Draft dated January 19, 2008

# HADRONIC MATHEMATICS, MECHANICS AND CHEMISTRY

Volume V: Experimental Verifications, Theoretical Advances and Industrial Applications in Chemistry

Ruggero Maria Santilli CV: http://www.i-b-r.org/Ruggero-Maria-Santilli.htm Institute for Basic Research P. O. Box 1577, Palm Harbor, FL 34682, U.S.A. ibr@gte.net, http://www.i-b-r.org http://www.neutronstructure.org http://www.magnegas.com

International Academic Press

#### Copyright ©2007 owned by Ruggero Maria Santilli P. O. Box 1577, Palm Harbor, FL 34682, U.S.A.

#### All rights reserved.

This book can be reproduced in its entirely or in part, or stored in a retrieval system or transmitted in any form, provided that the source and its paternity are identified fully and clearly. Violators will be prosecuted in the U. S. Federal Court and the lawsuits will be uploaded in the web site http://www.scientificethics.org

U. S. Library of Congress Cataloguing in publication data: Santilli, Ruggero Maria, 1935 -Foundations of Hadronic Mathematics Mechanics and Chemistry Volume II: Experimental Verifications, Theoretical Advances, and Industrial Applications in Chemistry with Bibliography and Index Additional data sup-plied on request

### INTERNATIONAL ACADEMIC PRESS

# Contents

| Fo | rewo        | rd               |   | vii |  |  |  |
|----|-------------|------------------|---|-----|--|--|--|
| Pr | eface       | face             |   |     |  |  |  |
| Le | egal Notice |                  |   |     |  |  |  |
| Ac | know        | vledgme          | ents  | XV  |  |  |  |
| 8. | EX          | PERIM            | ENTAL VERIFICATIONS AND   |     |  |  |  |
|    | API         | PLICAT           | TIONS IN SUPERCONDUCTIVITY  | 807 |  |  |  |
|    | 8.1         | 1 Introduction   |   |     |  |  |  |
|    | 8.2         | Anima<br>Verific | alu's Hadronic Superconductivity and its Experimental cation  | 808 |  |  |  |
|    | 8.3         | Novel            | Predictions of Animalu's Hadronic Superconductivity   | 816 |  |  |  |
|    | Refe        | erences          |   | 819 |  |  |  |
| 9. | EX          | PERIM            | ENTAL VERIFICATIONS AND   |     |  |  |  |
| -  | API         | PLICAT           | TIONS IN CHEMISTRY  | 821 |  |  |  |
|    | 9.1         | ISOC             | HEMICAL MODEL OF THE HYDROGEN MOLECULE  | 821 |  |  |  |
|    |             | 9.1.1            | Introduction  | 821 |  |  |  |
|    |             | 9.1.2            | Isochemical Model of Molecular Bonds  | 825 |  |  |  |
|    |             | 9.1.3            | The Limit Case of Stable Isoelectronium   | 834 |  |  |  |
|    |             | 9.1.4            | Isochemical Model of the Hydrogen Molecule with Stable Isoelectronium                                 | 840 |  |  |  |
|    |             | 9.1.5            | Exactly Solvable, Three-Body, Isochemical Model of the Hydrogen Molecule                              | 842 |  |  |  |
|    |             | 9.1.6            | Isochemical Model of the Hydrogen Molecule with<br>Unstable Isoelectronium                            | 845 |  |  |  |
|    |             | 9.1.7            | Gaussian Approximation of the Isochemical Model of the<br>Hydrogen Molecule as a Four-Body System     | 847 |  |  |  |
|    |             | 9.1.8            | Summary of the Results  | 852 |  |  |  |
|    |             | 9.1.9            | Concluding Remarks  | 855 |  |  |  |
|    | 9.2         | ISOC             | HEMICAL MODEL OF THE WATER MOLECULE   | 859 |  |  |  |
|    |             | 9.2.1            | Introduction  | 859 |  |  |  |
|    |             | 9.2.2            | Main Characteristics of the Water Molecule  | 865 |  |  |  |
|    |             | 9.2.3            | Exactly Solvable Model of the Water Molecule with Stable Isoelectronium                               | 869 |  |  |  |
|    |             | 9.2.4            | Gaussian Approximation of the Isochemical Model of the<br>Water Molecule with Unstable Isoelectronium | 873 |  |  |  |
|    |             | 9.2.5            | The Method  | 876 |  |  |  |

|     |   | 9.2.6            | The Main Results  | 879 |  |  |
|-----|---|------------------|---|-----|--|--|
|     |   | 9.2.7            | Conclusions   | 881 |  |  |
|     | 9.3 VARIATIONAL CALCULATIONS OF ISOCHEMICAL |                  |   |     |  |  |
|     |   | MODE             | ELS   | 883 |  |  |
|     |   | 9.3.1            | Introduction  | 883 |  |  |
|     |   | 9.3.2            | Aringazin-Kucherenko Study of the Restricted,<br>Three-Body Isochemical Model of the Hydrogen Molecule        | 883 |  |  |
|     |   | 9.3.3            | Aringazin Variational Study of the Four-Body Isochemical<br>Model of the Hydrogen Molecule                    | 889 |  |  |
|     | App   | endices          |   | 898 |  |  |
|     | 9.A   | Isoche           | mical Calculations for the Three-Body $H_2$ Molecule  | 898 |  |  |
|     | $9.\mathrm{B}$                              | Isoche           | mical Calculations for the Four-Body $H_2$ Molecule   | 900 |  |  |
|     | 9.C   | Exact            | Solution of the Restricted Three-Body Hydrogen Molecule   | 904 |  |  |
|     | 9.C.  | 1Introd          | uction  | 904 |  |  |
|     | 9.C.  | 2Confin          | ed Isoelectronium Approach  | 905 |  |  |
|     | 9.C.  | 3Exact           | Values from the Confined Isoelectronium Model   | 906 |  |  |
|     | 9.C.4                                       | 4Exact           | Values as Compared With KSM Ground State  | 909 |  |  |
|     | 9.C.  | 5Final 1         | Remark  | 910 |  |  |
|     | Refe  | rences           |   | 912 |  |  |
| 10. | . IND                                       | USTRI            | AL APPLICATIONS TO NEW  |     |  |  |
|     | CLE   | AN BU            | URNING, COST COMPETITIVE FUELS  | 917 |  |  |
|     | 10.1  | THE I            | NCREASINGLY CATACLYSMIC CLIMACTIC EVENTS  |     |  |  |
|     |   | FACIN            | IG MANKIND  | 917 |  |  |
|     |   | 10.1.1           | Foreword  | 917 |  |  |
|     |   | 10.1.2<br>10.1.3 | Origin of the Increasingly cataclysmic Climactic Events<br>Serious Environmental Problems Caused by Hydrogen. | 919 |  |  |
|     |   |                  | Natural Gas, Ethanol, Biogases and Fuels with Molecular   |     |  |  |
|     |   |                  | Structure   | 923 |  |  |
|     |   | 10.1.4           | Basic Needs for the Survival of Mankind   | 928 |  |  |
|     |   | 10.1.5           | Removing Carbon Dioxide from our Atmosphere and Car<br>Exhaust  | 929 |  |  |
|     | 10.2  | THE I            | NEW CHEMICAL SPECIES OF MAGNECULES  | 932 |  |  |
|     |   | 10.2.1           | Introduction  | 932 |  |  |
|     |   | 10.2.2           | The Hypothesis of Santilli Magnecules   | 934 |  |  |
|     |   | 10.2.3           | The Five Force Fields Existing in Polarized Atoms   | 937 |  |  |
|     |   | 10.2.4           | Numerical Value of Magnecular Bonds   | 939 |  |  |
|     |   | 10.2.5           | Production of Magnecules in Gases, Liquids and Solids   | 946 |  |  |

iv

| HADRO | NIC M         | ATHEMATICS, MECHANICS AND CHEMISTRY   | v    |
|-------|---------------|---|------|
|       | 10.2.6        | New Molecular Internal Bonds  | 951  |
|       | 10.2.7        | Main Features for the Detection of Magnecules   | 953  |
| 10.3  | THE U         | UNAMBIGUOUS DETECTION OF MOLECULES AND  |      |
|       | MAG           | NECULES   | 955  |
|       | 10.3.1        | Selection of Analytic Instruments   | 955  |
|       | 10.3.2        | Unambiguous Detection of Molecules  | 957  |
|       | 10.3.3        | Unambiguous Detection of Magnecules   | 959  |
|       | 10.3.4        | Apparent Magnecular Structure of $H_3$ and $O_3$  | 962  |
|       | 10.3.5        | Need for New Analytic Methods   | 964  |
| 10.4  | MAGN<br>MAGN  | NEGASES <sup><math>T</math></sup> $M$ , THE COMBUSTIBLE GASES WITH A NECULAR STRUCTURE  | 965  |
|       | 10.4.1        | $PlasmaArcFlow^{TM}$ Reactors for Recycling Liquid Waste<br>into the Clean Burning Cost Competitive Magnegas Fuel                 | 965  |
|       | 10.4.2        | Surpassing by Magnegas Exhaust of EPA Requirements<br>without Catalytic Converter   | 971  |
|       | 10.4.3        | Anomalous Chemical Composition of Magnegas  | 977  |
|       | 10.4.4        | GC-MS/IRD Measurements of Magnegas at the<br>McClellan Air Force Base   | 070  |
|       | 10.4.5        | CC MS/IRD Tests of Magnegas at Pinellas County  | 919  |
|       | 10.4.9        | Forensic Laboratory   | 981  |
|       | 10.4.6        | Interpretations of the Results  | 986  |
|       | 10.4.7        | Anomalous Energy Balance of Hadronic Molecular  |      |
|       |               | Reactors  | 991  |
|       | 10.4.8        | Cleaning Fossil Fuel Exhaust with Magnegas Additive   | 999  |
|       | 10.4.9        | Hy-Gasoline, Hy-Diesel, Hy-Ethanol, Hy-NG, Hy-Coal  | 1001 |
|       | 10.4.10       | Catastrophic Inconsistencies of Quantum Mechanics,<br>Superconductivity and Chemistry for Submerged Electric                      |      |
|       |               | Arcs  | 1002 |
|       | 10.4.1        | 1 Concluding Remarks  | 1004 |
| 10.5  | THE I<br>OXYC | NEW MAGNECULAR SPECIES OF HYDROGEN AND<br>GEN WITH INCREASED SPECIFIC WEIGHT  | 1007 |
|       | 10.5.1        | Resolution of Hyrogen Problems Permitted by the<br>Magnegas Technology  | 1007 |
|       | 10.5.2        | The Hypothesis of the New Chemical Species of MagneHydrogen <sup><math>TM</math></sup> and MagneOxygen <sup><math>TM</math></sup> | 1008 |
|       | 10.5.3        | Industrial Production of MagneHydrogen <sup><math>TM</math></sup> and MagneOxygen <sup><math>TM</math></sup> .                    | 1011 |
|       | 10.5.4        | Experimental Evidence on MagneHydrogen <sup><math>TM</math></sup> and   |      |
|       |               | MagneOxygen <sup>1</sup> <sup>M</sup>   | 1013 |
|       | 10.5.5        | Conclusions   | 1017 |

| 10.6 HHO, THE NEW GASEOUS AND COMBUSTIBLE FORM OF  | 1000 |
|--|------|
| WATER WITH MAGNECULAR STRUCTURE  | 1020 |
| 10.6.1 Introduction  | 1020 |
| 10.6.2 Experimental Measurements on the New HHO Gas  | 1021 |
| 10.6.3 Magnecular Interpretation of the Measurements   | 1030 |
| 10.6.4 the New Gaseous and Combustible Form of Water   | 1034 |
| 10.6.5 Contributions of Hadronic Chemistry Toward the Future<br>Understanding of the Complexities of Water | 1038 |
| 10.7 EXPERIMENTAL EVIDENCE OF MAGNECULES IN  |      |
| LIQUIDS AND SOLIDS   | 1041 |
| 10.7.1 Preparation of Liquid Magnecules used in the Tests  | 1041 |
| 10.7.2 Photographic Evidence of Magnecules in Liquids  | 1042 |
| 10.7.3 Spectroscopic Evidence of Liquid Magnecules at the  |      |
| Tekmar-Dohrmann Corporation  | 1042 |
| 10.7.4 Spectroscopic Evidence of Liquid Magnecules at Florida  |      |
| International University   | 1049 |
| 10.7.5 Experimental Verification of Mutated Physical   | 1050 |
| Characteristics  | 1050 |
| 10.7.6 Concluding Remarks  | 1060 |
| Appendices   | 1062 |
| 10.A Aringazin's Studies on Toroidal Orbits of the Hydrogen Atom   |      |
| under an External Magnetic Field   | 1062 |
| Appendix 7.A   | 1077 |
| References   | 1078 |
|  |      |
| 11. INDUSTRIAL APPLICATIONS TO   | 1001 |
| NEW OLEAN ENERGIES   | 1081 |
| 11.1 IN PREPARATION - NOVEMBER 1, 2005   | 1081 |
| Postscript   | 1082 |
| Index  | 1097 |
|  |      |

vi

## Foreword

These days, science is playing an ever increasing rle in the lives of each and every one of us. The public is being lectured on climate change by very authoritative sounding people; the problems of the energy requirements of the world as a whole are being discussed quite openly and widely; more and more scientific topics are being discussed openly by people in positions of authority. What is not emphasised, in fact is rarely mentioned, however, is that at the centre of all these various discussions is physics. In the world of science, physics plays a crucial, allpervading role. If science is viewed as a bicycle wheel, physics forms the hub at the centre; all the other branches of science act as the spokes of the wheel leading outwards from this central hub. In this context, mathematics is the language of physics and must always be subservient to the physics. Chemistry is merely one branch of physics; engineering may be viewed as the practical manifestation of physical principles; physics is seen by all to be playing a bigger and bigger rle in medicine; in biology even, physics is becoming important particularly through the influence of thermodynamic principles, including that of entropy, in the examination of the theory of evolution. Hence, it is certainly not unreasonable to claim an all-pervading influence of physics in science. It must always be remembered, but frequently isnt, that physics is concerned with describing, and gaining an understanding of, the world around us. It follows that any models devised by man to achieve this are only as good as their ability to achieve this goal. Mans models will always be approximate and, therefore, always flawed. It is this which spurred Ruggero Santilli to attempt to extend the theory behind quantum mechanics and relativity when he realised that neither was, in fact, complete as a theory.

The first volume of this two volume set was devoted to the mathematical theory developed by Ruggero Santilli over a period of years in an attempt to make headway with the enormous task he had set for himself, for he had always realised that, to make any progress at all, some new mathematics would need to be developed. Mathematics as a tool of physics will always have a potential to restrict progress in physics since it is a purely manmade tool. Also, if one looks back through history to the likes of Newton and Einstein, it is apparent that each developed or introduced new mathematics in order to proceed with prodigious advances in physics. The mathematics introduced in the first volume might reasonably be considered a separate piece of work to be considered and appreciated in its own right. However, its purpose had always been to provide a new tool to help us all in our quest to describe our universe and all that it contains. This means making the mathematics subservient to the physics; relegating the mathematics however beautiful it may be in its own right to a place on a spoke of that wheel of science referred to above. Once it takes on this rle, any results obtained theoretically are only as good as their ability to accurately portray physical phenomena. In this second volume, the link up of theory with experimental results and observation is presented. It is for the general scientific community and any other readers of this work to adjudicate on its success or failure but this judgement, which could be so crucial to us all, must be made with open minds.

The areas in which this new work may be applied are varied. At the present time, possibly the most important application might seem to be the prediction of new clean energies. This could help solve the problems of energy supply and atmospheric pollution if the predictions prove correct. Already, however, a new clean energy, magnegas, has been produced and tested independently. This fact alone must lend credence to the theory presented and should surely provide an impetus to moves to examine the other predictions in great detail on a much wider scale. This is especially important since, on the basis of our present scientific knowledge, the only realistic method of fulfilling the worlds energy needs in the not-too-distant future is via nuclear power. As well as offering possible alternatives, the new theory also offers a possible means of dealing with nuclear waste safely. This, one would have thought, would have been something governments throughout the world would have wanted to investigate as a matter of urgency. It is to be hoped that the publication of this book will refocus attention on this vitally important topic and produce the necessary reaction from around the world.

However, the new theory is not restricted in its application to matters of energy resources. For example, it also offers alternative explanations for problems in astrophysics and cosmology. One fascinating aspect of these two areas of intense scientific endeavour is that, although many observations are made, both are subject to theoretical speculation which can never be completely verified or totally disproved because the time scales involved are far too long; for example, no-one lives anywhere near long enough to truly know the full facts concerning the birth, life and death of any star the theory in that case may be beautiful, it may appear to be a reasonable explanation of all we see, but one can never be certain it is absolutely correct. This is another area where open minds are essential. However, Halton Arps observations relating to quasars caused great consternation among conventionally thinking astronomers to the extent that he has become largely ostracised by the astronomical community. It is interesting that Ruggero Santillis work leads to a possible explanation for Arps findings which should not offend those conventional astronomers too much if they view the ideas with open minds. Again, the same body of work offers an important contribution to the debate surrounding the existence of dark matter and dark energy. This lifes work truly makes contributions to thought in diverse areas of human endeavour and should be examined far more widely than it is.

It is often said that behind every great man there is a great woman. This is true of Ruggero Santilli. It is for history, not me, to label anyone great or not but it is undoubtedly true that he has benefitted from the unswerving support and encouragement of his wife Carla. It is doubtful he would have achieved so much without this seemingly unquestioning devotion. As I wrote earlier, all Ruggero Santillis scientific achievements may be seen to be the result of tremendous teamwork; a team comprising Ruggero himself and Carla Gandiglio in Santilli.

When anyone reaches the end of these two volumes then, and only then, will they be in a position to reflect on the work as a whole and think about coming to a conclusion. As stated previously, the theoretical framework is elegant but it is here to be judged on the basis of its use in physics, since that was the reason for its genesis. View the experimental and observational evidence, as well as the basic theoretical background, with open minds before coming to any final decision. Many, probably the majority, will then regard these two volumes as representing a truly monumental piece of work which deserves dissemination to a much wider circle of people scientists, politicians, the business community, and, most of all, the general populace which ultimately pays for all scientific work, whether successful or not! The general public needs to be aware of all that is on the table for consideration, not simply those little titbits which are released for ulterior motives.

#### Jeremy Dunning-Davies,

Physics Department, University of Hull, England. October 8, 2007

## Preface

Following fifty years of research experience, the author can state without hesitation that quantum chemistry is the most ascientific among all quantitative sciences because of widespread denial of insufficiencies, joint with truly unbelievable obstructions against their resolution.

We have denounced in Volume I the fact that quantum chemistry is mostly based on nomenclatures, as it is the case for the valence, since it lack the identification of the actual bonding force, the proof that it is attractive, and the verification of experimental data via its use. At any rate, two identical electrons in the valence bond must repeat each other according to the basic axioms of quantum chemistry, and definitely cannot attract each other.

In Volume I, we also denounced additional insufficiencies or sheer inconsistencies of quantum chemistry, some of which are truly embarrassing, such as the prediction that all substances are paramagnetic, a prediction that is an incontrovertible consequence of the current nomenclature on valence in which, lacking a serious attractive force, individual electrons are free to acquire an orientation under an external magnetic field resulting in universal paramagnetism.

What it is still astonishing for the author is to see seemingly serious chemists being fully satisfied with views, such as that the liquid state of water is caused by "H-ridges," while denying the purely nomenclature character of such a view and opposing quantitative treatments since they would evidently require rather drastic revisions.

With the understanding that basic advances in quantitative science rarely originate from a single try, and are instead the result of a laborious process of trials and errors, the author has experienced truly incredible obstructions against any attempt of resolving the above so manifest theoretical insufficiencies.

Additionally, the author has experienced, by far, the greatest obstructions in analytic laboratories because of the virtually universal belief by analysts that novelty in chemistry cannot exist, and if it is proposed for test, it is a fraud. As a result of this conviction, analysts generally perform incredible manipulations of data and equipment for the specific intent of suppressing any hint of novelty in the measurements, and deliver the "experimental results" solely in a way fully aligned with old knowledge.

An example, among too many for comfort, is given by the "measurement" of specific weight of gaseous species that is routinely done by submitting the species to infrared scan, identifying the percentages of its molecular constituents, and then *calculating*, rather than actually measuring, the specific weight from tabulated data, thus resulting in " experimental beliefs," and certainly not in serious experimental data.

In fact, various chemical species exposed to electric arcs show macroscopic peaks in the mass spectrum that are transparent to infrared scan, trivially, because the bond of said peaks is not that of valence for which infrared detectors where built, but much weaker. When analysts are told about the possible presence of peaks in macroscopic percentage in the mass spectrum that cannot appear in the infrared scan, thus requiring the actual measurement of the specific weight, the author has experienced the denial of the measurements, as recently the case from a large analytic laboratory in London.

The rejections by what are expected to be qualified chemical journals of any theoretical and/or experimental advance in chemistry are truly beyond belief, since the editors use the most implausible and scientifically vacuum argumentations for denying the existence of basic insufficiencies and then use them for corrupt rejections.

This ongoing theoretical and experimental conditions of chemistry is clearly unacceptable, and must be changed to prevent a historical condemnation by contemporary society, let alone by posterity, because chemistry is expected to provide the much needed new clean energies and fuels that cannot be even conceived with contemporary chemistry because, as shown in Volume I, all energy releasing processes are irreversible in time while quantum chemistry is invariant under time reversal.

By completely ignoring this ascientific condition of chemistry, this volume contains the must important experimental verification of hadronic mechanics and chemistry consisting of :

1) The achievement of a fully identified bonding force between valence electron pairs in singlet coupling originating from the deep mutual overlapping of the particle wavepackets, thus being of contact, nonlinear, nonlocal and nonpotential character, hence inconceivable with quantum chemistry due to its simplistic, purely Hamiltonian structure;

2) The proof that this new force, today called *Santilli strong valence force*, is indeed attractive; and, above all

3) The achievement for the first time of a numerically exact and (time) invariant representation of molecular characteristics for the hydrogen, water and other molecules from first axiomatic principles, without ad hoc adulterations such as the screening of the Coulomb law via its ,multiplication by an function of unknown physical or chemical origin.

The replacement of the valence nomenclature with a first, yet serious quantitative treatment then permits a number of advances yet to be explored, such as a quantitative representation of the liquid state of water, and, subsequently, of liquid fuels, and other chemical structure still unknown at this writing.

This volume also contains one of the most rewarding results of hadronic mechanics and chemistry, the prediction, quantitative treatment and industrial realization of a new class of fuels admitting a full combustion, thus alleviating the current environmental problems, today known as *fuels with Santilli magnecular structure*.

The gravity of the ascientific condition in contemporary academic chemistry is illustrated by the fact that large investments by industries in more than one continent have been made on fuels with Santilli magnecular structure due to their proven environmental qualities while, by comparison, most academic chemists cannot even acknowledge their existence, let alone participate in their development, for fear of instant disqualification by the establishment because the use of very large public funds depends on the academic belief that all possible chemical structures in the universe can only be of molecular nature.

The clear conclusion is that academia is no longer the arena for truly basic advances because basic novelty is the ennemy for academia to kill at whatever cost. In fact, the U.S. Military decided long ago to abandon the financial support of academic research and initiated the conduction of their advanced research in secrecy. The maturity of that decision is established by a comparison between the incredible scientific advances achieved by the military during the last decades, and the absence of any truly basic advance achieved by academia in Cambridge, Massachusetts or Cambridge, England.

Being the scientific advisor of various companies, Santilli can testify that companies in various countries are nowadays following the example of the U. S. Military. In fact, some of the research contracts from corporate investments carry the prohibition of disclosing to academic advances when of basic character. and new products now reach the market without academia knowing their origination.

The author ends this last preface with the indication of the great pleasure in seeing a lifelong environmental effort being fully rewarded with industrial developments under large corporate funds, and the comparative awkward feeling of seeing his former academic colleagues essentially remaining outside the pursuit of truly basic scientific knowledge.

**Ruggero Maria Santilli** January 9, 2008

## Legal Notice

The underwriter Ruggero Maria Santilli states the following:

1) To be the sole person responsible for the content of *Hadronic Mathematics, Mechanics and Chemistry,* Volumes I and II; to be the sole owner of the Copyrights on these two volumes; and to have recorded, beginning with 1992, the copyright ownership of a number of his main contributions in the field.

2) The undersigned hereby authorizes anybody to copy, and/or use, and/or study, and/or criticize and /or develop, and/or apply any desired part of these volumes without any advance authorization by the Copyrights owner under the sole condition of implementing known rules of scientific ethics, namely: 2A) The originating papers are clearly quoted in the initial parts; 2B) Scientific paternity are clearly identified and documented; and 2C) Any desired additional papers are additionally quoted at will, provided that they are directly relevant and quoted in chronological order. Violators of these known ethical rules will be notified with a request of immediate corrections essentially consisting publishing missed basic references. In the event of delays or undocumented excuses, authors who violate the above standard rules of scientific ethics will be prosecuted in the U. S. Federal Court jointly with their affiliations and funding sources.

3) There are insisting rumors that organized interests in science are waiting or the author's death to initiate premeditated and organized actions for paternity fraud via the known scheme, often used in the past, based on new papers in the field without the identification of the author's paternity, which papers are then quickly quoted as originating papers by pre-set accomplices and the fraud is then accepted by often naive or ignorant followers merely blinded by the academic credibility of the schemers. Members of these rumored rings should be aware that the industrial applications of hadronic mathematics, mechanics and chemistry have already provided sufficient wealth to set up a Paternity Protection Trust solely funded to file lawsuits against immoral academicians attempting paternity fraud, their affiliations and their funding agencies.

This legal notice has been made necessary because, as shown in Section 1.5, the author has been dubbed "the most plagiarized scientist of the 20-th century," as it is the case of the thousands of papers in deformations published without any quotation of their origination by the author in 1967. These, and other attempted paternity frauds, have forced the author to initiate legal action reported in web site [1].

In summary, honest scientists are encouraged to copy, and/or study, and/or criticize, and/or develop, and/or apply the formulations presented in these volumes in any way desired without any need of advance authorization by the copyrights owner, under the sole conditions of implementing standard ethical rules 2A, 2B, 2C. Dishonest academicians, paternity fraud dreamers, and other schemers are warned that legal actions to enforce scientific ethics are already under way [1], and will be continued after the author's death.

In faith

#### Ruggero Maria Santilli

U. S. Citizen acting under the protection of the First Amendment of the U. S. Constitution guaranteeing freedom of expression particularly when used to contain asocial misconducts.

Tarpon Springs, Florida, U. S. A.

