represented by the quantity n_4^2 with respect to the normalization value $n_4^2 = 1$ for the vacuum.

The reader should be aware that *isorelativity constitute the foundation of the industrial realization of controlled nuclear fusions proposed in this paper.* As an illustration, certain key features of controlled nuclear fusions predicted by isorelativity are dependent on the abandonment of the philosophical abstraction of the "universal constancy of the speed of light" and the assumption instead that light is indeed constant but *in vacuum only,* while within physical media the light speed is a local variable depending on the characteristics of the medium in which it propagates,

$$c = \frac{c_o}{n_4(t, r, p, \mu, \omega, ...)}, \tag{7.3}$$

assuming that light can propagate at all in a given medium. Fo instance, $c < c_o$ in water and media of light density, but we known today [3p] that $c > c_o$ within the hyperdense medium inside nuclei.

Another belief that has to be abandoned for the formulation of "new" energies is that the speed of light is the maximal causal speed, and its replacement with the new *maximal causal speed* that is characterized by the geometry of the medium, and it is given by

$$V_{max} = c_o \times \frac{n_4}{n_3}. \qquad (7.4),$$

Needless to say, the two speeds are identical in vacuum, $c = c_o$, but the distinction between maximal causal speed and the local speed of light is necessary within physical media, e.g., for media opaque to light for which the speed of light has no physical sense of any type for causality laws.

An illustration is given by water in which electrons can propagate at a speed 1/3-rd greater than the local speed of light (Cerenkov effect), with consequential catastrophic inconsistencies in case special relativity is assumed to be valid.

In fact, if the speed of light *in water* is assumed as the maximal causal speed, we have the violation of the principle of causality because electron would travel faster than the local causal speed. Similarly, if we assume the speed of light *in vacuum* to be the maximal causal speed *in water*, we have the violation of the relativistic addition of speeds. The statement that special relativity is recovered by reducing light to photons scattering among atoms has been proved to be nonscientific because:

i) Electromagnetic waves with, say, one meter wavelength cannot be credibly reduced to photons, while they also travel in water at about 2/3 the speed of light in vacuum;

ii) The reduction of light to photons in vacuum is nonscientific for light propagating at speed bigger than that in vacuum;

iii) The nonscientific character of the reduction of light to photon to maintain c_o as the maximal causal speed inside media, is established by the fact that, even when applicable, the reduction is afflicted by an error in defect of about 30% of the measured value, namely, the reduction of light to photon can only represent a few percentage of the reduction of the speed of light in water, and not its 33% reduction (due to the very low cross section of Compton scattering as serious scientist are expected to know).

In reality, there is no need for calculations, but only to observe and admit evidence visible to our naked eye. A source of light submerged within pure water shows no dispersion. This implies that photons have to scatter along a straight line to represent the lack of dispersion, that yields another impossibility. All these arguments and more [3p] show that the reduction to photons of light propagating within physical media to maintain c_o as the maximal causal speed within physical media is a pure political machination with embarrassing inconsistencies and disagreement with reality.

The familiar *mass-energy equivalence for point-like particles,* $E = m \times c_o^2$, is lifted by isorelativity into the following form for extended nuclei

$$E = m \times c_o^2 \times \frac{n_4^2}{n_3^2}, \tag{7.5}$$

that implies different values of the nuclear inertial masses of what currently believed. In fact, when the energy-equivalence E of a nucleus is known, the above law yields a value for the inertial mass m different from that currently believed.

We also have the following isoexpressions

$$\hat{\beta} = \frac{v}{c_o} \times \frac{n_4}{n_3} \tag{7.6a}$$

$$\hat{\gamma} = \frac{1}{(1 - \hat{\beta}^2)}, \tag{7.6b}$$

under which we have the following *isodoppler effect* for photons propagating within a nucleus

$$\hat{\omega} = \omega \times \hat{\gamma}, \qquad (7.7),$$

namely, we have a frequency shift different than the conventional relativistic one, essentially expressing the capability of light of losing or absorbing energy when propagating within physical media, a capability absolutely absent in special relativity although with huge implications from particle physics to cosmology [9p], such as a numerical representation of galaxy and quasars when physically connected while having dramatic differences in their cosmological redshifts because quasars have immense chromospheres as a result of which light exist them already *isoredshifted* (that is, redshifted due to loss of energy to the medium, rather than redshifted due to speed). For additional aspects we have to refer to the existing literature.

The above rudiments of isorelativity refer to the characterization of *one* nucleus. The fusion of *two* nuclei can be studied via Santilli isounit of type (5.18) in which one can see the appearance of the exponential representing contact, nonlinear, nonlocal and nonpotential effects, while conventional linear, local and potential interactions are represented with the usual Hamiltonian.

In this way, conventional, hamiltonian, quantum treatment of the fusion of two nuclei into a third can be lifted into a treatment via hadronic mechanics by presenting the conventional Hamiltonian, but adding all missing features via isounit of type (5.18) and related lifting of the entire formalism.

The reader should be aware that *isorelativity has nowadays vast experimental verifications in classical physics, particle physics, nuclear physics, superconductivity, astrophysics and cosmology* we cannot possibly review here [3n-3r].

It should be kept in mind that, due to the positive-definiteness of the isounit and rule (5.14c), all isosymmetries are locally isomorphic to the original symmetries, as necessary under isotopies, yet they provide the most general known nonlinear, nonlocal and non-Hamiltonian realizations of known spacetime and internal symmetries. Intriguingly, these isosymmetries generally reconstruct as exact on isospaces over isofield all symmetries believed to be broken [3h,3i].

The reader should also know that isorelativity is based on a *geometric unification of the Minkowskian and Riemannian geometries* [7i], *with consequential unification of special and general relativities* that are now differentiated by the selected realization of Santilli's isounit. These unifications permitted a novel formulation of gravity that is invariant under the Poincaré-Santilli isosymmetry. These advances have permitted the first and perhaps only known axiomatically consistent grand unification of electroweak and gravitational interactions [8], where the axiomatic consistency is achieved thanks to the reformulation of gravity via the axioms of electroweak interactions.

In conclusion, as clearly stated by Albert Einstein in his limpid writing, and as reviewed earlier, special relativity was conceived, constructed and verified *in vacuum.* The validity of special relativity for all conditions existing in the universe has been proffered by *Einstein's followers,* and not by Albert Einstein. Evidence beyond possible doubt establish that special relativity is inapplicable (rather than violated) for interior dynamical problems, including dynamics within physical media, or systems without a Keplerian nucleus (as it is the case for nuclear fusions) and others.

Rather than being topics of esoterica academic interest, the above issues have direct societal implications for the much needed new clean energies and fuels. In fact, *nuclei constitute some of the densest media measured by mankind until now.* It then follows that *nuclear fusions cannot be reduced to events in vacuum.* Any insistence without clear evidence on the exact validity of special relativity for nuclear fusions was tolerated in the past as an act of scientific fervor, but nowadays the potential severe injury to society forces causes the denunciation of such a fervor particularly when proffered by experts.

8. Physical laws of nuclear fusions as predicted by hadronic mechanics, hadronic chemistry and isorelativity.

One of the first contributions of hadronic mechanics, hadronic chemistry and isorelativity to new energies is the identification of seven different physical laws that have to be obeyed by all nuclear fusions to occur and must be subject to engineering optimization for their acquisition of industrial value. These laws were first derived in ref. [3k], they apply for cold, intermediate and hot fusions, and are referred to in the literature as *Santilli's laws for controlled nuclear fusions.* Let us begin with the following

DEFINITION 8.1: Controlled Nuclear Fusions (CNF) are given by energy releasing nuclear fusions whose rate of synthesis (or of energy production) is controllable via one or more mechanisms capable of performing the engineering optimization of the applicable laws.

We are not in a position to review here the derivation of the basic laws of CNF to avoid a prohibitive length. Nevertheless, for completeness of this presentation we provide below their conceptual outline with a few comments.

LAW I: A necessary condition for CNF to occur is to control the peripheral atomic electrons in such a way to allow nuclei to be exposed. Nature has set matter in such a way that nuclei are strongly shielded by their atomic clouds. It is evident that a "nuclear" synthesis between two conventional "atoms" is impossible at low energies because the electron clouds will never allow nuclei to approach each other, let alone to synthesize a new nucleus. This law explains the inability of the "cold" fusions to achieve industrial significance in energy output because, by definition, "cold fusions" do not have the energy necessary for the ionization of atoms. This law also illustrates the need for the proposed "intermediate fusions" in which the first energy requirement is precisely the control of atomic clouds. As we shall see, the first and prioritarian emphasis in the proposed CNF is precisely that of first exposing nuclei in a systematic and controlled way, in which absence the author has no interest in studying the deeper problems of nuclear syntheses.

LAW II: CNF must yield a positive energy output with the inclusion of the energy of all processes used in the synthesis. This seemingly trivial law is intended to eliminate the possibility that the energy obtained from the usual "mass defect" (the rest energy of the synthesized nucleus being smaller than the sum of the rest energies of the original nuclei) may not be sufficient to yield a positive energy output due to the energy needed for all collateral processes, as it has been the case for a number of "hot" fusions. Law II is also needed to keep in mind that the energy needed for the control of atomic clouds (Law I) should evidently be much smaller than the energy resulting from the mass defect so as to have industrial relevance.

LAW III: CNF only occur among nuclei whose spins are either in "singlet planar coupling" or "triplet axial coupling" of Figure 3. This is another law with profound engineering implications indicated later on. This law also illustrates the structural differences between quantum and hadronic mechanics, as well as the necessity of the latter for CNF. The constituents of a bound state of two quantum particles must necessarily be point-like to avoid structural inconsistencies beginning with the local-differential topology. Consequently, singlet and triplet couplings are equally possible for quantum mechanics. When the actual extended character of the constituents is taken into account, it is easy to see that *triplet planar couplings of extended particles at short distances are strongly repulsive, while singlet planar couplings are strongly attractive,* where the word "planar" is intended to indicate that the two nuclei have a common median plane, while "axial" indicates a common axial symmetry (Figure 3). This law was introduced by Santilli in the original proposal [5a] to build hadronic mechanics via the so-called *gear model.* In fact, the coupling of gears in triplet (parallel spins) causes extreme repulsion to the point of breaking the gear teeth, while the only possible coupling of gears is in singlet (antiparallel spins). The emergence of a strongly attractive force for the singlet planar or triplet axial couplings is one of the fundamental contributions of hadronic mechanics since such a force is totally absent for quantum mechanics due to its point-like abstraction of nuclei. The same force also emerges in a variety of similar cases, such as in the valence bond (Section 6). In all cases the new hadronic force is so "strong" to overcome the coulomb repulsion due to the same charge of the constituents. The reader should be aware that, without the emergence of the strongly attractive hadronic force for singlet planar or triplet axial couplings, this paper would not have written because the author would have considered as impossible all "cold" as well as "intermediate" nuclear syntheses.

