Foundations of Hadronic Chemistry

With Applications to New Clean Energies and Fuels

by

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This monograph is dedicated to

Professor **T. Nejat Veziroglu**,
Director,
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and
Editor in Chief,
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Elsevier Science, Oxford, England,

because his commitment to scientific democracy for qualified inquiries and his impeccable editorial processing have permitted the birth of the new discipline presented in this monograph.

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Preface

A Physicist's Perspective on the Insufficiencies and Generalizations of Quantum Chemistry

My Undergraduate and Graduate Studies in Italy on the Insufficiencies of Quantum Mechanics and Chemistry

I was first exposed to quantum chemistry during my undergraduate courses in physics at the University of Naples, Italy, in the late 1950s. My teacher was Prof. Bakunin, a well known lady chemist in Europe at that time, who escaped from Russia with her family during the advent of communism. My three exams with her (inorganic chemistry, organic chemistry, and laboratory chemistry) were, by far, the most difficult exams of my life (although I did please Prof. Bakunin during the examinations).

Besides chemistry, during my undergraduate studies I plunged into the study of physics, with particular reference to quantum mechanics and its mathematical structure. My mathematics teacher was Prof. Caccioppoli, one of the most famous Italian mathematicians of that time, who taught me the necessity of advanced mathematics for quantitative physical studies.

By reading the works of the founders of contemporary physics, it was easy for me to see the lack of final character of quantum mechanics already in these undergraduate studies.

For instance, I was impressed by Enrico Fermi (whose departure in 1954 was still felt in the physics classrooms of the late 1950s) when in p. 111 of his celebrated *Nuclear Physics* (University of Chicago Press, 1950) he states:

> *"there are doubts as to whether the usual concepts of geometry hold for such small region of space (those of nuclear forces)."*

I subsequently spent several years of my research life to construct geometries, which are more suitable to represent the complexity of the nuclear forces because physics can indeed be reduced to primitive geometrical notions.

Equally inspiring was the teaching of Emilio Segre, Victor Weisskopf and other leading scientists of the time when they showed the impossibility for quantum mechanics to achieve an exact representation of total nuclear magnetic moments of *all* nuclei, rather than that of the deuteron alone (impossibility still in full existence today) because of apparent "alterations" of the intrinsic characteristics of protons and neutrons in the transition from their condition in vacuum (which have been used for their detection until now) to the novel conditions when members of a nuclear structure.

For instance, I still remember vividly my first reading of the statement by Blatt and Weisskopf in their *Theoretical Nuclear Physics* (John Wiley & Sons, first edition, 1952) in the section on nuclear magnetic moments (page 31 of the 1963 edition):

> *"It is possible that the intrinsic magnetism of a nucleon is different when it is in close proximity to another nucleon."*

It was easy to see since my undergraduate studies the impossibility for quantum mechanics to represent the alteration of an *intrinsic* characteristic of a particle as stable as the proton, thus mandating a generalization of the theory. I subsequently spent years of my research life studying the problem and did indeed achieve more recently an exact representation of *all* total nuclear magnetic moments, thanks to the hadronic generalization of quantum mechanics at the foundation of this monograph (see later on footnotes 1 and 6 of this Preface and Vol. III of Refs. [9]).

I was also impressed by the *"lack of completion" of quantum mechanics* voiced by Einstein, Podolsky and Rosen (Phys. Rev. **47**, 777, 1935) which I was reading in epistemological books circulating in Italy at that time. In fact, I subsequently spent decades of my research life to identify an appropriate and consistent "completion" of quantum mechanics. The entire contents of this monograph, beginning with the contents of this Preface, can be considered a study on the completion of quantum mechanics and, therefore, of quantum chemistry.

I still remember articles in the Italian newspapers of my college years debating the numerous doubts expressed by Albert Einstein (then still alive, since he died in 1955) on the lack of deterministic character of quantum mechanics.