October 11, 2007

[1] International Committee on Scientific Ethics and Accountability http://www.scientificethics.org

 $\operatorname{xiv}$ 

## Acknowledgments

The author expresses his deepest appreciation in memory of:

- The late Werner Heisenberg, for supporting in epistolary exchanges studies a nonlinear generalization of his celebrated equation (today known as Heisenberg-Santilli isotopic, genotopic and hyperstructural equations at the foundations of hadronic mechanics), with particular reference to their treatment via a new mathematics capable of reconstructing linearity on generalized spaces over generalized fields, since Heisenberg dedicated his last years to the evident nonlinear character of nature;;

- The late Paul A. M. Dirac, for supporting in a short but memorable meeting reviewed in Section 6.2.8, nonunitary liftings of his celebrated equation (today known as Dirac-Santilli isotopic, genotopic and hyperstructural equations) for the representation of an electron within the hyperdense medium inside the proton, with particular reference to the development of a new mathematics eliminating the vexing divergencies in particle physics, since Dirac spent his last years in attempting the elimination of divergencies amidst strong opposition by organized interests on quantum chromodynamical theologies;

- The late British philosopher Karl Popper, for his strong support in the construction of hadronic mechanics, as shown in the Preface of his last book *Quantum Theory and the Schism in Physics;* 

- The late Ilya Prigogine, for pioneering the need of nonunitary broadening of quantum mechanics and statistics and his personal support for the organization of the *Hadronic Journal* since its inception;

- The late Italian physicist Piero Caldirola, for his pioneering work in noncanonical broadening of conventional theories, for initiating new notions of time as well as for support for the construction of hadronic mechanics;

- The Greek mathematician Grigorios Tsagas, for fundamental contributions in the Lie-Santilli isotheory underlying hadronic mechanics;

- The late Italian physicist Giuliano Preparata, for pioneering anisotropic departures from the geometric structure of special relativity, extended by hadronic mechanics into anisotropic and inhomogeneous media;

- The late American mathematician Robert Oehmke for pioneering work on the Lie-admissible structure of hadronic mechanics;

- The late Estonian mathematician Jaak Löhmus whose studies on nonassociative algebras, with particular reference to the octonion algebra, have been particularly inspiring for the construction of hadronic mechanics; - and other scholars who will be remembered by the author until the end of his life.

The author expresses his appreciation for invaluable comments to all participants of: the International Workshop on Antimatter Gravity and Anti-Hydrogen Atom Spectroscopy held in Sepino, Molise, Italy, in May 1996; the Conference of the International Association for Relativistic Dynamics, held in Washington, D.C., in June 2002; the International Congress of Mathematicians, held in Hong Kong, in August 2002; the International Conference on Physical Interpretation of Relativity Theories, held in London, September 2002, and 2004; and the XVIII Workshop on Hadronic Mechanics held in Karlstad, Sweden, in June 2005.

The author would like also to express his deepest appreciation to Professors: A. van der Merwe, Editor of *Foundations of Physics*; P. Vetro, Editor of *Rendiconti Circolo Matematico Palermo*; G. Langouche and H. de Waard, Editors of *Hyperfine Interactions*; V. A. Gribkov, Editor of *Journal of Moscow Physical Society*; B. Brosowski, Editor of *Mathematical Methods in Applied Sciences*; D. V. Ahluwalia, Editor of the *International Journal of Modern Physics*; T. N. Veziroglu, Editor of the *International Journal of Hydrogen Energy*; H. Feshback, Editor of the (MIT) *Annals of Physics*; the Editors of the Italian, American, British, French, Russian, Indian and other physical and mathematical societies; and other Editors for very accurate refereeing in the publication of papers that have a fundamental character for the studies presented in these monographs.

Particular thanks are also due for invaluable and inspiring, constructive and critical remarks, to Professors A. K. Aringazin, P. Bandyopadhyay, P. A. Bjorkum, J. Dunning-Davies, T. L. Gill, E. J. T. Goldman, I. Guendelman, F. W. Hehl, M. Holzscheiter, L. Horwitz, S. Kalla, J. V. Kadeisvili, N. Kamiya, A. U. Klimyk, S. Johansen, D. F. Lopez, J. P. Mills, jr., R. Miron, P. Rowlands, G. Sardanashvily, K. P. Shum, H. M. Srivastava, N. Tsagas, E. Trell, C. Udriste, C. Whitney, F. Winterberg, and others.

Special thanks are finally due to Professors D. V. Ahluwalia for an invaluable critical reading of an earlier version of the manuscript and for suggesting the addition of isodual space and time inversions. Additional thanks are due to Professors J. Dunning-Davies, V. Keratohelcoses and H. E. Wilhelm for an accurate reading of a later version of the manuscript.

Thanks are finally due to Prof. Richard Koch of the University of Oregon for assistance in composing this monograph with TexShop, and to Dr. I. S. Gandzha for assistance in the LaTeX composition, without which help these volumes would not have been printed. Thanks are finally due to various colleagues for a technical control, including Drs. G.Mileto, M. Sacerdoti and others, and to Mrs. Dorte Zuckerman for proofreading assistance. Needless to say, the author is solely responsible for the content of this monograph due also to several additions and improvements in the final version. Chapter 8

# EXPERIMENTAL VERIFICATIONS AND APPLICATIONS IN SUPERCONDUCTIVITY

### 8.1 Introduction

An understanding of hadronic mechanics requires the knowledge that the new discipline and its underlying new mathematics are applicable in fields beyond particle physics, nuclear physics, and astrophysics. Another field of applicability of hadronic mechanics is superconductivity.

There is no doubt that quantum mechanics provides a good description of an *ensembles* of *Cooper (or electron) pairs* in superconductivity (see, e.g., Ref. [1]), when necessarily represented as points in oder to prevent major conflicts with the basic axioms of the theory. However, there is equally no scientific doubt that quantum mechanics cannot possibly represent the *structure of one isolated Cooper pair*.

The Cooper pair is a physical system requiring an *attractive* interaction among two *identical* electrons via the intermediate action of Cuprate ions, and the bond-correlation of the two electron is so "strong" that cooper pairs can even tunnel as a single particle according to clear experimental evidence.

But electrons repel each other according to quantum mechanics. therefore, to achieve an understanding of the bond-correlation, a conjecture was submitted according to which there is a new interaction between the two electrons mediated by a hypothetical particle called "phonon."

However, phonons represent elementary heat excitations-oscillations in a *crys*tal. Consequently, it is difficult to understand how phonons can be propagated in vacuum from atom to atom in the fixed lattice of a crystal. Even assuming that this is possible, it is difficult to understand how phonons can create an *attraction* between pairs of identical electrons.

In any case, considered *ad litteram*, phonons are sound waves or at best, vibrations of the superconducting medium, in which case, again, it is evidently

difficult to understand how such vibrations could propagate in vacuum and, in case this can be explained, how could they produce a real attraction between identical electrons.

Also, the 20-th century physics has identified all possible particles. Yet, this branch of physics has no evidence of phonons, as well as of the interactions electron-phonon.

The Cooper pair (CP) is an excellent physical system to test the effectiveness of isotopic methods at large. Comprehensive studies along these lines have been conducted by A. O. E. Animalu [2] who has introduced a nonlinear, nonlocal, and non-Hamiltonian realization of hadronic mechanics for the Cooper pair known as *Animalu's isosuperconductivity* that is in remarkable agreement with experimental data, and possesses intriguing and novel predictive capacities.

### 8.2 Animalu's Hadronic Superconductivity and its Experimental Verification

The birth of Animalu's Hadronic Superconductivity, or *isosuperconductivity* for short can be traced back to the structure model of the  $\pi^o$  meson submitted by Santilli in the original proposal to build hadronic mechanics (Ref. [3], Sect. 5)

$$\pi^{0} = (\hat{e}^{+}_{\uparrow}, \hat{e}^{-}_{\downarrow})_{\rm HM}, \tag{8.1}$$

where HM stands for hadronic mechanics, and  $\hat{e}^-$  represents the *isoelectron*, that is, the ordinary electron when described via the isomechanics and related Galilei-Santilli isosymmetry for nonrelativistic description or the Poincaré-santilli isosymmetry for relativistic treatments. For brevity, in this chapter we study only the nonrelativistic profile, and refer to the quoted literature for the relativistic extension.

As familiar from Chapter 6, model (8.1) is based on the property that the nonlocal-nonpotential interactions due to deep wave-overlapping results in being strongly attractive for singlet coupling (only) irrespective of whether the Coulomb interaction is attractive or repulsive.

Isosuperconductivity is based on the *isoelectron pairs* (IEP) proposed by Animalu [2] and studied in details by Animalu and Santilli [3] at the 1995 Sanibel Symposium held in Florida that can represented with the symbol

$$\text{IEP} = (\hat{e}_{\uparrow}^{-}, \hat{e}_{\downarrow}^{-})_{\text{HM}}, \tag{8.2}$$

A main property of model (8.2) is that the attractive force caused by deep waveoverlapping of isoelectrons in singlet coupling is so strong to overcome the Coulomb interactions even when repulsive, thus permitting the extension from model (8.1) to (8.2).

The quantitative representation of the above property can be outline as follows. Consider one electron with charge -e, spin up  $\uparrow$  and wavefunction  $\psi_{\uparrow}$  in

808

the field of another electron with the same charge, spin down  $\downarrow$  and wavefunction  $\psi_{\downarrow}$  considered as *external*. Its Schrödinger equation is given by the familiar expression

$$H_{\text{Coul.}} \times \psi(t,r) = \left(\frac{1}{2m}p_k p^k + \frac{e^2}{r}\right) \times \psi_{\uparrow}(t,r) = E_0 \times \psi_{\uparrow}(t,r), \quad (8.3a)$$

$$p_k \times \psi_{\uparrow}(t, r) = -i \times \partial_k \psi_{\uparrow}(t, r), \qquad (8.3b)$$

where *m* is the electron rest mass. The above equation and related wavefunction  $\psi_{\uparrow}(t, r)$  represent *repulsion*, as well known. We are interested in the physical reality in which there is *attraction* represented by a new wavefunction here denoted  $\hat{\psi}_{\uparrow}(t, r)$ .

By recalling that quantum mechanical Coulomb interactions are invariant under unitary transforms, the map  $\psi_{\uparrow} \rightarrow \hat{\psi}_{\uparrow}$  is representable by a transform  $\hat{\psi} = U\psi$ which is *nonunitary*,  $U \times U^{\dagger} = U^{\dagger}U = \mathcal{I} \neq I$ , where  $\mathcal{I}$  has to be determined (see below). This activates *ab initio* the applicability of hadronic mechanics as per Sect. 1.8. The first step of the proposed model is, therefore, that of transforming system (1.28) in  $\psi_{\uparrow}$  into a new system in  $\hat{\psi}_{\uparrow} = U \times \psi_{\uparrow}$  where U is nonunitary,

$$U \times H_{\text{Coulomb}} \times U^{\dagger} \times (U \times U^{\dagger})^{-1} \times U \times \psi_{\uparrow}(t, r) =$$

$$= \hat{H}_{\text{Coulomb}} \times T \times \hat{\psi}_{\uparrow}(t, r) =$$

$$= \left(\frac{1}{2m}\hat{p}_{k} \times T \times \hat{p}^{k} + \frac{e^{2}}{r}\mathcal{I}\right) \times T \times \hat{\psi}_{\uparrow}(t, r) = E \times \hat{\psi}_{\uparrow}(t, r),$$

$$\hat{p}_{k} \times T \times \hat{\psi}_{\uparrow}(t, r) = -i \times T_{k}^{i} \times \partial_{i}\hat{\psi}_{\uparrow}(t, r).$$
(8.4*b*)

System (8.4) is incomplete because it misses the interaction with the Cu<sup>z+</sup> ion represented by the familiar term  $-ze^2/r$  [10]. The latter are not transformed (i.e., they are conventionally quantum mechanical) and, therefore, they should be merely added to the transformed equations (1.29). The formal equations of the proposed model CP =  $(e_{\uparrow}^-, e_{\bot}^-)_{HM}$  are therefore given by

$$\left(\frac{1}{2m}\hat{p}_{k}\times T\times\hat{p}^{k}+\frac{e^{2}}{r}\times\mathcal{I}-z\frac{e^{2}}{r}\right)\times T\times\hat{\psi}_{\uparrow}(t,r) = \\
=\frac{1}{2m}\hat{p}_{k}\times T\times\hat{p}^{k}\times T\times\hat{\psi}_{\uparrow}+\frac{e^{2}}{r}\hat{\psi}_{\uparrow}-z\frac{e^{2}}{r}\times T\times\hat{\psi}_{\uparrow}(t,r) = \\
=E\times\hat{\psi}_{\uparrow}(t,r), \quad \hat{p}_{k}\times T\times\hat{\psi}_{\uparrow}(t,r) = -i\times T_{k}^{i}\times\partial_{i}\hat{\psi}_{\uparrow}(t,r).$$
(8.5)

In order to achieve a form of the model confrontable with experimental data, we need an explicit expression of the isounit  $\mathcal{I}$ . Among various possibilities, Animalu [10] selected the simplest possible isounit for the problem at hand, which we write

$$\mathcal{I} = e^{-\langle \psi_{\uparrow} | \hat{\psi}_{\downarrow} \rangle \psi_{\uparrow} / \hat{\psi}_{\uparrow}} \approx 1 - \langle \hat{\psi}_{\uparrow} | \hat{\psi}_{\downarrow} \rangle \psi_{\uparrow} / \hat{\psi}_{\uparrow} + \dots, 
\mathcal{T} = e^{+\langle \hat{\psi}_{\uparrow} | \hat{\psi}_{\downarrow} \rangle \psi_{\uparrow} / \hat{\psi}_{\uparrow}} \approx 1 + \langle \hat{\psi}_{\uparrow} | \hat{\psi}_{\downarrow} \rangle \psi_{\uparrow} / \hat{\psi}_{\uparrow} + \dots,$$
(8.6)

under which Eqs. (8.5) can be written

$$\frac{1}{2m}\hat{p}_{k}T\hat{p}^{k}T\hat{\psi}_{\uparrow} - (z-1)\frac{e^{2}}{r}\hat{\psi}_{\uparrow} - (z-1)\frac{e^{2}}{r}\hat{\psi}_{\uparrow} - (z-1)\frac{e^{2}}{r}\hat{\psi}_{\uparrow}|\hat{\psi}_{\downarrow}\rangle(\psi_{\uparrow}/\hat{\psi}_{\uparrow})\hat{\psi}_{\uparrow}(t,r) = E\hat{\psi}_{\uparrow}.$$
(8.7)

Now, it is well known from quantum mechanics that the radial part of  $\psi_{\uparrow}$  in the ground state (L = 0) behaves as

$$\psi_{\uparrow}(r) \approx A e^{-r/R},\tag{8.8}$$

where A is (approximately) constant and R is the coherence length of the pair. The radial solution for  $\hat{\psi}_{\uparrow}$  also in the ground state is known from Eqs. (5.1.21), p. 837, Ref. [3] to behave as

$$\hat{\psi}_{\uparrow} \approx B \frac{1 - e^{-r/R}}{r},\tag{8.9}$$

where B is also approximately a constant. The last term in the l.h.s. of Eq. (8.9) behaves like a *Hulten potential* 

$$V_0 \times \frac{e^{-r/R}}{1 - e^{-r/R}}, \quad V_0 = e^2 \langle \hat{\psi}_{\uparrow} | \hat{\psi}_{\downarrow} \rangle.$$
(8.10)

After substituting the expression for the isomomentum, the radial isoschrödinger equation can be written

$$\left(-\frac{\mathcal{I}}{2\times\hat{m}}r^2\frac{d}{dr}r^2\frac{d}{dr} - (z-1)\frac{e^2}{r} - V_0\frac{e^{-r/R}}{1-e^{-r/R}}\right)\times\hat{\psi}_{\uparrow}(r) = E\times\hat{\psi}_{\uparrow}(r), \quad (8.11)$$

where  $\hat{m}$  is the isorenormalized mass of the isoelectron.

The solution of the above equation is known from Ref. [5e], Sect. 5.1. The Hulten potential behaves at small distances like the Coulomb potential,

$$V_{\text{Hulten}} = V_0 \times \frac{e^{-r/R}}{1 - e^{-r/R}} \approx V_0 \times \frac{R}{r}.$$
 (1.37)

At distances smaller than the coherent length of the pair, Eq. (1.36) can therefore be effectively reduced to the form

$$\left(-\frac{1}{2\times\hat{m}}r^2\frac{d}{dr}r^2\frac{d}{dr} - V\frac{e^{-r/R}}{1-e^{-r/R}}\right)\times\hat{\psi}_{\uparrow}(r) = E\times\hat{\psi}_{\uparrow}(r), \quad (8.12a)$$

$$V = V_0 \times R + (z - 1) \times e^2,$$
 (1.38b)

810

with general solution, boundary condition and related spectrum (see Ref. [3], pp. 837-838)

$$\hat{\psi}_{\uparrow}(r) = {}_{2}F_{1}(2 \times \alpha + 1 + n, 1 - \alpha, 2 \times \alpha + 1, e^{-r/R})e^{-\alpha \times r/R}\frac{1 - e^{-r/R}}{r}, \qquad (1.39a)$$

$$\alpha = (\beta^2 - n^2)/2n > 0, \quad \beta^2 = \hat{m} \times V \times R^2/\hbar^2 > n^2, \tag{8.12b}$$

$$E = -\frac{\hbar^2}{4 \times \hat{m} \times R^2} \left(\frac{\hat{m} \times V \times R^2}{\hbar^2} \frac{1}{n} - n\right)^2, \quad n = 1, 2, 3, \dots$$
(8.12c)

where we have reinstated  $\hbar$  for clarity.

Santilli [3] identified the numerical solution of Eqs. (8.12) for the hadronic model  $\pi^0 = (\hat{e}^+_{\uparrow}, \hat{e}^-_{\downarrow})_{\text{HM}}$  (in which there is evidently no contribution from the Cuprate ions to the constant V), by introducing the parameters

$$k_1 = \hbar/2 \times \hat{m} \times R \times c_0, \quad k_2 = \hat{m} \times V \times R^2/\hbar, \tag{8.13}$$

where  $c_0$  is the speed of light in vacuum. Then,

$$V = 2 \times k_1 \times k_2^2 \times \hbar \times c_0 / R, \qquad (8.14)$$

and the total energy of the state  $\pi^0 = (e^+_{\uparrow}, e^-_{\downarrow})_{\text{HM}}$  becomes in the ground state (which occurs for n = 1 for the Hulten potential)

$$E_{\text{tot},\pi^0} = 2 \times k_1 \times [1 - (k_2 - 1)^2/4] \times \hbar \times c_0/R =$$
  
= 2 × k<sub>1</sub>(1 - \varepsilon^2) × \bar{h} × c\_0/R. (8.15)

The use of the total energy of the  $\pi^0$  (135 MeV), its charge radius ( $R \approx 10^{-13}$  cm) and its meanlife ( $\tau \approx 10^{-16}$  sec), then yields the values (Eqs. (5.1.33), p. 840, Ref. [3])

$$k_1 = 0.34, \quad \varepsilon = 4.27 \times 10^{-2},$$
 (8.16a)

$$k_2 = 1 + 8.54 \times 10^{-2} > 1. \tag{8.16b}$$

Animalu [10a] identified the solution of Eqs. (1.39) for the Cooper pair by introducing the parameters

$$k_1 = \varepsilon \times F \times R/\hbar \times c_0, \quad k_2 = KR/\varepsilon_{\rm F},$$
(8.17)

where  $\varepsilon_{\rm F}$  is the iso-Fermi energy of the isoelectron (that for hadronic mechanics). The total energy of the Cooper pair in the ground state is then given by

$$E_{\text{Tot, Cooper pair}} = 2 \times k_1 \times [1 - (k_2 - 1)^2/4] \times \hbar \times c_0/R \approx k_2 \times T_c/\theta_{\text{D}}, \qquad (8.18)$$

where  $\theta_{\rm D}$  is the Debye temperature.



Figure 8.1. A reproduction of Fig. 10 of Ref. [10a] illustrating the remarkable agreement between the predicted dependence of  $T_c$  from the effective valence z of ions (continuous curve) and the experimental values on the "jellium temperature" for various compounds (solid dots).

Several numerical examples were considered in Refs. [2]. The use of experimental data for aluminum,

$$\theta_{\rm D} = 428^0 K, \ \varepsilon_{\rm F} = 11.6 {\rm C}, \ T_c = 1.18^0 K,$$
 (8.19)

yields the values

$$k_1 = 94, \quad k_2 = 1.6 \times 10^{-3} < 1.$$
 (8.20)

For the case of  $YBa_2Cu_3O_{6-\chi}$  the model yields [*loc. cit.*]

$$k_1 = 1.3z^{-1/2} \times 10^{-4}, \quad k_2 = 1.0 \times z^{1/2},$$
 (8.21)

where the effective valence  $z = 2(7 - \chi)/3$  varies from a minimum of z = 4.66 for YBa<sub>2</sub>Cu<sub>3</sub>O<sub>6.96</sub> ( $T_c = 91^0 K$ ) to a maximum of z = 4.33 for YBa<sub>2</sub>Cu<sub>3</sub>O<sub>6.5</sub> ( $T_c = 20^0 K$ ). The general expression predicted by hadronic mechanics for YBa<sub>2</sub>Cu<sub>3</sub>O<sub>6- $\chi$ </sub> is given by (Eq. (5.15), p. 373, Ref. [10a])

$$T_c = 367.3 \times z \times e^{-13.6/z},\tag{8.22}$$

and it is in remarkable agreement with experimental data (see Figs. 1.21–1.23).

A few comments are now in order. The above Animalu-Santilli model of the Cooper pair is indeed nonlinear, nonlocal and nonpotential. In fact, the nonlinearity in  $\hat{\psi}_{\uparrow}$  is expressed by the presence of such a quantity in Eqs. (1.31). The nonlocality is expressed by the term  $\langle \hat{\psi}_{\uparrow} | \hat{\psi}_{\downarrow} \rangle$  representing the overlapping of the wavepackets of the electrons, and the nonpotentiality is expressed by the presence of interactions, those characterized by the isounit, which are outside the representational capabilities of the Hamiltonian H. This illustrates the necessity of using hadronic mechanics or other similar nonhamiltonian theories (provided that they are physically consistent), because of the strictly linear-local-potential character of quantum mechanics.

Note that, whenever the wave-overlapping is no longer appreciable, i.e., for  $\langle \hat{\psi}_{\uparrow} | \hat{\psi}_{\downarrow} \rangle = 0$ ,  $\mathcal{I} \equiv I$ , quantum mechanics is recovered identically as a particular case, although without attraction.

The mechanism of the creation of the *attraction* among the *identical* electrons of the pair via the intermediate action of Cuprate ions is a general law of hadronic mechanics according to which *nonlinear-nonlocal-nonhamiltonian interactions due to wave-overlappings at short distances are always attractive in singlet couplings and such to absorb Coulomb interactions, resulting in total attractive interactions irrespective of whether the Coulomb contribution is attractive or repulsive.* As noted earlier, the Hulten potential is known to behave as the Coulomb one at small distances and, therefore, the former absorbs the latter.

Alternatively, we can say that within the coherent length of the Cooper pair, the Hulten interaction is stronger than the Coulomb force. This results in the overall attraction. Thus, the similarities between the model for the  $\pi^0$  and that for the Cooper pair are remarkable. The applicability of the same model for other aspects should then be expected, such as for a deeper understanding of the valence, and will be studied in the next chapters.

Another main feature of the model is characterized also by a general law of hadronic mechanics, that bound state of particles due to wave-overlappings at short distances in singlet states suppress the atomic spectrum of energy down to only one possible level. The Hulten potential is known to admit a finite number



*Figure 8.2.* A reproduction of Fig. 5, p. 380 of Ref. [10a] showing the agreement between the prediction of isosuperconductivity for the doped 1:2:3 Cuprates and the experimental data.

of energy levels. Santilli's [5e] solution for the  $\pi^0$  shows the suppression of the energy spectrum of the positronium down to only one energy level, 135 MeV of the  $\pi^0$  for  $k_2 > 1$ . Similarly, the solutions for the Cooper pair [10] also reduce the same finite spectrum down to only one admissible level.

| Table 1. | YBapCun. | Mn.O. |
|----------|----------|-------|
|          |          | 1     |

(After N.L. Saini et al., Int. J. Mod. Phys. B6, 3515 (1992)

| x    | y    | Z     | $T_c$ (theory) | $T_c$ (expt.) |
|------|------|-------|----------------|---------------|
| 0.00 | 6.92 | 4.613 | 88.9           | 91            |
| 0.03 | 6.88 | 4.541 | 83.5           | 86.6          |
| 0.09 | 6.87 | 4.447 | 76.7           | 79.0          |
| 0.15 | 6.91 | 4.387 | 72.6           | 75.0          |
| 0.21 | 6.92 | 4.312 | 67.6           | 72.0          |
| 0.30 | 6.95 | 4.212 | 61.3           | 67.0          |

Note:  $T_c$  (theory) = 367.3z exp(-13.6/z), where the effect of replacing Cu<sub>3</sub> by

 $Cu_{3-x}Mn_x$  is obtained by replacing 3 by (3-x)+2x=3+x, which lowers the

effective valence (z) on  $Cu^{z+}$  ions to z = 2y/(3+x).

**Table 2.**  $GdBa_2(Cu_{1-x}Ni_x)_3O_{7-\delta}$ (After, Chin Lin *et al.*, Phys. Rev. B42, 2554 (1990))

| x     | y = 7-δ | Z     | $T_c$ (theory) | $T_c$ (expt.) |
|-------|---------|-------|----------------|---------------|
| 0.000 | 6.96    | 4.640 | 91.0           | 91            |
| 0.025 | 6.96    | 4.527 | 82.4           | 79            |
| 0.050 | 6.96    | 4.419 | 74.8           | 71            |
| 0.075 | 6.96    | 4.316 | 67.9           | 65            |
|       |         |       |                |               |

Note:  $T_c$  (theory) = 367.3z exp(-13.6/z), z = 2y/3(1+x) as discussed in Table 1.

Table 3. GdBa<sub>2</sub>(Cu<sub>1-x</sub>Zn<sub>x</sub>)<sub>3</sub>O<sub>7-8</sub>

| ţ | After, | Chin | Lin e | 1 al., | Phys. | Rev. | B42, | 2554 | (1990 | J |
|---|--------|------|-------|--------|-------|------|------|------|-------|---|
|   |        |      |       |        |       |      |      |      |       |   |

| x     | y = 7–δ | z     | $T_c$ (theory) | $T_c$ (expl.) |
|-------|---------|-------|----------------|---------------|
| 0.000 | 6.96    | 4.640 | 91.0           | 91            |
| 0.025 | 6.96    | 4.309 | 67.4           | 54            |
| 0.050 | 6.96    | 4.009 | 49.0           | 37            |
| 0.075 | 6.96    | 3.737 | 36.1           | 35            |
|       |         |       |                |               |

Figure 8.3. A reproduction of the tables of p. 379, Ref. [10a] illustrating the agreement between the predictions of the model with experimental data from other profiles.

Excited states are indeed admitted, but they imply large distances R for which nonlinear-nonlocal-nonhamiltonian interactions are ignorable. This implies that all excited states are conventionally quantum mechanical, that is, they do not represent the  $\pi^0$  or the Cooper pair. Said excited states represent instead the discrete spectrum of the ordinary positronium, or the continuous spectrum of repulsive Coulomb interactions among the two identical electrons.

Alternatively, we can say that, in addition to the conventional, quantum mechanical, Coulomb interactions among two electrons, there is only one additional system of hadronic type with only one energy level per each couple of particles, one for  $\pi^0 = (e^+_{\uparrow}, e^-_{\downarrow})_{\text{HM}}$  and the other for the Cooper pair,  $\text{CP} = (e^-_{\uparrow}, e^-_{\downarrow})_{\text{HM}}$ .

The case of possible triplet couplings also follows a general law of hadronic mechanics. While singlets and triplets are equally admitted in quantum mechanics (read, coupling of particles at large mutual distances under their point-like approximation), this is no longer the case for hadronic mechanics (read, couplings

of particles when represented as being extended and at mutual distances smaller than their wavepackets/wavelengths). In fact, all triplet couplings of particles under nonlinear-nonlocal-nonhamiltonian interactions are highly unstable, the only stable states being the singlets.