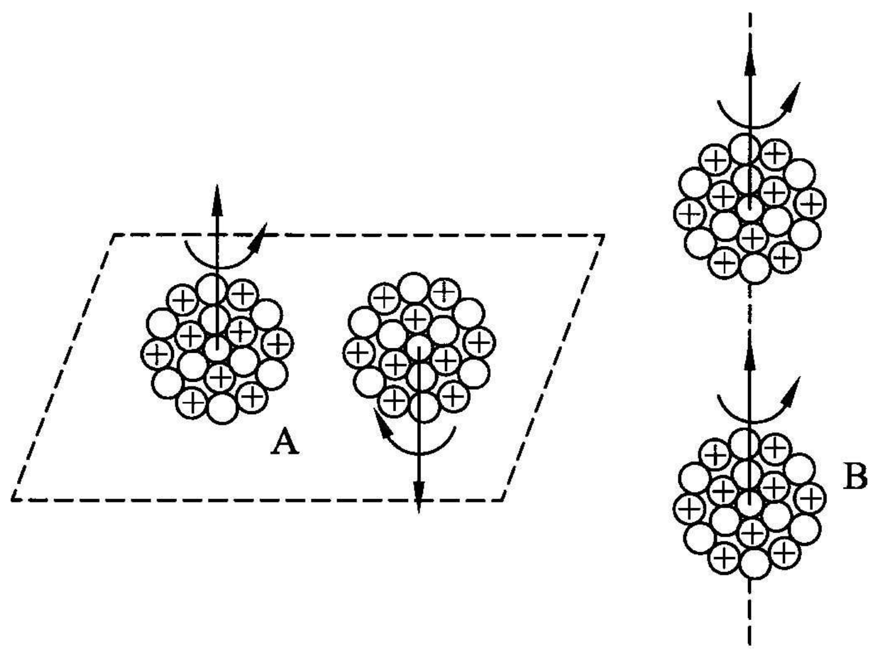

Figure 3: *A schematic view of the only two stable couplings permitted by hadronic mechanics for nuclear fusions, the "singlet planar coupling" of the l.h.s. and the "triplet axial coupling" of the r.h.s. All other spin configurations have been proved to produce strongly "repulsive" forces under which no CNF is credibly possible. The configuration preferred in this paper is the axial one for reasons of easier engineering realization and bigger efficiency in the energy output.*

LAW IV: The most probable CNF are those occurring under the separate conservation of the linear and angular momenta. The differences between quantum and hadronic mechanics begin to emerge. The law herein considered is trivial for quantum mechanics since the individual conservation of the linear and angular momenta are secured by the Poincaré symmetry. However, such a symmetry is not exactly valid for the nuclear structure (Figure 1). One of the consequences is precisely given by interchanges, thus nonconservations, of linear into angular momenta, of course, under the conservation of their energy. Alternatively, we can say that, when nuclei are assumed as dimensionless points, as necessary for the Poincaré symmetry and quantum mechanics, they cannot have collisions in which case the linear and angular momenta cannot have exchanges. However, when nuclei are represented as they are in the physical reality, extended, the interchange between linear and angular momenta becomes a physical reality clearly established at the classical level, e.g., in billiard games. Almost needless to say, the acquisition of angular momenta by a given nucleus merely create an unstable state that re-establish the original state via secondary processes. Once these basic notions are understood, the physical law herein considered can be understood: it represents the fact that collisions sufficiently energetic to have interchanges between linear and angular momenta *decrease* the probability of the nuclear fusion because of evident instability, as a result of which the most probable fusions occur when the linear and angular momenta are individually conserved without interchanges.

LAW V: The most probable CNF are those occurring at threshold energies (namely, at the minimum value of the energy of the original nuclei needed to verify all other laws). A main reason of this law is that *all energies below said threshold value do not allow industrially meaningful nuclear syntheses (this is the case for "cold" fusions), and all energies above the indicated threshold value cause instability that reduce the rate of synthesis in a way proportional to the energy excess (this is the case for "hot" fusions).* As we shall see, the lack of engineering implementation of this law constitutes another reason "cold" and "hot" fusions have not achieved industrial relevance until now. The above law also identifies the need for and characterizes the proposed "intermediate" nuclear fusions. Intriguingly, experts readers should not need calculations to verify this law since the case of energy below threshold is trivial, and the case of energies much bigger than is also self-evident since the large excess of energy can only be dissipated by the nuclei themselves, thus causing immense engineering problems that, as indicated in Section 1, have not been resolved despite the investment of one billion dollars of collective funds. The occurrence also suggests caution in the use of public funds without a serious appraisal of engineering feasibility.

LAW VI: The most probable CNF are those without the release of massive particles (such as protons, neutrons and electrons). This law was not expected by the author. Yet, contrary to popular beliefs, explicit calculations based on hadronic (and certainly not quantum) mechanics indicated that the probability of a nuclear synthesis with the release of neutrons is much *smaller* than that of another synthesis without the emission of massive particles. As we shall see, this fourth law appears to be verified by nuclear syntheses spontaneously occurring in nature. It should be stressed that this law does not preclude the study of CNF with secondary emission of massive particles. It only suggest the preferred study of nuclear syntheses without release of massive particles for evident reasons, such as lack of harmful radiations. Note that Law VI implicitly favor CNF among *light* nuclei, rather than heavy ones since the hadronic (and certainly not quantum) probability of releasing massive particles at threshold energy is much smaller for the former as compared to the latter.

LAW VII: CNF cannot occur without a trigger (that is, an external mechanism forcing exposed nuclei through the hadronic horizon). All nuclei are positively charged, thus repelling each other. Without a mechanism that overcomes the Coulomb repulsion and brings nuclei inside the hadronic horizon of 1 $fm = 10^{-13} cm$, no nuclear synthesis is evidently possible. By contrast, when inside the hadronic horizon and the preceding laws are verified (with particular reference to law III on the singlet planar or triplet axial couplings), the synthesis is inevitable, as we shall see, due to the strongly attractive hadronic forces that overcomes and absorb the repulsive Coulomb force. The case is similar to that of identical valence electrons that evidently repel each other for all distances bigger than 1 fm, but strongly attract each other at distances of the order of 1 fm as established by the strength of molecular structures. As a matter of fact, interested readers can easily adapt the valence model (6.3) to nuclear syntheses via the mere change of the sign and the value of the charge.

Evidently, the achievement of industrially relevant energy outputs by CNF requires the engineering optimization of all preceding laws. This is less obvious of what may appear at a first inspection because each law can be realized in a number of different engineering versions. This does not means that all realizations have equal efficiency. Maximization of the energy output is realized only when said engineering realizations "optimize" the laws.

It is instructive to examine a representative case of "cold" fusion under the above physical laws. Consider the *Fleishmann-Pons electrolytic cell* [1a]. It is easy to see that this cell does indeed verify Law II (conservation of the energy), Law IV (conservation of the angular momentum), and law VII (the trigger being characterized in this case by the electrostatic pressure compressing deuteron atoms inside the palladium).

However, Fleishmann-Pons electrolytic cell [1a] does not verify Laws I (control of atomic clouds to expose nuclei), Law III (control of spin couplings) and other laws . In fact, nuclear spin couplings occur at random, there is no clearly identified mechanism to expose nuclei, and there is an equally clear lack of optimization of the verified laws. Consequently, nuclear syntheses occur at random, thus preventing industrial values of the energy output.

It is an instructive exercise for researchers serious in real advances in new clean energies to inspect other realizations of "cold" fusions' among the large variety existing in the literature [1b-1c]. One can see in this way that, to our best knowledge at this time, *none of available "cold" fusions realizes "all" seven basic laws* (the indication of the contrary would be appreciated). Above all, there is no evidence known to the author that available "cold" fusions are conducted with the minimum threshold energy needed for the synthesis.

In conclusion, Santilli's Laws on Controlled Nuclear Fusions practically rule essentially out the possible achievement of industrially meaningful "cold" and "hot" fusions, by confirming in this way a rather widespread consensus in the scientific community and, at the same time, setting us the need for basically new approaches.

9. Proposed industrial realizations of controlled intermediate nuclear fusions.

9A. Verification of CNF laws via the new chemical species of Santilli's magnecules.

Inspection of Laws I-VII for Controlled Nuclear Fusions (CNF) reveals that the most difficult engineering realization is that of Law I on the control of electron clouds so as to expose nuclei as a pre-requisite for for their fusion. Following a decade of research, and thanks to large private funds, the author has achieved industrial maturity for gaseous and liquid fuels with a new chemical structure permitting indeed the needed exposure of nuclei (see the industrial web site [9d]). The solution is such to verify also all remaining laws, with the exception of Law VII on the trigger.

The current environmental problems are not caused by fossil fuels per se, but rather by the strength of their valence bonds that has prevented the achievement of a full combustion for over one century. In fact, hydrocarbons and other pollutants in the exhaust literally are chunks of uncombusted molecules (for which very reason these pollutants are carcinogenic).

A solution was proposed in Ref. [9c] of 1998 consisting of a new chemical species, today known as *Santilli magnecules* (in order to distinguish them from the conventional molecules) whose bond is stable, but sufficiently weaker than the conventional valence bond to permit full combustion (see website [9d] and monograph [3l] for comprehensive studies).

The new species required the identification of a *new attractive force among atomic constituents that is not of valence type as a central condition, thus occurring among atoms irrespective of whether valence electrons are available or not.* Additionally, said force must characterize stable species but be *weaker* than the valence, evidently to prevent a repetition of increase of the environmental problems caused by valence bonds. Finally, said force should disappear at the combustion temperature to maximize the energy output as well as to achieve full combustion.

The solution proposed in Ref. [9c] was the use of an external magnetic field sufficient to create the polarization of atomic orbitals into toroids, as a result of which the orbiting electrons create a magnetic moment along the symmetry axis of the toroid that is non-existing in the conventional spherical distribution of the same orbitals.

Evidently, individual toroidal polarizations are, individually, extremely unstable because the spherical distribution is recovered in nanoseconds following the removal of the external magnetic field due to temperature related effects. Nevertheless, when two toroidal polarizations are bonded together by opposing magnetic polarities North-South-North-South- etc. as in Figure 4, spherical distributions are again recovered in nanoseconds following the removal of the external magnetic field, but this time such distribution occurs for the bounded pair as a whole.

It is evident that the above magnecular character of the bond verifies the additional requirements, since: it does create stable species as established industrially [9d]; it is weaker than the valence bond; and does indeed disappear at the combustion temperature as it is the case for all magnetic effects.

DEFINITION 9.1 [9c,3k,3l,]: Santilli's magnecules are stable clusters consisting of individual atoms (H, C, O, etc.), dimers (OH, CH, etc.) and ordinary molecules (CO, H_2O, etc.) bonded together by opposing magnetic polarities originating from toroidal polarizations of the orbitals of atomic electrons and other polarization effects.