I felt the expression of these basic doubts to be the ultimate manifestation of teaching as well as of science, because it stimulates minds of all ages. I did and still feel ascientific any teaching or textbook presenting a discipline as the end of the scientific adventure in the field.

In my undergraduate studies of the history of science, I saw the evidence that *science will never admit final theories.* I therefore acquired the conviction that the *belief on the terminal character of a given discipline is purely political-nonscientific.* True scientists can indeed debate the way in which a given theory should be generalized, but questioning, obstructing, or jeopardizing qualified technical studies on broader theories is scientific dishonesty. After all, history teaches that studies on the generalization of existing theories are always productive, irrespectively of whether successful or not, while their suppression is manifestly sterile.

As is well known and lamented by various scholars, in the remaining decades of the 20-th century, physics and chemistry evolved into a form of scientific religion because of the lack of proper treatment of historical doubts recalled above. Jointly, we have passed from the momentous discoveries of the first half of the 20-th century to a virtually stagnating scientific scene. On my part, I always ignored these political trends in science and remained always faithful to the historical doubts on the final character of quantum mechanics[1].

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[1]It is important for the reader to understand how valid said doubts remain to this day. Consider, for instance, the problem of the total nuclear magnetic moments addressed by Segre, Weisskopf, and others. The unadulterated use of quantum mechanics and the value of the intrinsic magnetic moments of protons and neutrons as measured when in vacuum, miss about 3.8% of the experimental value of the magnetic moment of the simplest possible nucleus, the deuteron, when in its ground state. The error becomes bigger in heavier nuclei, to assume very large values for heavy nuclei such as the Zirconium. Various recent papers and monographs claim the reduction of the error for the deuteron down to 1% for nonrelativistic treatments and claim essentially smaller errors for relativistic corrections. However, these claims demand the mixing of three or more energy levels of the deuteron, thus losing scientific credibility (no matter how authoritative the source) for various reasons, such as: 1) the experimental value of the magnetic moment of the deuteron is measured for its *ground state*, and definitely not for a mixture of different energy states; 2) the claims assume the joint existence of different energy levels without any emission or absorption of quanta, thus violating basic laws of quantum mechanics; 3) the reduction of the unsolved problem to quarks *multiplies* the inconsistencies, rather than reduces them, as we shall see later on in this Preface. At any rate, assuming that the above manipulations (perpetrated in the intent of preserving at whatever cost a beloved theory against basic advances) are indeed successful in representing the magnetic moment of the deuteron, can *the same manipulations work for the remaining nuclei, such as the Copper, the Gadolinium or the Zirconium?* Any scholar with a minimum of ethical standards must answer in the negative, thus confirming that, on real scientific grounds without academic politics, quantum mechanics *cannot* represent *exactly* the magnetic ,moments of *all* nuclei. Quantum mechanics certainly remains valid, but only as a first approximation of an expected more adequate theory. Numerous additional insufficiencies and inconsistencies not reported here for brevity (see papers [12]) imply beyond *credible* doubts that quantum mechanics *cannot* be exactly for the nuclear structure, thus requiring a suitable generalization.

As the reader will see, the novel hadronic mechanics and chemistry presented in this monograph see their ultimate inspiration and guidance, first, on the teaching of Lagrange, Hamilton and Jacobi, and, second, on the more recent teaching by Fermi, Segre, Weisskopf, Einstein, and numerous other founders of contemporary science (see later).

Upon the completion of my undergraduate studies in Naples, in the early 1960s I initiated my graduate studies in physics at the University of Turin, Italy, with the specific intent of dedicating my research life to the structural generalization of quantum mechanics. An outline of my early studies appears to be significant for this monograph.

