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A Gist of Comprehensive Review of Hadronic Chemistry and its Applications[1]

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Abstract. 20th century theories of Quantum Mechanics and Quantum Chemistry are exactly valid only when considered to represent the atomic structures. While considering the more general aspects of atomic combinations these theories fail to explain all the related experimental data from first unadulterated axiomatic principles. According to Quantum Chemistry two valence electrons should repel each other and as such there is no mathematical representation of a strong attractive forces between such valence electrons. In view of these and other insufficiencies of Quantum Chemistry, an Italian-American Scientist Professor Ruggero Maria Santilli during his more than five decades of dedicated and sustained research has denounced the fact that quantum chemistry is mostly based on mere nomenclatures. Professor R M Santilli first formulated the iso-, geno- and hyper- mathematics [1, 2, 3, 4] that helped in understanding numerous diversified problems and removing inadequacies in most of the established and celebrated theories of 20th century physics and chemistry. This involves the isotopic, genotopic, etc. lifting of Lie algebra that generated Lie admissible mathematics to properly describe irreversible processes. The studies on Hadronic Mechanics in general and chemistry in particular based on Santilli's mathematics[3, 4, 5] for the first time has removed the very fundamental limitations of quantum chemistry [2, 6, 7, 8]. In the present discussion, a comprehensive review of Hadronic Chemistry is presented that imparts the completeness to the Quantum Chemistry via an addition of effects at distances of the order of 1 fm (only) which are assumed to be *Non-linear, Non-local, Non-potential, Non-hamiltonian and thus Non-unitary*, stepwise successes of Hadronic Chemistry and its application in development of a new chemical species called *Magnecules*.

Keywords: Quantum Mechanics, Hydrogen bonding, Nonlinear or nonlocal theories and models, Iso-Mathematics, Magnecules
PACS: 03.65.-w;82.30.Rs; 11.10.Lm;

INTRODUCTION

Following almost a century Quantum Chemistry was unable to represent most of the molecular data and could never explain the exact representation of attractive forces mathematically. In comparison hadronic chemistry permitted the first exact and invariant representation of molecular binding energies and other data from the first principle without adhoc adulteration of basic axioms. In HMMC-I [3] some additional inconsistencies have been spelled out and denounced which are truly embarrassing, such as - it does not characterize an attractive force among neutral atoms of hydrogen molecule; why hydrogen and water molecules admit only two H-atoms and not three or more; characteristics like binding energy, electric and magnetic dipole and multi-pole moments of hydrogen and other molecules have not been represented accurately; and the basis of introduction of an arbitrary function to describe screening of coulomb potential between two electrons to arrive at a more accurate numerical representation of molecular binding energies and other data. Moreover, the unitary structural departure of theory from the basic axioms of quantum mechanics and chemistry could not be justified; a larger percentage are missing in the representations of electric and magnetic moments, sometimes even have wrong signs; the absence of explanation for electron 'correlation energy', etc.

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More so the quantum chemistry is structurally linear theory, thus representing complex multi-body systems via the factorization of the total wave function into its individual components which requires the adoption of the superposition principle as a prerequisite for its consistency. However, multi-body systems like water molecules are nonlinear for which the superposition principle is inapplicable, with consequential impossibility of formulating a consistent factorization that reveals the inability of quantum chemistry to rationally deal complex structures.

The synthesis of water molecule is structurally irreversible process whereas quantum chemistry is a reversible theory indicating the possibility of spontaneous decay of water molecule which became a serious drawback of the theory.

Beside all these limitations quantum chemistry admits an additional rather crucial limitation given by poor convergence of the perturbation series. That is, water molecule and other complex structures require Gaussian and other methods, all based on expansions whose calculations require the use of computers due to their complexities. The insufficiency here referred to is given by the fact that the time required for basic calculations even on large computers is generally excessive, thus implying an inherent lack of strong convergence of the underlying perturbation series, with consequential debatable accuracies.

All these limitations motivated Santilli [9] to construct, first, the covering of quantum mechanics known as *hadronic mechanics,* and, subsequently, the corresponding covering of quantum chemistry known as *hadronic chemistry* [1] and these names are nowadays internationally known.

HADRONIC CHEMISTRY

According to the original literature of Santilli [8] *Hadronic Chemistry* is a diversified discipline with the following main branches:

- **ISOCHEMISTRY:** characterized by a Lie-isotopic, time invariant, axiom-preserving, non-unitary covering of quantum chemistry formulated over Hilbert-Santilli isospaces over Santilli isofields for the representation of *isolated and reversible chemical structures and processes*;

- **GENOCHEMISTRY:** characterized by a Lie-admissible, time irreversible covering of isochemistry formulated on Hilbert-Santilli genospaces over Santilli genofields for the representation of *irreversible chemical structures and processes*;

- **HYPERCHEMISTRY:** characterized by a multi-valued covering of genochemistry for the representation of *multi-valued organic structures and processes*;

- **ISODUALS of ISO-, GENO-, and HYPER-CHEMISTRY:** characterized by the isodual (anti-Hermitean) map of iso-, geno-, and hyper-chemistry for the description of the *antimatter chemical structures and processes*.