This law was first derived in Ref. [5e] via the "gear model", i.e., the illustration via ordinary mechanical gears which experience a highly repulsive force in triplet couplings, while they can be coupled in a stable way only in singlets. The possibility of applying the model to a deeper understanding of Pauli's exclusion principle is then consequential, and will be studied in Chapters 4 and 5.

The connection between the proposed model and the conventional theory of the Cooper pair is intriguing. The constant in the Hulten potential can be written

$$V_0 = \hbar\omega, \tag{8.23}$$

where  $\omega$  is precisely the (average) *phonon frequency*. The total energy can then be rewritten

$$E_{Tot} = 2 \times \varepsilon_{\rm F} - E \approx 2 \times k_1 \times k_2 \times \hbar \times c_0 / R(e^{1/N \times V} - 1), \tag{8.24}$$

where  $N \times V$  is the (dimensionless) *electron-phonon coupling constant*.

In summary, a main result of studies [2] is that the conventional representation of the Cooper pair via a mysterious "phonon" can be reformulated without any need of such a hypothetical particle, resulting in a real, sufficiently strong attraction between the identical electrons, that is absent in the phonon theory.

The above model of the Cooper pair see its true formulation at the relativistic level because it provides a *geometrization* of the Cooper pair, better possibilities for novel predictions and the best possible experiments tests. These profiles [10] will not be reviewed for brevity.

### 8.3 Novel Predictions of Animalu's Hadronic Superconductivity

As indicated in Section 1.2, besides the inability to achieve any understanding of the Cooper pair, another major insufficiency of quantum mechanics is superconductivity is the well known exhaustion of all predictive capacities for the main objective of the theory, the achievement of superconductive capacity at ambient temperature.

Besides the achievement of a quantitative representation of the structure of the Cooper pair, one of the most important features of hadronic mechanics in superconductivity is precisely its capability of permitting *new* predictions.

One of them is a realistic possibility of achieving a form of superconductivity at ambient temperature that can be outlined as follows. Recall that the electric resistance originates from the interactions between the electric and magnetic fields of the electrons and those of atomic electron clouds (see Figure 8.4). Particular



*Figure 8.4.* A schematic view of a conventional electric current, here represented with one electron (top view), moving in the surface of an ordinary conductor (lower view), illustrating the origin of the electric resistance due to interactions of both electric and magnetic type with the electromagnetic fields of the atoms of the conductor.

"obstructions" against the flow of electrons in conductors (thus causing resistance) originates from the interaction of the intrinsic magnetic field of electrons and the atomic electron cloud of the conductor.

The achievement of a quantitative understanding of the Cooper pair then permits the prediction and quantitative treatment of a *new electric current characterized by a flow through ordinary conductors of isoelectron pairs, rather than individual electrons*, as illustrated in Figure 8.4.

In fact, the total magnetic moment of the isoelectron pair can be considered as being null at interatomic distances, thus implying a dramatic decrease of the electric resistance, due to the reduction of the interactions between the current and the conductor to the sole Coulomb interactions.

Moreover, hadronic mechanics can assist in the creation of such a new current via the removal under sufficiently intense external electric fields of "valence pairs", rather individual electrons, from various substances (including plastic compounds and non-conducting materials), said substances being selected under the condition of having two unbonded valence electrons.

This is due to the fact that, as experimentally established in the helium, when not bonded into molecules, the electrons of a valence pair are not separated in an orbital but are generally coupled in singlet exactly along the structure of the isoelectron pair.



Figure 8.5. A schematic view of the new electric current predicted by hadronic superconductivity, consisting of the current of *electron pairs bonded in singlet*, in which case there is the absence of the magnetic field of the current constituents, with consequential reduction of the electric resistance.

A rather intense research to achieve superconductivity at ambient temperature is under way in corporate circles which research, unfortunately, is not generally available to academia due to its novelty, that is, the use of methods and theories generally opposed by organized interests in academia at this time. It is regrettably for scientific knowledge that this type of advanced corporate research cannot be reported in this monograph at this time.

## References

- [1] xxxxx
- [2] A. O. E. Animalu, Hadronic J. **17**, 379 (1994).
- [3] R. M. Santilli, Hadronic J. 1, 224, 574 and 1267 (1978).
- [4] A. O. E. Animalu Animalu and R. M. Santilli, Int. J. Quantum Chemistry 29, 175 (1995).

Chapter 9

# EXPERIMENTAL VERIFICATIONS AND APPLICATIONS IN CHEMISTRY

## 9.1 ISOCHEMICAL MODEL OF THE HYDROGEN MOLECULE

#### TO BE EDITED

#### 9.1.1 Introduction

Chemistry provides some of the most important experimental verifications and applications of hadronic mechanics in its version known as *hadronic chemistry* essentially consisting of the isotopic methods of Chapter 3 for chemical processes that are invariant under time reversal (*isochemistry*), the genotopic methods of Chapter 4 for irreversible processes (*genochemistry*), the multi-valued methods of Chapter 5 for biological structures (*hyperchemistry*), and their isoduals for the first known formulation of antimatter chemistry (*isodual iso-, geno- and hyperchemistry*). A comprehensive study of these formulations is presented in monograph [67]. This chapter is essentially dedicated to a review of the experimental verifications and scientific applications of isochemistry. Industrial applications of hadronic chemistry are presented in Chapters 11 and 12.

As an indication, in Sections 1.2 and 1.3 we showed that, following one century of failed attempts, quantum chemistry was unable to represent from unadulterated basic axioms a residual amount of 2% of molecular binding energies with electric and magnetic moments being wrong even in their signs, while the improvement of the representation via the so-called "screenings of the Coulomb law" causes the loss of the quantum of energy as well as other inconsistencies.

By comparison, in this chapter we show that hadronic chemistry has permitted the first exact and invariant representation from first principles of molecular binding energies and other molecular data without adulteration of the basic axioms, while admitting as particular cases conventional screenings of the Coulomb law.

The studies presented in this chapter are devoted to the representation of molecular structures assumed as isolated from the rest of the universe, thus being invariant under time reversal. Consequently, unless otherwise stated, all studies of this chapter are based on *isochemistry*. various experimental verifications and applications of the broader *genochemistry* and *hyperchemistry* and their isoduals are under way by various scholars and they will be reported in their works.

As it is well known, the primary structural characteristics of quantum chemistry (see, e.g., Refs. [1]) are those of being:

1) *linear*, in the sense that eigenvalue equations depend on wavefunctions only to the first power;

2) local-differential, in the sense of acting among a finite number of isolated points; and

3) potential, in the sense that all acting forces are derivable from a potential energy.

Therefore, quantum chemistry is a *Hamiltonian theory*, i.e., models are completely characterized by the *sole* knowledge of the Hamiltonian operator, with a *unitary structure*, i.e., the time evolution verifies the unitarity conditions

$$U = e^{iH \times t}, \quad U \times U^{\dagger} = U^{\dagger} \times U = I, \quad H = H^{\dagger}, \tag{9.1.1}$$

when formulated on conventional Hilbert spaces over the conventional fields of complex numbers.

Despite outstanding achievements throughout the 20-th century, quantum chemistry cannot be considered as "final" because of numerous insufficiencies identified in Chapter 1.

A most important insufficiency is the inability to represent deep mutual penetrations of the wavepackets of valence electrons in molecular bonds. The latter interactions are known to be:

1) nonlinear, i.e., dependent on powers of the wavefunctions greater than one;

 $\hat{2}$ ) nonlocal-integral, i.e., dependent on integrals over the volume of overlapping, which, as such, cannot be reduced to a finite set of isolated points; and

3) nonpotential, i.e., consisting of "contact" interactions with consequential "zero range," for which the notion of potential energy has no mathematical or physical sense.

A representation of the latter features evidently requires a *nonhamiltonian the*ory, i.e., a theory which cannot be solely characterized by the Hamiltonian, and requires additional terms. It then follows that the emerging theory is *nonunitary* i.e., its time evolution verifies the law,

$$U \times U^{\dagger} = U^{\dagger} \times U \neq I, \qquad (9.1.2)$$

when formulated on conventional Hilbert spaces over conventional fields.

#### 822

It is evident that the above features are beyond any hope of scientific-quantitative treatment via quantum mechanics and chemistry.

In the preceding Chapter 3 we have submitted the foundations of a generalization covering of quantum chemistry under the name of *hadronic chemistry*, first submitted by Santilli and Shillady in Ref. [2], which is capable of providing an invariant representation of the above-mentioned nonlinear, nonlocal, nonpotential, nonhamiltonian, and nonunitary interactions in deep correlations of valence electrons.

In Chapter 3, we have also shown that the conventional "screenings" of the Coulomb potential (which are necessary for a better representation of experimental data) are outside the axiomatic structure of "quantum" chemistry because such screenings can only be reached via nonunitary maps of the Coulomb law, thus resulting in being particular cases of the broader hadronic chemistry.

The main purpose of this chapter is the application of hadronic chemistry to the construction of a new model of molecular bonds and its verification in the representation of experimental data of the hydrogen molecule.

Since molecular structures are considered as isolated, thus being closed, conservative, and reversible, the applicable branch of hadronic chemistry is *isochemistry*, which is characterized by the identification of the nonunitary time evolution with the generalized unit of the theory, called *isounit*,

$$U \times U^{\dagger} = I(r, p, \psi, \partial \psi, ...) \neq I, \qquad (9.1.3)$$

assumed hereon not to depend explicitly on time, and the reconstruction of the totality of the formalism of quantum chemistry into a new form admitting of  $\hat{I}$ , rather than I, as the correct right and left new unit.

The capability by the isounit to represent nonlinear, nonlocal, and nonhamiltonian interactions is evident. Its selection over other possible choices is mandated by the condition of *invariance*, that is, the prediction of the same numerical values for the same quantities under the same conditions, but at different times. In fact, whether generalized or not, the unit of any theory is the basic invariant.

A central assumption of this chapter is that quantum mechanics and chemistry are exactly valid at all distances of the order of the Bohr radius ( $\simeq 10^{-8}$  cm), and the covering hadronic chemistry only holds at distance of the order of the size of the wavepackets of valence electrons (1 fm =  $10^{-13}$  cm).

This condition is evidently necessary, on one side, to admit the conventional quantum structure of the hydrogen atom, and, on the other side, to admit quantitative studies of the nonhamiltonian interactions of short range valence bonds.

The above condition is readily achieved by imposing that all isounits used in this chapter recover the conventional unit at distances greater than 1 fm,

$$\lim_{r\gg1\,\text{fm}}\hat{I}(r,p,\psi,\partial\psi,\dots) = I,$$
(9.1.4a)



Figure 9.1. A schematic view of the central conditions studied in this chapter, the deep overlapping of the wavepackets of valence electrons in singlet coupling (to verify Pauli's exclusion principle). These conditions are known to be nonlinear, nonlocal, and nonpotential (due to the zero-range, contact character of the interactions), thus not being representable via a Hamiltonian, and, consequently, not being unitary. As a result, the ultimate nature of valence bonds is outside any credible representation via quantum chemistry. Hadronic chemistry (Chapter 3) has been built for the specific scope of representing the conditions herein considered of the bonding of valence electrons.

$$|\ddot{I}| \ll 1, \quad |\ddot{T}| \gg 1.$$
 (9.1.4b)

In fact, under the above condition, hadronic chemistry recovers quantum chemistry everywhere identically. The reader should keep in mind the crucial implications of conditions (9.1.4b) which, as shown in Sect. 3.4, permit a dramatic increase of the convergence of chemical series, with corresponding decrease of computer time, as verified in the models of this chapter and of the following ones.

The reader should also note that, quite remarkably, rather than being imposed, both conditions (9.4a) and (9.4b) are naturally verified by actual chemical models.

It should be recalled that, under the assumption of representing closed-isolated systems, isochemistry verifies all conventional laws and principles of quantum mechanics (Chapter 3). Therefore, there is no a priori mean for rejecting the validity of hadronic chemistry within the small region of space of valence bonds.

It then follows that the selection of which theory is valid is referred to the capability to represent experimental data. Quantum mechanics has been capable of achieving an exact representation of all experimental data for the structure of *one individual* hydrogen atom. Therefore, quantum mechanics is here assumed as being exactly valid within such a well defined physical system, any possible improvement being redundant at best.

By comparison, quantum mechanics and chemistry have not been able to achieve an exact representation of the experimental data of the *different* conditions of molecular structures, as discussed in detail in Chapter 1. As a result,



Figure 9.2. A schematic unit of the hadronic horizon, namely, of the sphere of radius 1 fm (=  $10^{-13}$  cm) outside which quantum chemistry is assumed to be exactly valid, and inside which nonlinear, nonlocal, and nonpotential effects are no longer negligible, thus requesting the use of hadronic chemistry for their numerical and invariant treatment.

these theories are *not* considered as being exactly valid for the different conditions of molecular bonds (see Fig. 1.7).

As we shall see in this chapter, hadronic chemistry can indeed provide an exact representation of molecular characteristics, and, therefore, it is consider as being exactly valid for the indicated conditions of applicability.

A knowledge of *isomathematics* of Chapter 3 is essential for a technical understanding of the content of this chapter. A comprehemnsive presentation is available in monograph [67]

(see also representative papers [3, 4]).

For mathematically less inclined readers, we recall from Sect. 3.3.6 that specific applications of isochemistry can be constructed in their entirety via a simple nonunitary transform of conventional quantum chemical models. In fact such a transform adds precisely the desired short range, nonlinear, nonlocal, and nonhamiltonian effects.

### 9.1.2 Isochemical Model of Molecular Bonds

We now present the conceptual foundations of our isochemical model of molecular bonds for the simplest possible case of the  $H_2$  molecule, which was first submitted by Santilli and Shillady in Ref. [5]. We shall then extend the model to the water and to other molecules in the subsequent chapter.

Since the nuclei of the two H-atoms remain at large mutual distances, the bond of the  $H_2$  molecule is evidently due to the bond of the peripheral valence electrons, as generally acknowledged [1].

Our main assumption [5] is that pairs of valence electrons from two different atoms can bond themselves at short distances into a singlet quasi-particle state



Figure 9.3. A schematic view of the proposed isochemical model of the hydrogen molecule with fully stable isoelectronium, where the top view refers to absolute zero degree temperature and in the absence of any motions, while the lower view includes rotations, thus recovering the conventional spherical distribution. The view is complementary to that of Fig. 9.7 for the unstable isoelectronium. The model is here depicted in terms of orbits of the valence electrons, rather than in terms of orbitals, or density distributions. The fundamental assumption is that the two valence electrons, one per each atom, correlate themselves into a bonded singlet state at short distance we have called *isoelectronium*, which is assumed in this figure to be stable. In this case the only orbit yielding a stable H-molecule is that in which the isoelectronium describes a *oo*-shaped orbit around the respective two nuclei, as it occurs for planets in certain systems of binary stars. The isoelectronium is then responsible for the *attractive force* between the two atoms. The binding energy is instead characterized by the oo-shaped orbit of the isoelectronium around the two nuclei, conceptually represented in this figure via a standing wave for a particle of spin 0, charge -2e, and null magnetic moment. As we shall see in this chapter, the model then permits a representation of: the reason why the  $H_2$  and  $H_2O$  molecules have only two hydrogen atoms; the exact representation of the binding energy; the resolution of some of the inconsistencies of the conventional model; and other advances. Note finally that the model is easily extendable to dimers such as HO, HC, etc., as studied in Chapter 3. The novelty in predictive character of the model can be seen from these preliminary lines. For instance, the model depicted in this figure predicts that the hydrogen molecule becomes asymmetric, thus acquiring an infrared signature, under sufficient magnetic polarization, which removes its rotational motions.

called "isoelectronium," which describes an oo-shaped orbit around the two nuclei similar to that of planets in binary star systems (Fig. 9.3).

It is important to note that recent studies in pure mathematics [39] have established that the *oo*-shaped orbit, called the *figure eight* solution, is one of the most stable solutions of the N-body problem.

The primary binding force of the isoelectronium is assumed to be of nonlinear, nonlocal, and nonpotential type due to contact effects in deep overlappings of the wavepackets of the valence electrons, as studied in Sect. 9.3.


Figure 9.4. A schematic view of the conventional Coulomb forces of electrostatic and magnetostatic type in the structure of the isoelectronium. Since the charges are equal, they cause a repulsion. However, since the coupling is in singlet, the magnetic polarities are opposite, thus implying an attraction. Elementary calculations show that the magnetostatic attraction equals the electrostatic repulsion at a mutual distance of the order of 1 fm, while it becomes bigger at smaller distances, thus explaining the reason why the hadronic horizon has been set at  $10^{-13}$  cm. This evidence establishes that the bonding force of the isoelectronium can also see its origin on purely Coulomb forces and, more particular, on the dominance of magnetic over electric effects at short distances, which is a rather general occurrence under the proper conditions (see the new chemical special of magnecules in Chapter 8). Despite this fully potential attractive total force, it should be stressed that the isoelectronium cannot be treated within a purely quantum mechanics context for various reasons. The first reason is that with the decrease of the distance, both electrostatic and magnetostatic effects diverge, thus preventing any serious scientific study. Hadronic mechanics and chemistry have been built precisely to remove these divergencies via the isotopies of generic products  $A \times B = A \times \hat{T} \times B$  with  $|\hat{T}| \ll 1$  (Chapter 3). Therefore, the hadronic treatment of the isoelectronium permits convergent numerical predictions which would be otherwise impossible for quantum chemistry. Independently from that, the nonunitary lifting of quantum chemistry is mandated by the need to achieve an exact representation of experimental data on molecules which, as now established, requires screenings solely obtainable via nonunitary transforms of the Coulomb potential. Thus, any attempt to preserve old theories as exactly valid is doomed to failures. Despite that, the electrostatic and magnetostatic effects depicted in this figure illustrate that conventional potential effects should also be expected in the structure of the isoelectronium. In other words, rather than assuming either a purely quantum or a purely hadronic setting, we have in media virtus, i.e., the most plausible origin of the bonding force of the isoelectronium is that partially of potential and partially of nonpotential type. Still in turn, this implies the possibility of a significant (negative) binding energy for the isoelectronium, which is evidently that characterized by the potential component (Sect. 9.3).

However, the reader should be aware that the isoelectronium is expected to have a component of the binding force of purely potential type because, when the electrons are in singlet coupling, the magnetostatic *attraction* may be conceivably bigger than the electrostatic *repulsion* at distances of the order of one fermi or less (see Fig. 9.4 for details).

It should be stressed, however, that a purely potential origin of the isoelectronium is not expected to be exactly valid for various reasons, the most visible one being the fact that, at the very small mutual distances here considered, magnetostatic and electrostatic laws diverge, thus prohibiting reliable quantitative studies.

Hadronic chemistry has been built to resolve all divergences in the study of the isoelectronium thanks to the isomathematics with product  $A \times B = A \times \hat{T} \times B$ , and the isotopic element  $\hat{T}$  restricted to have absolute values much smaller than 1. In this way, the hadronic component of the isoelectronium binding force will "absorb" all divergent or otherwise repulsive effects, resulting in convergent numerical values.

The reader is also discouraged to reduce the isoelectronium to a purely quantum structure because, in this way, the theory would preserve all the insufficiencies of chemistry studied in Chapter 1, most importantly, the inability to reach an exact representation of molecular characteristics from the strict application of first quantum principles without *ad hoc* adulterations. In fact, as now well established, such an exact representation requires screenings of the Coulomb law, which can only be obtained via nonunitary transforms. The same nonunitary broadening of quantum chemistry is requested on numerous other counts independent from the isoelectronium.

Despite these limitations, the purely magnetostatic-electrostatic structure of the isoelectronium remains important *in first approximation*, because it recovers in a very simple way the hadronic horizon (Fig. 9.2), as well as the prediction by hadronic mechanics dating back to 1978 that triplet couplings are highly unstable. In fact, in the latter case, both electrostatic and magnetostatic forces would be *repulsive*, thus prohibiting any possible bound state, in beautiful agreement with Pauli's exclusion principle.

It is easy to predict that the isoelectronium cannot be permanently stable when interpreted as a quasi-particle of about 1 fm charge diameter. In fact, the mere presence of exchange forces, which remain fully admitted by isochemistry, prevents the achievement of a complete stability under the indicated small mutual distances of the electrons. As we shall see in more details in Chapter 6, there are additional technical reasons which prevent the complete stability at short distances, and actually render the isoelectronium a short lived quasi-particles when the valence electrons are assumed at mutual distances of 1 fm.

However, it is easy to see that the isoelectronium must be fully stable when the mutual distance of the two valence electrons is permitted to be of the order of molecular size. In fact, any instability under the latter long range conditions would imply a necessary violation of the fundamental Pauli's exclusion principle.

In different words, the isoelectronium is one of the first known quantitative representations of Pauli's principle, in the sense that:

1) When assumed to be of potential type, the interaction responsible for Pauli's principle implies catastrophic inconsistencies, such as shifts of experimentally established energy levels, deviations from all spectroscopic lines, etc. As a result, a quantitative representation of Pauli's principle is *impossible* for quantum mechanics, evidently due to its strictly potential character. For this reason, Pauli's principle is merely imposed in quantum mechanics without any explanations, as well known. By comparison, a quantitative representation is possible for hadronic mechanics precisely because of its admission of *nonpotential* interactions, that is, interactions which have no bearing on energy levels and spectroscopic lines.

2) Quantum mechanics admits, in general, both singlet and triplet couplings because particles are assumed to be point like as per the very topological structure of the theory. By comparison, hadronic mechanics represents particles as expended at mutual distances smaller than their wavepackets, and solely admits singlet couplings due to highly repulsive-unstable forces predicted for all triplet couplings. The latter repulsive forces originate from the drag experienced by one wavepackets when rotating within and against the rotation of the other wavepacket, as well as by the fact that in triplet couplings both magnetostatic and electrostatic effects are repulsive (Fig. 9.4); and

3) Quantum mechanics cannot provide an exact representation of an *attrac*tion between *identical* electrons at very short distances, as discussed earlier, in disagreement with the experimental evidence, e.g., that the two electrons of the helium are bonded most of the time, to such an extent that they are emitted in such a bonded form during photodisintegrations, and in other events. By comparison, hadronic mechanics has been built to represent precisely the *bonding* of identical electrons in *singlet* coupling under interactions *not* derivable from a potential.

The assumption of the isoelectronium as being unstable when its valence electrons are at mutual distances of molecular order, implies a violation of Pauli's principle, e.g., because of the automatic admission of triplet couplings for two electrons at the same energy level.

When assumed as being stable in the limit case of a quasi-particle of 1 fm charge radius, the most stable trajectory of the isoelectronium is of oo-type, each o-branch occurring around each nucleus (Fig. 9.3). As illustrated in Fig. 9.4 (see also Chapter 8), such a shape automatically prevents the inconsistent prediction of ferromagnetic character of all molecules.

When the correlation-bond is distributed over the entire molecular orbit, the trajectory of the isoelectronium is also expected to be oo-shaped around the two nuclei with inverted direction of rotation from one o-branch to the other. This is suggested by a variety of reasons, such as: the need of avoiding the inconsistent prediction of ferromagnetic character, the compatibility with the limit case of a

fully stable particle at short distance (which, as we shall see, can describe several *oo*-shaped orbits prior to separation), and others.

It should be indicated that the assumption of a finite lifetime of the isoelectronium irrespective of size implies the possibility of adding several H-atoms to the  $H_2$  molecule for the duration of the unbound valence electrons, as well as other inconsistencies, such as the capability by hydrogen and water to be paramagnetic (Chapter 8).

In this chapter, we apply the above hypothesis to the construction of a new model of the hydrogen molecule and prove its capability to:

1) provide an essentially exact representation of the binding energy and other characteristics of the hydrogen molecules;

2) said representation occurs from first axiomatic principles without exiting from the underlying class of equivalence as occurring for Coulomb screenings;

3) explain for the first time to our knowledge the reason why the hydrogen molecule has only two atoms;

4) introduce an actual "strongly" attractive molecular bond;

5) achieve a much faster convergence of power series with consequential large reduction in computer times;

6) prevent inconsistencies such as the prediction that the hydrogen is ferromagnetic. In fact, whatever magnetic polarity can be acquired by the orbit around one nucleus, the corresponding polarity around the second nucleus will necessarily be opposite, due to the opposite direction of the rotations in the two *o*-branches, thus preventing the acquisition of a net total polarity North-South of the molecule.

By recalling from Chapter 3 that Gaussian screenings of the Coulomb law are a particular case of the general nonunitary structure of hadronic chemistry, one can see from these introductory lines that our first achievement on scientific records of an essentially exact representation of molecular characteristics is reduced to the proper selection of the basic nonunitary transform, because the latter will permit dramatically more restrictive screenings.

The derivability of the essentially exact representation from first axioms of hadronic chemistry without adulterations is evident.

Equally evident is the first introduction of an actual, "strongly" attractive interatomic force (where the word "strongly" does not evidently refer to strong interactions in hadron physics), which is absent in current models due to the notorious "weak" nature of exchange and other forces of current used in molecular structures (where the word "weak" does not evidently refer to the weak interactions among leptons).

The representation of the reason why the hydrogen (or water) molecule has only two H-atoms is inherent in the very conception of the isoelectronium. Once the two valence electrons of the H-atoms couple themselves into a singlet quasi-



Figure 9.5. A schematic view of the impossibility for the isochemical model of the hydrogen molecule to acquire a net magnetic polarity, thus resolving a serious inconsistency of quantum chemistry. Recall from Chapter 1 that current molecular models are based on exchange, van der Waals, and other forces of nuclear origin, all implying the independence of the orbitals of the individual atoms. Under these assumptions, quantum electrodynamics demands that all molecules acquire a net total magnetic polarity North-South when exposed to an external magnetic field, in dramatic disagreement with reality. The isochemical model of molecular structure resolves this inconsistency because, as indicated in Fig. 4.3, the most stable trajectory for the isoelectronium is *oo*-shaped as it also occurs for the trajectory of planets in binary stars, with each *o*-branch around each nucleus. In this case, the rotation of the two *o*-branches are necessarily opposite to each other, thus resulting in *opposite* magnetic polarities, with the consequential impossibility to reach a *net* molecular magnetic polarity. As we shall see in Chapter 7, the above features have important industrial applications for new clean fuels and energies.

particle state, there is no possibility for a third valence electron to participate in the bound state, e.g., because we would have an impossible bound state between a fermion (the third electron) and a boson (the isoelectronium).

The achievement of a much faster convergence of the power series, or, equivalently, a dramatic reduction of computer times for the same calculations, is evident from the structure of hadronic chemistry as discussed in Chapter 3.

The avoidance of the prediction of ferromagnetic features (acquisition of a total North-South polarity under an external magnetic field) is due to the nature of the orbit of the isoelectronium, as discussed in details below and in Chapter 8.

In this chapter, we shall study two realizations of the proposed new model of the hydrogen molecule, the first model is a limiting case in which the isoelectronium is assumed to be *stable* (with an infinite lifetime) at ordinary conditions, and the second model in which the isoelectronium is assumed to be *unstable* (with a finite lifetime). The lifetime of the isoelectronium will then be computed in Chapter 6.



*Figure 9.6.* A schematic view of the *trigger*, namely, the external means suitable to force electrons with the same charge to penetrate the hadronic barrier (Fig. 9.2), in which attractive hadronic forces overcome the repulsive Coulomb barrier.

The hypothesis of the bonding of electrons at short distances was first introduced by Santilli [7a] for the structure of the  $\pi^0$  meson as a hadronic bound state of one electron and one positron. Animalu [7b] and Animalu and Santilli [7c] extended the model to the Cooper pair in superconductivity as a hadronic bound state of two identical electrons.