It is now customary in the field to denote a molecular bond with the symbol "$-$" and a magnecular bond with the symbol "$\times$." Consequently, the hydrogen molecule is represented with $H_2 = H - H$, the first hydrogen magnecule is given by 9(igure 4)

$$2H = H \times H \tag{9.1}$$

the next is the species H_3 often identified in mass spectrometry that is interpreted as having the combined valence and magnecular structure

$$3H = H - H \times H, \tag{9.2}$$

while a general hydrogen magnecule is represented with the symbol

$$MH = (H - H) \times (H - H) \times .... \times H \times H \times ... \tag{9.3}$$

In fact, a species of MagneHydrogen $14H$ having about *seven* times the amu of H_2 while being 99.8 % hydrogen has been detected in independent

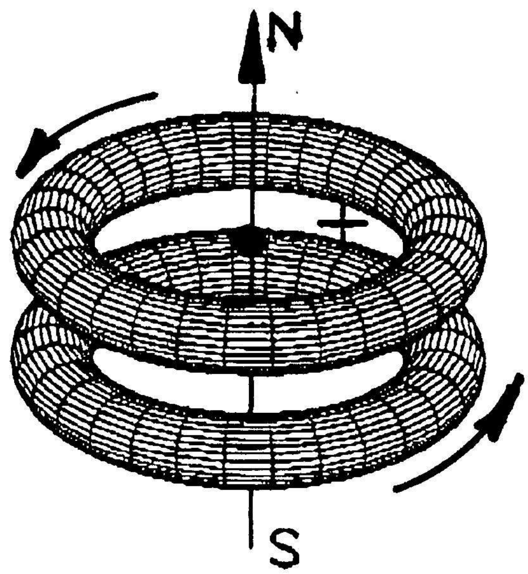

Figure 4: *A schematic view of a "diatomic Santilli magnecule" consisting of the bonding of two atoms caused by the attractive force between opposing polarities North-South-North-South- etc. of toroidal polarizations of at least some peripheral atomic electrons [9c,3s]. Note that, in reality, the "magnecular bond" is rather complex since it is characterized by the attraction among "three" magnetic moments (those of the toroids, plus the intrinsic magnetic moments of the electrons and of the nuclei), as well as the repulsive force among equal nuclear and electron charges. Consequently, the figure depicts a condition of equilibrium between these opposing forces. Note also the absence in magnecular bonds of considerations pertaining to the nature of the atoms and the possible availability of valence electrons. Note finally the lack of limits in the number of constituents in magnecules except limits set by instabilities due to collisions. Note that Santilli's magnecules naturally realize the "axial" (but not the "planar") compatible spin coupling of Law I (see Figure 3, and monographs [3l,3r,3s] for comprehensive studies).*

laboratories [9h]. The latter measurements provide final confirmation on the existence of magnecules due to the evident impossibility of any credible interpretation via valence. Similar symbolism is used for other magnecules.

Depending on the selected fluid feedstock, a generic MagneCule (MC) from Definition 9.1. can then be written

$$MC = (H \times H \times ...) \times C \times C \times ...) \times O \times O \times ...$$

$$\times (C - H) \times (O - H) \times ... \times (H - H) \times (C - O) \times ... \tag{9.4}$$

Numerous new substances with magnecular structures have been identified experimentally to date, among which we indicate MagneGas^{TM} [9d], MagneHydrogen^{TM} [9h], HHO^{TM} [9i], and others under industrial development. Their primary features (for which large industrial investments have been made) is the complete combustion without contaminant in the exhaust and cost competitiveness over fossil fuels.

The experimental detection of magnecules is rather difficult since it requires analytic instruments and methods different than those currently used to detect molecules. Vice versa, analytic methods so effective to detect molecules generally reveals no magnecules, and this explains their lack of detection since the discovery of molecules in the mid of the 19-th century.

An analytic equipment developed for molecules that is also effective for the detection of gaseous (liquid) magnecules is given by a Gas (Liquid) Chromatographer Mass Spectrometer necessarily equipped with InfraRed Detector for gases (GC-MS/IRD) or with UltraViolet Detector for liquids (LC-MS/UVD).

Let us recall that large clusters (of the order of hundreds of amu or more) cannot be constituted by molecules when without an IR signature for gases or a UV signature for liquids, because that would require perfect spheridicity that is prohibited by nature for a large number of constituents.

The detection of a magnecule requires its identification, firstly, with a peak in the MS that must result to be unknown following the computer search among all known molecules and, secondly, that peak must show no IR or UV signature at its amu value. The latter condition explains the need for a GC-MS (or LC-MS) necessarily equipped with IRD (UVD). In fact, if the same species is tested with an IRD (or UVD) disjoint from the MS, the IRD

(UVD) is not generally focused on the selected MS peak at its amu value, resulting in the detection of a variety of signatures of conventional molecular species that, in reality, are the *constituents* of the considered magnecule. Note that the lack of IR or UV signature also confirms the achievement of the desired *bond weaker than the valence,* as needed to achievement full combustion (see, for details, website [9c]).

As indicated in Section 2, the word "valence" is essentially a nomenclature due to the lack of explicit and concrete identification of the "attractive" force necessary to produce a valence bond (for Santilli-Shillady strong valence force as in Eq. (2.19), see Refs. [9a,9b,3l]). By comparison, Santilli identified in the original proposal [9c] the *attractive character* of the magnecular forces as well as its *numerical value,* that was confirmed by Kucherenko and Aringazin [9e] as well as by others [3l].

The importance of the new species of magnecules for controlled nuclear fusions is established by an inspection of Figure 4, where one can see that *the toroidal polarizations of the peripheral orbitals does indeed expose nuclei, as desired.* The configuration clearly result to be preparatory for the subsequent nuclear synthesis studied below. Finally, the absence of IR signatures for gases or UV signatures for liquids confirms that the bond can occur at threshold energy, as necessary for controlled nuclear fusions.

It is easy to see that, under suitable engineering optimization studied in the next section, the magnecular structure of Figure 4 also allows the verification of the remaining laws. In fact, Law II can be verified because the binding energy of magnecules is immensely smaller than nuclear energies; Law III on the spin coupling is automatically verified via the triplet axial coupling; Law IV on the individual conservation of linear and angular momenta can also be verified at threshold energies due to minimal relative motions of the nuclei; the magnecular structure is ideally suited for using the threshold energy for the nuclear fusion due to the indicated coupling and proximity of the nuclei; and the realization of law VI depends on the proper selection of isotopes.

9.B. Engineering conception and realization of hadronic refineries. We differentiate hereon between *Hadronic Refineries* (HF) and *Hadronic Reactors* (HR), the former an equipment suitable for the recycling of liquids (or liquid waste) into a gaseous *fuel* with magnecular structure (magnegases) via a submerged electric arc, the latter being an equipment primarily devoted to the production of industrially significant *heat* via an electric arc submerged within a properly selected fluid. Both reactors have the name "hadronic" because based on a submerged electric arc that, as such, requires the use of hadronic mechanics due to excessive deviations from quantum mechanics (see Vol. I of Ref. [3o]).

To proceed in stages, in this section we outline engineering details on hadronic refineries, and pass later on to the more complex hadronic reactors of main interest for this paper.

One of the biggest engineering difficulties for the creation of the new chemical species of Santilli magnecules, whether for hadronic refineries or reactors, is that the toroidal polarization of spherical atomic orbitals requires very strong magnetic fields of the order of billions of Gauss, which fields have to be realized in an industrially viable and cost effective way (for details, see Appendix 8A of monograph [3ℓ]). The solution identified by the author following long studies is that via the use of DC electric arcs submerged within a properly selected liquid.

With reference to Figure 5, at atomic distances from the DC arc, the magnetic field can reach values of 10^{11} Gauss or more, thus being sufficient for the desired polarization; said magnetic field naturally couples polarized atoms into magnecules with triplet axial coupling North-South-North-South- ...; and the arc compresses magnecules toward its axial symmetry at the time of disconnect and re-initiation (for reasons not entirely understood so far), thus favoring the application of the trigger toward the achievement of nuclear syntheses.

In figure 6 we provide the conceptual lines of hadronic refineries used in the industry consisting of a metal vessel capable of withstanding pressures up to 300 psi; the vessel is filled up with the selected liquid feedstock, and houses a DC electric arc among one or more pairs of electrodes that are submerged within the selected fluid and powered by an external AC-DC converter with at least 100 Kw. Electrodes are selected depending on the need at hand. For instance, in the event carbon is needed for to stabilize the fuel produced or for nuclear syntheses, the electrodes can be composed of commercially available graphite.

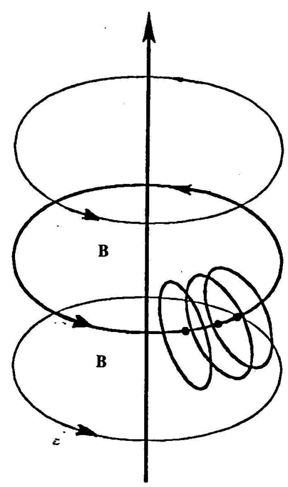

Figure 5: *A schematic view of the geometry of a DC electric arc represented by the vertical line, with the associated magnetic field represented by horizontal circles, and the created magnecules represented by circles perpendicular to the latter. This geometry has the following primary implications: 1) Since the magnetic field M is proportional to I/r, one can see that at atomic distances* $r = 10^{-8}$*cm from electric arcs with* $I = 10^3 A$ *the magnetic field is of the order of* $10^{11} G$*, thus being amply sufficient to polarize atomic orbitals [3l,9f,9g]; 2) Following said polarization, the geometry of electric arcs is such to align automatically polarized atoms with opposing polarities North-South-North-South-..., thus creating magnecular bonds with the axial spin couplings of Figure 3; and 3) For reasons not entirely understood [9c], electric arcs compress magnecules toward their axis at the time of their initiation or shut off, thus assisting in the realization of the trigger necessary for nuclear fusions.*

Information from Data File:
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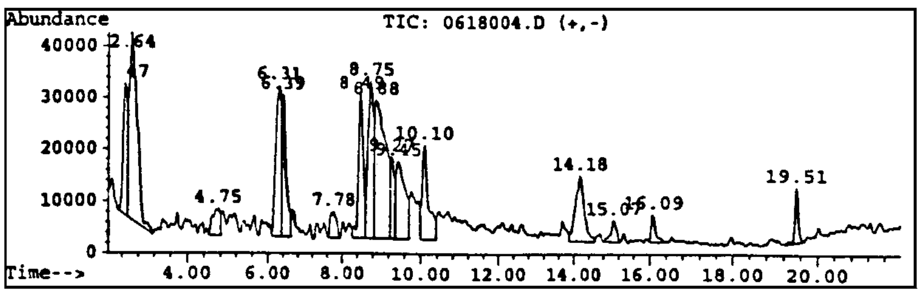
Operator : NAW
Acquired : 18 Jun 98 3:01 pm using AcqMethod VOC_IRMS
Sample Name: TOUP'S TECH
Misc Info : 1ML LOOP; 10C ● ULTRA COLUMN
Vial Number: 1
CurrentMeth: C:\HPCHEM\1\METHODS\DEFAULT.M



Retention Time	Area	Area %	Ratio %
Total Ion Chromatogram			
2.474	1753306	5.386	32.724
2.644	5091514	15.641	95.030
4.754	641528	1.971	11.974
6.307	2737749	8.411	51.098
6.390	2211258	6.793	41.272
7.782	592472	1.820	11.058
8.490	2357396	7.242	43.999
8.754	2784829	8.555	51.977
8.882	5357812	16.460	100.000
9.265	1123809	3.452	20.975
9.448	2421234	7.438	45.191
10.098	1946292	5.979	36.326
14.177	2129791	6.543	39.751
15.073	435208	1.337	8.123
16.085	389822	1.198	7.276
19.509	577433	1.774	10.777

Figure 6: *A view of a large number of scans conducted in various countries of magnegas produced via hadronic refineries (that of Figure 8 below) from tap water and graphite electrodes, ranging from* 40 *amu to* 500 *amu and obtained via a GC-MS equipped with IRD. According to quantum chemistry, the scan should have solely contained a large peak at* 44 *amu representing the maximal predicted molecule in large percentage, that of* CO_2. *The absence of the dominant peak at* 44 *amu plus the large variety of peaks all the way to* 500 *amu, each in macroscopic percentage and not identified by the computer, establishes beyond credible doubt a basically new species called by the author magnecules (see [3r,3s] for details and references).*