For detailed historical and technical descriptions on hadronic chemistry, the reader is advised to study the monograph [1], scientific summary [10] and original papers quoted therein.

In Hadronic Chemistry one studies the completion of quantum mechanics and chemistry via the addition of effects at distances of the order of 1 fm (only) which are assumed to be - (1) *Nonlinear*: the dependence of operators on powers of the wave functions greater than one; (2) *Nonlocal*: dependence on integrals over the volume of wave-overlapping that, as such, cannot be reduced to a finite set of isolated points; (3) *Nonpotential*: consisting of contact interactions caused by the actual physical contact of wavepackets at 1 *fm* mutual distance with consequential zero range, for which the notion of potential energy has no mathematical or physical meaning; (4) *Non-Hamiltonian structure*: lack of complete representability of systems via a Hamiltonian, thus requiring additional terms; and consequently (5) *Non-Unitary*: the time evolution violating the unitary condition $U \times U^{\dagger} = U^{\dagger} \times U = I$. Notice that the condition of non-unitarity is necessary, otherwise one would fall back fully within the class of unitary equivalence of basic axioms of quantum chemistry.

Santilli applied the mathematical structure of hadronic mechanics to chemical systems thereby achieving results amenable to exact representation of molecular data, precise experimental verifications and novel industrial applications.

This comprehensive review includes: (a) The First Success of Hadronic Chemistry: The Isochemical Model of the Hydrogen Molecule [6]; (b) The second Success of Hadronic Chemistry: Newly proposed isochemical structure of water molecule[8]; (c) The Third Success of Hadronic Chemistry: Industrial application of Hadronic Chemistry in formulating the basically new chemical species of Magnecule [8, 13, 14, 15]; (d) The Fourth Success of Hadronic Chemistry: Magnecular Combustion; and (e) the Fifth Success of Hadronic Chemistry: Intermediate Controlled
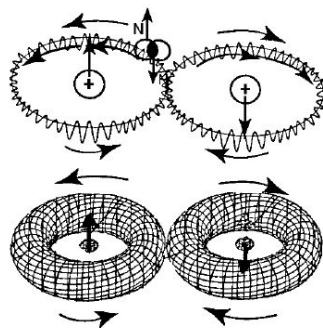
FIGURE 1. A view of isochemical model of the Hydrogen molecule at absolute zero degree temperature without any rotational degrees of freedom, with the Santilli-Shillady strong valence bond between the valence electrons pair into *isoelectronium* quasi-particle. Note the oo-shape orbital of the isoelectronium, thus allowing a representation of the diamagnetic character of the H-molecule since, under an external strong magnetic field, the two H atoms acquire parallel but opposite magnetic polarities with null value of the total magnetic field at sufficient distances. (see the monograph *Hadronic Mathematics, Mechanics and Chemistry* Volume V [8]).

Nuclear Synthesis (ICNS). Additionally, the aspects of Magnecular Combustion over that of the Molecular Combustion will be discussed in a brief.

First Success - Isochemical Model of the Hydrogen Molecule (1999)

According to quantum chemistry, the hydrogen molecule is a four body system comprising two protons and two electrons. Due to its four body character, the standard Schrödinger equation for hydrogen molecule, does not admit any analytic solution. Even on using variational method the outcome misses at least 2% of the binding energy; and predicts that the hydrogen molecule is paramagnetic due to the independence of the spin of electrons.

Thanks to the isochemical model of hydrogen molecule proposed by Santilli and Shillady [6] that for the first time represented the exact binding energy and other basic features on the hydrogen molecule. Also, the diamagnetic character of hydrogen molecule got apparently justified from the structure of isoelectronium as shown in figure 1. In isochemical Schrödinger equation generated after the isochemical lifting in hadronic chemistry, the new term of Hulthén potential appears, which is attributed to the strong Santilli-Shillady valence bond that absorbs all coulomb potentials. This Hulthén potential potential is much stronger than the columbic potential within the orbital overlap of short range distance of 1 fm (say).

Moreover, a fundamental implication of hadronic chemistry is that of restricting the four-body model of hydrogen molecule to a three-body structure, evidently composed of the two protons at mutual distance and the two valence electrons strongly bonded into the isoelectronium quasiparticle. Recall that Hulthén potential behaves at small distances like the coulomb one and therefore, there exist a strong bond between valence pairs. Thus, isochemical model of hydrogen molecule as a three-body system does admit an analytic solution that have been investigated in references [11, 12] in its restricted form.