A notion which is important for the very existence of the isoelectronium is that of a trigger, namely, external (conventional) interactions, which cause the identical electrons to move one toward the other and to penetrate the hadronic horizon (Fig. 9.2) against their repulsive Coulomb interactions. Once inside the above mentioned horizon, the attractive hadronic forces overcome the repulsive Coulomb interaction, resulting in a bound state.

In the case of the  $\pi^0$  model as a bound state of an electron and a positron at short distances, there is no need for a trigger because the constituents naturally attract each other. On the contrary, the existence of the Cooper pair does indeed require a trigger, which was identified by Animalu [7b] and Animalu and Santilli [7c] as being provided by the Cuprate ions. For the case of an isolated hydrogen molecule, we conjecture that the trigger is constituted by the two H-nuclei, which do indeed attract the electrons. We essentially argue that the attraction of the electrons by the two nuclei is sufficient to cause the overlapping of the two wavepackets, thus triggering the electrons beyond the hadronic horizon.

It should be indicated that we cannot use the term "electronium" because it would imply a bound state of two identical electrons under *quantum* mechanics, which is known to be impossible. The term "electronium" would also be technically inappropriate because the constituents *are not* ordinary electrons, but rather "isoelectrons," i.e., the image of ordinary particles under *nonunitary* transforms or, more technically, irreducible isounitary representations of the covering of the Poincarè symmetry known as the *Poincarè-Santilli isosymmetry* [3c, 3d, 4a].

We cannot close this conceptual section without a few comments regarding the possibility of treating the isoelectronium via quantum electrodynamics (QED), since the latter appears to be the natural discipline for a valence bond of two identical electrons at short distance. This issue is compounded by the general belief of the unrestricted exact validity of QED all the way to very small distances of the order of  $10^{-24}$  cm.

It is easy to see that, as it is the case for quantum mechanics, a quantitative treatment of the isoelectronium is beyond the technical capabilities of QED for numerous conceptual and technical reasons. In fact, QED is purely linear, local and potential, while the interactions we are interested in representing are nonlinear, nonlocal and nonpotential.

In any case, it is easy to prove via the use of the Feynman diagrams that QED cannot represent any attraction between identical electrons in singlet coupling at short distance, as it occurs in the physical reality for the two electrons of the Helium, the Cooper pair, the valence electrons, and other systems. On the contrary, the *isotopies of quantum electrodynamics* (ISOQED) are expected to provide such a representation, but their study here would be vastly beyond the limited scope of this monograph.

The reconciliation between the current belief of the unrestricted exact validity of QED and the bonding of identical electrons is permitted by the fact that all experimental verifications of QED at shorter and shorter distances have been conducted via the use of *higher and higher energies*. On the contrary, the experimental verification of QED for the conditions of the isoelectronium require *smaller and smaller energies* which experimental verifications have been absent in the physics of the 20-th century due to the notorious emphasis on high energies.

As a final comment, it should be noted that the limitations of QED for the study of the isoelectronium are purely classical, and rest on the inability of classical electrodynamics to represent the physical evidence of the attraction of identical spinning charges at sufficiently small distances, evidence which is even visible to the naked eyes, e.g., in ball lighting as created by nature, in microwave ovens or other means.

As a matter of fact, no classical theory of electromagnetism can possibly be considered as "final" until it achieves the capability of representing the attraction of identical charges under suitable conditions. As a result, no quantum theory of electromagnetism, including QED, can be considered as "final" unless it is based on the preceding classical theory. One of the objectives of classical and operator isochemistry is precisely that of achieving such a missing representation.

### 9.1.3 The Limit Case of Stable Isoelectronium

We are now equipped to conduct a nonrelativistic study of the isoelectronium (Fig. 9.3) in the limit case of full stability under the assumption that the binding force is of purely hadronic type without potential contributions (Fig. 9.4). This approach is evidently done to test the effectiveness of hadronic chemistry for the numerical studies of the problem considered, since corrections due to potential effects can be easily added.

The reader should be aware upfront that the above assumptions imply that the isoelectronium has no binding energy, trivially, because nonpotential forces have no potential energy by conception.

The reader should be aware that the actual hadronic treatment should be conducted within the context of isomathematics, that is, on isoeuclidean and isohilbert spaces defined over isofields. To avoid excessive mathematical complexity, in this section we study the *projection* of this isotopic treatment on conventional spaces over conventional fields. However, it should be stressed that the only correct formulation remains the isotopic one.

As we shall see, the hadronic treatment of the isoelectronium yields an attraction of the type of the Hulten potential which is so strong to "absorb" at short distances all other forces, whether attractive or repulsive. However, the direct interpretation of the Hulten potential as an actual potential would be erroneous, since it solely occurs in the *projection* of the model on conventional spaces, while being completely absent in the technically appropriate treatment on isospaces over isofields. The direct interpretation of the Hulten potential as an actual potential well of quantum mechanical nature would also be in direct contradiction with the absence of binding energy.

Therefore, the assumption of the projected model as the correct one leads to insidious inconsistencies and misrepresentations, such as the possible interpretation of the isoelectronium via a potential well, which treatment is very familiar in quantum mechanics, but the same treatment has no physical meaning for the isoelectronium. This is due to the fact that, as stressed earlier, a necessary condition to avoid inconsistencies in the interpretation of Pauli's principle is that its interaction *does not* admit a potential energy, thus rendering meaningless, or at best contradictory, conventional potential wells.

Note that the emergence of a "strong" Hulten potential eliminates the issue whether the isoelectronium is due to the dominance of the attractive magnetostatic forces over the repulsive electric ones (Fig. 9.4). This is due to the fact that the Hulten potential, as we shall review shortly in detail, behaves at short distances as constant/r, thus absorbing all Coulomb forces, irrespective of whether attractive or not. Moreover, the unified treatment via the Hulten potential presented below eliminates the divergent character of these forces at short distances, thus permitting meaningful numerical results. We should finally indicate, to avoid inconsistencies, that the study of this section deals with the *limit* case of a perfectly stable isoelectronium interpreted as a quasi-particle of about 1 fm charge diameter, while in reality such form of the isoelectronium is unstable. Moreover, in this section we shall not study the expectation that the isoelectronium persists beyond the 1 fm mutual distance of the valence electrons, as necessary to prevent violations of Pauli's principle.

We begin our quantitative analysis with the nonrelativistic quantum mechanical equation of two ordinary electrons in singlet couplings,  $e_{\downarrow}^{-}$  and  $e_{\uparrow}^{-}$  represented by the wavefunction  $\psi_{\uparrow\downarrow}(r) = \psi(r)$ ,

$$\left(\frac{p \times p}{m} - \frac{e^2}{r}\right) \times \psi(r) = E \times \psi(r).$$
(9.1.5)

To transform this state into the isoelectronium representing the bonding of the H-electron with a valence electron of another atom of generic charge ze, we need first to submit Eq. (9.1.5) to a nonunitary transform characterizing the short range hadronic effects, and then we must add the *trigger*, namely, the Coulomb attraction by the nuclei.

This procedure yields the *isoschrödinger equation* for the *isoelectronium* (Chapter 1),

$$U \times U^{\dagger} = \hat{I} = 1/\hat{T} > 0,$$
 (9.1.6*a*)

$$\hat{A} = U \times A \times U^{\dagger}, \quad A = p, \ H, \dots,$$
 (9.1.6b)

$$U \times (A \times B) \times U^{\dagger} = \hat{A} \times \hat{B} = \hat{A} \times \hat{T} \times \hat{B}, \quad \hat{\psi} = U \times \psi, \qquad (9.1.6c)$$

$$\left(\frac{1}{m}\hat{p}\times\hat{T}\times\hat{p}\times\hat{T}+\frac{e^2}{r}\times\hat{T}-\frac{z\times e^2}{r}\right)\times\hat{\psi}(r)=E_0\times\hat{\psi}(r),\qquad(9.1.6d)$$

$$\hat{p} \times \hat{\psi}(r) = -i \times \hat{T} \times \nabla \hat{\psi}(r), \qquad (9.1.6e)$$

where the factor  $\hat{T}$  in the first Coulomb term originates from the nonunitary transform of model (9.1.5), while the same factor is absent in the second Coulomb term because the latter is long range, thus being conventional. As a result, in the model here considered the trigger is merely added to the equation.

The angular component of model (9.1.6) is conventional [3], and it is here on ignored. For the radial component  $r = |\mathbf{r}|$ , we assume the isounit [7]

$$\hat{I} = e^{N \times \psi/\hat{\psi}} \approx 1 + N \times \psi/\hat{\psi}, \quad N = \int dr^3 \,\hat{\psi}^{\dagger}(r)_{1\downarrow} \times \hat{\psi}(r)_{2\uparrow}, \tag{9.1.7a}$$

$$\hat{T} \approx 1 - N \times \psi/\hat{\psi},$$
 (9.1.7b)

$$|\hat{I}| \gg 1, \quad |\hat{T}| \ll 1,$$
 (9.1.7c)

$$\lim_{r\gg1\text{fm}}\hat{I} = 1,\tag{9.1.7d}$$

where one should note that Eqs. (9.1.7c) and (9.1.7d) are automatically verified by expressions (9.1.7a) and (9.1.7b).

Note that the explicit form of  $\psi$  is of Coulomb type, thus behaving like

$$\psi \approx N \times \exp(-b \times r),$$
 (9.1.8)

with N approximately constant at distances near the hadronic horizon of radius

$$r_c = \frac{1}{b},\tag{9.1.9}$$

while  $\hat{\psi}$  behaves like

$$\hat{\psi} \approx M \times \left(1 - \frac{\exp(-b \times r)}{r}\right),$$
(9.1.10)

with M being also approximately constant under the same range [7a]. We then have

$$\hat{T} \approx 1 - \frac{V_{\text{Hulten}}}{r} = 1 - V_0 \frac{e^{-b \times r}}{(1 - e^{-b \times r})/r},$$
(9.1.11)

namely, we see the appearance of a Hulten potential in this local approximation. But the Hulten potential behaves at short distances like the Coulomb one,

$$V_{\text{Hulten}}r \approx \frac{1}{b} \approx \frac{V_0}{b} \times \frac{1}{r}.$$
 (9.1.12)

As a result, inside the hadronic horizon we can ignore the repulsive (or attractive) Coulomb forces altogether, and write

$$+\frac{e^2}{r} \times \hat{T} - \frac{e^2}{r} \approx +\frac{e^2}{r} \times \left(1 - \frac{V_{\text{Hulten}}}{r}\right) - \frac{z \times e^2}{r} = -V \times \frac{e^{-b \times r}}{1 - e^{-b \times r}}, \quad (9.1.13)$$

by therefore resulting in the desired overall *attractive* force among the identical electrons inside the hadronic horizon.

By assuming in first approximation  $|\hat{T}| = \rho \approx 1$ , the radial equation of model reduces to the model of  $\pi^0$  meson [7a] or of the Cooper pair [7b, 7c], although with different values of V and b.

$$\left[\frac{1}{r^2}\left(\frac{d}{dr}r^2\frac{d}{dr}\right) + \frac{m}{\rho^2 \times \hbar^2}\left(E_0 + V \times \frac{e^{-b \times r}}{1 - e^{-b \times r}}\right)\right] \times \hat{\psi}(r) = 0..$$
(9.1.14)

The exact solution and related boundary conditions were first computed in Ref. [7a], Sect. 5, and remain fully applicable to the isoelectronium.

The resulting spectrum is the typical one of the Hulten potential,

$$|E_0| = \frac{\rho^2 \times \hbar^2 \times b^2}{4 \times m} \left(\frac{m \times V}{\rho^2 \times \hbar^2 \times b^2} \times \frac{1}{n} - n\right)^2, \qquad (9.1.15)$$

which evidently possesses a *finite* spectrum, as well known.

To reach a numerical solution, we introduce the parametrization as in Ref. [7a],

$$k_1 = \frac{1}{\lambda \times b},\tag{9.1.16a}$$

$$k_2 = \frac{m \times V}{\rho^2 \times \hbar^2 \times b^2}.\tag{9.1.16b}$$

We note again that, from boundary conditions,  $k_2$  must be bigger than but close to one,  $k_2 \approx 1$  [7].

We therefore assume in first nonrelativistic approximation that

$$\frac{m \times V}{\rho^2 \times \hbar^2 \times b^2} = 1. \tag{9.1.17}$$

By assuming that V is of the order of magnitude of the total energy of the isoelectrons at rest as in the preceding models [7],

$$V \approx 2 \times \hbar \times \omega \approx 2 \times 0.5 \text{MeV} = 1 \text{MeV},$$
 (9.1.18)

and by recalling that  $\rho \approx 1$ , we reach the following estimate for the radius of the isoelectronium

$$r_{c} = b^{-1} \approx \left(\frac{\hbar^{2}}{m \times V}\right)^{1/2} = \left(\frac{\hbar}{m \times \omega_{0}}\right)^{1/2} = \left(\frac{1.054 \times 10^{-27} \text{erg} \cdot \text{sec}}{1.82 \times 10^{-27} \text{ g} \times 1.236 \times 10^{20} \text{ Hz}}\right)^{1/2} =$$
(9.1.19)

$$= 6.8432329 \times 10^{-11} \text{cm} = 0.015424288 \text{ bohrs} = 0.006843 \text{ Å}_{2}$$

It should be noted that: 1) the above values of  $r_c$  and V are only upper boundary values in the center-of-mass frame of the isoelectronium, i.e., the largest possible values under the assumptions of this section; 2) the values have been computed under the approximation of null relative kinetic energy of the isoelectrons with individual total energy equal to their rest energy; and 3) the values evidently decrease with the addition of the relative kinetic energy of the isoelectrons (because this implies the increase of m in the denominator).

The actual radius of the isoelectronium, when considered to be an quasiparticle as in this section, is also expected to vary with the trigger, that is, with the nuclear charges, as confirmed by the calculations presented in the next sections. This illustrates again the upper boundary character of value (9.1.19).

The value  $k_1$  is then given by

$$k_1 = \frac{V}{2 \times k_2 \times b \times c_0} = 0.19, \quad k_2 \approx 1.$$
 (9.1.20)

Intriguingly, the above two values for the isoelectronium are quite close to the corresponding values of the  $\pi^0$  [7a] and of the Cooper pair [7b, 7c] (see also Sect. 1.9),

$$k_1 = 0.34, \quad k_2 = 1 + 8.54 \times 10^{-2},$$
 (9.1.21*a*)

$$k_1 = 1.3 \times \sqrt{z} \times 10^{-4}, \quad k_2 = 1.0 \times \sqrt{z},$$
 (9.1.21b)

It is important to see that, at this nonrelativistic approximation, the binding energy of the isoelectronium is not only unique, but also identically null,

$$|E_0| = \frac{\rho^2 \times \hbar^2 \times b^2}{4 \times m} \left(\frac{m \times V}{\rho^2 \times \hbar^2 \times b^2} - 1\right)^2 = \frac{V}{4 \times k_2} \times (k_2 - 1)^2 = 0.$$
(9.1.22)

This result is crucial to prevent inconsistencies with Pauli's exclusion principle, which, as indicated earlier, requires no potently energy between the two electrons for its interpretation in a way consistent with experimental data.

The notion of a bound state with only one allowed energy level (called "hadronic suppression of the atomic spectrum" [7a]) is foreign to conventional quantum mechanics and chemistry, although it is of great importance for hadronic mechanics. In fact, any excitation of the constituents, whether the  $\pi^0$ , the Cooper pair or the isoelectronium, causes their exiting the hadronic horizon, by therefore re-acquiring the typical atomic spectrum. Each of the considered three hadronic states has, therefore, only one possible energy level.

The additional notion of a bound state with null binding energy is also foreign to quantum mechanics and chemistry, although it is another fundamental characteristic of hadronic mechanics and isochemistry. In fact, the hadronic interactions admit no potential energy, and as such, they cannot admit any appreciable binding energy, as typical for ordinary contact zero-range forces of our macroscopic Newtonian reality.

The null value of the binding energy can be confirmed from the expression of the meanlife of the isoelectronium, which can be written in this nonrelativistic approximation [7a]

$$\tau = \frac{\hbar}{4 \times \pi \times \hbar^2} |\hat{\psi}(0)| \times \alpha \times E_{\hat{e}}^{\text{Kin}} = 7.16 \times 10^4 \times \frac{k_1}{(k_2 - 1)^3 \times b \times c_0}.$$
 (9.1.23)

The full stability of the isoelectronium,  $\tau = \infty$ , therefore, requires the exact value  $k_2 \equiv 1$ , which, in turn, implies  $E_0 \equiv 0$ .

The above derivation characterizes the limiting assumption of a fully stable isoelectronium in nonrelativistic approximation. By comparison, the Cooper pair under the same derivation is not permanently stable because its binding energy is very small, yet finite [7b], thus implying a large yet finite meanlife. Also by comparison, the  $\pi^0$  cannot be stable, and actually has a very small meanlife, evidently because the constituents are a particle-antiparticle pair and, as such, they annihilate each other when bound at short distances.

Another important information of this section is that the isoelectronium is sufficiently small in size to be treated as a single quasi-particle. This property will permit rather important simplifications in the isochemical structure of molecules studied in the next sections.

By comparison, the Cooper pair has a size much bigger than that of the isoelectronium [7b, 7c]. This property is fundamental to prevent that the Cooper pair takes the role of the isoelectronium in molecular bonds, i.e., even though possessing the same constituents and similar physical origins, the isoelectronium and the Cooper pair are different, non-interchangeable, hadronic bound states.

The lack of binding energy of the isoelectronium is perhaps the most important information of this section. In fact, it transfers the representation of the binding energy of molecular bonds to the motion of the isoelectronium in a molecular structure, as studied in the next sections.

A novelty of isochemistry over quantum chemistry is that the mutual distance (charge diameter) between the two isoelectrons in the isoelectronium could, as a limited case, also be identically null, that is, the two isoelectrons could be superimposed in a singlet state. Rather than being far fetched, this limit case is intriguing because it yields the value -2e for the charge of the isoelectronium, the null value of the relative kinetic energy, and an identically null magnetic field. This is a perfectly diamagnetic state, which evidently allows a better stability of the isochemical bond as compared to a quasi-particle with non-null size.

Note that, if conventionally treated (i.e., represented on conventional spaces over conventional fields), the nonunitary image of model (9.1.5) would yield *noninvariant numerical results* which, as such, are unacceptable (Sect. 1.7). This occurrence mandates the use of the covering isochemistry and related isomathematics which assures the achievement of invariant results.

Note also that the main physical idea of isounit (9.1.7) is the representation of the overlapping of the wavepackets of the two electrons under the condition of recovering conventional quantum chemistry identically whenever such overlapping is no longer appreciable. In fact, for sufficiently large relative distances, the volume integral of isounit (9.1.7a) is null, the exponential reduces to I, Eq. (9.1.7d), the nonunitary transform becomes conventionally unitary, and quantum chemistry is recovered identically.

It is also important to see that, under transform (9.1.7a), model (9.1.5) is implemented with interactions which are: nonlinear, due to the factor  $\psi/\hat{\psi}$  in the exponent; nonlocal, because of the volume integral in (9.1.7a); and nonpotential, because not represented by a Hamiltonian.

We finally note that the explicit form of the isotopic element  $\hat{T}$ , Eq. (9.1.7b), emerges in a rather natural way as being *smaller than one* in absolute value, Eq. (9.1.7c), i.e.,

$$|\ddot{T}| = |1 - N \times \psi/\psi| \ll 1.$$
 (9.1.24)

As pointed out in Chapter 3, this property alone is sufficient to guarantee that all slowly convergent series of quantum chemistry converge faster for isochemistry.

### 9.1.4 Isochemical Model of the Hydrogen Molecule with Stable Isoelectronium

We are now sufficiently equipped to initiate the study of the *isochemical model* of the hydrogen molecule, first submitted by Santilli and Shillady in Ref. [5] (see Figs. 9.3, 9.4 and 9.5). In this Section we shall begin the study by identifying the equation of structure of the H-molecule under the limit assumption that the isoelectronium is perfectly stable at short distances, namely, that the two valence electrons are permanently trapped inside the hadronic horizon, resulting in the main features derived in the preceding section

mass 
$$\approx 1 \text{MeV}$$
, spin = 0,  
charge = 2 × e, magnetic moment  $\approx 0$ ,  
radius =  $r_c = b^{-1} = 6.8432329 \times 10^{-11} \text{cm} =$   
= 0.015424288 bohrs = 0.006843 Å.  
(9.1.25b)

The more realistic case when the isoelectronium is unstable at such small distances is studied later on in this chapter, where we shall also reach an essentially exact representation of the characteristics of the hydrogen molecule.

The main reason for assuming the isoelectronium to be stable at short distances with characteristics (9.1.25) is that such an approximation permits rather major structural simplifications, most notably, the transition, from the conventional hydrogen molecule (which is a *four-body system*), to the isochemical model of this section (which is a *three-body system*, Fig. 9.3). By recalling that four-body systems do not admit an exact solution, while restricted three-body systems do admit an exact analytic solution, the implications of the approximate model of this section are sufficient to warrant an inspection.

Our foundation is the conventional quantum model of  $H_2$  molecule [1],

$$\left(\frac{1}{2\mu_1}p_1 \times p_1 + \frac{1}{2\mu_2}p_2 \times p_2 + + \frac{e^2}{r_{12}} - \frac{e^2}{r_{1a}} - \frac{e^2}{r_{2a}} - \frac{e^2}{r_{1b}} - \frac{e^2}{r_{2b}} + \frac{e^2}{R}\right) \times |\psi\rangle = E \times |\psi\rangle.$$
(9.1.26)

Our task is that of subjecting the above model to a transform

$$U \times U^{\dagger}|_{r \approx r_c} = \hat{I} = 1/\hat{T} \neq I, \qquad (9.1.27)$$

which is nonunitary only at the short mutual distances

$$r_c = b^{-1} = r_{12} \approx 6.8 \times 10^{-11} \text{cm},$$
 (9.1.28)

and becomes unitary at bigger distances,

$$U \times U^{\dagger}|_{r \le 10^{-10} \text{cm}} \ne I, \quad I_{r \gg 10^{-10} \text{cm}} = I.$$
 (9.1.29)

This guarantees that our isochemical model coincides with the conventional model everywhere except for small contributions at small distances.

Assumption (9.1.29) also guarantees that the conventional energy level of the individual hydrogen atoms are not altered. In other words, assumption (9.1.29) realizes the main conception of this monograph, the exact character of quantum mechanics for the structure of one hydrogen atom, and its insufficiency for two hydrogen atoms bounded into the hydrogen molecule (Chapter 1).

The Hilbert space of systems (9.1.26) can be factorized in the familiar form (in which each term is duly symmetrized or antisymmetrized) as in Refs. [1]

$$|\psi\rangle = |\psi_{12}\rangle \times |\psi_{1a}\rangle \times |\psi_{1b}\rangle \times |\psi_{2a}\rangle \times |\psi_{2b}\rangle \times |\psi_R\rangle, \qquad (9.1.30a)$$

$$\mathcal{H}_{\text{Tot}} = \mathcal{H}_{12} \times \mathcal{H}_{1a} \times \mathcal{H}_{1b} \times \mathcal{H}_{2a} \times \mathcal{H}_{2b} \times \mathcal{H}_R.$$
(9.1.30b)

The nonunitary transform we are looking for shall act only on the  $r_{12}$  variable while leaving all others unchanged. The simplest possible solution is given by

$$U(r_{12}) \times U^{\dagger}(r_{12}) = \hat{I} = \exp\left[\frac{\psi(r_{12})}{\hat{\psi}(r_{12})} \int dr_{12} \hat{\psi}^{\dagger}(r_{12})_{1\downarrow} \times \hat{\psi}(r_{12})_{2\uparrow}\right], \qquad (9.1.31)$$

where the  $\psi$ 's represent conventional wavefunctions and the  $\hat{\psi}$ 's represent isowavefunctions.

As an alternative yielding the same results, one can transform short-range terms (isochemistry), and add un-transformed long-range terms (quantum chemistry), resulting in the radial equation

$$\left(-\frac{\hbar^2}{2\times\mu_1}\hat{T}\times\nabla_1\times\hat{T}\times\nabla_1-\frac{\hbar^2}{2\times\mu_2}\hat{T}\times\nabla_2\times\hat{T}\times\nabla_2+\right.\\\left.+\frac{e^2}{r_{12}}-\frac{e^2}{r_{1a}}-\frac{e^2}{r_{2a}}-\frac{e^2}{r_{1b}}-\frac{e^2}{r_{2b}}+\frac{e^2}{R}\right)\times|\hat{\psi}\rangle=E\times|\hat{\psi}\rangle.$$
(9.1.32)

By recalling that the Hulten potential behaves at small distances like the Coulomb one, Eq. (9.1.32) becomes

$$\left(-\frac{\hbar^2}{2 \times \mu_1} \times \nabla_1^2 - \frac{\hbar^2}{2 \times \mu_2} \times \nabla_2^2 - V \times \frac{e^{-r_{12} \times b}}{1 - e^{-r_{12} \times b}} - \frac{e^2}{r_{1a}} - \frac{e^2}{r_{2a}} - \frac{e^2}{r_{1b}} - \frac{e^2}{r_{2b}} + \frac{e^2}{R}\right) \times |\hat{\psi}\rangle = E \times |\hat{\psi}\rangle.$$
(9.1.33)

The above equation does indeed achieve our objectives. In fact, it exhibits a new explicitly attractive force between the neutral atoms of the hydrogen molecule, which force is absent in conventional quantum chemistry. The equation also explains the reasons why the H<sub>2</sub> molecule admits only two H-atoms. As we shall see in the remaining sections, Eq. (9.1.33) also permits essentially exact representations of the binding energy and other molecular characteristics, yields much faster convergence of series with much reduced computer times, and resolves other insufficiencies of conventional models.

## 9.1.5 Exactly Solvable, Three-Body, Isochemical Model of the Hydrogen Molecule

Our isochemical model of the hydrogen molecule, Eqs. (9.1.33), can be subjected to an additional simplification, which is impossible for quantum chemistry. In our isotopic model, the two isoelectrons are bonded together into a single state we have called isoelectronium. In particular, the charge radius of the latter is sufficiently small to permit the values (see Fig. 9.3)

$$r_{12} \le r_{1a}$$
, and  $r_{1b}$ ,  $r_{12} \approx 0$ , (9.1.34a)

$$r_{1a} \approx r_{2a} = r_a, \quad r_{1b} \approx r_{2b} = r_b.$$
 (9.1.34b)

Moreover, the H-nuclei are about 2,000 times heavier than the isoelectronium. Therefore, our model (9.1.33) can be reduced to a restricted three body problem similar to that possible for the conventional  $H_2^+$  ion [1], but not for the conventional  $H_2$  molecule.

Such a restricted model essentially consists of two H-protons at rest at a fixed mutual distance plus the isoelectronium moving around them in the *oo*-shaped orbit of Fig. 9.4, according to the structural equation

$$\left(-\frac{\hbar^2}{2\mu_1} \times \nabla_1^2 - \frac{\hbar^2}{2\mu_2} \times \nabla_1^2 - V \times \frac{e^{-r_{12}b}}{1 - e^{-r_{12}b}} - \frac{2e^2}{r_a} - \frac{2e^2}{r_b} + \frac{e^2}{R}\right) \times |\hat{\psi}\rangle = E \times |\hat{\psi}\rangle.$$
(9.1.35)

Under the latter approximation, the model permits, for the first time, the achievement of an exacts solution for the structure of the  $H_2$  molecule, as it is the case for the  $H_2^+$  ion or for all restricted three-body problems. This solution will be studied in Chapter 6 via variational methods. The exact analytic solution has not been studied at this writing, and its study is here solicited by interested colleagues. At this introductory level we only limit ourselves to a few comments.