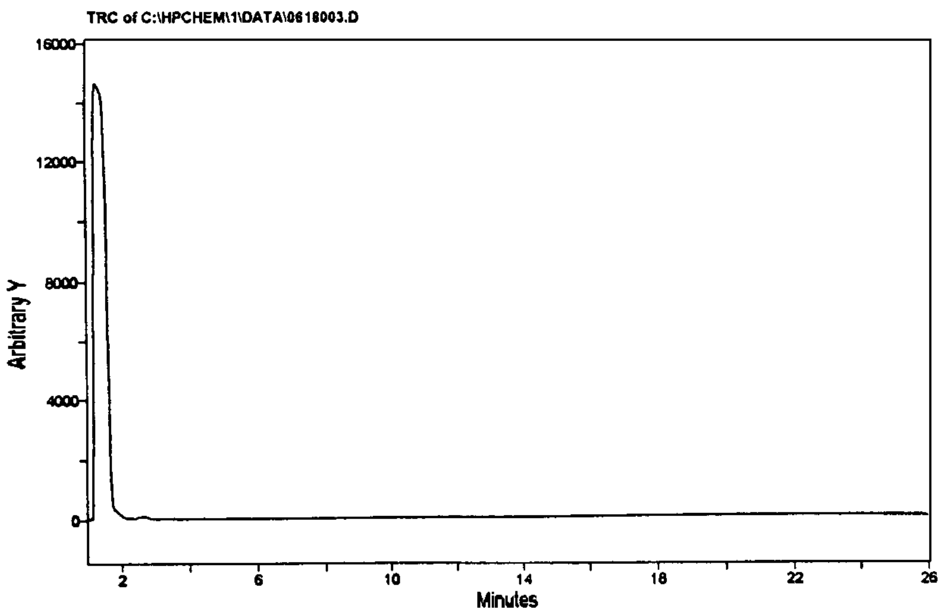


Figure 7: *A view of the IR scan of the same peaks of Figure 6 with the same GC-MS equipped with IRD that provides final experimental evidence that none of the peaks of Figure 6 can be conventional molecules. This is due to the lack of IR signatures that is impossible for molecules with such large atomic masses, since lack of IR signature implies perfect spheridicity only possible for light molecules such as* H_2. *As a matter of fact, the sole large peak of the IR scan here reproduced confirms that the sole molecular species over* 40 *amu present in magnegas is indeed given by* CO_2 *as predicted by quantum mechanics. However, such a molecule is a mere "constituent" of the magnecules of Figure 6 (see [3r,3s] for details and references).*

The equipment includes means for the continuous recirculation of the fluid through the arc so that magnecular structures are continuously removed from the arc following their creation. In the case of a liquid feedstock, the submerged arc produces a clean burning cost competitive magnecular fuel that bubbles to the surface where it is collected for use (see web site [9d] and for technical details one may inspect the various U. S. Patents in the process known as *Santilli PlasmaArcFlow*).).

The heat produced by the equipment is acquired by the liquid feedstock and it is used via its recirculation through an external heat exchanges that can power a turbine for the production of electricity (following additional input to the steam to reach supercritical temperatures) or other uses. The equipment is completed by means for the automatic control of all operations, including the DC arc, the pressure, feedstock flow, feedstock temperature, compression of the fuel produced, etc.

The efficiency of hadronic refineries is quite big and not entirely understood until now (see Section 7.11 of ref. [7ℓ]). In essence, the arc turns the liquid into a gaseous state; decomposes the gas molecule into their atomic constituents; ionizes the resulting atoms; and forms a plasma at $10,000^o\ F$ (for $100Kw$) composed of ionized H, O, C and other atoms. The known affinity between C and O creates C-O in single, double and triple couplings, the combustion in part of $C-O$ into CO_2, the synthesis of $H-H$ and magnecules, all reactions being very esoenergetic.

Because of the above features, *hadronic refineries (or reactors) provide a new form of carbon combustion that is cleaner and more efficient than preexisting forms.* In fact, the gaseous fuel produced is cleaned via its passage through the liquid feedstock with the released impurities being processed by the arc, thus providing a form of carbon combustion transparently cleaner than existing forms. The new carbon combustion is also more esoenergetic than conventional forms for the evident reason that the latter solely allow conventional chemical reactions for CO, CO_2 and other lesser relevant reactions, while the former admit additional very esoenergetic reactions such as the synthesis of H_2 as well as of magnecules.

Clearly anomalous species are easily established because in using pure graphite electrodes within distilled water, the maximal species predicted by quantum chemistry is $CO2$ with 44 amu, while clusters in macroscopic per-

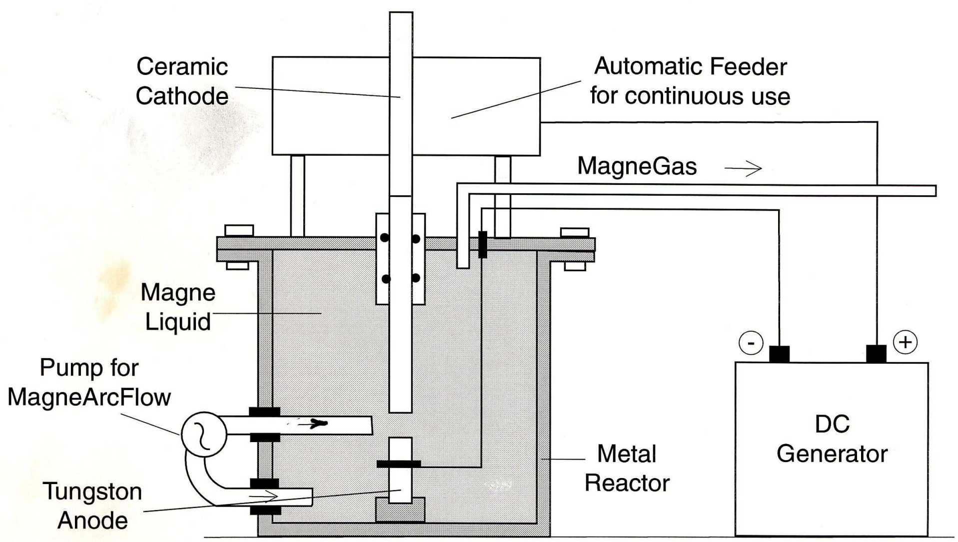


Figure 8: *The main lines of the hadronic refinery converting liquid waste into a clean burning cost competitive gaseous fuel with magnecular structure, showing: the pressure metal vessel; the submerged electrodes; the recirculation of the feedstock through the arc; the external AC-DC converter; the external automatic controls of the arc; and the collection of the magnecular fuel produced [3s].*

centages are detected all the way to 500 *amu*, and all the way to $1,000$ *amu* in lesser percentages, which clusters can only be Santilli magnecules. Additional large deviations from quantum chemistry are visible in the exhaust and other aspects (see [3ℓ,9d]).

Figure 9: *A picture of the IBR engineer Richard Lyons operating a 50 Kw hadronic refinery on a trailer for the production of a magnecular fuel where and when desired, currently operating in Florida showing the various components, including: the panels for the completely automatic operations (on the right); the horizontal PlasmaArcFlow (in the center) and the automatic magnegas compression station (in the left); the power unit and heat exchangers being in the back [9d].*

To conduct measurements, Santilli [loc. cit.] has introduced first the *Scientific Efficiency* (SE) as the ratio between the energy output (given by the heat energy contained in magnegas E_{mg} plus the heat acquired by the

Figure 10: *Pictures of IBR engineer Tom Judy operating* 100 *Kw unified hadronic refinery on a trailer during final tests prior to shipment to India [9d].*

Figure 11: *A view of the* 100 *Kw unified hadronic refinery on a trailer of the preceding picture showing additional equipment for further enhancements of energy efficiency and uses [9d].*

liquid feedstock E_{lf}) and the energy input (given by the electric energy E_{El} used by the refineries plus the energy released by carbon combustion and the other above indicated reactions E_{cc}),

$$SE = \frac{E_{mg} + E_{lf}}{E_{el} + E_{cc}} < 1. \tag{9.5}$$

It is evident that this efficiency *must* be smaller than one because of the conservation of the energy, dispersions and other reasons.

However, oil waste is very rich in carbon and its recycling not only has no cost, but actually brings an income. For this reason, industrial applications of the technology use the *Commercial Efficiency* (CE) given by the preceding definition with the sole electric energy in the denominator because the sole carrying a cost,

$$CE = \frac{E_{mg} + E_{lf}}{E_{el}} \gg 1. \tag{9.6}$$

The latter efficiency can be greater than one, as established by certified and independent measurements [9d], because (see Section 7.11, Ref. [3ℓ])

$$E_{cc} \gg E_{el}. \tag{9.7}$$

As an illustration with data verifiable at the IBR lab in Florida, a hadronic refinery operating with 100 Kw, 200 psi, and $300^o F$ for the recycling of an oil-base liquid feedstock (such as automotive oil waste, biodiesel byproducts, frying liquid waste, etc.) produces magnegas at the rate of about about $1,500 scf/h = 42,000\ L/h$ corresponding to about $1,350,000$ - BTU, plus heat acquired by the liquid feedstock of about $600,000\ BTU$ per hour, while using 100 Kw that correspond to about $340,000\ BTU$. In this case the scientific efficiency is, evidently, smaller than one, but the commercial efficiency is bigger than one and given by

$$CE = \frac{1,350,000 + 600,000\ BTU}{340,000\ BTU} = 5.73. \tag{9.8}$$

which value establishes the *industrial relevance of hadronic refineries due to their large efficiency.*

The reader should be aware that commercial efficiencies (as above defined) of the order of 10 have already been measured in prototypes because , the total net energy output of hadronic refineries increases nonlinearly with the increase of the operating power, pressure and temperature [3s].

It should be stressed that, despite initial studies conducted in Ref. [3m], the origin of the excess energy of hadronic refineries and its maximal attainable value are basically unknown at this writing because, as shown in Section 9, systematic measurements of excess nitrogen in the produced magnegas fuel that cannot be explained via the sole use of nitrogen occluded in the original liquid feedstock.

It is indeed possible that the excess energy produced by hadronic refineries is a combination of energy released via conventional chemical reactions, plus energy released by the synthesis of nitrogen and possibly other elements. Therefore, we now pass to the study of the latter possibility for its definition, quantitative treatment and experimental verification.

9C. The physics of controlled intermediates nuclear fusions.

The physics of CINF was first presented by Santilli in monograph [3k] of 1998 and then studied from a chemical viewpoint in monograph [3ℓ]. In this section we shall review and upgrade these studies via the following main assumptions:

ASSUMPTION I: The synthesis of neutrons from protons and electrons is the first and most fundamental synthesis in stars. Nuclear fusions can only follow that of the neutron. Hence, no nuclear fusion is expected to occur at energies intermediates between the "cold" and the "hot" fusions unless reactors are jointly capable of achieving the neutron synthesis. Consequently, CINF should take into consideration possible contributions from the synthesis of neutrons from protons and electrons (Section 4)

ASSUMPTION II: Quantum mechanics is fundamentally inapplicable to the neutron synthesis as well as that of all nuclear syntheses due to its reversible structure compared to the irreversibility of the syntheses considered and many other reasons (Section 1,2,3). Consequently, any appraisal of nuclear fusions basically dependent on quantum descriptions is fundamentally flawed.