The foundations of quantum mechanics are given by Lie's theory in its operator realization on a Hilbert space $\mathcal{H}$ over the field $\mathbb{C}$ of complex numbers, which is characterized by the celebrated *Heisenberg's representation* in finite and infinitesimal forms

$$A(t) = U \times A(0) \times U^\dagger = e^{i \times H \times t} \times A(0) \times e^{-i \times t \times H}, \tag{1a}$$

$$i \frac{dA}{dt} = [A, B]_{\text{operator}} = A \times H - H \times A, \tag{1b}$$

$$U = e^{i \times H \times t}, \quad U \times U^\dagger = U^\dagger \times U = I, \tag{1c}$$

with the complementary *Schrödinger representation*

$$H(r, p) \times |\psi\rangle = E \times |\psi\rangle, \tag{2a}$$

$$p_k \times |\psi\rangle = -i \times \hbar \times \partial_k |\psi\rangle, \tag{2b}$$

and classical counterpart given by the celebrated *Hamiltonian mechanics*

$$A(t) = e^{-t \times (\partial H / \partial r^k) \times (\partial / \partial p_k)} \times A(0) \times e^{t \times (\partial / \partial r^k) \times (\partial H / \partial p_k)}, \tag{3a}$$

$$\frac{dr^k}{dt} = \frac{\partial H(t, r, p)}{\partial p_k}, \quad \frac{dp_k}{dt} = -\frac{\partial H(t, r, p)}{\partial r^k}. \tag{3b}$$

$$\frac{dA}{dt} = [A, H]_{\text{classical}} = \frac{\partial A}{\partial r^k} \times \frac{\partial H}{\partial p_k} - \frac{\partial H}{\partial r^k} \times \frac{\partial A}{\partial p_k}. \tag{3c}$$

where $\times$ represents the conventional associative product.

In this way, *Lie groups* are realized by the finite time evolutions (1a) and (3a), while *Lie algebras* are realized by the brackets $[A, B]$ of the infinitesimal forms.

A dominant physical characteristic at both classical and operator levels is that the antisymmetric character of brackets $[A, B]$ implies the familiar *conservation laws of total physical quantities*, such as that of the total energy

$$i \times \frac{dH}{dt} = [H, H] = H \times H - H \times H = 0. \tag{4}$$

The starting point of my research (which I realized since the early days of my graduate studies) was the clear insufficiency of the above theory for the representation of *nonconservative systems*, trivially, because the emphasis of quantum mechanics is on *total conservation laws*, while the systems considered need *time-rate-of-variations of physical quantities*, such as the energy, linear momentum, angular momentum, *etc*[2].

In my first paper [1] of 1967 (which was part of my Ph.D. thesis, see also [2]) I submitted the following generalization (I call "lifting") of Heisenberg's representation

$$A(t) = U \times A(0) \times W^\dagger = e^{i \times H \times q \times t} \times A(0) \times e^{-i \times t \times p \times H}, \quad H = H^\dagger, \quad (5a)$$

$$\begin{aligned} i\, dA/dt = (A, B)_{\text{operator}} &= p \times A \times H - q \times H \times A = \\ &= m \times (A \times B - B \times A) + n \times (A \times B + B \times A) = \\ &= m \times [A, B] + n \times \{A, B\}, \end{aligned} \quad (5b)$$

where: the right and left operators U, W are now different, $p = m + n$, $q = m - n$ and $p \pm q$ are non-null *parameters*, with lifting of classical Hamiltonian mechanics [3]

$$\begin{aligned} A(t) = \left[e^{-t \times q \times (\partial H/\partial r^k) \times (\partial/\partial p_k)}\right] \times \\ \times A(0) \times \left[e^{t \times p \times (\partial/\partial r^k) \times (\partial H/\partial p_k)}\right], \end{aligned} \quad (6a)$$

$$\frac{dr^k}{dt} = p \times \frac{\partial H(t, r, p)}{\partial p_k}, \quad \frac{dp_k}{dt} = -q \times \frac{\partial H(t, r, p)}{\partial r^k} \quad (6b)$$