Second Success - The Isochemical Model of Water Molecule (2000)

Subsequent to the successful study of hydrogen molecule using isochemical molecular model of *isoelectronium* [6]; Santilli and Shillady proposed their second historical study [7] of hadronic chemistry for debatable water molecule resulting from the first axiomatic unadulterated principles of binding energy, sign and values of electric and magnetic moments and other data. The hypothesis was that the two valence electrons, one per each pair of hydrogen and oxygen atoms, correlate themselves into a bonded singlet state at a short distance resulting in two *isoelectronia*, one per each H-O dimer. The bonding force between the two H- and O- atoms was justified by Hultén force between the two valence electrons in the *isoelectronia*. Therefore, the binding energy is characterized by two oo-shaped orbits of isoelectronia around the H-O-H nuclei and molecule itself is characterized by two isoelectronia, one per each H-O dimer. This then

renders the system of H-O dimer as a three body system (two protons of hydrogen atoms and two electrons strongly bound into an isoelectronium quasiparticle) with an exact solution.

A more accurate isochemical model of water molecule was given by a *five-body* system comprising the two H nuclei, the O atom assumed with all electrons concentrated in the nucleus except for two valence electrons, and two isoelectronia assumed as fully stable. This model admits no analytic solution, thus requiring variational or other approaches.

Third Success - The New Chemical Species of MAGNECULE

Keeping the needs of the society in view to contains the increasingly cataclysmic climactic events caused by global warming and other environmental problems originating from conventional fossil fuels containing valence bond, Professor Santilli proposed a basically new fuels [13, 14] admitting a complete combustion so as to release no toxic substances in the exhaust. The central assumption, is based on a bond much weaker than that of valence bonds so as to permit full combustion. For certain technical reasons the new species was submitted under the name of *Magnecules* in order to distinguish the species from the conventional *molecules* and the new species is known today as *Santilli Magnecules*. *Santilli Magnecules* in gases, liquids, and solids consist of stable clusters composed of conventional molecules, and/or dimers, and/or individual atoms bonded together by opposing magnetic polarities of toroidal polarizations of the orbits of at least the peripheral atomic electrons when exposed to sufficiently strong external magnetic fields, as well as the polarization of the intrinsic magnetic moments of nuclei and electrons. A population of *Magnecules* constitutes a chemical species when essentially pure, i.e., when molecules or other species are contained in very small percentages in a directly identifiable form [14].

The theoretical and experimental evidences of this new chemical species has been proved beyond any scientific doubt [15] and are being studied widely [17, 16, 18, 19, 20, 21, 22, 23, 24] which implies the prediction of the broader chemical species of hypermagnecules that apparently are more suitable to represent living organisms due to its inherent irreversibility, multidimensional structure compatible with our three-dimensional sensory perception, and other features needed for a more adequate representation of the complexities of living organisms [15].

Fourth Success - Santilli's Magnecular Combustion

In conventional molecular combustion usually the constituents of the original fuel undergo oxidation to form the new valence bonds between the reduced constituents of the fuel molecules. That means a significant amount of energy is used up in the separation of intermediate atomic constituents. Therefore, we get the less amount of energy than the expected calculations using the conventional molecular combustion. On the contrary, in magnecular combustion using *Santilli's Magnecular Fuels*[14] individual atoms are under a weak bond than a conventional valence bond and the energy required to separate the atomic constituents is conserved. Therefore, magnecular fuels yield an energy output greater than that of molecular fuels with the same atomic constituents. Although a few of the examples like methane combustion and a process of water synthesis are studied for their energetics using magnecular combustion, a lot of cases are needed to attend.

Fifth Success - Nuclear Energies without Radiations

The fifth and rather the most crucial success of Hadronic Chemistry is the *Nuclear Syntheses without the Harmful Radiations*[25]. It is a way out for systematic energy releasing nuclear synthesis whose reaction rate is controllable via one or more mechanisms capable of performing the engineering optimization of the applicable laws. The *Controlled Nuclear Syntheses* (CNS) is governed by Santilli's laws for controlled nuclear synthesis: (1) The orbitals of peripheral atomic electrons are controlled such that nuclei are systematically exposed; (2) CNS occurs when nuclei spins are either in singlet planar coupling or triplet axial coupling; (3) The most probable CNS are those occurring at threshold energies and without the release of massive particles; (4) CNS requires trigger, an external mechanism that forces exposed nuclei to come in femto-metre range. Magnecules have systematic and controlled exposure of nuclei which have singlet planar or triplet axial coupling. In case of Intermediate Controlled Nuclear Syntheses (ICNS) [25, 26], proposed by Prof. Santilli, energy supplied is of threshold value just sufficient to expose the atomic nuclei from within

the electron cloud. Since the energy is not very high production of ionizing radiations or sub-nuclear particles are avoided. ICNS [26] provides green path for fusion reaction but the reaction needs to be quantified using energetic parameters like reaction cross-section etc.

ACKNOWLEDGMENTS

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