Gas Chromatographic Analyses

Component	Volume Percent		
	FID Analysis	TCD Analysis	
	Actual	Actual	Normalized
Hydrogen		62.6	50.0
Carbon monoxide		54.0	42.9
Ethyne	10.8	4.9	3.9
Methane	3.6	3.0	2.4
Nitrogen		1.9	0.0
Carbon dioxide		0.9	0.7
Ethene	0.8	0.4	0.3
Ethane	<0.1	<0.1	<0.1

Figure 12: *One of numerous measurements currently under verification showing a macroscopic percentage of nitrogen in magnegas produced from tap water and graphite electrodes in the refineries of the preceding figures. Due to its high value (1.9 %), the presence of nitrogen cannot be explained via old orthodox theologies as originating from nitrogen occluded in water and requires for its quantitative treatment the assumption that nitrogen is synthesized by the electric arc of hadronic refineries. The old hypothesis that nitrogen is synthesized from carbon and deuterium also lacks scientific credibility due to the basically insufficient percentage of deuterium in water. This scenario mandating the addressing of the fundamental issue of all nuclear fusions: the synthesis of the neutron studied in Section 9. Note that the detection in the above data of ethyne, methane, ethene and ethane are misinterpretations by the analyst based on mere identity of amu values, because none of these HC can exist in magnegas due to its formation at about* $10,000^o$ *F at which temperature none of said compounds can survive. In reality, the measurements herein reported were obtained in 2000 by a laboratory (Spectra Lab of Largo, Florida) solely equipped with GC. In the event the test had been conducted with a GC-MS equipped with IRD, all amu values would have been confirmed (including the crucial value of 28 amu for* N_2*), but the peaks for said HC would have shown no IR signature, thus being magnecules as illustrated by Figures 6, 7. The above so important measurements have not been repeated since the year 2000 because of: the basic absence of analytic equipment specifically intended for magnecules; the extreme unwillingness of analytic laboratory in using molecular equipment in the unusual ways needed for the detection of magnecules, and the extreme repugnance by academic and industrial laboratories to admit scientific novelty [3r,3s].*

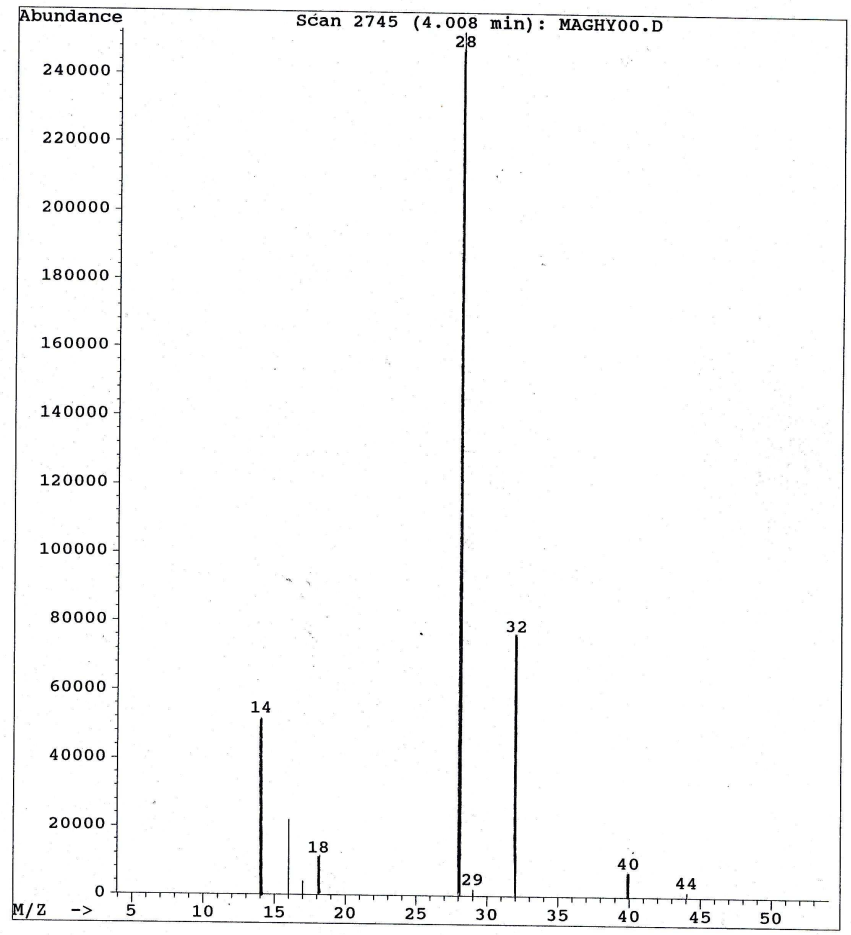


Figure 13: *One of the numerous GC-MS scans of magnegas, this one (conducted by Spectra Lab of Los Angeles in 2000) at* 4.008 *min elusion time, showing the clear presence of molecular nitrogen* N_2 *at* 28 *amu. Note the scan presents the reduction of the mass peak to conventional molecules. This feature motivates at times the "experimental belief" by chemists that magnegas has a conventional molecular structure. The statement is political, rather than scientific, because it ignores the clear experimental evidence that all species depicted in this scan are part of a fully stable cluster fully identified in macroscopic percentage in the MS scan of magnegas whose bond cannot possibly be of valence type. The reader with serious interest in science (rather than in academic politics) should know that molecular nitrogen as well as atomic nitrogen (see the signal at* 14 *amu) have been identified in numerous magnecular clusters all the way to* 500 *amu, thus being "constituents" of magnecules in macroscopic percentage [3r,3s].*

ASSUMPTION III: Operator mechanics applicable to nuclear fusions should first achieve a time invariant numerical representation of all characteristics of the fundamental synthesis, that of neutrons from protons and electrons, as a condition to be applicable to subsequent nuclear syntheses. Hadronic mechanics is the only mechanics verifying these pre-requisites at this writing. Other theories will be dismissed unless: 1) they achieve said "numerical" representation of "all" characteristics of the neutron; 2) said representation are invariant over time (predict the same numbers under the same conditions at different times; and 3) are proved to be inequivalent to hadronic mechanics.

With the clear understanding that the commercial efficiency (7.6) of hadronic refineries is already sufficiently large to have allowed large industrial investments in various countries, hadronic reactors are under study via suitable implementations of hadronic refineries for the possible enhancement of their energy output via Controlled Intermediates Nuclear Fusions (CINF). The implementations are essentially given by: operating power, pressure and temperature much larger than those in industrial use for hadronic refineries; the addition of more adequate heat exchangers and the addition of the *trigger* activating nuclear syntheses that is absent in hadronic refineries. The control of the expected nuclear syntheses is done via the control of the power, pressure, flow, trigger and other operating features.

The guidelines for the conception of hadronic reactors has been based on nature, rather than on pre-existing research. As established by chemical analyses of air bubbles in amber, about one hundred millions years ago Earth's atmosphere had about 40% nitrogen, while its current percentage is about double that value. Other chemical analyses show that the increase of nitrogen in our atmosphere has been gradual.

These data suggest *the apparent existence in our atmosphere of a process causing the natural synthesis of nitrogen from lighter elements.* Since nature is notoriously friendly toward the environment, such a process is expected to synthesize nitrogen without the release of of harmful massive radiation such as neutrons, protons and alpha radiations, from, which the CINF Law VI was derived.

Among all possible origins of a nitrogen synthesis in our atmosphere, the most probable one is given by *lighting,* because a serious scientific (that is, quantitative) explanation of *thunder* cannot be achieved with conventional chemical reactions, thus requiring requires nuclear syntheses. In fact, a numerical explanation of thunder requires energy equivalent to hundreds of tons of explosives that simply cannot be explained via conventional processes due to the very small cylindrical volume of air affected by lightning combined with its extremely short duration of the order of nanoseconds (serious scholars with dissident views are suggested to do these calculations to prevent venturing political opinions).

The nitrogen syntheses by lighting provides indeed a numerical explanation of thunder as well as the slow rate of nitrogen increase in our atmosphere. Among all possible syntheses, the most probable one results to be the *synthesis of nitrogen from carbon and deuterium.* However, the deuterium presence in our atmosphere is excessively small to permit a numerical explanation of thunder. *It is at this point where the synthesis of neutrons by lighting from protons and electrons enters rather forcefully into the arena of nuclear syntheses, as we shall see.* In fact, the neutron synthesis is a necessary pre-requisite for the synthesis of deuterium that, in turn, allow a number of nitrogen syntheses sufficient to reach a numerical explanation of thunder. At any rate, Santilli [9k] succeeded in synthesizing neutrons from protons and electrons precisely via the use of an electric discharge in a hydrogen gas. Needless to say, numerous additional fusions are also possible under lighting and some of them will be indicated below.

Hadronic reactors have been conceived to reproduce lighting processes within a fluid as close as technically possible at the moment which explains their being based on a submerged electric arc. In the author's view, the biggest unknown at this writing is not given by the identification of possible nuclear syntheses triggered by lighting, but by our insufficient knowledge of lighting itself due to dramatic departures from quantum mechanics and studies via the covering hadronic mechanics not yet completed at this writing.

We are here referring to the apparent natural tendency by an electric arc of compressing polarized atoms, molecules and magnecules toward its symmetry axis. Such a compression is an excellent trigger when under the very large voltages of lighting. However, such large voltage cannot be realized in hadronic reactors in an industrially viable way and its engineering realization without a quantitative understanding of the principles of the compression remains difficult.

The successful achievement of industrial relevance with CINF crucially depends on the proper selection of the basic feedstock for hadronic reactors, called *hadronic fuel.* In this section, we study a few examples of hadronic fuels selected under the conditions that:

1) The original and final nuclei are light, natural, and stable isotope;

2) The nuclear syntheses cause no emission of harmful radiations, such as $n,\ p, \alpha$*, etc.; and*

3) The energy produced ΔE *is much bigger than the total energy used by the equipment for its production.*

Note the dramatic difference between the conventional *nuclear fission,* where the emphasis is in the use of *very large isotopes,* and the proposed novel hadronic energy, where the emphasis is in the opposite selection of *isotopes as light as possible.* As indicated earlier, the latter emphasis is necessary to achieve a *basically novel, clean nuclear energy, namely, a nuclear energy without harmful radiations and without harmful waste.* As shown below, these main objectives are indeed realistic, certainly not via the use of quantum theories, but via the use of the covering hadronic mechanics and its seven laws for CNF.

By using standard nuclear terminologies and symbols with: $A,\ Z,\ J^p,\ u$ denoting the atomic number, the nuclear charge, the nuclear angular momentum, the parity, and the nuclear energy in *amu* units, respectively, the desired CINF are of the generic type

$$TR + N_1(A_1, Z_1, J_1^{p_1}, u_1) + N_2(A_2, Z_2, J_2^{p_2}, u_2) \quad \rightarrow$$

$$\rightarrow \ N_3(A_3, Z_3, J_3^{p_3}, u_3) + Heat, \tag{9.9a}$$

$$A_1 + A_2 = A_3,\ Z_1 + Z_2 = Z_3,\ J_1 + J_2 = J_3,\ p_1 = p_2 = p_3, \tag{9.9b}$$

$$\Delta E = E_3 - (E_1 + E_2) > 0 \tag{9.9c}$$

where E is measured in units u and TR denotes the hadronic trigger and the heat is essentially produced by the release of expected states of the synthesized nucleus N_3 under energies insufficient to produce secondary massive radiations.