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[2]Dissipative nuclear models and other theories representing dissipation via "imaginary potentials" in the Hamiltonian were initiated in the first half of the 20-th century and are still of widespread use nowadays. These theories are afflicted by problems of physical consistency so severe to prevent serious scientific applications. In this case the Hamiltonian is *nonhermitean*, $H = p^2/2m + i \times V \neq H^\dagger$; then, the Lie group (1a) becomes $A(t) = \{e^{i \times H \times t}\} \times A(0) \times \{e^{-i \times t \times H^\dagger}\}$; and Lie brackets (1b) are generalized into the triple system $idA/dt = [A, H, H^\dagger] = A \times H^\dagger - H \times A$. It then follows that dissipative models with "imaginary potentials" lose *all algebras* in the brackets of the time evolution, let alone all Lie algebras (because algebras, as currently understood in mathematics, require *bilinear* brackets verifying certain basic axioms). Under these conditions, words such as "neutrons" and "protons" are deprived of any physical meaning, because of: the impossibility of introducing the SU(2) symmetry necessary for the characterization of the spin; the violation of the Poincare symmetry necessary for the correct definition of the mass; and numerous additional flaws. Above all, quantities to be measured, such as the nonconserved energy H, are no longer observable (because non-Hermitean). On the contrary, the studies presented herein are based on the requirement that *all nonconserved quantities to be measured must be Hermitean as a necessary condition for observability* (see Sect. 1.7, Chapter 1, for additional inconsistencies of pre-existing nonconservative theories and Sect. 2.10, Chapter 1, for their resolution).

$$\frac{dA}{dt} = (A, H)_{\text{classical}} = p \times \frac{\partial A}{\partial r^k} \times \frac{\partial H}{\partial p_k} - q \times \frac{\partial H}{\partial r^k} \times \frac{\partial A}{\partial p_k}. \tag{6c}$$

Since the new brackets (A, B) *are not* antisymmetric by conception, they are indeed suitable to represent the *nonconservation (or time-rate-of-variation) of the energy*

$$i \times \frac{dH}{dt} = (H, H) = (p - q) \times H \times H \neq 0. \tag{7}$$

As one can see, the main idea of papers [1-3] is that *the Hamiltonian remains fully Hermitean, thus observable, while its nonconservation is characterized by the generalized mathematical structure of the theory.*

Evidently, the latter theory is no longer Lie. Nevertheless, brackets (A, B) remain bilinear, thus characterizing a consistent algebra which results in verifying the axioms of the covering *Lie-admissible algebras* first identified by the American mathematician A.A. Albert, although without specific realizations. A generic nonassociative algebra with brackets (A, B) is said to be Lie-admissible when the attached antisymmetric brackets are Lie,

$$[A\hat{,}B] = (A, B) - (B, A) = \text{Lie}, \tag{8}$$

(see Sect. 1.7 of Chapter 1 for details).

This means that, even though non-Lie, the new time evolutions preserve a well defined Lie content, as necessary for a *covering theory*. It turns out that the new theory also admits a well defined content of *Jordan algebras* because the attached symmetric brackets are Jordan

$$\{A\hat{,}B\} = (A, B) + (B, A) = \text{Jordan}. \tag{9}$$

The above structure realized, for the first time to my knowledge, Jordan's search for physical applications of his algebras. Regrettably, Refs. [1, 2, 3] on the first (p, q)-deformations of Lie's theory dating back to 1967 are generally ignored in the rather vast contemporary literature on the simpler q-deformations.

My Proposal at Harvard University to Construct the Hadronic Generalization of Quantum Mechanics under DOE Support

In 1967 I emigrated with my wife and daughter to the USA, where I soon discovered that, being still vastly unknown at that time in *mathematical*, let alone physical circles, Lie-admissible algebras were not conducive to my locating an academic position. I therefore dedicated myself to a decade of publishing a variety of papers on research lines fully conventional for the time.