Note that the above exact solution of the hydrogen molecule is only possible for the case of the isoelectronium fully stable at short mutual distances. In fact,

for the case of the mutual distance of the valence electrons no longer restricted to 1 fm, the model is a full *four-body structure*, which, as such, admits no exact solution.

Note also that model (9.1.35) is the isochemical model of the H<sub>2</sub> molecule inside the hadronic horizon. The matching representation *outside* the hadronic horizon is presented in the next section.

Note also that the above restricted three-body model can be used for the study of the bonding of an H-atom to another generic atom, such as HO, thus permitting, again for the first time, novel exact calculations on the water as HOH, namely, as two intersecting isotopic bonds HO and OH, each admitting an exact solution, with possible extension to molecular chains, and evident extensions to other molecules.

Readers interested in studying model (9.1.35) should keep in mind that the rest energy of the isoelectronium is unknown at this writing, thus being a free parameter suitable for fitting experimental data. More specifically, in Eq. (9.1.35) we have assumed from Sect. 9.3 that

$$m_{\text{isoelectronium}} = 2 \times m_{\text{electron}}.$$
 (9.1.36)

However, the results of Sect. 9.3 are approximate. In particular, they hold under the assumption that the isoelectronium has no internal binding energy. Such an assumption was made for the specific purpose of proving that nonpotential forces represented with the isounit can indeed yield a bound state. In particular, the assumption was suggested by the need to represent Pauli's exclusion principle without the introduction of a potential.

However, such a view may be solely valid at molecular distances of valence electrons, and not necessarily at short distances. As a result, the isoelectronium may indeed have an internal binding energy, that is, it can have internal forces derivable from a potential in addition to the nonpotential forces without binding energy of hadronic chemistry, as outlined in Fig. 9.4.

This is due to the fact that the structure of the isoelectronium implies three acting forces: one repulsive Coulomb force due to the same changes, plus two attractive forces due to the two pairs of opposite magnetic polarities in singlet configuration. The latter two attractive forces may overcome the repulsion due to the change beginning at distances of the order of one Fermi, resulting in a conceivable net attractive force derivable from a potential.

Under the latter conditions, the isoelectronium would indeed have a *negative* binding energy, resulting in the unknown value

$$m_{\rm isoelectronium} < 2 \times m_{\rm electron}.$$
 (9.1.37)

The understanding is that the case  $m_{\text{isoelectronium}} > 2 \times m_{\text{electron}}$  is impossible.

The unknown character of the isoelectronium mass alters considerably the perspective of restricted model (9.1.35). As we shall see in Chapter 6, it is possible

to prove via variational and other methods that model (9.1.35) under assumption (9.1.36) does not admit exact solutions accurately representing the binding energy of the hydrogen molecule. However, under the use of the isoelectronium mass free for fitting experimental data, the situation may be different.

Another information which should not be assumed to be exact is the size of the isoelectronium, Eq. (9.1.19). In fact, as stressed in Sect. 9.3, such a value too must be assumed to be an upper boundary value. In model (9.1.35) the isoelectronium is assumed to be point-like. However, the model can be first extended via Eq. (9.1.35) for a stable isoelectronium with a fixed unknown radius

$$r_c = b^{-1} \le 6.8 \times 10^{-11} \text{cm.}$$
 (9.1.38)

A second extension of model (9.1.35) should also be taken into consideration, that in which

$$r_c = b^{-1} \ge 6.8 \times 10^{-11} \text{cm},$$
 (9.1.39)

because, as stressed in Sects. 9.2 and 9.3, any assumption that the isoelectronium ceases to exist at distances bigger than  $10^{-11}$  cm would imply a violation of Pauli's exclusion principle.

As a matter of fact, the assumed mass (9.1.36) is more in line with assumption (9.1.39), than with assumption (9.1.38), again, to prevent the existence at large mutual distances of the valence electrons of attractive internal potential forces with a binding energy which would alter conventional atomic structures.

Even though, admittedly, the size of the isoelectronium is variable in the physical reality, its average into a constant value may have meaning, of course, as a first approximation.

A third quantity of model (9.1.35) deserving inspection is the experimental value of the bond length, which is generally referred to the distance between the two nuclei R. In principle, such a distance is expected to be altered by a fully stable isoelectronium. Therefore, a solution of model (9.1.35) in which R is fitted from the experimental data is indeed meaningful, of course, as a first approximation.

In conclusion, in both, the four-body model (9.1.33) and the restricted threebody model (9.1.35), we have three quantities which, in principle, can be assumed to be unknown and, therefore, should be derived from the fit of experimental data: 1) the mass of the isoelectronium; 2) the size of the isoelectronium; and 3) the bond length.

There is no doubt that an exact analytic solution of model (9.35) suitable to represent the binding energy of the hydrogen is permitted by the above three free fits with intriguing implications for all H-bonds whose study is left to interested researchers.

### 9.1.6 Isochemical Model of the Hydrogen Molecule with Unstable Isoelectronium

In this section we review the study of Ref. [5] on the solution of the restricted isochemical model of the hydrogen molecule, Eq. (9.1.35) and Fig. 9.3, via conventional variational methods used in chemistry, under the assumption that the isoelectronium has characteristics (9.3.21). As we shall see, these studies have achieved an essentially exact representation of experimental data on the hydrogen molecule, including its binding energy and bond length, for the first time from exact first principles without ad hoc adulterations.

For historical papers in chemistry connected to our model, see Refs. [6]. Representative, more recent papers with technical connections to our study as outlined below are given by Refs. [8 - 38].

The possibilities that the mass of the isoelectronium be smaller than  $2 \times \text{mass}$  of electron and its radius be bigger than  $6.8 \times 10^{-11}$  cm will not be considered in this section.

For this purpose we first note that the solution of the full model with the Hulten potential  $e^{-rb}/(1-e^{-rb})$  where  $r_c = b^{-1}$  is the size of the isoelectronium, implies rather considerable technical difficulties. Therefore, we shall study model (9.1.35) under an approximation of the Hulten potential given by one Gaussian of the type

$$\frac{e^{-rb}}{1 - e^{-rb}} \approx \frac{1 - Ae^{-br}}{r},$$
(9.1.40)

with A a constant identified below.

It is known that a linear combination of sufficient number of Gaussians can approximate any function. Therefore, the achievement of an essentially exact representation of molecular data via approximation (9.1.40) will evidently persist under the full use of the Hulten potential.

Recall from Sect. 9.3 that the *stable* character of the isoelectronium is crucially dependent on the use of the attractive Hulten potential, which "absorbs" repulsive Coulomb forces at short distances resulting in attraction. Therefore, the weakening of the Hulten potential into the above Gaussian form has the direct consequence of turning the isoelectronium into an *unstable* state.

In this and in the following sections, we shall therefore study an isochemical model of the hydrogen molecule which is somewhat intermediary between the conventional chemical model and the isochemical model with a fully stable isoelectronium.

It should be indicated that the terms "unstable isoelectronium" should be referred as the period of time in which the two valence electrons remain within the hadronic horizon of  $6.8 \times 10^{-11}$  cm. The same terms *should not* be interpreted to the fact that the isoelectronium does not exist outside the hadronic horizon, because the latter view implies a number of inconsistencies, such as possible

violation of Pauli's exclusion principle, acquisition by molecules of ferromagnetic character, *etc.* 

The main objective of this section is to show the achievement of the exact representation of molecular characteristics even for the case of one Gaussian approximation (9.1.40). The question whether the isoelectronium is stable or unstable evidently depends on the amount of instability and its confrontation with experimental data, e.g., on magnetic susceptibility. As such, the issue will be addressed theoretically and experimentally in a future paper.

Under the above assumption, our first step is the study of model (9.1.35) in an exemplified Coulomb form characterized by the following equation, here on expressed in atomic units (a.u.)

$$H \times \Psi = \left(-\frac{1}{2}\nabla^2 - \frac{2}{r_a} - \frac{2}{r_b} + \frac{1}{R}\right) \times \Psi,$$
 (9.1.41)

where the differences from the corresponding equation for the  $H_2^+$  ion [1] are the replacement of the reduced mass  $\mu = 1$  with  $\mu = 2$ , and the increase in the electric charge from e = 1 to e = 2.

The standard method for solving the above equation is the following. The variational calculation is set up in matrix algebra form in a nonorthogonal basis set S which has been normalized to 1. The metric of this non-orthogonal system of equations S is used to set up the orthogonal eigenvalue problem and the eigenvalues are sorted to find the lowest value. H and S are Hermitean matrices. E is a diagonal matrix with the energy eigenvalues

$$HC = ESC;$$
 define  $C = S^{-\frac{1}{2}}C'$ , then  $HS^{-\frac{1}{2}}C' = ES^{-\frac{1}{2}}C'$ , (9.1.42a)

$$(S^{-\frac{1}{2}}HS^{+\frac{1}{2}}C') = H'C' = E(S^{-\frac{1}{2}}SS^{-\frac{1}{2}})C' = EC', \qquad (9.1.42b)$$

where the last equation is obtained by multiplying the first equation from the left by  $S^{-\frac{1}{2}}$ , and use the unitary property that  $S^{-\frac{1}{2}} = S^{+\frac{1}{2}}$  to form an orthogonal eigenvalue problem. Finally we solve for C' by diagonalizing H' and obtain  $C = S^{-\frac{1}{2}}C'$ .

Here the basis is formed from contracted basis sets  $\Phi$ , which are fixed linear combinations of Gaussian spheres  $\chi$  fitted to real shapes of spherical harmonic functions. The eigenvector column in C gives the basis coefficients of the molecular orbitals according to the expression

$$\Psi_i = \sum_{c_{i,j}} (j : \Psi_j = \sum_{a_{j,k}} \Psi_k; \ \chi = \left(\frac{2\alpha}{\pi}\right)^{3/4} \exp[-(\alpha - A)^2] = /\alpha, A).$$
(9.1.43)

The problem of how to form a sharp cusp on a 1s orbital is solved to a practical extent by using up to six Gaussians; here we use the very best "least-energy" 1s

orbital from Pople's group [18]. In this problem the s-, p-, d- and f-orbitals are polarization functions that merely serve to evaluate the effect of other angular components on the 1s orbitals which are the main terms of the 1s-sigma bond in H<sub>2</sub>.

Gaussian orbitals can easily be scaled to screened nuclear charge values by multiplying the Gaussian exponents by the square of the scaling factor (in effect, shrinking the space of the H-atom model) followed by renormalization of the linear combination of Gaussians. In this work the scaling constant of the 1s orbitals was optimized to 1.191 and the 2-, 3- and 4-shell orbitals optimized as scaled shells rather than optimizing each orbital individually.

As the orbitals were optimized using parabolic fitting to three energy values as a function of the scaling value, it became apparent that the bond length of the three-body model is much shorter than the usual value of 1.4011 Bohr (= 0.74143 Angströms). Thus, the bond length was re-optimized after optimization of the scaling for each principle shell. The scaling constants and the orbital contractions are Angströms at an energy of -7.61509174 Hartrees (= -207.2051232 eV) where the achievement of an exact representation of the binding energy is studied in detail.

Although a large basis set of 1s, 2s, 2p, 3s, 3p, 3d, 4s, 4p, and 4f orbitals was used, this variational energy is probably higher than the exact solution of the type used by Bates, Ledsham and Stewart [12]. However, the energy of the 6-gaussian (6G) Least-Energy 1s function [18] is -0.499946 Hartrees for the H atom so the energy quoted here should be within 0.001 Hartrees of the exact solution.

While it is expected that a collapsed isoelectronium pair would be even more unstable than a collapsed positronium quasi-particle due to the repulsive interaction of the electrons, this three-body model of H<sub>2</sub> predicts over 6 Hartrees added molecular stability and a substantial decrease in bond length. The E(1) value of the electronium-pair of some -11.473164 Hartrees is lower than the total energy of the molecule due to the repulsion of the proton-nuclei from the 1/R term of the Hamiltonian.

### 9.1.7 Gaussian Approximation of the Isochemical Model of the Hydrogen Molecule as a Four-Body System

As indicated earlier, it is possible that the valence electrons bond themselves into the isoelectronium not in a permanent fashion, but rather in a statistical fashion, with only a percentage of their time in a bonded state, in which case the restricted three-body model is evidently insufficient. In this section we review the studies of Ref. [5] on the full four-body isochemical model of  $H_2$ , which model also permits the achievement of an exact representation of the binding energy from first principles without adulterations (see Fig. 9.7).



Figure 9.7. A schematic view of the isochemical model of the hydrogen molecule with unstable isoelectronium due to the weakening of the Hulten potential and consequential relaxation of the infinite lifetime, as a view complementary to that of Fig. 9.4 with stable isoelectronium. In this case the notion of isoelectronium essentially represents a tendency of pairs of valence electrons to correlate-bond in singlet states at short distances. The use of isochemistry, rather than conventional chemistry, is necessary because even this weaker form of the isoelectronium, as well as all screenings of the Coulomb potential at large, are nonunitary images of conventional Coulomb settings, as established in Chapter 1. Therefore, all these models require a representation on isospaces over isofields for their invariant formulation. In the text, we present the projection of such an invariant formulation on conventional spaces over conventional fields for simplicity.

A considerable effort has been made since the time of Hylleraas [20] in the 1930's to find a way to calculate the last 2% of the binding energy of molecules. Boys [22] derived a form of "configuration interaction" which offered exact variational solutions, but this proved to be very slowly convergent and only applicable to small molecules. Moller-Plesset perturbation developed by Pople *et. al.* [23] is popular today, but studies up to eighth order have been shown not to converge after huge expense in computer time. Linked-cluster diagrams by Bartlett *et. al.* [24]) multiconfiguration-self-consistent-field (MCSCF) calculations by Schaefer *et. al.* [25] and Goldstone-Bruekner-Feynman diagrammatic perturbation by Kelly [26] have all been shown to require very large computer resources, are limited to small molecules and sometimes fail to give even negative binding energies as shown by Goddard [27] for  $Cr_2$ .

All these slow and expensive methods seem to share one common feature, the use of high energy empty "virtual" orbitals from a ground state calculation, usually of Hartree-Fock-Roothaan type, to improve the representation of the ground state.

One might ask how it is possible to lower the energy by using higher energy wavefunctions. The fact that some energy lowering is found suggests electron dynamics is indeed complicated, and the rate of convergence of this method is quite slow.

The method adopted here is to use the usual Hartree-Fock-Roothaan selfconsistent-field equations [1] (which also has some formal flaws such as the selfinteraction terms [27]), and question the form of the Coulomb interaction of the electron.

Note that reducing the values of the Coulomb integrals will lower the energy by reducing the electron-electron repulsion while reducing the exchange terms will raise the energy, but the 1/2 factor reduces the effect of the exchange terms. Thus, a reduction of the value of the integrals will lower the energy. Note that Goddard [27] has already recommended reducing the atomic self-energy by subtracting 1.39 eV from Hartree-Fock exchange integrals in the cases of  $Cr_2$  and  $Mo_2$ . In this way, we reach the expressions

$$FC = ESC; \quad F_{i,j} = H_{i,j} + \sum_{k,l} P_{k,l}[(i,j|k,l) - \frac{1}{2}(i,k|j,l)], \quad (9.1.44a)$$

$$(i,j|k,l) = \iint \chi_i(1)\chi_j(1)\frac{1}{r_{12}}\chi_k(2)\chi_l(2)\,d\tau_1d\tau_2,\tag{9.1.44b}$$

$$P_{i,j} = 2\sum_{n} c_{n,i} c_{n,j}$$
 (sum *n* only over occupied orbitals). (9.1.44c)

The 1995 paper on Cooper pairs by Santilli and Animalu [7c] invokes the nonlocal hadronic attractive force first identified in the  $\pi^0$ -meson [7a] as applied to singlet-paired electrons which form a boson particle. After using a non-local isotopic nonlinear transformation, the hadronic attraction was transformed back to real-space and modeled resulting into an attractive force which overcomes the repulsive Coulomb force. In turn, the latter occurrence constitutes the physicalchemical origin in the use of a suitably screened Coulomb potential for the binding energy.

Examination of the original 1978 paper on positronium collapse by Santilli [7a], reveals that the Hulten potential is not necessarily a unique representation of the hadronic force; since a linear combination of similar potentials could be used to represent the same hadronic bound state, provided that they characterize an attractive force among the electrons capable of overcoming their Coulomb repulsion.

This work assumes that until matrix elements of a two-Gaussian-screened-Coulomb potential can be used to approximate the real-space form of the hadronic attraction. This form has the important property that it can be merged with the general case of the four-center Coulomb or exchange integral derived by Shavitt [16] using the famous Gaussian transform technique.

$$\frac{1}{r_{12}} = \sqrt{\frac{1}{\pi}} \int_{0}^{\infty} s^{-\frac{1}{2}} \exp[-sr_{12}^{2}] ds, \qquad (9.1.45a)$$

$$1 + \frac{p+q}{pq}s = \frac{1}{1-t^2}.$$
(9.1.45b)

For future reference, note that this transform already has a pole at the lower limit where s = 0. This pole was removed at the last step by a change in variable, given as Eqs. (9.1.45). Shavitt was able (as a former graduate student of S.F. Boys) to show that the Gaussian transform technique reproduced the formula previously derived by Boys [6] in 1950 using electrostatic arguments. The Gaussian-lobe basis SCF programs by Shillady [8, 28] and others.

It is important to note that the formula is completely general in orientation of four Gaussian sphere lobe-orbitals as well as the distance between two electrons. As modified for description of correlation of two electrons, such a general formula can describe angular correlation as well as distance interaction. Thus, matrix Coulomb repulsion to model the real-space form of the hadronic attraction of two electrons.

Well-founded admiration for Shavitt's work in deriving the Coulomb interaction was rekindled as his derivation was checked. This work added the Gaussian screening as  $\exp[-r^2]/r$  so that the special properties of Gaussians could be used, especially the property that polar coordinates readily separate into factorable x, y, z components. The goal is to evaluate the two-electron four-center matrix elements of the Gaussian-screened-Coulomb potential as shown below,

$$Y(r) = \frac{1 - 2\exp[-\alpha r^2]}{r}.$$
(9.1.46)

Intriguingly, the Gaussian exponent carried through the original derivation of the Coulomb interaction by resorting to a well known auxiliary function  $F_0$  which has been studied by Shillady [8, 28] and others. Since both  $s^{\frac{1}{2}}$  and  $(s+\alpha)^{\frac{1}{2}}$  occur in the denominator of the screened-Coulomb form, two poles occur in the integral. A change of variable absorbs the term

$$1 + \frac{p+q}{pq}(s+\alpha) = \frac{1}{1-t^2},$$
(9.1.47)

while the pole due to  $(s + \alpha)^{-1/2}$  shifts the other pole at  $s^{-\frac{1}{2}}$  to the lower limit of the integral. A smooth spike is evident at the lower value of the integration using a 70 point Simpson's Rule Integration (two ranges are used with 20 points more closely spaced near the pole and 50 points for the remaining range.)

The above work was carried out using 64 bit double precision arithmetic which provides 14 significant figures. A simple offset ( $\delta$ ) of  $1.0 \times 10^{-15}$  has provided useful results with this simple offset to avoid numerical overflow. While this pole is a problem in need of a continuous function to integrate, numerical integration seems to handle this well to 14 significant figures, particularly since the routines used for the Coulomb integrals are known to be accurate only to 12 significant figures [28].

The area under the pole-spike is estimated as a narrow triangle upon a rectangle  $1.0 \times 10^{-15}$  wide with the height of the triangle set at  $1.79940 \times 10^{13}$  times the height of the point set  $1.0 \times 10^{-15}$  into the range of integration (the first Simpson point).

The present code for this screened-Coulomb integral is presently slower than the corresponding function used for the Coulomb integrals due to the 70 point Simpson integration [28], but the integrand is nearly flat after the spike at s = 0.0so that portion of the integrand can be evaluated more rapidly with fewer points. The simple offset of the lower limit by  $1.0 \times 10^{-15}$  is adequate for this monograph.

$$\left( aA(1), bB(1) \left| \frac{\exp(-\alpha(r_{12})^2)}{r_{12}} \right| cC(2), dD(2) \right) =$$

$$= \frac{2\pi^{5/2}}{pq\sqrt{p+q}} e^{[ab/(a+b)]\overline{AB}^2 - [cd/(c+d)]\overline{CD}^2} \times$$

$$\times \int_{\rho}^{1} e^{-[pq/(p+q)]\overline{PQ}^2 t^2} \left( \frac{[pq/(p+q)]t^2}{[pq/(p+q)]t^2 + \alpha(t^2 - 1)} \right)^{1/2} dt,$$

$$(9.1.48b)$$

$$\rho = \delta + \frac{\alpha\sqrt{p+q}}{pq+(p+q)\alpha}, \quad p = (a+b), \quad q = c+d, \quad \delta = 1.0 \times 10^{-15}, \quad (9.1.48c)$$

pole = 
$$(1.79940 \times 10^{13})e^{-[pq/(p+q)]\overline{PQ}^2\rho^2}$$
. (9.1.48d)

The new integral was incorporated into the same routine used to evaluate the usual Hartree-Fock-Roothaan SCF scheme except  $F_0$  was supplemented by the new auxiliary function (9.1.46). The H<sub>2</sub> molecule was treated using the same fixed-nuclei method with a bond distance of 1.4011 Bohrs. A simple basis set of just one Least-Energy 6G-1s orbital [18] centered on each H-nucleus was used to test the new program "Santilli-Animalu-Shillady-Lobe" (SASLOBE), which is set to handle up to 512 contracted orbitals.

It must be stated that the energies given are now parametrically dependent on the Gaussian-screening constant as  $E(\alpha)$ . The energy is variationally bound to be above the true energy in a narrow range around the optimum value. It is extremely important to note that the energy is lowered using the new attractive hadronic term, but the optimum value is difficult to locate and "variational collapse" occurs when  $r_c$  is extended or reduced away from a shallow minimum in the energy.

In order to minimize the number of parameters in the model (only one, the Coulomb screening constant A) two equations were imposed on the Gaussian-function. First, the function was required to be equal to zero at some radial cutoff value  $r_c$  which is assumed to be the inverse of the *b*-variable of Sect. 9.1.5,

$$b = \frac{1}{r_c} = A \frac{\exp[-\alpha r_c^2]}{r_c}, \quad A = \exp[+\alpha r_c^2].$$
(9.1.49)

Second, this radial cutoff value was used as sigma of the inverted Gaussian (radius at half-height),

$$A \exp\left[-\frac{\ln 2}{r_c^2}r_c^2\right] = \frac{A}{2}, \quad \alpha = \frac{\ln 2}{r_c}, \quad A = 2.$$
 (9.1.50)

The upper boundary of the radius of the isoelectronium has been estimated in Sect. 9.3 to be about  $0.6843 \times 10^{-10}$  cm, which corresponds to 0.012931401 Bohrs. This radius does lower the Hartree-Fock-Roothaan energy noticeably for H<sub>2</sub>, and further optimization of the pole-spike produced an SCF energy of -1.17446875 Hartrees with a cutoff radius of 0.0118447 Bohrs or  $1.18447 \times 10^{-10}$  cm using the minimum 1s basis. In conclusion, the fitted value of  $b \equiv 1/r_c$  is reasonably close to the estimate value for the H<sub>2</sub> molecule. The minimum basis was later extended to 6G-1s, 1G-2s, 1G-2p for pole calibration.

Details of the exact representation of the binding energy via the above second method are presented in Appendix 9.B.

#### 9.1.8 Summary of the Results

In order to demonstrate the advantage of the isochemical model using a Gaussianscreened-Coulomb attraction between electrons, a standard Boys-Reeves [22] calculation was carried out in Ref. [2]. This included all single- and double-excitations CISD from the ground state Hartree-Fock-Roothaan SCF orbitals for a  $99 \times 99$ "codetor" [6] interaction. Only the 1s orbitals were optimized with a scaling of 1.191 for the Least-Energy 6G-1s orbitals, but the basis also included 1G-2s, 2G-2p, 1G-3s, 1G-3p, 3G-3d, Thd 1G-4sp (tetrahedral array of four Gaussian spheres), and 4G-4f orbitals scaled to hydrogenic values as previously optimized [17].

The additional basis functions provide opportunity to excite electrons to higher orbitals as is the standard technique in configuration interaction, somewhat contrary to the main hypothesis of this work, which is that there is an attractive hadronic force between electron pairs inside the  $r_c$  critical radius. The results of the above calculations are summarized in Table 9.1.

| Species                      | Ho          | $H_2^{a}$   | Ho          |
|------------------------------|-------------|-------------|-------------|
|                              |             |             |             |
| Basis screening              |             |             |             |
| 1s                           | 1.191       | 6.103       | 1.191       |
| 2s                           | 0.50        | 24.35       | 0.50        |
| 2p                           | 0.50        | 24.35       | 2.36        |
| 3s                           | 0.34        | 16.23       | *           |
| 3p                           | 0.34        | 16.23       | *           |
| 3d                           | 0.34        | $-16.2^{b}$ | *           |
| 4sp                          | 0.25        | 12.18       | *           |
| $4\overline{f}$              | 0.25        | 12.18       | *           |
| Variational energy (a.u.)    | *           | -7.61509174 | *           |
| SCF energy (a.u.)            | -1.12822497 | *           | -1.13291228 |
| CI energy (a.u.)             | -1.14231305 | *           | *           |
| CINO energy (a.u.)           | -1.14241312 | *           | *           |
| SAS energy (a.u.)            | *           | *           | -1.174444   |
| Exact energy (a.u.) [30]     | -1.174474   | *           | -1.174474   |
| Bond length (bohr)           | 1.4011      | 0.2592      | 1.4011      |
| Isoelectronium radius (bohr) | *           | *           | 0.01124995  |

Table 9.1. Summary of results for the hydrogen molecule.

<sup>a</sup>Three-body Hamiltonian (5.1).

<sup>b</sup>The negative 3d scaling indicates five equivalent three-sphere scaled to 16.20 rather than "canonical" 3d shapes.

The Boys-Reeves C.I. achieved an energy of -1.14241305 Hartrees based on an SCF energy of -1.12822497 Hartrees. This was followed by one additional iteration of "natural orbitals" (CINO), in which the first order density matrix is diagonalized to improve the electron pairing to first order [29]. The fact that this procedure lowered the energy only slightly to -1.14241312 Hartrees (i.e.,  $-7.0 \times 10^{-7}$  Hartrees), indicates the 99-configuration representation is close to the lower energy bound using this basis set while the isochemistry calculation produced the exact energy with a comparatively much smaller basis set.

Since SASLOBE has only a  $n^7$  routine for the necessary integral transformation instead of the most efficient  $n^5$  algorithm ( $\simeq n$  is the number of basis functions), the SASLOBE C.I. runs are somewhat slow and required about 20 hours on a 300 MFLOPS Silicon Graphics computer.

With more efficient routines, this time can be reduced to about three hours. However, the screened-Coulomb attraction method used a smaller basis and achieved lower energies in a few seconds. It is also estimated that careful spacing of fewer quadrature points in the new integral routine can certainly reduce the SASLOBE run times by a factor of 2 at least. Therefore it is clear that calculations in hadronic chemistry are, conservatively, at least 1,000 times faster than a C.I. calculation, an occurrence fully similar to the corresponding case in hadronic vs. quantum mechanics.