It should be stressed that a number of alternatives to synthesis (9.9) are possible, particularly those based on intermediates processes such as Electron Capture (EC), or emission of electrons that is not considered harmful since electrons can be stopped with a thin metal shield. Needless to say, in the latter cases, the conservation of the charge is different than that in Eq. (9.9b).

The following unit conversions may be helpful:

$$1\ u = 931.494\ MeV;\ \ 1\ MeV = 1.602 \times 10^{-13}\ J =$$
$$= 4.45 \times 10^{-17}\ Wh = 1.511 \times 10^{-16} BTU; \tag{9.10a}$$
$$1\ Wh = 3.397\ BTU;\ \ 1\ C = 6.241 \times 10^{18}\ e;\ \ 1\ A = 1\ C/1\ s, \tag{9.10b}$$

where e is the elementary charge of the electron. The energy used by the proposed hadronic reactor is essentially given by

$$50\ Kwh \approx 1.69 \times 10^5\ BTU. \tag{9.11}$$

Hence, to be industrially relevant, the proposed hadronic reactors must produce energy at an hourly rate much bigger that that used for their operations, such as 50 $Kwh \approx 1.7 \times 10^5\ BTU$.

Let us first study the synthesis of nitrogen as predicted to occur in lighting as well as in hadronic refineries prior to any implementation into hadronic reactors. The simplest reaction with related energy output is given by:

$$TR + C(12, 6, 0^+, 12.0000) + H(2, 1, 1^+, 2.0141) \quad \rightarrow$$
$$\rightarrow \quad N(14, 7, 1+, 14.0030) + Heat, \tag{9.12a}$$
$$\Delta E = (E_C + E_H) - E_C = 0.0111\ u = 10.339\ MeV \approx 1.5 \times 10^{-15}\ BTU, \tag{9.12b}$$

where very light elements, such as hydrogen and helium, are expected to be completely ionized at the intermediate energies needed for the CINF, namely, $H(1, 1, \frac{1}{2}^+, 1.0078)\ = p,\ \ H(2, 1, 1^+, 2.0141) = \alpha$, etc., an assumption tacicly implemented hereon. Note that the preceding reaction verifies conventional nuclear conservation laws and can be engineered to verify the additional CINF laws I to VII.

The above synthesis is indeed of potential industrial interest because the hourly rate of 10^{30} CINF, a rather reasonable expectation due to the volume of available gas, would overcome the used energy and yield the hourly production of about 10^{10} BTU, namely, a rather significant new clean energy patterned along natural lighting.

Nuclear synthesis (9.12) is experimentally supported by the significant and repeated experimental evidence according to which the magnegas produced from water and graphite electrodes in hadronic refineries contains a macroscopic percentage of nitrogen that simply cannot be explained as originating from atmospheric nitrogen occluded in the water prior to its use in the reactors (Figures 12, 13).

Despite these promising premises, the restriction of CINF to synthesis (9.12) would be fundamentally flawed, because positively there is not sufficient deuterium in tap water to account for any numerical representation of the nitrogen synthesis as measured in magnegas. It is at this point, as indicated earlier, that the need to re-examine the foundations of nuclear fusions at large emerges rather forcefully.

The *only* way known to the author to achieve a quantitative representation of the nitrogen synthesis in hadronic refineries is to admit the prior synthesis of neutrons according to reaction (4.3) as a basic part of the deuterium needed for the nitrogen synthesis. Hence, fusion (9.12) is more deeply interpreted as originating from the following two step process

$$\begin{aligned} TR + C(12,6,0^+,12.0000) + 2\times H(1,1,\frac{1}{2}^+,1.0078) + EC + a \quad &\rightarrow \\ TR + C(12,6,0^+,12.0000) + H(2,1,1^+,2.0141) \quad &\rightarrow \\ \rightarrow \quad N(14,7,1+,14.0030) + Heat, & \qquad (9.13) \end{aligned}$$

namely:

1) The electric arc first polarizes the carbon and hydrogen atoms by forming the magnecule $C_\uparrow \times H_\uparrow \times H_\uparrow$ as in Figure 4. including the necessary triplet axial coupling of spins.

2) Under a suitable trigger, the magnecule $C_\uparrow \times H_\uparrow \times H_\uparrow$ can only yield a nucleus with $A = 14,\ Z = 8,\ J^p = 1^+$ that is known not to exist (since $O(14,8)$ has spin $J = 0$). The sole electron capture (EC) would also yield a nucleus known not to exist.

3) The only explanation known to the author is therefore that nature synthesize the neutron from protons, electrons and etherinos according to the sequence:

$$C_\uparrow \times H_\uparrow \times H_\uparrow \ \rightarrow C(12,6,0) + p^+_\uparrow + p^+_\uparrow + e^- + a \ \rightarrow$$
$$\rightarrow \ C(12,6,0) + H(2,1,1) \ \rightarrow N(14,8,1). \tag{9.14}$$

Another CINF also suggested by lighting is given by

$$TR + O(16,8,0^+,15.9949) + H(2,1,1^+,2.0141) \quad \rightarrow$$
$$\rightarrow \quad F(18,9,1+,18.0009), \tag{9.15a}$$
$$\Delta E_1 = 0.0081\ u = 7.545\ MeV, \tag{9.15b}$$

and secondary process due to the instability of $F(18,9,1+,18.0009)$

$$F(18,9,1+,18.0009) + EC \quad \rightarrow \quad O(18,8,0^+,17.9991) + 1.656\ MeV, \tag{9.16}$$

resulting in the following total energy output per synthesis

$$\Delta E_{tot} = 9.201\ MeV \ \approx \ 1.30 \times 10^{-15}\ BTU, \tag{9.17}$$

in which case, again, 10^{30} syntheses per hour would yield a rather substantial new clean energy.

An additional selection of hadronic fuel is a 50-50 mixture of deuteron and helium gases according to the following CINF

$$TR + H(2,1,1^+,2.0141) + He(4,2,0^+,4.0026) \quad \rightarrow$$
$$\rightarrow \quad Li(6,3,1^+,6.0151) + heat \tag{9.18}$$

with energy output

$$\Delta E = 0.0016 \ \ u \approx 2.5 \times 10^{-16}\ BTU, \tag{9.19}$$

that verifies all CNF laws. Hence, one can see that a hadronic reactor with the above hadronic fuels becomes industrially relevant under the achievement of about 10^{30} CNF per hour, that would yield the hourly production rate of about 10^9 BTU.

Note the need, again, of deuterium for CINF (9.15) and (9.18)and the need that deuterium be synthesized following the prior synthesis by lighting of the neutron. In turn, as the reader with serious interest in new knowledge will see, these aspects have a crucial relevance for the achievement of CINF with industrially valuable energy output.

Another CINF based on lithium is given by

$$TR + Li(7, 3, \frac{3}{2_{\uparrow}}^{-}, 7.0160) + H(1, 1, \frac{1}{2_{\downarrow}}^{+}, 1.0078) \rightarrow$$

$$\rightarrow \ 2 \times He(4, 2, 0^{+}, 4.0026), \tag{9.20a}$$

$$\Delta E = 2.887 \times 10^{-12} \ J, \tag{9.20b}$$

where one should know the opposing nuclear polarizations $Li_{\uparrow}$ and $H_{\downarrow}$ to verify the law on the conservation of the angular momentum,a feature of crucial relevence for the engineering realization to have any hope of achieving industrial relevance.

The energy output of reactions (9.20) is significant. by using one mole of lithium that has 20^{23} nuclei; by assuming an efficiency of 10^{16} per minute; and by using energy units in Joules, we have the energy output

$$E_{out} = (2.88 \times 10^{-12} \ J) \times 10^{16} = 2.8 \times 10^{4} J/min = 1.7 \times 10^{6} J/h. \tag{9.21}$$

that is indeed industrially relevant.

At this point it is important to identify the rather dramatic differences, with negative environmental implications, between a number of studies via the "cold fusion" and the proposed CINF. A typical reaction believed to be *necessary* for the "cold fusion" of two deuterium nuclei, is that into the tritium plus the emission of a neutron,

$$TR + H(2, 1, 1^{+}, 2.0141) + H(2, 1, 1^{+}, 2.0141) \quad \rightarrow$$

$$\rightarrow \ He(3, 2, \frac{1}{2}^{+}, 3.0160) + n. \tag{9.22}$$

Hence, *the existence of cold fusions" of two deuterium nuclei is often judged on whether neutrons are emitted or not.*

It is essential for the protection of the environment to show that the above criterium to appraise "cold fusions" is a pure theology if used as a basis to deny their existence. In fact, the belief is based on the need to conserve the total angular momentum that normally would yield the value $J = 2$ for the l.h.s of reaction (9.20). However, hadronic mechanics does indeed admit the synthesis of $He-4$ from two deuterium nuclei without any emission of massive radiation, yet via the appropriate use of deuterium nuclei with opposing polarizations according to the law

$$TR + H(2, 1, 1^+_\uparrow, 2.0141) + H(2, 1, 1^+_\downarrow, 2.0141) \quad \rightarrow$$

$$\rightarrow \quad He(4, 2, 0^+, 4.0026) + heat, \tag{9.23}$$

trivially, because

$$1^+_\uparrow \ + \ 1^+_\downarrow = 0^+. \tag{9.24}$$

The engineering realization of the latter reaction is studied in the next section.

At this stage we limit ourselves to indicate that *the denial of nuclear syntheses based on the lack of neutron emissions is purely political and without serious scientific foundation, particularly when proffered by experts,* because the latter are expected to know possibility (9.24) to qualify as such. It is at this point where problems of scientific ethics also emerges forcefully as a prerequisite for the solution of our serious environmental problems.

The difference between pre-existing studies on "cold fusion" and the proposed CINF is also illustrated by the well known setting in which the reactor is filled up with hydrogen, and the electrodes are made up of palladium 106. In these cases we should have fusions *inside the palladium cathode* of the type

$$TR + Pd(106, 46, 0^+, 105.9034) + H(1, 1, \frac{1}{2}^+, 1.0078) \quad \rightarrow$$

$$\rightarrow \quad Ag(107, 47, \frac{1}{2}^+, 106.90509). \tag{9.25}$$

The above reactions do verify *conventional* nuclear conservation laws. However, the engineering implementation of the new CNF laws inside the palladium electrodes is virtually impossible, thus explaining the reason for the lack of consideration in the industrial research herein reported. The above occurrences also illustrates the viewpoint expressed from Section 1 to the effect that the author believes that nuclear fusions do indeed occur in setting of the type (9.25). However, they can at best be at random, thus precluding a serious hope to achieve the controlled energy output necessary for industrial relevance.

9D. Engineering realizations of hadronic reactors.

By using all the preceding advances, we are now in a position to identify specific and concrete engineering realizations of hadronic reactors first presented by Santilli in monograph [3k] of 1998 and partially reviewed in the subsequent monograph [3ℓ]. We begin with a generic embodiment suitable for a variety of hadronic fuels, and then pass to more specific reactors with specific hadronic fuels.