In 1978, while at Harvard University, I resumed the research significant for this monograph, thanks to financial support from the U.S. Department of Energy, which I still remember with gratitude today. In fact, in 1978 I proposed [4] the construction of a generalization of quantum mechanics specifically built for a representation of hadrons as they are in the physical reality: extended, nonspherical, and deformable charge distributions possessing some of the highest densities measured in laboratory until now.

I suggested for the new mechanics the name of *hadronic mechanics* to indicate its primary application, the study of strongly interacting particles known as hadrons, with the understanding that the mechanics was expected to be equally applicable to other fields (in the same way as quantum mechanics for the atomic structure is also applicable to crystal and other fields).

Hadronic mechanics was subsequently studied by numerous authors among whom I indicate: S. Okubo, S. Adler, T. Gill, L. Lindesay, C. Wolf, and others in the USA; J. Ellis, M.E. Mavromatos, N. Nanopoulos at CERN, and others in Switzerland; J.V. Kadeisvili, Yu. Arestov and A.K. Aringazin in the USSR; R. Mignani, M. Gasperini, F. Cardone and others in Italy; A. Jannussis, F. Brodimas, C.N. Ktorides, and others in Greece; J. Lohmus, E. Paal, L. Sorgsepp and others in Estonia; D. Schuch, C.A.C. Dreismann and others in Germany; N. Ntibashirakandi, D.K. Callebaut, and others in Denmark; E. Trell and others in Sweden; D. Rapoport-Campodonico and others in Argentina; M. Nishioka and others in Japan; A.O.E. Animalu and others in Africa; M. Mijatovic, B. Veljanovski, and others in Yugoslavia; and others (see Vol. II of monographs [9] for comprehensive listings)[3].

The original proposal of 1978 was based on the following main generalizations:

I) General Lie-admissible Lifting, which can be expressed via the following generalization of Heisenberg's representation [4]

$$A(t) = U \times A(0) \times W^{\dagger} = e^{i \times H \times Q \times t} \times A(0) \times e^{-i \times t \times P \times H}, \qquad (10a)$$

$$i\,\frac{dA}{dt} = (A \hat{,} H)_{\text{operator}} = A < H - H > A = A \times P \times H - H \times Q \times A =$$

[3]The studies on hadronic mechanics have resulted to date in some 2,000 papers, about 20 monographs and some 40 volumes of conference proceedings for over 10,000 pages of research published in America, Europe, and Asia.

$$= (A \times T \times H - H \times T \times A) + (A \times W \times H + H \times W \times A) = \\ = [A\hat{,}H] + \{A\hat{,}H\}, \tag{10b}$$

$$H = H^{\dagger}, \quad P = Q^{\dagger}, \tag{10c}$$

where $P = T + W$, $Q = T - W$ and $P \pm Q$ are nonsingular operators (or matrices), with complementary *lifting of the Schrödinger representation* [5]

$$H(r,p) > |\hat{\psi}\rangle = H(r,p) \times Q \times |\hat{\psi}\rangle = E \times |\hat{\psi}\rangle, \tag{11a}$$

$$\langle\hat{\psi}| < H = \langle\hat{\psi}| \times Q \times H(r,p) = \langle\hat{\psi}| \times E', \quad E' \neq E, \tag{11b}$$

and classical counterparts [4]

$$A(t) = \left[e^{-t \times (\partial H/\partial r^j) \times Q_i^j \times (\partial/\partial p_i)}\right] \times \\ \times A(0) \times \left[e^{t \times (\partial/\partial r^j) \times P_i^j \times (\partial H/\partial p_i)}\right], \tag{12a}$$

$$\frac{dr^k}{dt} = P_i^k(t,r,p) \times \frac{\partial H(t,r,p)}{\partial p_i}, \\ \frac{dp_k}{dt} = -Q_k^i(t,r,p) \times \frac{\partial H(t,r,p)}{\partial r^i}, \tag{12b}$$

$$\frac{dA}{dt} = (A\hat{,}H)_{\text{classical}} = \frac{\partial A}{\partial r^i} \times P_j^i \times \frac{\partial H}{\partial p_j} - \frac{\partial H}{\partial r^i} \times Q_j^i \times \frac{\partial A}{\partial p_j}, \tag{12c}$$

under the condition that the antisymmetric brackets $[A\hat{,}B] = (A\hat{,}B) - (B\hat{,}A)$ are Lie and the symmetric operator brackets $\{A\hat{,}B\} = (A\hat{,}B) + (B\hat{,}A)$ are Jordan.