Another estimate is that, since the new integral corrections require a little more time than the usual Coulomb integrals (but do not take any additional storage space), the computer run-times for an isochemistry calculation should only be about three times the run-times for the corresponding Hartree-Fock-Roothaan calculation in any given basis set.

The extension of the isochemical model of the  $H_2$  molecule to other molecules is conceptually straightforward. In particular, the notion of isoelectronium essentially restricts all possible bonds to the established ones, as it is the case for the water molecule (see next chapter).

In order to generalize the underlying quantitative treatment to molecules containing H-to-F, the pole-spike was re-optimized to obtain 100% of the correlation energy below the SCF energy in the given basis set since the SCF energy here was not quite at the Hartree-Fock limit.

| Species   | $H_2$           | $H_2O$           | HF                |
|---|-----------------|------------------|-------------------|
| SCF-energy (DH) (a.u.)                          | $-1.132800^{a}$ | -76.051524       | -100.057186       |
| Hartree-Fock <sup><math>d</math></sup> (a.u.)   |                 |                  | $-100.07185^d$    |
| Iso-energy (a.u.)                               | $-1.174441^{c}$ | $-76.398229^{c}$ | $-100.459500^{c}$ |
| Horizon $R_c$ (Å)                               | 0.00671         | 0.00038          | 0.00030           |
| QMC energy $^{d,e}$ (a.u.)                      | -1.17447        | $-76.430020^{e}$ | $-100.44296^{d}$  |
| Exact non-rel. (a.u.)                           | $-1.174474^{f}$ |                  | $-100.4595^{d}$   |
| Corellation (%)                                 | $99.9^{b}$      | $91.6^{b}$       | 103.8             |
| SCF-dipole (D)                                  | 0.0             | 1.996828         | 1.946698          |
| Iso-dipole (D)                                  | 0.0             | 1.847437         | 1.841378          |
| Exp. dipole (D)                                 | 0.0             | $1.85^{g}$       | $1.82^{g}$        |
| $\operatorname{Time}^{h}(\operatorname{min:s})$ | 0:15.49         | 10:08.31         | 6:28.48           |

Table 9.2. Isoelectronium results for selected molecules.

 $(DH^+)$  Dunning-Huzinaga (10S/6P), [6,2,1,1,1/4,1,1]+H<sub>2</sub>P<sub>1</sub>+3D1.

 $^{a}$ LEAO-6G1S + optimized GLO-2S and GLO-2P.

 ${}^b\mathrm{Relative}$  to the basis set used here, not quite HF-limit.

 $^c\mathrm{Iso-energy}$  calibrated to give exact energy for HF.

 $^d\mathrm{Hartree}\xspace$  Fock and QMC energies from Luchow and Anderson [33].

 $^{e}$ QMC energies from Hammond *et al.* [30].

<sup>f</sup>First 7 sig. fig. from Kolos and Wolniewicz [34].

<sup>g</sup>Data from Chemical Rubber Handbook, 61st ed., p. E60.

 $^{h}$ Run times on an O2 Silicon Graphics workstation (100 MFLOPS max.).

The energy obtained here results from the calibration of the pole-spike to the experimental value of HF, and is below the Quantum Monte Carlo (QMC) energy

of Luchow and Anderson [33], which requires hours on a much larger computer, as compared to less than 10 minutes for this work. In fact, the run times for HF were about 8 CPU minutes on a 100 MFLOP Silicon Graphics O2 workstation.

The principal value of the pole (9.1.48d) was calibrated for 100% energy of HF,  $H_2O$  has two tight sigma bonds and two diffuse lone-pairs so a single compromise value is a good test of the method. In HF the F<sup>-</sup> is nearly spherical so an average  $r_c$  value does a better job of describing the "correlation hole" of transient isoelectronium. The computed dipole moments are in excellent agreement with the experimental values. The use of the same pole value for  $H_2O$  and HF degrades the  $H_2$  energy slightly. The results of our studies for H–to–F based molecules are summarized in Table 9.2.

A comparison of the above date (particularly those on computer times) with corresponding data obtained via conventional approaches is instructive.

### 9.1.9 Concluding Remarks

The fundamental notion of the new model of molecular bonds studied in this chapter [5] is the bonding at short distances of pairs of valence electrons from two different atoms into a singlet quasi-particle state we have called *isoelectronium*, which travels as an individual particle on an oo-shaped orbit around the two respective nuclei.

The isoelectronium and related methodology are then characterized by a covering of contemporary chemistry called *isochemistry*, which is the branch of the more general *hadronic chemistry* specifically constructed to represent closedisolated systems with linear and nonlinear, local and nonlocal, and potential as well as nonpotential internal forces.

A main assumption is that linear, local, and potential interactions are sufficient for atomic structures since the atomic distances are much bigger than the size of the wavepackets of the electrons. However, in the transition to molecular structures we have the additional presence of nonlinear, nonlocal, and nonpotential effects due to the deep penetration of the wavepackets of valence electrons, which is essentially absent in atomic structures (Fig. 1.7).

The attractive short-range interactions needed to overcome the repulsive Coulomb force in the isoelectronium structure originate precisely from nonlinear, nonlocal, and nonhamiltonian effects in deep wave-overlappings; they are described by *had-ronic mechanics* [3b]; and their invariant formulation is permitted by the recently achieved broadening of conventional mathematics called *isomathematics*.

Specific experimental studies are needed to confirm the existence of the isoelectronium, by keeping in mind that the state may not be stable outside a molecule in which the nuclear attraction terms bring the electron density to some critical threshold for binding, a feature we have called the "trigger." Nonrelativistic studies yield a radius of the isoelectronium of  $0.69 \times 10^{-10}$  cm. This "horizon" is particularly important for isochemical applications and developments because outside the horizon the electrons repel one-another while inside the horizon there is a hadronic attraction.

The same nonrelativistic studies also predict that, as a limit case, the isoelectronium is stable within a molecule, although partially stable configurations also yield acceptable results. The question of the stability vs. instability of the isoelectronium inside the hadronic horizon must therefore also be left to experimental resolutions.

The understanding is that, when the restriction to the hadronic horizon is lifted, and molecular dimensions are admitted for the inter-electron distance, the isoelectronium must be stable, otherwise violations of Pauli's exclusion principle could occur. In this sense, the isoelectronium is a direct representation of Pauli's exclusion principle.

The foundations of the isoelectronium can be seen in a paper by Santilli [7a] of 1978 on the structure of the  $\pi^0$ -meson as a bound state of one electron and one positron. The latter model also illustrates the capability of hadronic mechanics vs. quantum mechanics. In fact, quantum mechanics *cannot* represent the  $\pi^0$  as the indicated bound state of one electron and one positron because of numerous inconsistencies, such as: the inability to represent the rest energy of the  $\pi^0$ , which would require a "positive" binding energy, since the sum of the rest energies of the constituents is much smaller than the rest energy of the bound state; the impossibility to represent the charge radius of the  $\pi^0$ , which can only be that of the positronium for quantum mechanics; the lack of representation of the meanlife of the  $\pi^0$ ; and other insufficiencies.

By comparison, all the above insufficiencies are resolved by hadronic mechanics, which permits the first quantitative, numerical representation of all characteristics of the  $\pi^0$  as a bound state of one electron and one positron at short distances, including its spontaneous decay with the lowest mode  $\pi^0 \rightarrow e^- + e^+$ , which results in being the hadronic tunnel effect of the constituents [7a].

In particular, the indicated model of the  $\pi^0$  contains the first identification of the attractive character of nonlinear, nonlocal, and nonhamiltonian interactions due to deep wave-overlappings in singlet coupling (and their repulsive character in triplet coupling).

The isoelectronium also sees its foundations in subsequent studies by Animalu [7b] of 1994 and Animalu and Santilli [7c] of 1995 on the construction of hadronic superconductivity for a quantitative representation of the structure of the Cooper pair. We have in this case an occurrence similar to the preceding one for the structure of the  $\pi^0$ . In fact, quantum mechanics can indeed represent superconductivity, but only via an ensemble of Cooper pairs, all assumed to be point-like. In particular, quantum mechanics simply cannot represent the structure.

ture of *one* Cooper pair, due to the divergent character of the Coulomb repulsion between the identical electrons of the pair.

Again Animalu-Santilli hadronic superconductivity did indeed resolve this insufficiency and permitted, for the first time, the achievement of a structure model of one Cooper pair in remarkable agreement with experimental data. Hadronic superconductivity also shows predictive capacities simply absent in quantum mechanics, such as the prediction of a new electric current mostly given by the motion of electron pairs, rather than the conventional electric current composed of individual electrons (patent pending). Such a new hadronic current implies an evident reduction of the electric resistance due to the essentially null magnetic moment of the pair, as compared to the large magnetic moment of individual electrons, and its interactions with atomic electrons when moving within a conductor.

Note finally that the preceding hadronic model of the  $\pi^0$  and of the Cooper pair are ultimately due to the capability of hadronic mechanics to eliminate divergencies at short distances, which is technically realized via the isotopies of the unit and related associative products of quantum mechanics

$$I \to \hat{I} = 1/\hat{T},\tag{9.1.51a}$$

$$|\hat{I}| \gg 1, \quad |\hat{T}| \ll 1,$$
 (9.1.51b)

$$A \times B \to A \times T \times B,$$
 (9.1.51c)

under which divergent or slowly convergent series can be evidently turned into rapidly convergent forms.

The tendency of identical valence electrons to bond into the isoelectronium is additionally confirmed by other evidence, such as ball lighting, which are composed by a very large number of electrons bonded together into a small region.

In summary, incontrovertible experimental evidence establishes that electrons have the capability of bonding themselves at short distances contrary to their Coulomb repulsion. Quantum mechanics simply cannot provide a scientific study of this physical reality. Hadronic mechanics resolved this impasse, by first identifying the conditions needed to achieve attraction, called "trigger," and then permitting quantitative numerical study of the bond.

The isoelectronium results in having deep connections with a variety of studies in chemistry conducted throughout the 20-th century [6, 8 - 38], and actually provides the physical-chemical foundations for these studies as well as their appropriate mathematical formulation for the invariance of the results.

In summary, the isochemical model of molecular bonds submitted by Santilli and Shillady [5] is supported by the following conceptual, theoretical and experimental evidence: 1) The isoelectronium introduces a new attractive force among the neutral atoms of a molecular structure which is absent in quantum chemistry and permits a quantitative understanding of the strength and stability of molecular bonds.

2) The isoelectronium permits an immediate interpretation of the reasons why the  $H_2$  and  $H_2O$  molecules only admit two H-atoms.

3) The isoelectronium permits the achievement of a representation of the binding energy of the hydrogen molecule which is accurate to the *seventh digit*, thus allowing meaningful thermodynamical calculations.

4) The isoelectronium provides an explanation of the long known, yet little understood Pauli's exclusion principle, according to which electrons correlate themselves in singlet when on the same orbital without any exchange of energy, thus via a process essentially outside the representational capabilities of quantum mechanics and chemistry.

5) The isoelectronium is consistent with the known existence of superconducting electron-pairs which bond themselves so strongly to tunnel together through a potential barrier.

6) The isoelectronium provides a quantitative model for the explanation of electron correlations. Instead of a complicated "dance of electrons" described by positive energy excitations, the isochemistry explanation is that electrons are energetically just outside the horizon of a deep attractive potential well due to their wavefunctions overlapping beyond the critical threshold of the hadronic horizon.

7) The isoelectronium is consistent with the "Coulomb hole" studied by Boyd and Yee [35] as found from subtracting accurate explicitly-correlated wavefunctions from self-consistent-field wavefunctions. In our studies the "Coulomb hole" is re-interpreted as a "hadronic attraction".

8) The isoelectronium is also in agreement with the "bipolaron" calculated for anion vacancies in KCl by Fois, Selloni, Parinello and Car [36] and bipolaron spectra reported by Xia and Bloomfield [37].

9) The isoelectronium permits an increase of the speed in computer calculations conservatively estimated at least 1,000-fold, and prevents the inconsistent prediction that all molecules are ferromagnetic (see Chapter 7).

Moreover, another remarkable result of this study is that the value of the radius of the isoelectronium,  $0.69 \times 10^{-10}$  cm, computed via dynamical equations in Sect. 9.3 has been fully confirmed by the independent calculations conducted in Sects. 9.1.6 and 9.1.7 via the Gaussian-lobe basis set, yielding 0.00671 Å.

We should also mention preliminary yet direct experimental verifications of the isoelectronium offered by the ongoing experiments on photoproduction of the valence electrons in the helium indicating that electrons are emitted in pairs [38]. The studies of this monograph warrant the systematic conduction of these experiments specifically for the hydrogen molecule, and the experimental finalization as to whether electrons are emitted in an isolated form or in pairs, including relative percentages of both emissions. If conducted below the threshold of disintegration of the isoelectronium, the proposed experiments can evidently provide final proof of the existence of the isoelectronium.

We should finally note that the representation of the binding energy and other characteristics of the hydrogen molecule exact to the seventh digit first achieved in Ref. [5] constitutes the strongest experimental evidence to date on the insufficiency of quantum mechanics and the validity of the covering hadronic mechanics for the representation of nonlinear, nonlocal, and nonpotential, thus nonhamiltonian and nonunitary effects due to deep overlappings of the "extended wavepackets" of electrons with a "point-like charge structure."

It is evident that all the above results provide scientific credibility for the isoelectronium, the related isochemical model of molecular bonds, and the underlying hadronic chemistry, sufficient to warrant systematic theoretical and experimental studies.

As shown in Chapter 7, a significant feature of the proposed novel isochemistry is not only the capability to provide accurate representations of experimental data in shorter computer times, but also the capability to predict and quantitatively treat new industrial applications.

# 9.2 ISOCHEMICAL MODEL OF THE WATER MOLECULE

### 9.2.1 Introduction

Water is an extremely important compound on Planet Earth in a biological as well as geophysical sense. As a consequence, comprehensive studies on water have been conducted since the beginning of quantitative science with outstanding scientific achievements (see, e.g., Ref. [1]). Nevertheless, despite all these efforts, a number of fundamental issues on the structure of the water molecule remain still open, such as:

1) The total electrostatic force among the atomic constituents of a water molecule is null in semiclassical approximation, while the currently used forces (exchange, van der Waals and other forces [40]) are known from nuclear physics to be "weak," thus insufficient to fully explain the "strong" bond among the constituents (where the words "weak" and "strong" do not refer hereon to the corresponding interactions in particle physics). In different words, the representation of the nuclear structure required the introduction of the "strong nuclear force" because of the insufficient strength of the exchange, van der Waals and other forces. It appears that current models on the water molecule lack the equivalent of the "strong nuclear force" to achieve a full representation of molecular structures. 2) Quantum chemistry has not provided a rigorous explanation of the reason why the water molecules only has *two* hydrogen atoms. This is an evident consequence of the assumption of exchange and other nuclear-type forces which were built in nuclear physics for an *arbitrary number of constituents*, a feature which evidently persists in its entirety in molecular structures.

3) Quantum chemistry has been unable to achieve an exact representation of the binding energy of the water molecule under the rigorous implementation of its basic axioms, such as the Coulomb law. In fact, there is a historical 2% still missing despite efforts conducted throughout the 20-th century.

4) More accurate representations have been recently achieved although via the use of Gaussian screenings of the Coulomb law, which, however, are outside the class of equivalence of quantum chemistry, since they are *nonunitarily* connected to the Coulomb law.

5) Quantum chemistry cannot provide a meaningful representation of thermodynamical properties related to water. In fact, the value of 2% missing in the representation of binding energy corresponds to about 950 Kcal/mole while an ordinary thermodynamical reaction takes about 50 Kcal/mole. The use of quantum chemistry in thermodynamical calculations would, therefore, imply an error of the order of 20 times the value considered.

6) Quantum chemistry has been unable to reach an exact representation of the electric and magnetic dipole and multipole moments of the water molecule to such an extent that, sometimes, the models result in having even the *wrong sign* (see, e.g., Ref. [42a], p. 22). This insufficiency is generally assumed to be due to the incompleteness of the assumed basis, although one should not keep adding terms without deeper analysis.

7) Computer usages in quantum chemical calculations require excessively long periods of time. This occurrence, which is due to the slow convergence of conventional quantum series, has persisted to this day, despite the availability of more powerful computers.

8) Quantum chemistry has been unable to explain the "correlation energy" which is advocated for the missing percentages of the binding energies. Orbital theories work well at qualitative and semi-empirical levels, but they remain afflicted by yet unresolved problems, such as the currently used correlation among many electrons as compared to the evidence that the correlation solely occurs for electron pairs.

9) Quantum chemistry predicts that the water molecule is ferromagnetic, in dramatic disagreement with experimental evidence. This prediction is a consequence quantum electrodynamics, which establishes that, under an external magnetic field, the orbits of valence electrons must be polarized in such a way as to offer a magnetic polarity opposite to that of the external homogeneous field. As it is well known, the individual atoms of a water molecule preserve

their individuality in the current model of chemical bonds. As a result, quantum electrodynamics predicts that all valence electrons of the individual atoms of a water molecule acquire the same magnetic polarization under a sufficiently strong external magnetic field, resulting in a total net magnetic polarity North-South.

Particularly insidious are variational methods because they give the impression of achieving exact representations within the context of quantum chemistry, while this can be easily proved *not* to be the case. To begin, representations of 100% of the experimental data occur with the introduction of a number of *empirical parameters* which lack a physical or chemical meaning. Moreover, it is easy to prove that variational solutions cannot be the solution of quantum chemical equations, trivially, because the former provide 100% representations, while the latter do not. In reality, the arbitrary parameters introduced in variational and other calculations are a measure of the deviation from the basic axioms of quantum chemistry.

When passing from the structure of one water molecule to more general molecular structures the number of open, basic, unsolved issues increases. For instance, it is generally admitted that quantum chemistry has been unable to provide a systematic theory of the liquid state in general, let alone that of liquid water in particular [40].

Also, chemical reactions in general are *irreversible*, while the axiomatic structure of quantum chemistry is *strictly reversible* because the theory is strictly Hamiltonian and all known potential forces are reversible. This results in an irreconcilable incompatibility between the very axiomatic structure of quantum chemistry and chemical reactions in general, and those involving water in particular. In fact, an axiomatically consistent representation of irreversibility is expected to imply effects which are simply inconceivable for quantum chemistry, evidently because they are outside its structure.

When passing to water as a constituent of biological entities, the limitations of quantum chemistry reach their climax. In fact, biological structures (such as a cell) are not only irreversible (because they grow, age and die), but have such a complex structure to require multi-valued theories (also known in mathematics as hyperstructures). The expectation that quantum chemistry, with its reversible and single-valued structure, can effectively represent biological systems and their evolution is beyond the boundaries of science.

In view of the above numerous and basic limitations, in the preceding works [41] Santilli and other scientists have constructed a covering of quantum mechanics under the name of *hadronic mechanics*. By conception and construction, quantum and hadronic mechanics coincide everywhere, except inside a small sphere of radius of the order of 1 fm (=  $10^{-13}$  cm) called *hadronic horizon*, in which interior (only) the broader theory holds.

Hadronic mechanics results in being a form of "completion" of quantum mechanics much along the historical Einstein-Podolsky-Rosen argument, although achieved via the addition of contact, nonhamiltonian, nonlinear, nonlocal, and nonpotential forces due to deep overlappings of the wavepackets of particles.

On more technical grounds, hadronic mechanics is based on *new mathematics*, called *iso-*, *geno-* and *hyper-mathematics* [41c] (see Chapter 2) for the characterization of reversible, irreversible, and multivalued systems, respectively, possessing features not representable via the Hamiltonian.

These new mathematics are characterized by a progressive generalization of the trivial unit I of quantum mechanics into generalized units  $\hat{I}$  of Hermitean single-valued, nonhermitean single-value, and nonhermitean multi-valued character, respectively, first proposed by Santilli in 1978 (see Refs. [41]),

$$I \to \hat{I} = \hat{I}^{\dagger}, \quad I \to \hat{I} \neq \hat{I}^{\dagger}, \quad I \to \{\hat{I}\} = \{\hat{I}_1, \hat{I}_2, \hat{I}_3, ...\} \neq \{\hat{I}\}^{\dagger}.$$
 (9.2.1)

The new mathematics then emerge from the reconstruction of the conventional mathematics of quantum mechanics in such a way as to admit  $\hat{I}$ , rather than I, as the correct left and right unit at all levels.

The iso-, geno-, and hyper-mathematics characterize corresponding branches of hadronic mechanics, called *iso-*, *geno-*, *and hyper-mechanics*, which have been constructed for the corresponding representation of:

1) closed-isolated, reversible, single-valued systems with Hamiltonian and nonhamiltonian internal forces;

2) open-nonconservative, irreversible, single valued systems with unrestricted interactions with an external system; and

3) open-nonconservative, irreversible, multi-valued systems of arbitrary structure.

Subsequently, Animalu and Santilli [43] constructed hadronic superconductivity, with corresponding iso-, geno-, and hyper-branches (Sect. 9.1.9) for the representation of the *structure* (rather than an ensemble) of the Cooper pairs, in a way remarkably in agreement with experimental data.

In 1999, Santilli and Shillady [43a] constructed hadronic chemistry (Chapter 3) with corresponding branches called *iso-*, *geno-*, *and hyperchemistry*. Since molecules are considered as isolated from the rest of the universe, and are reversible in time, they are studied via *isochemistry*.

Santilli and Shillady [43a] also constructed a new isochemical model of the hydrogen molecule (Chapter 4) based on the assumption that pairs of valence electrons from different atoms couple themselves into a singlet quasi-particle state called isoelectronium.

As shown in Chapter 4, the new model was proved to resolve at least the major insufficiencies of the quantum chemical model of the hydrogen molecule, such as: explain why the molecule has only two H-atoms; represent the binding energy
to the seventh digit; achieve computer calculations which converge at least 1,000 times faster than those of quantum chemistry; and permit other advances.

The main scope of this chapter is that of studying the new isochemical model of the water molecule first submitted by Santilli and Shillady in Ref. [43b] via a suitable expansion of the results obtained for the hydrogen molecule.

The main assumption is that, when the valence electrons of the water molecule correlate-bond themselves into singlet pairs in accordance with Pauli's exclusion principle, there is the emergence of new interactions structurally beyond any hope of representation by quantum mechanics and chemistry, trivially, because they are nonhamiltonian.

In particular, the new interactions are strongly attractive, thus introducing, for the first time, a molecular bond sufficiently "strong" to represent reality. These and other features of the model, such as the sole possible correlation-bond being in pairs, will resolve all insufficiencies 1)-9 indicated earlier, as we shall see.

To provide introductory guidelines, let us recall that the main function of the isounit  $\hat{I}$  (hereon assumed to be Hermitean, single-valued and positive-definite) is that of representing all interactions, characteristics and effects outside the representational capabilities of a Hamiltonian. This includes the representation of contact, nonpotential and nonhamiltonian interactions in deep overlapping of the wavepackets of valence electrons.

By recalling that, whether conventional or generalized, the unit is the fundamental invariant of any theory, the representation of the new interactions via the generalized unit assures invariance, that is, the prediction of the same numbers for the same quantities under the same conditions but at different times.

Representation of nonhamiltonian effects via quantities other than the generalized unit are encouraged, provided that they achieve the indicated invariance, as a necessary condition to avoid the catastrophic inconsistencies of Sect. 9.1.7.

The most fundamental mathematical, physical, and chemical notion of the new model of structure of the water molecule studied in this Chapter is, therefore, the generalization of the trivial unit +1 of current models into the isounit.

On pragmatic grounds, isochemistry can be easily constructed via a step-bystep application of the nonunitary transform

$$\hat{I} = 1/\hat{T} = U \times U^{\dagger} > 0,$$
 (9.2.2)

to all aspects of quantum chemistry (Sect. 9.1.4). In particular, we shall assume that the above isounit recovers the conventional unit outside the hadronic horizon, and its average value is much bigger than 1,

$$\lim_{r\gg1\,\mathrm{fm}}\hat{I} = I. \tag{9.2.3a}$$

$$|\tilde{I}| \gg 1. \tag{9.2.3b}$$

Assumption (9.2.3a) will assure the compatibility of a generalized discipline for the bonding of valence electrons, while preserving conventional quantum mechanics identically for the structure of the individual atoms composing the water molecule. Assumption (9.2.3b) will assure a much faster convergence of perturbative expansions, and other features.

In summary, the new isochemical model of the water molecule [43b] studied in this chapter can be constructed via the following steps:

1) Select a nonunitary transforms according to rules (9.2.2) and (9.2.3) which is representative of contact, nonlinear, nonlocal, and nonpotential effects in deep wave-overlapping, essentially similar to that used for the hydrogen molecule [43a] of the preceding Chapter;

2) Submitting to the selected nonunitary transform the totality of the notions, equations, and operations of the conventional quantum chemical model of the water molecule; and

3) Reconstructing the entire mathematics of the conventional model in such a way as to admit  $\hat{I}$ , rather than I, as the correct left and right unit at all levels, with no known exceptions. This lifting is necessary to avoid the catastrophic inconsistencies of Sect. 1.7 (e.g., to achieve invariance), thus requiring the isotopic lifting of numbers and fields, Cartesian and trigonometric functions, ordinary and partial differential equations, *etc.* 

The axiomatically correct isochemical model of the water molecule is that formulated on isospaces over isofields. However, on pragmatic grounds, one can study its *projection* on ordinary spaces over ordinary numbers, *provided* that the results are interpreted with care.

For instance, in the indicated projection there is the general emergence of a *potential*, which, as such, may lead to imply that the model carries a *potential* energy and/or it can be treated via a conventional *potential well*. Such interpretations are correct if and only if the potential is well defined on isospaces over isofields. On the contrary, if said potential solely emerges in the projection, then it has a purely mathematical meaning without any associated energy.

The best illustration of the above seemingly contradictory occurrences was that for the isoelectronium of Sect. 9.3, whose structure did indeed exhibit the appearance of the *Hulten potential*, yet the quasi-particle had *no binding energy*. The reason is that binding energies are indeed well defined on isospaces over isofields via the isoschrödinger's equation and related isoeigenvalues, while the Hulten potential does not exist on isospaces, and solely occurs in the projection of the isoschrödinger's equation on ordinary Hilbert spaces. To illustrate this important point, consider the isotopies of the conventional Schrödinger's equation via the nonunitary transform indicated above,

$$U \times (H \times |\psi\rangle) = (U \times H \times U^{\dagger}) \times (U \times U^{\dagger})^{-1} \times (U \times |\psi\rangle) =$$
  
=  $\hat{H} \times \hat{T} \times |\hat{\psi}\rangle = \hat{H} \times |\hat{\psi}\rangle = U \times (E \times |\psi\rangle) =$   
=  $[E \times (U \times U^{\dagger})] \times (U \times U^{\dagger})^{-1} \times (U \times |\psi\rangle) = \hat{E} \times \hat{T} \times |\hat{\psi}\rangle =$   
=  $E \times |\hat{\psi}\rangle,$   
(9.2.4)

with corresponding liftings of numbers and Hilbert spaces,

$$U \times n \times U^{\dagger} = n \times (U \times U^{\dagger}) = n \times \hat{I}, \quad \hat{n} \in \hat{\mathbf{R}},$$
(9.2.5a)

$$U \times \langle \psi | \times | \psi \rangle \times U^{\dagger} = \langle \hat{\psi} | \times \hat{T} \times | \hat{\psi} \rangle \times (U \times U^{\dagger}) = \langle \hat{\psi} | \times | \hat{\psi} \rangle \times \hat{I} \in \hat{\mathcal{C}}.$$
 (9.2.5b)

As one can see, binding energies  $\hat{E} = E \times \hat{I}$  are fully defined on isohilbert spaces  $\hat{\mathcal{H}}$  over isofields  $\hat{\mathbf{R}}$ , and actually acquire the conventional value E following the simplification  $\hat{E} \times \hat{T} \times |\hat{\psi}\rangle = (E/\hat{T}) \times \hat{T} \times |\hat{\psi}\rangle = E \times |\hat{\psi}\rangle$ .