Figure 14 presents a conceptual outline of a simple hadronic reactor in which the primary differences with the hadronic refineries of Figure 6 are: feedstock can also given by a gas and not solely a liquid; increased capacity of the internal metal vessel to operate at $5,000$ psi with impulse pressures (rapid burst of pressures) up to $50,000!psi$; a much more efficient heat exchanger based on passing a coolant around the entire reactor; and the engineering realization of the trigger identified below.

In more engineering details with respect to Figure 15, the proposed hadronic reactor comprises: a metal vessel 232 with hemispherical heads 233, fasteners 252 and bases 234 capable of withstanding a pressure of at least 10,000 psi (666 bars); a stationary, negatively charged, anode 235 that protrudes outside the hemispherical head 233 for connection via cable 299 to the negative polarity of a steady or pulsing AC-DC converter with at least 50 Kw power (not shown in the figure), said protrusion occurring through insulating pressure resistant bushing 236 in phenolic G10 or equivalent material; an internally movable, positively charged cathode 237 connected via cable 300 and insulating bushing 301 to the positive polarity of said outside power source; said cathode 237 being connected via insulating phenolic G10 block 238 to a metal rod equipped with rake 239 that is internally fastened

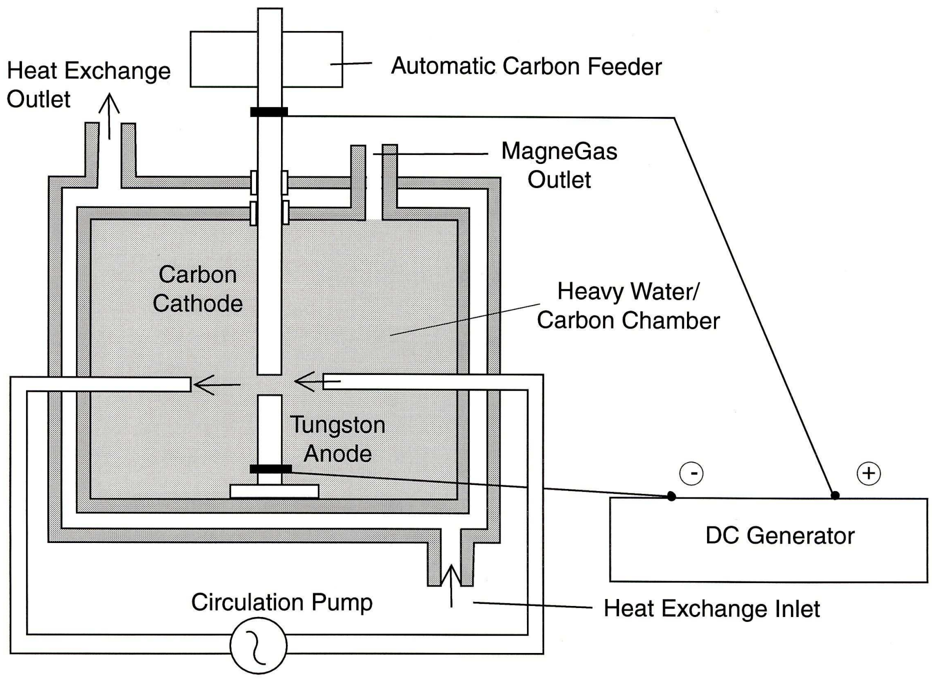


Figure 14: *A schematic view of the Hadronic Reactor, essentially based on an engineering upgrade of the Hadronic Refineries of the preceding figures, showing the shift of emphasis, from the production and use of a magnecular fuel in the latter, to the production and use of heat in the former.*

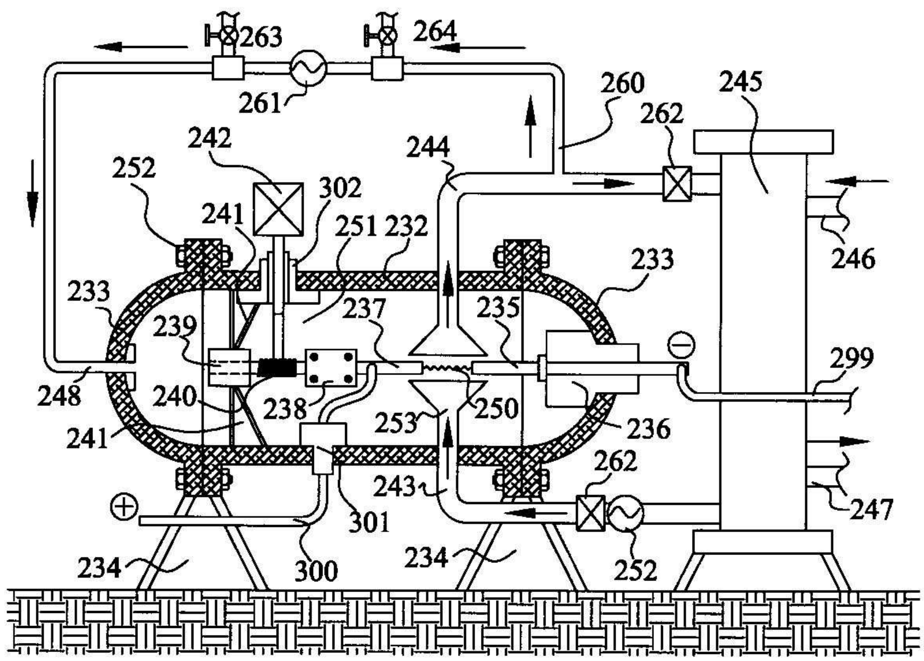


Figure 15: *A more detailed view of a preferred embodiment for the industrial realization of hadronic reactors proposed for the industrial realization of CINF.*

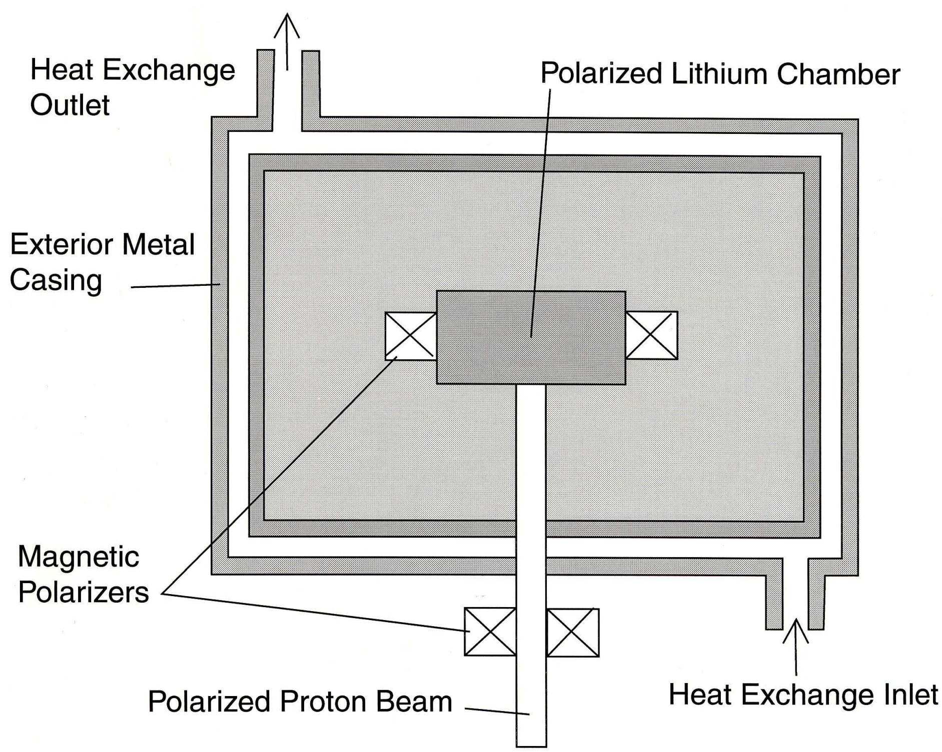


Figure 16: *A schematic view of one of the simplest hadronic reactor, that for the synthesis of the lithium as per Eqs (9.18).*

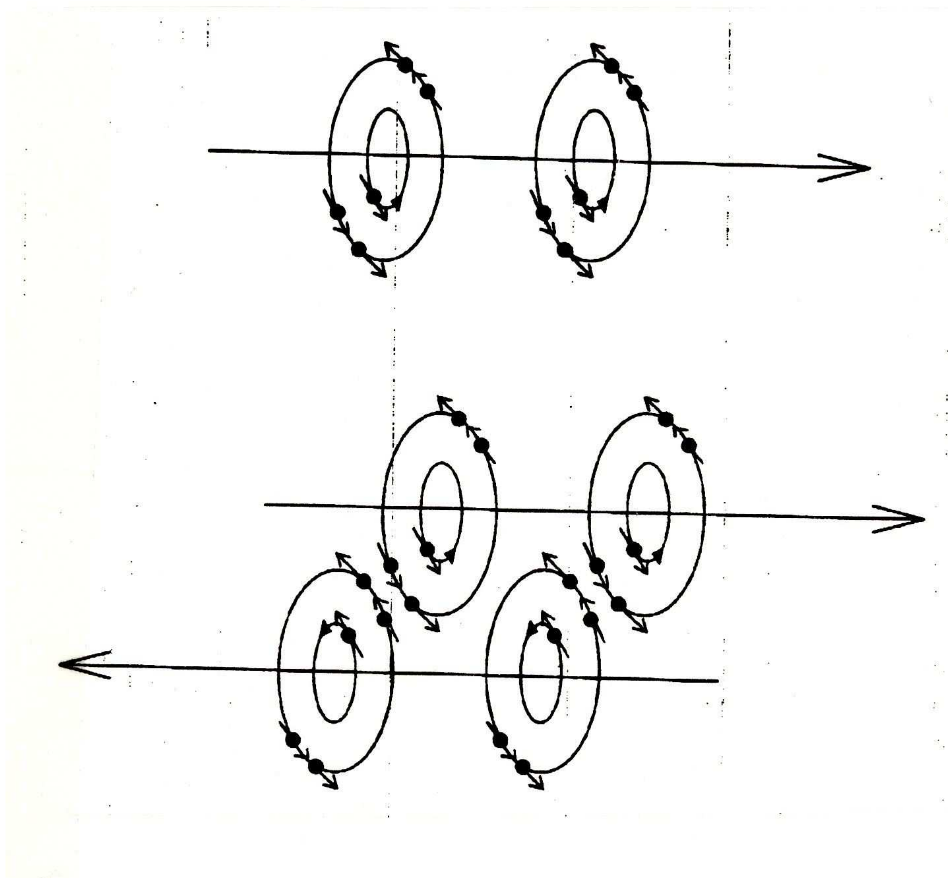


Figure 17: *A schematic view of the two deuterium beams with opposing spin polarization permitting the necessary conservation of the total angular momentum in the CINF of the helium, as per Eq. (9.21). Note that, in the absence of such a controlled opposing polarizations, the nuclear synthesis of the helium cannot be controlled, but may occur at random, thus cannot possibly have industrial relevance.*