The needs to generalize the parameter into the operator form of Lie-admissible theories were numerous. First, Lie-admissible theory (5) clearly offered no possibility for a genuine lifting of Schrödinger's representation, while the broader theory (10) did admit the nontrivial liftings (11).

Also, the time evolution of the former, Eqs. (5a), is clearly *nonunitary*,

$$U = e^{i \times H \times p \times t}, \quad W = e^{i \times t \times q \times H}, \quad U \times W^{\dagger} \neq I. \tag{13}$$

It is a useful exercise for the reader interested in studying the new chemistry to prove that the application of time evolution (5a) to itself yields precisely the operator time evolution (10). In turn, the application of the latter time evolution to itself preserves the Lie-admissible structure (although with different values of P and Q).

This is a confirmation of the fact that brackets $(A\hat{,}B)$ are the most general possible bilinear nonassociative brackets [because they are the most general possible combination of antisymmetric and symmetric brackets, as shown in Eqs. (10b)].

As a result, dynamical equations (10) are "directly universal," that is, inclusive of all infinitely possible theories with an algebra in the brackets of the time evolution directly in the coordinate frame of the experimenter.

The representation of time-rate-of-variations of nonconserved quantities is evidently of the type

$$i \times \frac{dH}{dt} = (H\hat{,}H) = H < H - H > H = H \times P \times H - H \times Q \times H \neq 0. \quad (14)$$

In particular, *Lie-admissible theories (10)-(14) are structurally irreversible, that is, irreversible for reversible Hamiltonians.*

II) General Lie-Isotopic lifting. While studying theory (10)-(14), I realized back in 1978 that the attached antisymmetric algebra *is not* characterized by the conventional Lie brackets $[A, B] = A \times B - B \times A$, but instead by the more general brackets

$$[A\hat{,}B] = (A, B) - (B, A) = A \times T \times B - B \times T \times A, \quad (15a)$$

$$T = P + Q = P^\dagger + Q^\dagger = Q + P = T^\dagger, \quad (15b)$$

which brackets verify the abstract Lie axioms although in a generalized form.

I therefore called the latter theory an *isotopy* of Lie's theory from the Greek meaning of being "axiom-preserving" [4]. I called the full Lie-admissible theory (10)-(13) a *genotopy* of Lie's theory [4] from the Greek meaning of being "axiom inducing."

The corresponding mechanics were called *isomechanics* and *genomechanics*, while the mathematics needed for the treatment of the corresponding theories were called *isomathematics* and *genomathematics*, respectively.

As a result of the latter property, in memoirs [4] of 1978 I proposed the following *Lie-isotopic lifting of Heisenberg's representation*

$$A(t) = U \times A(0) \times U^\dagger = [e^{i \times H \times T \times t}] \times A(0) \times [e^{-i \times t \times T \times H}], \quad T = T^\dagger, \quad (16a)$$

$$i \frac{dA}{dt} = [A\hat{,}H]_{\text{operator}} = A \hat{\times} H - H \hat{\times} A = A \times T \times H - H \times T \times A, \quad (16b)$$

where T is a nonsingular operator (or matrix), with corresponding lifting of Schrödinger's equation

$$H(r, p) \times T \times |\hat{\psi}\rangle = E \times |\hat{\psi}\rangle, \quad \langle\hat{\psi}| \times T \times H(r, p) = \langle\hat{\psi}| \times E, \quad (17)$$