However, the Hulten potential does not exist on isospaces over isofields, trivially, because it does not exist in the Hamiltonian  $\hat{H}$  which is fully conventional.

The Hulten potential of the isoelectronium of Sect. 9.3 emerge only when we project the real system, that on isohilbert spaces with equation  $\hat{H} \times |\hat{\psi}\rangle = E \times |\hat{\psi}\rangle$ , on conventional Hilbert spaces. As such, one should not expect that the Hulten potential necessarily carries an actual binding energy.

The reader should equally exercise caution for other aspects, and generally abstain from formulating opinions for hadronic chemistry essentially dependent on quantum chemical concepts and notions.

## 9.2.2 Main Characteristics of the Water Molecule

Water is a mixture of several different molecules in different percentages and molecular weights. In fact, we know three different isotopes of the hydrogen, <sup>1</sup>H, <sup>2</sup>H and <sup>3</sup>H, and six different isotopes of the oxygen ranging from <sup>14</sup>O to <sup>19</sup>O. In this monograph, we shall solely study the molecule <sup>1</sup>H<sub>2</sub>-<sup>16</sup>O, and denote it H<sub>2</sub>O = H-O-H where the symbol "-" is referred to the molecular bond. Such a water molecule will be studied hereon under the following conditions: 1) at absolute zero degrees °K; 2) in the absence of any rotational, vibrational, translational, or other motions; and 3) with all atoms in their ground state (see Ref. [40] for all details contained in this section).

The electrons of the individual H-atoms are assumed to be in the ground state 1s. Of the eight electrons of the oxygen, two electrons with opposite spin orientation are in the lowest 1s state which is tightly bound to the nucleus; two electrons are in the next possible state 2s; and the remaining four electrons are in the 2p state.



Figure 9.8. A conceptual rendering of the conventional water molecule with its typical electric polarization. Note the consequential predominance of a positive charge in the two hydrogen atoms that is responsible in part for the angle of  $105^{\circ}$  between the two HO radicals.

By using a three-dimensional reference frame with the y-z plane containing the nuclei of the H and O-atoms with origin in the latter, the 1s and 2s electrons have a spherical distribution while the 2p electrons are in orbitals perpendicular to the yz plane denoted  $2p_x$ ; the remaining two electrons have orbitals perpendicular to the xz and xy planes denoted  $2p_y$  and  $2p_z$ , respectively.

Also, the energy of formation of the water molecule from hydrogen and oxygen is -9.511 eV; the binding energy is -10.086 eV; the sum of the ground state energies of the three separate atoms is -2,070.46 eV; the total molecular energy at 0°K is -2,080.55 eV as a result of kinetic energy +2,080.6 and potential energy -4,411.4; the nuclear repulsion energy is +250.2 eV; the total electrostatic energy is -2,330.8 eV; the dissociation energy of O-H is 5.11 eV and that of H alone is 4.40 eV.

Again at 0°K and for all atoms in their ground states, the bond length of the H-O dimer is  $0.95718 \times 10^{-8}$  cm, while the two dimers H-O and O-H form a characteristic angle of  $104.523^{\circ}$ . Therefore, by no means the scripture H-O-H denotes that the water has a linear structure because of the indicated characteristic angles in between the two dimers H-O and O-H.

It is evident that when the individual atoms are in their excited states, the bond length and the characteristic angle change. In fact, increases of up to 8.5° have been measured for the characteristic H-O-H angle for excited states. The same characteristic angle is expected to be altered by the application of sufficiently strong electric and magnetic fields, although we are unaware of accurate measurements under the indicated conditions.

The water molecule possesses an electric dipole moment of  $1.83 \times 10^{-8}$  e.s.u. cm and a mean quadrupole moment of  $-5.6 \times 10^{-26}$  e.s.u. cm. It should be recalled that the very existence of a non-null value of electric dipole and quadruple moments excludes the linear structure of the water H-O-H in ordinary isolated conditions (that with a characteristic angle of  $180^{\circ}$ ).

Water is a diamagnetic substance with a magnetic polarization (also called susceptibility) of  $(2.46, 0.77 \text{ and } 1.42) \times 10^{-6} \text{ e.m.u./mole for the corresponding three space-dimension <math>xx$ , yy and zz, respectively.

In first approximation, the water molecule can be represented via two individual H-O dimers with wavefunction of the molecular orbitals (m.o.'s),

$$\psi_1 = \lambda \phi(\mathbf{H}', 1s) + \mu \phi(\mathbf{O}, 2p_z), \qquad (9.2.6a)$$

$$\psi_2 = \lambda \phi(\mathbf{H}'', 1s) + \mu \phi(\mathbf{O}, 2p_y), \qquad (9.2.6b)$$

where  $\lambda$  and  $\mu$  are parameters.

However, the above simple model predicts a characteristic angle of  $90^{\circ}$ . As a consequence, the model is generally modified with a mixture of electrons from the 2p and 2s states also called *hybridization*. The occurrence confirms that any model of the water with charge distributions of the valence electrons in the H-O-H plane is insufficient to represent the experimental data. In turn, this mixing creates the known two *lobes* on the side of the oxygen atom, away from the hydrogen atoms, above and below the molecular plane. This results in models of the type

$$\psi_1 = \lambda [\cos \varepsilon \psi(\mathbf{O}, 2s) + \sin \varepsilon \phi((\mathbf{O}, 2p)] + \mu \phi(\mathbf{H}', 1s), \qquad (9.2.7a)$$

$$\psi_2 = \lambda [\cos \varepsilon \psi(\mathbf{O}, 2s) + \sin \varepsilon \phi((\mathbf{O}, 2p)] + \mu \phi(\mathbf{H}'', 1s), \qquad (9.2.7b)$$

where  $\varepsilon$  is the hybridization parameter with generic value of the order of  $\cos \varepsilon = 0.093$  confirming that the valence electrons are mainly from 2p states.

It should be indicated that the exact configuration, location and function of the two lone-pair electron lobes are unsettled at this writing, since they are evidently dependent on the selected theoretical model. Also, the individual electric and/or magnetic dipoles of the lobes cannot be measured (only their total values is measurable), thus implying lack of direct experimental evidence on the individual lobes.

We should also recall that the individual H-O and O-H bonds are not independent from each other, as confirmed by the different values of the dissociation energies.

Water is both an acid and a base due to dissociation of  $H_2O$  into  $H^+$  and  $O-H^-$  to the extent that the product of the concentrations  $[H^+][O-H^-]$  sets up

an equilibrium whose constant value is  $1.0 \times 10^{-14}$ , which is the well known pH scale of the equations

$$pH = -\log_{10}[H^+], \quad pOH = 14 - pH.$$
 (9.2.8)

In neutral water the ion concentrations are  $[H^+] = [O-H^-] = 1.004 \times 10^{-7}$  mole/liter.

Water is quite polar with a dipole moment of 1.84 to 1.834 Debye and a bulk dielectric constant of 80 at 20 °C. This implies that pure water is not a good conductor, with a direct current conductivity of only  $5.7 \times 10^{-8}$  ohm<sup>-1</sup>·cm<sup>-1</sup>.

However, it is well known that small amounts of strong acids such as HCl or  $H_2SO_4$  can make water highly conducting due to the ease with which  $H^+$  can attach to  $H_2O$  to form  $H_3O^+$  which then offers a *domino effect* for one  $H^+$  to successively "bump" an  $H^+$  off the other side of  $H_3O^+$  and so produce a very effective conduction mechanism [44]. In fact it is well known that in aqueous solutions the transport numbers for the anions and cations are not equal, because up to 70% of the current is carried by  $H^+$ . Although  $OH^-$  typically carries much less current than  $H^+$  in aqueous conduction of electricity (due to its larger size and lack of the domino-effect cited earlier for  $H^+$ ), once a current flow is initiated additional ions are created due to collisions in solution.

An important aspect is the known existence of an equilibrium between H-O-O-H and HO<sup>-</sup> around pH 11.63 [45] with a voltage dependence of  $1.363 \pm 0.0293$  pH as given by M. Pourbaix for aqueous equilibria involving H<sup>+</sup>, O-H<sup>-</sup>, H<sup>-</sup>, H-O-O-H and H-O<sup>-</sup>. Thus, there is no doubt of the existence of small amounts of H-O-O-H in water at high pH.

In a high current process the flow of  $H^+$  will be much greater than that of  $OH^-$  so that as  $H_2O$  is electrolyzed to  $2H_2$  and  $1O_2$ , local concentrations/fluctuations will slightly favor higher pH (local depletion of  $H^+$ ) and hence favor the existence of H-O-O-H.

We should finally mention the inability of quantum chemistry to achieve a scientific-quantitative representation (or at least an understanding) of the *dif*ferent types of water when exposed to magnetic fields, as established by the evidence, e.g., that plants grow faster when irrigated with water exposed to one type of magnetic field, while they die rapidly when exposed to a different type of magnetic field. In fact, quantum chemistry admits only one type of water,  $H_2O$ .

It is easy to see that this additional insufficiency of quantum chemistry is a direct consequence of the current use of exchange, van der Waals and other forces of nuclear origin under which the individual H and O atoms in the H<sub>2</sub>O molecule preserve their individuality, thus resulting in one single configuration.

On the contrary, isochemistry introduces a real, strong bond for the valence electrons via the notion of isoelectronium. In this latter case different types of water, that is, water molecules with different physical characteristics, are indeed readily possible, as we shall see.

# 9.2.3 Exactly Solvable Model of the Water Molecule with Stable Isoelectronium

In the preceding Chapter 3 [43a], we have introduced the main hypothesis of the *isochemical molecular model*, according to which two electrons from two different atoms bond themselves into a singlet quasi-stable and quasi-particle state called *isoelectronium*, which describes an *oo*-shaped orbit around the nuclei, as it is the case for planets in certain binary stars (Fig. 9.3). The main characteristics of the isoelectronium in first nonrelativistic approximation are calculated in Sect. 9.3 and resulted in being:

charge - 2e, spin 0, magnetic dipole moment 0,  
mass 1.022MeV, radius = 
$$r_c = b^{-1} \approx$$
  
 $\approx (\hbar^2/m \times V)^{1/2} = (\hbar/m \times \omega)^{1/2} = 6.8432329 \times 10^{-11} \text{cm} =$   
= 0.015424288 bohrs = 0.006843 Å.  
(9.2.9)

In the above nonrelativistic approximation, the meanlife resulted in being infinite (full stability, with the understanding that relativistic corrections are expected to render such a meanlife finite (partial stability). All conventional forces of current use in chemistry (exchange, van der Waals and other forces) then hold when the valence electrons are at mutual distances bigger than the hadronic horizon.

In this Chapter, we study the isochemical model of the water molecule  $H_2O=H$ -O-H first introduced by Santilli and Shillady [43b], under the assumption that the molecule is considered at °C and in the absence of any rotational, oscillation or other motion. The main hypothesis is that each electron from the two H-atoms couples in singlet with one 2p electron from the O-atom, resulting in two isoelectronia, one per each H-O dimer as in Fig. 9.8.

In this Section we shall study a hadronic/isoschrödinger equation for the water molecule under the above assumptions, which equation evidently approximate, yet exactly solvable for the first time to our knowledge. We shall then show that the model is extendable to all other dimers comprising one hydrogen atom, such as H-C.

For this purpose, we approximate the H-O-H molecule as being composed of two intersecting identical dimers H-O with evidently only one oxygen atom. This requires a first correction due to the lack of independence of said dimers reviewed in Sect. 9.2. Moreover, in each H-O dimer we shall assume that the oxygen appears to the isoelectronium as having only one net positive charge +e located in the nucleus. This evidently requires a second correction which essentially represents the screening of the various electrons of the oxygen. Additional corrections are also in order along conventional lines [40].



Figure 9.9. A schematic view of the proposed isochemical model of the water molecule here depicted at absolute zero degrees temperature and in the absence of any motion for the case of fully stable isoelectronium. It should be stressed that at ordinary temperature rotational motions recover the conventional space distribution, thus recovering the conventional "Mickey Mouse" configuration of the water. Also, the model is presented in terms of the orbits of the valence electrons (rather than in terms of *density distributions*). The fundamental assumption is that the two valence electrons, one per each pair of atoms, correlate themselves into two bonded singlet states at short distance we have called *isoelectronia*, one per each dimer H-O, which states are assumed to be mostly stable (see the text for the mostly unstable case). The water molecule is then reducible to two intersecting H-O dimers with a common O-atom. The only orbits yielding a stable water molecule are those in which each isoelectronium describes a *oo*-shaped orbit around the respective two nuclei of the H- and O-atoms. The isoelectronia are then responsible for the attractive force between the atoms. The binding energy is instead characterized by the *oo*-shaped orbits of the isoelectronia around the respective two nuclei, conceptually represented in this figure via a standing wave for a particle of spin 0 and charge -2e. Note that, in the absence of molecular motions, the orbits of the two isoelectronia are perpendicular to the H-O-H plane, thus confirming a characteristic of the water molecule reviewed in Sect. 9.2. Conventional exchange, van der Waals and other forces remain admitted by the model when the isoelectronia are mostly unstable. The model permits a representation of: 1) the "strong" value of the molecular bond; 2) the reason why the  $H_2O$  molecule has only two hydrogen atoms and one oxygen atom; 3) a representation of the binding energy, electric and magnetic moments accurate to several digits; and other advances studied in the text. The above model of the H-O dimer is then extendable to other H-based dimers, such as H-C.

A study of these corrections has indicated that they can all be represented via one single Gaussian screening of the Coulomb law of the type [43b]

$$\frac{+e}{r} \to \frac{+e(1 \pm e^{-\alpha r^2})}{r},$$
 (9.2.10)

where  $\alpha$  is a positive parameters to be determined from experimental data, the sign "-" applies for the screened O-nucleus as seen from an *electron* (because of

the repulsion caused by the electron clouds of the oxygen), while the sign "+" applies for the screened O-nucleus as seen from the H-nucleus (because of the attraction this time caused by said electron clouds).

The resulting model is structurally equivalent to the isochemical model of the hydrogen molecule of Chapter 3 [43a], except for the modifications indicated about, and can be outlined as follows.

By denoting with the sub-indices 1 and a the hydrogen, 2 and b the oxygen, prior to the indicated screening and in the absence of all hadronic effects, the conventional Schrödinger equation of the H-O dimer with the oxygen assumed to have only one elementary charge +e in the nucleus is given by

$$\left(\frac{1}{2\mu_1}p_1 \times p_1 + \frac{1}{2\mu_2}p_2 \times p_2 - \frac{e^2}{r_{1a}} - \frac{e^2}{r_{2a}} - \frac{e^2}{r_{1b}} - \frac{e^2}{r_{2b}} + \frac{e^2}{r_R} + \frac{e^2}{r_{12}}\right) \times |\psi\rangle = E \times |\psi\rangle, \qquad (9.2.11)$$

As it was the case for the H<sub>2</sub>-molecule, our task is that of subjecting the above model to a transform, which is nonunitary only at the short mutual distances  $r_c = b^{-1} = r_{12}$  of the two valence electrons (here assumed to be hadronic horizon), and becomes unitary at bigger distances  $\hat{I}_{r \leq 10^{-10} \text{cm}} \neq I$ ,  $I_{r \gg 10^{-10} \text{cm}} = I$ .

We assume that the state and related  $\overline{\text{Hilbert}}$  space of systems (9.2.11) can be factorized in the familiar form (in which each term is duly symmetrized or antisymmetrized)

$$|\psi\rangle = |\psi_{12}\rangle \times |\psi_{1a}\rangle \times |\psi_{1b}\rangle \times |\psi_{2a}\rangle \times |\psi_{2b}\rangle \times |\psi_R\rangle, \qquad (9.2.12a)$$

$$\mathcal{H}_{\text{Tot}} = \mathcal{H}_{12} \times \mathcal{H}_{1a} \times \mathcal{H}_{1b} \times \mathcal{H}_{2a} \times \mathcal{H}_{2b} \times \mathcal{H}_R.$$
(9.2.12b)

The nonunitary transform we are looking for shall act only on the  $r_{12}$  variable characterizing the isoelectronium while leaving all other variables unchanged. The simplest possible solution is given by

$$U(r_{12}) \times U^{\dagger}(r_{12}) = \hat{I} = e^{[\psi(r_{12})/\hat{\psi}(r_{12})] \int d\mathbf{r}_{12} \hat{\psi}^{\dagger}(r_{12})_{1\downarrow} \times \hat{\psi}(r_{12})_{2\uparrow}}, \qquad (9.2.13)$$

where the  $\psi$ 's represents conventional wavefunction and the  $\hat{\psi}$ 's represent isowavefunctions, for which we have, again the fundamental condition of fast convergence

$$|\hat{T}| = |(U \times U^{\dagger})^{-1}| \ll 1.$$
 (9.2.14)

We now construct the isochemical model by transforming short-range terms (isochemistry) and adding un-transformed long range ones (chemistry), thus resulting in the radial equation

$$\left(-\frac{\hbar^2}{2\times\mu_1}\times\hat{T}\times\nabla_1\times\hat{T}\times\nabla_1-\frac{\hbar^2}{2\times\mu_2}\times\hat{T}\times\nabla_2\times\hat{T}\times\nabla_2+\right.$$

$$+\frac{e^2}{r_{12}} \times \hat{T} - \frac{e^2}{r_{1a}} - \frac{e^2}{r_{2a}} - \frac{e^2}{r_{1b}} - \frac{e^2}{r_{2b}} + \frac{e^2}{R} \times |\hat{\psi}\rangle = E|\hat{\psi}\rangle.$$
(9.2.15)

By recalling that the Hulten potential behaves at small distances like the Coulomb one, Eq. (9.2.15) becomes

$$\left(-\frac{\hbar^2}{2 \times \mu_1} \times \nabla_1^2 - \frac{\hbar^2}{2 \times \mu_2} \times \nabla_2^2 - V \times \frac{e^{-r_{12} \times b}}{1 - e^{-r_{12} \times b}} - \frac{e^2}{r_{1a}} - \frac{e^2}{r_{2a}} - \frac{e^2}{r_{1b}} - \frac{e^2}{r_{2b}} + \frac{e^2}{R}\right) \times |\hat{\psi}\rangle = E \times |\hat{\psi}\rangle.$$
(9.2.16)

The above model can be subjected to an important simplification. In first approximation under the assumption herein considered, the H-O dimer (9.2.16) can be reduced to a restricted three body problem similar to that possible for the conventional  $H_2^+$  ion [41], but not for the conventional  $H_2$  molecule, according to the equation

$$\left(-\frac{\hbar^2}{2\mu_1} \times \nabla_1^2 - \frac{\hbar^2}{2\mu_2} \times \nabla_1^2 - V \times \frac{e^{-r_{12}b}}{1 - e^{-r_{12}b}} - \frac{2e^2}{r_a} - \frac{2e^2}{r_b} + \frac{e^2}{R}\right) \times |\hat{\psi}\rangle = E \times |\hat{\psi}\rangle.$$
(9.2.17)

The indicated corrections due to the screening of the various electrons in the oxygen and other corrections are needed in the "sensing" of the O-nucleus by the isoelectronium as well as by the H-nucleus, yielding in this way our final model

$$\left(-\frac{\hbar^2}{2\mu_1} \times \nabla_1^2 - \frac{\hbar^2}{2\mu_2} \times \nabla_2^2 - V \times \frac{e^{-r_{12}b}}{1 - e^{-r_{12}b}} - \frac{2e^2}{r_a} - \frac{2e^2(1 - e^{-\alpha r_b})}{r_b} + \frac{e^2(1 + e^{-\alpha R})}{R}\right) \times |\hat{\psi}\rangle = E \times |\hat{\psi}\rangle, \qquad (9.2.18)$$

where:  $\alpha$  is a positive parameter; E is half of the binding energy of the water molecule; and, as it was the case for model (9.1.35), the mass of the isoelectronium, the internuclear distance, and the size of the isoelectronium can be fitted from the value of the binding energy and other data.

Under the latter approximation, the model admits an exact analytic solution, for the first time to our knowledge, which solution however exists only for the case of the *fully stable isoelectronium*. In fact, for the unstable isoelectronium, the model becomes a *four-body structure*, which as such admits no exact solution.

Besides being exactly solvable, model (9.2.18) exhibits a new explicitly attractive "strong" force among the neutral atoms of the H-O dimer, which is absent in conventional quantum chemistry; the equation also explains the reasons why the water molecule admits only two H-atoms.

872

As we shall see in the remaining sections, the model permits an essentially exact representation of the binding energy, electric and magnetic moments; the model yields much faster convergence of series with much reduced computer times, and resolves other insufficiencies of conventional models.

Finally, the model is evidently extendable with simple adjustment to an exact solution of other dimers involving the hydrogen, such as H-C. In addition, it permits the identification of electric and magnetic polarizations, which are not predictable with quantum chemistry (Chapter 8).

# 9.2.4 Gaussian Approximation of the Isochemical Model of the Water Molecule with Unstable Isoelectronium

The solution of the exactly solvable model (9.2.18) are not available at this writing, and its study is here encouraged. In this section, we review the studies of Ref. [43b] on a Gaussian approximation of the isochemical model of the water molecules, with the Hulten potential approximated to a certain Gaussian form.

It should be indicated from the onset that such an approximation implies an evident weakening of the Hulten attraction among the two isoelectrons of the isoelectronium, which, in turn, implies the instability of the isoelectronium itself, thus reaching a model which is somewhat intermediate between the full isochemical model and the conventional quantum chemical model of the water.

Despite this approximate character, the results of this section are significant because they show the capability of isochemistry to achieve an essentially exact representation of the binding energy, electric and magnetic moments and other characteristics of the water molecule.

The results of this study can be outlined as follows. Since HOOH will be slightly more allowed under the assumed conditions, collisions of HO<sup>-</sup> with neutral H<sub>2</sub>O and the internal repulsion within the anion could favor the release of a quasiparticle with charge -2e to form OH<sup>+</sup>. Collisions of OH<sup>+</sup> with OH<sup>-</sup> will then further enhance the concentration of HOOH, and transport of -2e will contribute to the current.

The question here is whether under extreme cases of forced conduction a singlet-pair of electrons (isoelectronium), can be "triggered" (Fig. 9.6) within a water molecule to form and release a -2e charged isoelectronium particle which will provide an additional conduction mechanism analogous to Cooper-pairs of electrons in superconducting solids.

Since the energy depth of the  $V_0$  parameter in the isoelectronium Hulten potential of the original 1978 derivation by Santilli [42] is not known, nor how closely the Gaussian representation fits the Hulten form, we can only match the radius of the two potentials and calculate the energy differences caused by the "sticky-electrons" model in which a transient form of isoelectronium can occur (the Gaussian potential well may not be deep enough to ensure a permanent bound state for the isoelectronium).

The "sticky-electron" model is a parametric model which includes the magnetic dipole attraction between singlet-paired electrons, as well as the nonlocal merging of the wave-packets of each electron at short distance. The radius of the Gaussian screening is then determined empirically by fitting the calculated energy as nearly as possible to the most accurate energy values available.

As used here, it should be emphasized that the off-axis positions of the Gaussianlobe basis sets [46-48] ensure that angular correlation is included as well as radial dependence, and can include the magnetic dipole attraction of opposite electron spins as well as merger of wavepackets.

One radial screening parameter used with off-axis basis sets parametrically covers all forms of short range attraction which may include angular dependence. Thus the present model can give us an approximate energy difference required to release an electron-pair from OH<sup>-</sup>.

$$OH^- \to OH^+ + (2e)^{-2}.$$
 (9.2.19)

It will be seen below that the energy difference between  $OH^-$  and  $OH^+$  as calculated, allowing a transient form of isoelectronium, is well within the voltage accessible using capacitive discharge through water. Such a mechanism which would allow -2e particles to flow through water would not be superconductivity as conventionally understood, since the freely moving molecules and ions are not constrained to lattice positions as in solids, so that resistive  $I^2R$  heating will still occur.

This is mainly due to the fact that conduction in liquids occurs by mobility of both anions and cations along with size differences, polarizability differences and special mechanisms such as the hydrogen-bonding "domino effect" for  $H^+$ transport. In solid-state conduction, only the electrons move by ignoring in-place phonon oscillations because the atoms do not travel from one electrode to the other.

Despite the indicated lack of superconducting character, it should be indicated that yet, the essentially null magnetic moment of the -2e particle would imply indeed a reduction of the resistivity.

The apparent motion of positively charges "holes" is also due to motion of electrons while the atoms merely oscillate about mean lattice positions. In solutions there is a two-way traffic with positive and negative ions travelling in opposite directions and with differing velocities, thus leading to resistive heat even up to the vaporization of the water as well as a high probability of ion collisions.

It should be noted that in recent work Ashoori *et. al.* [49] have measured migration of paired-electrons to quantum dot wells in GaAs, while Boyd and Yee [50] have observed "bipolaron" electron pairs in alkali halide lattice vacancies. Calculations leading to unexpected bipolarons in crystal lattice vacancies have

also been observed by using the method of Car and Parinello [51]. These findings in solids lend support to the concept of an electron pair as an individual particle, called by the authors isoelectronium.

The calculations given here do not prove the presence of isoelectronium particles in high current aqueous electrical conduction; they only indicate the energy threshold necessary to form the isoelectronium within the conducting solution by double-ionization of OH<sup>-</sup>.

It is not easy to envision an experiment that would be able to analyze components of a given current, due to multiple ion species in terms of the amount of current due to -2e particles, and none is proposed here. However, there may be a chemical test for such a mechanism. Once OH<sup>-</sup> is doubly-ionized to form OH<sup>+</sup>, collisions with -2e particles would regenerate OH<sup>-</sup> ions just as collisions of H<sup>+</sup> with OH<sup>-</sup> will reform H<sub>2</sub>O, and no new species will be evident.

However, if  $OH^-$  collides with  $OH^+$  a new chemical species HO-OH will be formed that may last long enough in the liquid to behave as a strong oxidizing agent. Thus, organic compounds with double bonds (alkenes), which have negligible conductance, could be added to water undergoing a high current flow to cause hydroxylation of such compounds [52], (i.e., conversion of alkenes to epoxide, which are then readily hydrolyzed in the presence of H<sup>+</sup> to diols). Enhanced concentrations of epoxides and diols would be indirect evidence of double ionization of OH<sup>-</sup>, according to the expressions

$$OH^+ + OH^- \rightarrow HO - OH,$$
 (9.2.20)

If the isoelectronium can be detected indirectly by a chemical method, this would in itself be an important inference on the existence of a two-electrons, spin-zero particle. More importantly, "isochemical reactions" could be driven by high conduction "liquid plasma" environments where the isoelectronium is at an enhanced concentration.

Another case of interest is that of aqueous mixtures of insoluble organic compounds forming a separate oil layer over water in an intense magnetic field of several Tesla. At normal thermal energy of room temperature  $kT \cong RT$  per mole the main energy form would be random Brownian motion.

However, in the presence of a strong magnetic field  $HO^+$  and  $HO^-$  would be constrained to favor circular motions in the magnetic field by the "cyclotron effect," but there is no obvious source of  $HO^+$ .