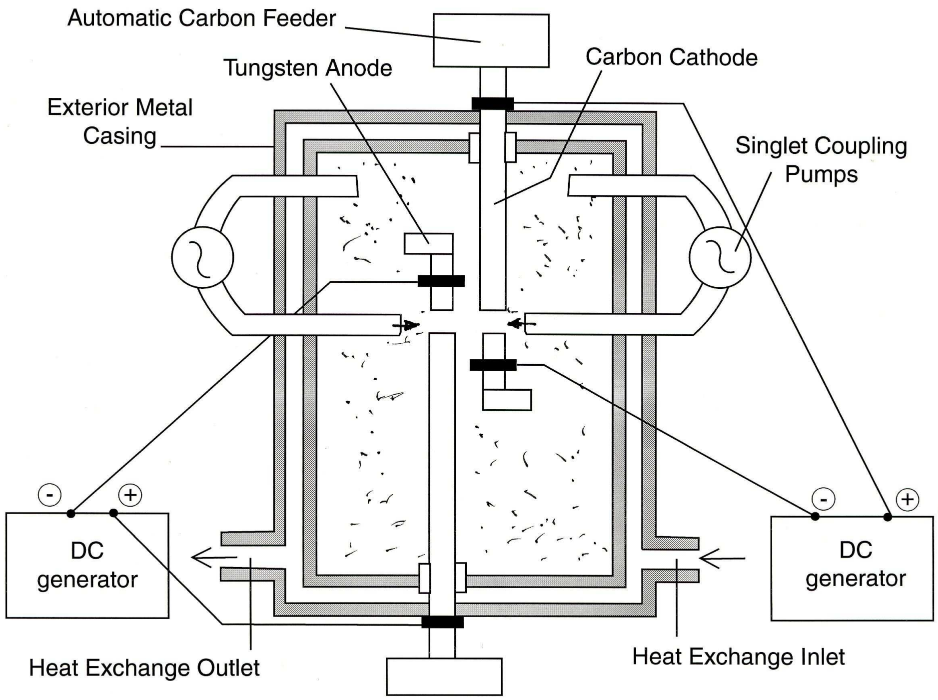


Figure 18: *A schematic view of one of the most difficult hadronic reactors, that for the synthesis of the helium from two deuterium atoms with opposing polarization.*

to vessel 232 via brackets 240; said rake 239 being operated by a pignon 240 that is controlled by an outside servomotor 242 through insulating pressure resistant thrust bearing 302; vessel 232 being filled up with a gaseous or liquid feedstock 251 that is recirculated through the electric arc 250 via pump 252 through pipe 253; the feedstock is then forced via pipe 244 for passage through heat exchanger 245 for continuous recirculation through the arc 250 via pump 252 and pipe 253; the heat acquired by heat exchanger 245 being utilizes via an external fluid via inlet 246 and outlet 247; the proposed hadronic reactor being completed by pipe 248 for burst of pressure of the gaseous feedstock inside vessel 232 to realize the hadronic trigger, said burst of pressure being realized by outlet 260 and impact blower 261, check valves 262 protecting the primary pump 252 and the heat exchanger 245.

The operation of the proposed hadronic reactor is the following. Firstly, a vacuum inside vessel 232 is secured via valve 263. Subsequently, valve 263 is closed and the vessel is filled up with feedstock 251 via valve 264 up to the preset pressure of at least 5,000 psi (333 bars) for gases and up to 2/3 of the interior volume for liquids. Upon completion of the filling operation, the automatic controls activate the AC-DC converter and the primary pump 252 with the continuous recirculation of the feedstock through the arc. When the electrodes are at such a distance not allowing an arc for the pre-selected feedstock and for the pre-selected pressure (open arc), the automatic controls activate servomotor 242 acting on pignon 240 that activates rake 239 solidly connected to cathode 237 via insulating bushing 238, to move said cathode 237 toward the stationary anode 235 until such a distance at which an electric arc of high current (e.g., 1,000 A) within said feedstock is initiated. This first phase serves to create magnecules. The automatic controls then increase the gap between the electrodes to such a value for which the variation of the voltage is within preset values (one of the twenty adjustable parameters of the automatic controls of the Magnegas Technology [9d]), so as to maximize the voltage, or the gap between the electrodes, or the travel of the arc within the feedstock. Following a preset duration of such high current arc, the automatic control activate the high voltage impulse current as a partial realization of the trigger. According to a pre-set frequency, the automatic control also activate the impulse pump 261 to create burst of very high pressure inside vessel 232. This provides an engineering realization of the trigger via a combination of the following three means: 1) Impulse high voltage arcs; 2) Impulse high pressures; and 3) the enhancement of both preceding contributions by the arc geometry (Figure 5). It would be naive to assume that the above description is exhaustive, since numerous other features are needed to render the above hadronic reactor industrially viable. The author regrets not to have received the necessary authorization by the investors for their disclosure at this writing.

1. Hadronic nitrogen reactor. The engineering realization of CINF for reaction (9.12) is conceptually simple. It is given by a reactor with general lines depicted in Figure 14 and engineering realization in Figure 19 or 20. The metal vessel is filled up with deuterium gas at $5,000$ *psi* pressure that is recirculated through graphite electrodes. The trigger is realized by pulse DC with with $100,000\ V$ and $5\ mA$. The heat is dissipated by the external heat exchanger. According to mechanisms not entirely understood, this reactor can also be filled up with water, in which case the plasma surrounding the arc first synthesize the neutron [9k], then synthesize the deuterium, and finally synthesize the nitrogen via ionized carbon atoms from the electrodes.

Measurements supporting the above reactor were conducted in the year 2000 and reported in figures 12, 13. These so important measurements have not been repeated since the year 2000 because of: the basic absence of analytic equipment specifically intended for magnecules; the extreme unwillingness of analytic laboratory in using molecular equipment in the unusual ways needed for the detection of magnecules [3ℓ]; and the extreme repugnance by analysts to admit scientific novelty to the extreme of doing incredible manipulations of evidence for the specific scope recovering old orthodox data.

Scientific ethics, or lack thereof, emerges rather forcefully as quite damaging the resolution of our environmental problems. In fact, the author industrial realizations of hadronic reactors is funded by private investors who have no intention in seeing their money being the victim of academic manipulations for personal political gains, hence the difficulties experienced by the author in securing funds for additional measurements.

The author would gratefully appreciate the indication of analysts having access to GC-MS necessarily equipped with IRD [3ℓ], Raman spectrometry, and other needed analytic equipment, being willing to use them according to our unusual but uncompromisable requirements to have any hope of detecting magnecules (such as biggest available feeding lines of at least 0.5 mm radius, lowest possible column temperature, lowest possible ionization energy, longest possible elusion time, etc.), and being willing to release the *requested* scans (such as the main peaks in MS and IR scans, their percentages and their failed computer identification) rather than releasing scans in their decomposition into conventional constituents (Figure 13).

2. Hadronic oxygen reactor: The engineering realization of CINF (9.15)-(9.17) is, conceptually, one of the simplest because the reaction does not require spin polarizations for the conservation of the angular momentum. Hence, it is sufficient to use the embodiment conceptually outlined in Figure 14 with engineering realization in Figures 19 or 20. The metal vessel is filled up with a $50-50$ mixture of oxygen 16 and helium at $5,000$ psi, which mixture is recirculated through a 50 Kw electric arc between carbon electrodes, thus creating magnecules of the type $O \times He$. The trigger can be given by DC pulses with $100,000$ V and 5 mA, by impulse pressures or other mechanisms. The heat produced is absorbed by the external all encompassing vessel and used via heat exchangers.

Contrary to political postures by orthodox physicists when exposed to "cold fusion" identified in the preceding section, the detection of neutrons or other massive radiation outside the reactor would signal the failure of the industrial objectives, since the latter are restricted to the production of heat without harmful radiations or harmful waste.

3. First hadronic lithium reactor: The engineering realization of the first lithium reaction, Eq. (9.18), is essentially the same as that for the oxygen reactor, the only difference is that the vessel is filled up with a $50-50$ mixture of hydrogen and helium gases also at $5,000$ psi. The mixture is also recirculated through a 50 Kw electric arc that creates magnecules $H \times He$. The trigger is also given by a high voltage pulse DC current or impulse pressure or other mechanism.

4. Second hadronic lithium reactor: The engineering realization of the second lithium reaction, Eq. (9.20), is more complex than the preceding one because of the need of lithium nuclei and a beam of protons with opposite polarization as a necessary condition to avoid a random reactions as occurring in "cold fusions". Current technology allows a variety of engineering realization of the needed polarization represented in Figure 16 where a proton beam with down polarization enters a chamber of lithium with up polarization, both polarizations being realized via magnetic fields. The efficiency of the hadronic reactor is then dependent on the geometry of both the proton beam and the lithium chanber plus an adequate trigger the author has not been authorized to disclose here at this time.

5. Hadronic helium reactor: The engineering realization of reaction (9.23) is one of the most difficult because it requires the application of a trigger to two beams of deuterium gas with opposite spin polarizations. The main idea expressed in the embodiment of Figure 18 is that of a metal vessel as in the preceding reactors that houses two parallel but separate electric arcs with opposing polarities so as to produce opposite polarizations of said deuterium gas. The flow of the gas through said arcs from opposite directions then creates the superposition of said beams in the area located between said arcs with spin couplings depicted in Figure 17. In this case the trigger may be given by impulse pressure or other means. More descriptive details are given in Ref. [3k], Section IV-3.4.

9E. Concluding remarks.

We have first reviewed existing industrial refineries for the production of a gaseous fuel via electric arcs between carbon electrodes submerged within a liquid feedstock, which reactors have already reached energy output about five times bigger than the used electric energy, as verifiable in the IBR laboratory in Florida.

The chemical reactions occurring in the the plasma surrounding the arc include the synthesis of $H_2, CO, CO2$, etc., thus being very esoenergetic. Nevertheless, it is not clear as to whether these chemical reactions can account for the entire energy output. This is also due to the presence in the produced gaseous fuel of an anomalous percentage of nitrogen that is not explainable with the nitrogen occluded in the original liquid feedstock.

Figure 19: *A view of a small 15 Kw Hadronic Reactor currently used for tests of theCINF*

Figure 20: *A view of a 50 Kw Hadronic Reactor currently used for tests of the CINF.*

Figure 21: *The author discussing with IBR electronic engineer Michael Rodriguez the optimization of the 22 parameters of the automatic control of hadronic reactors intended for CINR.*

Figure 22: *IBR engineer Jim Alban operating a brand new version of hadronic reactors with vertical vessel currently under tests for CINF.*

Figure 23: *A view of the author discussing with IBR engineers Tom Judy, Eugene West and Michael Rodrigues the optimization of the interior chamber of a large hadronic reactor and its interior trigger under construction for CINF.*

We have then provided a progress report on the ongoing industrial efforts in turning fuel refineries into reactors specifically conceived for the optimization of heat production via nuclear syntheses and the engineering realizations of their controlled energy output via the control of power, pressure, temperature and other features. The results of the latter efforts will be reported at some future time.

The main conclusion that can be reached at this writing on controlled nuclear syntheses are:

1) To be really controllable, nuclear syntheses have to occur at the threshold energy necessary for the engineering realization of all physical laws, which energy results to be intermediate between the "cold" and "hot" fusions;

2) No serious scientific conclusion or prediction on nuclear syntheses can be achieved without the inclusion of the most fundamental nuclear synthesis in nature, that of neutrons from protons and electrons.

3) Since the neutron synthesis is irreconcilably incompatible with quantum mechanics on a variety of established grounds, serious studies of nuclear syntheses requires the use of a covering mechanics specifically constructed for the task at hand.

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