and classical counterparts

$$A(t) = e^{-t\times(\partial H/\partial r^j)\times T_i^j\times(\partial/\partial p_i)} \times A(0) \times e^{t\times(\partial/\partial r^j)\times T_i^j\times(\partial H/\partial p_i)}, \quad (18a)$$

$$\frac{dr^k}{dt} = T_i^k(t,r,p) \times \frac{\partial H(t,r,p)}{\partial p_i}, \quad \frac{dp_k}{dt} = -T_k^i(t,r,p) \times \frac{\partial H(t,r,p)}{\partial r^i}, \quad (18b)$$

$$\frac{dA}{dt} = [A\hat{,}H]_{\text{classical}} = \frac{\partial A}{\partial r^i} \times T_j^i \times \frac{\partial H}{\partial p_j} - \frac{\partial H}{\partial r^i} \times T_j^i \times \frac{\partial A}{\partial p_j}. \quad (18c)$$

A dominant feature of the isomechanics is that of characterizing conventional total conservation laws in view of the antisymmetric character of the brackets, e.g.,

$$i \times \frac{dH}{dt} = H\hat{\times}H - H\hat{\times}H = H \times T \times H - H \times T \times H \equiv 0. \quad (19)$$

The theory is therefore suitable to represent *closed-isolated systems with conventional total conservation laws.*

Nevertheless, the theory is not purely Hamiltonian. In fact, it requires *two operators for the characterization of systems*, the conventional Hamiltonian $H = p^2/2m + V$ plus the new operator T. I therefore assumed that the conventional Hamiltonian represents all conventional potential interactions, while the operator T represents *new interactions not derivable from a potential.*

Note that *the above features imply a new notion of bound state with conventional total conservation laws, yet internal forces that are both conservative and nonconservative.* We merely have internal exchanges of energy, angular momentum and all other physical quantities, but always in such a way that the total quantities are conserved, the systems being isolated.

A classical example is given by the structure of Jupiter (considered isolated from the rest of the Solar system) which evidently verifies the conservation of the total angular momentum, yet one can directly observe via telescopes internal vortices with *varying angular momenta*. In my monograph on theoretical mechanics published by Springer-Verlag [14] I then used classical Hamiltonian mechanics for the study of planetary systems, and its isotopic covering for the study of the structure of individual planets.

Operator examples of closed-isolated non-Hamiltonian systems studied in my monograph [9] published by the Ukraine Academy of Sciences are given by hadrons, nuclei, or stars owing to their hyperdense structure which renders them conceptually equivalent to Jupiter. I used quantum mechanics for the study of the atomic structure and the covering hadronic mechanics for the structure of hadrons, nuclei, and stars. At any rate, the belief that the hadronic constituents can freely move within the hyperdense hadronic medium in the core of a star as the atomic constituents do, has no scientific credibility [12].

III) General, multi-valued Lie-admissible and Lie-isotopic liftings. More recently, by applying to my own studies the belief of the lack of final character of any theory, I realized that, despite their remarkable generality, theory (10)-(14) was still insufficient to represent complex systems such as biological structures, because recent studies have shown that they generally require irreversible and *multivalued* formulations.

I therefore proposed the still more general lifting of Lie-admissible theories into their multi-valued covering form [6]

$$A(t) = U \times A(0) \times U^\dagger = e^{i \times H \times \{Q\} \times t} \times A(0) \times e^{-i \times t \times \{P\} \times H}, \quad P = Q^\dagger, \quad (20a)$$

$$\begin{aligned} i\, dA/dt = (A\hat{;}H)_{\text{operator}} &= A\{<\}H - H\{>\}A = \\ &= A \times \{P\} \times H - H \times \{Q\} \times A = \\ &= (A \times \{T\} \times H - H \times \{T\} \times A) + \\ &+ (A \times \{W\} \times H + H \times \{W\} \times A) = [A\hat{;}H] + \{A\hat{;}H\}, \end{aligned} \quad (20b)$$

$$\{P\} = \{P_1, P_2, P_3, \ldots\}, \quad \{Q\} = \{Q_1, Q_2, Q_3, \ldots\}, \quad (20c)$$

where $\{P\}$, $\{Q\}$ and $\{P \pm Q\}$ are now nonsingular (ordered) *sets* of operators (or matrices), with complementary lifting of Schrödinger's equations

$$H(r,p) \times \{P\} \times |\{\hat{\psi}\}\rangle = \{E\} \times |\{\hat{\psi}\}\rangle, \quad (21a)$$

$$\langle\{\hat{\psi}\}| \times \{Q\} \times H(r,p) = \langle\{\hat{\psi}\}| \times \{E\}, \quad (21b)$$

and classical counterparts [*loc. cit.*]

$$A(t) = \left[e^{-t \times (\partial H/\partial r^j) \times \{Q\}_i^j \times (\partial/\partial p_i)}\right] \times \quad (22a)$$

$$\times A(0) \times \left[e^{t \times (\partial/\partial r^j) \times \{P\}_i^j \times (\partial H/\partial p_i)}\right], \quad (22a)$$

$$\begin{aligned} \frac{dr^k}{dt} &= \{P\}_i^k(t,r,p) \times \frac{\partial H(t,r,p)}{\partial p_i}, \\ \frac{dp_k}{dt} &= -\{Q\}_k^i(t,r,p) \times \frac{\partial H(t,r,p)}{\partial r^i}, \end{aligned} \quad (22b)$$

$$\frac{dA}{dt} = (A\hat{;}H)_{\text{classical}} = \frac{\partial A}{\partial r^i} \times \{P\}_j^i \times \frac{\partial H}{\partial p_j} - \frac{\partial H}{\partial r^i} \times \{Q\}_j^i \times \frac{\partial A}{\partial p_j}. \quad (22c)$$

under the condition again that the attached antisymmetric (operator symmetric) brackets are of Lie (Jordan) type although in a broader multi-valued version.

The existence of the multi-valued Lie-isotopic particularization of the above theory is evident and will be implied hereon.

The Forgotten Historical Legacy of Lagrange, Hamilton, and Jacobi on the Origin of Irreversibility

There is little doubt that one of the most fundamental open problems of contemporary physics, directly relevant to chemistry, is an axiomatically consistent representation of the *irreversibility* of numerous physical and chemical systems.

The problem is created by the fact that quantum mechanics is structurally *reversible* in time, namely, the time reversal image of systems are as physical as the original systems. This feature is certainly verified for the systems for which quantum mechanics was built for, the atomic structure. However, the belief that the entire microscopic world is as irreversible as electron orbits is purely nonscientific.

Moreover, all action-at-a-distance, potential forces identified so far and, thus, all possible Hamiltonians, are also reversible. These features are in manifest disagreement with the evidence of the irreversibility of nature.

In view of the above occurrences, a virtually endless number of studies have been conducted during the 20-th century in the dream of reconciling the irreversibility of reality with the reversibility of quantum mechanics.

Even though I respected these studies, I never accepted them, and followed a basically different approach since my Ph.D. studies in physics.

In essence, I always accepted the exact validity of quantum mechanics for the conditions for which it was constructed, the description of *stable-reversible orbits of electrons in the structure of the hydrogen atom.*

However, the belief that the same discipline is equally exact for the dramatically different conditions of electrons in the core of a collapsing star, is so farfetched, to constitute the negation of science. In fact, the belief necessarily implies the local stability of electrons moving within hyperdense media with consequential local conservation of the angular momenta (from a pillar of the theory, the rotational symmetry), thus accepting in its totality the existence of the perpetual motion.

While my contemporaries attempted to adapt the irreversible physical reality to a beloved theory, I adopted the opposite approach of adapting the theory to physical reality. I therefore initiated the search of a generalization of quantum mechanics suitable to represent irreversibility.