Since two ions of opposite sign charges would be favored to collide by both electrical attraction and by opposite path curvature in a magnetic field, there is an enhancement that when created as a normal result of  $H^+$ ,  $OH^-$ ,  $H^-$ ,  $H_2O_2$ ,  $HO_2^-$ ,

 $H_2O$  equilibrium system studied by Pourbaix [45], any natural concentration of HOOH would be augmented by collision of  $H^+$  with HOO<sup>-</sup>.

In addition there is some slight chance that  $H^+$  would collide with  $OH^-$  with sufficient excess energy to produce  $OH^+$  and  $H^-$ . Thus the presence of an intense magnetic field would cause positive and negative ions to collide more easily while travelling in opposite rotational arcs in such a way as to enhance the concentration of HOOH,

$$\mathrm{H}^{+} + \mathrm{HOO}^{-} \to \mathrm{HOOH}, \qquad (9.2.21a)$$

$$H^+ + OH^- \to H^- + OH^+,$$
 (9.2.21b)

$$OH^+ + OH^- \to HOOH,$$
 (9.2.21c)

which could then epoxidate alkenes and upon hydrolysis would lead to diols.

A direct measure of this effect would be to determine the enhanced solubility of alkenes in water. The alkenes are only slightly soluble in water ("oil and water do not mix") but alkenes converted to diols will have a measurably greater solubility in water due to the attached OH-groups. Again. If such enhanced solubility of alkenes in water can be caused by intense magnetic fields, this would be indirect evidence of the existence of an electron-pair particle with charge -2e.

In the description of the calculations below the key to the above possibility is that it is easy to calculate the energy of  $OH^-$  when one subtracts a small amount from the two-electron repulsion terms in the usual HFR-SCF treatment, due to the attraction of singlet-paired electrons at close range within 1.0 picometer.

In the recent Handbook of Computational Quantum Chemistry by Cook, Ref. [53], p. 438, it is noted that solutions to the HFR-SCF scheme may not always exist for anions. However, in the method used here convergence of the HFR-SCF method was normal for an SCF process, because the so called "selfenergy" error of the Hartree-Fock method [54] (in which each electron repels all electrons including itself) is largely cancelled by the new attractive terms used here. In effect, this description of  $OH^-$  is possible because of the easy convergence of the "correlated-SCF process."

## 9.2.5 The Method

The model adopted in Ref. [43b] is to use the usual Hartree-Fock-Roothan self-consistent-field equations [55] (which also has some formal flaws such as the self-interaction terms [54]) and lift in a nonunitary way the form of the Coulomb interaction of the electrons.

Note that reducing the values of the Coulomb integrals will lower the energy by reducing the electron-electron repulsion while reducing the exchange terms will raise the energy, but the factor 1/2 reduces the effect of the exchange terms. Thus a reduction of the value of the integrals will lower the energy.

876

Note that Goodgame and Goddard [54] have already recommended reducing the atomic self-energy by subtracting 1.39 eV from Hartree-Fock exchange integrals in the cases of  $Cr_2$  and  $Mo_2$ .

FC = ESC; 
$$F_{i,j} = H_{i,j} + \sum_{k,l} P_{k,l}[(i,j|k,l) - 1/2(i,k|j,l)],$$
 (9.2.22a)

$$(i,j|k,l) = \iint \chi_i(l)\chi_j(l)\frac{1}{r_{12}}\chi_k(2)\chi_l(2)d\tau_1 d\tau_2, \qquad (9.2.22b)$$

$$P_{i,j} = 2\sum_{n} c_{n,i} c_{n,j} \quad \text{(sum $n$ only over occupied orbitals)}. \tag{9.2.22c}$$

The 1995 paper on electron-electron pairs by Animalu and Santilli [42b] invokes the non-local hadronic attractive force evident in the  $\pi^0$ -meson by Santilli [42a] applied to a pair of singlet-paired electrons which form a boson quasiparticle. However, the "collapsed positronium" rapidly decays since the particleantiparticle annihilation takes place in less than a picosecond.

In the electron-electron case it is believed that there may be a stable quasiparticle singlet bond we have called the isoelectronium. After using a non-local isotopic nonlinear transformation, the hadronic attraction was projected into realspace, and modeled with a Hulten potential.

Considerable effort was made to evaluate the matrix elements for the Hulten potential without success. Examination of the original 1978 paper on positronium collapse by Santilli [6a] revealed that the Hulten potential is not necessarily a unique representation of the hadronic force. In fact, a linear combination of similar potentials could be used to represent the Hulten potential if matrix elements of such other potentials could be evaluated.

The depth of the screened Gaussian approximation is determined by requiring that the width at half height of the Gaussian is equal to the *b* value of the Hulten horizon (the radius at which the Coulomb repulsion is annulled by other attractive forces). Thus, the screened Gaussian potential probably has a depth which is too shallow although the  $V_0$  depth parameter for the Hulten potential is not known at present.

This work assumes that until matrix elements of a two-electron interaction for singlet-pairs can be found for the Hulten potential, a Gaussian-screened-Coulomb potential can be used to describe the real-space form of the hadronic attraction and as a parameter fitted to experimental energies the screening exponent probably includes other effects such as the magnetic dipole interaction of two electrons with opposite spin-magnetic-moments. This form has the important property that it can be merged with the general case of the four-center Coulomb or exchange integral derived by Shavitt [56] using the famous Gaussian transform technique. The Gaussian transform two-electron integral for four Gaussian spheres has been used in a number of Gaussian-lobe basis SCF programs written by Shillady [57, 58] and others. It is important to note that the formula is completely general in orientation of four Gaussian sphere lobe-orbitals as well as the distance between two electrons.

As modified for a description of the correlation of two electrons, such a general formula can describe angular correlation as well as distance interaction. Thus matrix elements of a screened-Coulomb interaction were subtracted from the usual 1/r Coulomb repulsion to model the real-space form of the hadronic attraction of two electrons. The work outlined in this section, first presented in Ref. [43b], added the Gaussian screening as  $\exp[-\alpha r^2]/r$  so that the special properties of Gaussians could be used, especially the properties that the product of two Gaussians form another Gaussian (times a re-centering factor), and that polar coordinates readily separate into factorable x, y, z components.

The goal was to evaluate the two-electron four-center matrix elements of the Gaussian-screened Coulomb potential in the expression

$$Y(r) = \frac{1 - 2\exp[-\alpha r^2]}{r}.$$
(9.2.23)

Amazingly, the Gaussian-Gaussian exponent and carried through the original derivation until the last step when integration over "s" is required.  $\alpha$  is usually a very high number, this work used  $0.13441885 \times 10^7$ . At this point the usual Coulomb interaction resorts to a well known auxiliary function  $F_0$  which has been studied by Shillady [57] and others.

Since both  $s^{1/2}$  and  $(s + \alpha)^{1/2}$  occur in the denominator of the screened-Coulomb form, two poles occur in the integral. A change of variable absorbs the pole due to  $(s + \alpha)^{-1/2}$  and shifts the other pole due to  $s^{-1/2}$  to the lower limit of the integral. A smooth spike is evident at the lower limit of the numerical integration using a 70 point Simpson's Rule integration (two ranges are used with 20 points more closely spaced near the pole and 50 points for the remaining range).

This work was carried out using 64 bit double precision arithmetic, which provides 14 significant figures. A simple offset  $\delta$  of  $1.0 \times 10^{-15}$  has provided useful results with this simple offset to avoid numerical overflow.

While this pole is formally a problem in needing a continuous function to integrate, numerical integration seems to handle these Coulomb integrals are known to be accurate only to 12 significant figures. The area under the polespike is estimated as a narrow triangle upon a rectangle  $1.0 \times 10^{-15}$  wide with the height of the triangle set at  $3.43207 \times 10^8$  times the height of the point set  $1.0 \times 10^{-15}$  into the range of integration (the first Simpson point).

The present code for this screened-Coulomb integral is presently slower that the corresponding  $F_0$  function [56] used for the Coulomb integrals due to the

878

70 point Simpson integration, but the integrand is nearly flat after the spike at s = 0.0 so that portion of the integrand can be evaluated more rapidly with fewer points. For results presented here, the simple offset of the lower limit by  $1.0 \times 10^{-15}$  is adequate for this monograph. Further details on the auxiliary integral can be found in a previous paper on the H<sub>2</sub> molecule [59].

Work in progress indicates it may be possible to express the new auxiliary integral to an analytical expression involving the erf(x) function (see Chapter 6), but until further checks are completed this work used the Simpson integration. Note the integral is a result of a simplification of a twelve-fold integration over the volume elements of two electrons, and has been reduced to a one-dimensional integration multiplied by appropriate factors.

## 9.2.6 The Main Results

The geometry given for H<sub>2</sub>O by Dunning [60] was used to carry out the usual HFR-SCF calculation after an additional 3*d* orbital mimic [58] was optimized in Ref. [43b] for the O atom and (2s,2p) orbitals were added for the H atoms. The exponent for the O3*d* orbitals was optimized to three significant figures and the (O3d,H2s,H2p) exponents were (2.498, 0.500, 1.000). These polarization orbitals were added to the Dunning-Huzinaga (10*s*6*p*) [59] basis with the H1*s* orbitals scaled to 1.2 which produced a lower energy than that of a 6-31*G*<sup>\*\*</sup> basis using the GAMESS program. The bond length of OH<sup>+</sup> was Angströms.

The same bond length was used for  $OH^-$  since the anion calculation using the usual HFR-SCF process was not feasible, and, in any case, the bond length is only slightly longer than that in water. The horizon cutoff value of 0.00038 Angströms optimized for H<sub>2</sub>O was also used for OH<sup>+</sup> and OH<sup>-</sup>.

The spike in the numerical integral routine was optimized by fitting the  $R_c$  cut-off value so as to obtain as near as possible the non-relativistic energy of the HF molecule as determined from Quantum Monte Carlo calculations [60]. The dipole moments for the ions are not very useful since ion dipoles are origin dependent, but they were calculated using the center-of-mass as the origin.

As we see in Table 9.3, the difference in energy between  $OH^-$  and  $OH^+$  is 0.497621 Hartrees (13.54 eV) according to the Correlated-SCF calculations. It is clear from the standard SCF energy value for H<sub>2</sub>O that this basis is very good, but not quite at the Hartree-Fock limit of energy. In addition, the fitting of the numerical integration spike so as to most nearly reproduce the total energy of HF is not exact.

These two artifacts introduce an energy uncertainty of about 0.0115 Hartrees, but this is less uncertainty than that of the Quantum Monte Carlo (QMC) energy of Luchow and Anderson [61]. Note that the Iso-Dipoles for  $H_2O$  and HF are very close to the experimental values which indicates that the calculated wavefunctions are of high quality.

|  | $OH^+$         | $OH^{-}$   | $H_2O$     | HF               |
|--|----------------|------------|------------|------------------|
| $SCF-Energy^{a}$                       | -74.860377     | -75.396624 | -76.058000 | -100.060379      |
| Hartree-Fock <sup><math>b</math></sup> |                |            |            | $-100.07185^{b}$ |
| Iso-Energy <sup><math>c</math></sup>   | -75.056678     | -75.554299 | -76.388340 | -100.448029      |
| Horizon $R_c$ (Å)                      | 0.00038        | 0.00038    | 0.00038    | 0.00030          |
| QMC Energy <sup><math>b,d</math></sup> | $-76.430020^d$ |            |            | $-100.44296^{b}$ |
| Exact non-rel.                         |                |            |            | -100.4595        |
| Iso-Dipole $(D)$                       | 5.552581       | 8.638473   | 1.847437   | 1.8413778        |
| Exper. Dipole                          |                |            | 1.84       | 1.82             |

Table 9.3. Isoelectronium results for selected molecules [43b].

<sup>a</sup> Dunning-Huzinaga (10s/6p), (6,2,1,1,1/4,1,1)+H2s1+H2p1+3d1.

<sup>b</sup> Iso-Energy calibrated to give maximum correlation for HF.

<sup>c</sup> Hartree-Fock and QMC energies from Luchow and Anderson [61].

<sup>d</sup> QMC energies from Hammond, Lester and Reynolds [60].

Since the ionization energy of a neutral H atom is 13.60 eV and the energy difference of 13.54 eV would convert  $OH^-$  to  $OH^+$ , a threshold of about 13.7 eV should maintain  $H^+$  in solution as well as transfer  $(2e)^{-2}$  through an aqueous solution to or from the  $OH^-/OH^+$  system.

These calculations indicate that there may be an enhancement of current flow with a potential above 13.7 volts across an aqueous cell and that the enhanced concentration of HOOH may be measurable above a potential of 13.7 volts. It is worth repeating that this estimate is possible largely due to the easy convergence of the Correlated-SCF process for a negative ion species; a process which is formally not defined under the usual Hartree-Fock-Roothan process [53], and most quantum chemists are familiar with the difficulty in treating negative ions using the standard Hartree-Fock-Roothaan method.

Admitting that the Correlated-SCF equations are a parametrized approximation to the Santilli derivation of the Hulten potential [42a] for a bound electronpair, the method has the advantage of easy incorporation into an existing Hartree-Fock-Roothaan Gaussian basis program merely by subtracting a small "correlation integral" from the usual two-electron integrals.

With some thought, one should realize that fitting the single parameter (Gaussian screening exponent,  $\alpha$ ) to experimental energies, and/or Quantum Monte Carlo results will incorporate another attraction in the form of a magnetic dipole interaction between the spin moments of paired electrons. Including the magnetic dipole interaction and substituting a Gaussian form for the Hulten exponential potential leaves only a simulation of the bound electron-pair Isoelectron-ium. Thus, these results are for a model in which the usual HFR-SCF method

is corrected for at least two attractive interactions of electrons causing them to approach each other as if they were "sticky"; hence the term "sticky-electron-pair model."

#### 9.2.7 Conclusions

In Chapter 3, we have presented a covering of quantum chemistry under the name of *hadronic chemistry*. In Chapter 4, we have applied the new discipline to the construction of a new model of molecular structures based on the bonding of a pair of valence electrons from different atoms into a singlet quasi-particle state called *isoelectronium*.

We have then applied the model to the structure of the hydrogen molecule, by achieving results manifestly not possible with quantum chemistry, such as: a representation of the binding energy and other features of the hydrogen molecule accurate to the *seventh digit*; an explanation of the reason why the hydrogen molecule has only *two* hydrogen atoms; a reduction of computer usage at least 1,000 fold; and other advances.

In this chapter, we have applied the isochemical model of molecular bonds to the water and other molecules with similar results. In fact, the isochemical model of the water and other molecules is supported by the following conceptual, theoretical and experimental evidence:

1) It introduces a new strong binding force (which is absent in current models) capable of explaining the strength and stability of molecules;

2) It explains the reason why the water molecule has only two hydrogen atoms and one oxygen;

3) It permits a representation of the binding energy of the water and other molecules, which are accurate to several digits;

4) It represents electric and dipole moments and other features of the water and other molecules, also accurate to *several digits*;

5) It permits a reduction of computer usages in calculations at least 1,000 fold; as well as it permits other achievements similar to those obtained for the hydrogen molecule.

Moreover, as it happened for the hydrogen molecule in Chapter 4, the value of the radius of the isoelectronium, Eqs. (9.2.9) computed via dynamical equations has been fully confirmed by independent calculations for the water and other molecules conducted via the Gaussian-lobe basis set.

The emission of electron pairs in superconductivity has been emphasized in Chapter 3. In Chapter 4 we also indicated preliminary, yet direct experimental verifications of the isochemical model of molecular bonds offered by the ongoing experiments on photoproduction of the valence electrons in the helium indicating that electrons are emitted in pairs [62]. The systematic repetition of these experiments specifically for water is here recommended. The statistical percentages of electron pairs over the total number of emitted electrons would then establish whether the isoelectronium is fully or only partially stable.

We should finally note that the representation of the binding energy, electric and magnetic moments and other characteristics of the water and other molecules exact to the several digits, as first achieved in Refs. [43] constitutes the strongest experimental evidence to date on the insufficiency of quantum mechanics and the validity of the covering hadronic mechanics for the representation of nonlinear, nonlocal and nonpotential-nonunitary effects, due to deep overlappings of the "extended wavepackets" of electrons with a point-like charge structure.

The new isochemical model of the water molecule outlined in this chapter has a number of intriguing new applications. For instance, the correlated-SCF method is used to easily obtain an energy for the OH- anion in water, while the OH<sup>+</sup> ion is easily treated in either the standard or modified method. The difference in energy between the 8-electron OH<sup>+</sup> system and the 10-electron OH<sup>-</sup> system is found to be 13.54 eV. This represents the energy needed to remove  $(2e)^{-2}$  from OH<sup>-</sup>. This indicates there may be a threshold for current flow in terms of  $(2e)^{-2}$  as a quasi-particle in aqueous media at 13.6 eV. This voltage will also maintain H<sup>+</sup> in solution to some extent. Organic alkenes in solution should undergo epoxidation followed by solvolysis to diols under the conditions of abundant  $(2e)^{-2}$ .

Another interesting result is that the natural trace amounts of HOOH in water may be increased in water by merely placing the sample in an intense magnetic field. Positive and negative ions will traverse short arc segment paths driven by simple thermal Brownian motion in a way which will lead to an increase in collisions of oppositely charged ions. In particular,  $OH^-$  and  $OH^+$  may undergo collisions more frequently leading to an increase in HOOH.

This additional HOOH should then be available to react with alkenes to form epoxides which will then hydrolyze in water to form diols. Such diols would be much more soluble in water than the original alkenes. This leads to the important possibility that merely exposing water-insoluble alkenes to water in a magnetic field will lead to a chemical reaction of the alkenes to form modified compounds which are more soluble in water. In other words, organic oils containing some double bonds may be made somewhat more soluble in water just by mechanical emulsification of the oils in water in an environment of a high magnetic field.

Thus, mixtures of oils and water could be mechanically agitated in a magnetic field of several Tesla to produce new oils which are chemically similar to the original oils (assuming a large organic structure) but more soluble in water after exposure to the magnetic field (see Chapter 8 for details).

Similarly, it is easy to see that, while the conventional quantum chemical model of the water molecule predicts one and only configuration, our isochemical model predicts various physically inequivalent configurations depending on the relative orientation of the two *oo*-shaped orbits and other properties, which are under separate study.

The industrial significance of the studies outlined in this chapter will be presented in Chapters 7 and 8.

# 9.3 VARIATIONAL CALCULATIONS OF ISOCHEMICAL MODELS

#### 9.3.1 Introduction

In Ref. [64a] outlined in Chapter 4, Santilli and Shillady introduced a restricted isochemical three-body model of the hydrogen molecule admitting an exact solution, and a full four-body isochemical model of the hydrogen molecule which no longer admits an exact solution.

In Ref. [64b] outlined in Chapter 5, Santilli and Shillady introduced two corresponding isochemical models of the water and other molecules, one based on a restricted three-body model of the HO dimer admitting exact solutions, and a second fully isochemical four-body model.

As also reviewed in Chapters 4 and 5, Shillady's SASLOBE variational method [64] showed the capability of the isochemical models to reach an essentially exact representation of experimental data on the hydrogen, water and other molecules, as well as resolving other shortcomings or inconsistencies of conventional quantum chemical molecular models.

A greatly detailed, independent verification of models [64a,64b] was conducted by A.K. Aringazin and M.G. Kucherenko [65a] via exact solution and by A.K. Aringazin [65b] via Ritz's variational method, by confirming all numerical results of Refs. [64].

In this chapter we outline Refs. [65] since they achieve new important insights and results on isochemistry of rather general character, and possible application to a variety of other molecules and applications of isochemistry.

# 9.3.2 Aringazin-Kucherenko Study of the Restricted, Three-Body Isochemical Model of the Hydrogen Molecule

In this section we outline the studies by Aringazin and Kucherenko [65a] of Santilli-Shillady exactly solvable, restricted three-body isochemical model of the H<sub>2</sub> molecule [64a], Eq. (9.1.35),  $r_{12} \simeq 0$ , i.e.,

$$-\frac{\hbar^2}{2M}\nabla_{ab}^2\psi + \left(-\frac{2e^2}{r_a} - \frac{2e^2}{r_b} + \frac{2e^2}{R}\right)\psi = E\psi.$$
(9.3.1)

As the reader will recall from Chapter 4, model (9.3.1) constitutes a limit case in which the two valence electrons are assumed to be permanently bonded together

into the stable singlet quasi-particle state with features (9.1.25), i.e.,

mass 
$$\simeq 1$$
 MeV, spin = 0, charge = 2e, magnetic moment  $\simeq 0$ ,  
radius =  $r_c = b^{-1} = 6.8432329 \times 10^{-11}$  cm = (9.3.2)  
= 0.015424288 bohrs = 0.006843 Å,

which we have called *isoelectronium*.

The assumption of stationary nuclei (or, equivalently, nuclei with infinite inertia), then turns the four-body hydrogen molecule  $H_2$  into a restricted three-body system which, as such, admits exact solution.

The reader should also recall that, the assumption of the rest energy of the isoelectronium as given by twice the electron mass is merely an upper boundary occurring when the internal forces are of purely nonpotential type. In reality, a total attractive force of purely potential type is possible because the magneto-static attraction is bigger than the electrostatic repulsion as illustrated in Fig. 9.4. It is evident that the latter bond implies a negative binding energy resulting in a value of the isoelectronium mass

$$M_{\rm isoelectronium} < 2m_{\rm electron},$$
 (9.3.3)

which is unknown, and should be derived from fitting experimental data.

As one can see, the above restricted isochemical model of the H<sub>2</sub> molecule is similar to the conventional restricted three-body  $H_2^+$  ion. To avoid confusion, we shall denote the three-body isochemical model with the "hat",  $\hat{H}_2$ , and the conventional (four-body) model without the "hat," H<sub>2</sub>.

More specifically, studies [65a] were conducted under the following conditions: 1) the isoelectronium is stable;

2) the effective size of the isoelectronium is ignorable, in comparison to internuclear distance of  $H_2$ ;

3) the two nuclei of  $H_2$  are at rest;

4) the rest energy of the isoelectronium is assumed to be unknown and to be determined by the fit of the binding energy of the molecule;

5) the internuclear distance R of H<sub>2</sub> is also assumed to be unknown and to be fitted from the stability condition of the solution, and then compared with its experimental value.

A main result of Ref. [65a] is that the restricted three-body Santilli-Shillady model  $\hat{H}_2$  is capable to fit the experimental binding energy for the following value of the isoelectronium mass,

$$M = 0.308381m_e, \tag{9.3.4}$$

although its stability condition is reached for the following internuclear distance

$$R = 1.675828 \text{ a.u.}, \tag{9.3.5}$$

884

which is about 19.6% bigger than the conventional experimental value  $R[H_2] = 1.4011$  a.u. = 0.742 Å.

These results confirm that the isochemical model (9.3.1) is indeed valid, but only in first approximation, in accordance with the intent of the original proposal [64a].

In Born-Oppenheimer approximation, i.e., at fixed nuclei, the equation for the  $H_2^+$  ion-type system for a particle of mass M and charge q is given by

$$\nabla^2 \psi + 2M \left( E + \frac{q}{r_a} + \frac{q}{r_b} \right) \psi = 0.$$
(9.3.6)

In spheroidal coordinates,

$$x = \frac{r_a + r_b}{R}, \quad 1 \le x \le \infty; \quad y = \frac{r_a - r_b}{R}, \quad -1 \le y \le 1; \quad 0 \le \varphi \le 2\pi, \quad (9.3.7)$$

where R is the separation distance between the two nuclei a and b, we have

$$\nabla^{2} = \frac{4}{R^{2}(x^{2} - y^{2})} \left( \frac{\partial}{\partial x} (x^{2} - 1) \frac{\partial}{\partial x} + \frac{\partial}{\partial y} (1 - y^{2}) \frac{\partial}{\partial y} \right) +$$

$$+ \frac{1}{R^{2}(x^{2} - 1)(1 - y^{2})} \frac{\partial^{2}}{\partial \varphi^{2}}.$$
(9.3.8)

Eq. (9.3.1) then becomes

$$\left[\frac{\partial}{\partial x}(x^2-1)\frac{\partial}{\partial x} + \frac{\partial}{\partial y}(1-y^2)\frac{\partial}{\partial y} + \frac{x^2-y^2}{4(x^2-1)(1-y^2)}\frac{\partial^2}{\partial \varphi^2} + \frac{MER^2}{2}(x^2-y^2) + 2MqRx\right]\psi = 0,$$
(9.3.9)

where

$$\frac{1}{r_a} + \frac{1}{r_b} = \frac{4}{R} \frac{x}{x^2 - y^2}.$$
(9.3.10)

The use of the expression

$$\psi = f(x)g(y)e^{im\varphi}, \qquad (9.3.11)$$

then allows the separation

$$\frac{d}{dx}\left((x^2-1)\frac{d}{dx}f\right) - \left(\lambda - 2MqRx - \frac{MER^2}{2}x^2 + \frac{m^2}{x^2-1}\right)f = 0,$$
  
$$\frac{d}{dy}\left((1-y^2)\frac{d}{dy}g\right) + \left(\lambda - \frac{MER^2}{2}y^2 - \frac{m^2}{1-y^2}\right)g = 0,$$
 (9.3.12)

where  $\lambda$  is the separation constant. The exact solutions for f(x) and g(y) are given by the angular and radial Coulomb spheroidal functions (CSF) containing infinite recurrence relations.

Aringazin and Kucherenko [65a] calculated the energy levels via the use of recurrence relations of the type

$$Q_{k+1} = Q_k \bar{\kappa}_{N-k} - Q_{k-1} \bar{\rho}_{N-k} \bar{\delta}_{N-k+1}, \quad Q_{-1} = 0, \quad Q_0 = 1, \quad (9.3.13)$$

where the coefficients are

$$\rho_s = \frac{(s+2m+1)[b-2p(s+m+1)]}{2(s+m)+3},$$
  

$$\kappa_s = (s+m)(s+m+1) - \lambda,$$
  

$$\delta_s = \frac{s[b+2p(s+m)]}{2(s+m)-1}.$$
(9.3.14)

Ref. [65a] then used the value N = 16 for the power degree approximation of both the radial and angular components. The two polynomials have 16 roots for  $\lambda$  from which only one root is appropriate due for its asymptotic behavior at  $R \to 0$ . Numerical solution of the equation,

$$\lambda^{(x)}(p,a) = \lambda^{(y)}(p,b), \qquad (9.3.15)$$

gives the list of values of the electronic ground state energy,

$$E(R) = E_{1s\sigma}(R), \qquad (9.3.16)$$

which corresponds to  $1s\sigma_g$  term of the H<sub>2</sub><sup>+</sup> ion-like system, as a function of the distance R between the nuclei. Note that the term "exact solution" refers to the fact that by taking greater values of N, for example N = 50, one can achieve higher accuracy, up to a desired one (for example, twelve decimals).

Also, the scaling method based on the Schrödinger equation has been developed which enables one to relate the final E(R) dependence of different  $H_2^+$  ion-like systems to each other.

Table 9.4 presents result of the calculations of the *minimal total energy* and the corresponding *optimal distance*, at various values of the isoelectronium mass parameter

$$M = \eta m_e, \tag{9.3.17}$$

where  $M = \eta$ , in atomic units.

Aringazin and Kucherenko [65a] computed some 27 tables, each with the identification of the minimum of the total energy, together with the corresponding optimal distance R. Then, they collected all the obtained energy minima and optimal distances in Table 9.4.

886

| Ман                              | Emin a u         | Reat a u   | M a u     | Emin a u         | Rent a u    |
|----------------------------------|------------------|------------|-----------|------------------|-------------|
| <i>m</i> , <i>w</i> . <i>w</i> . | $D_{min}$ , u.u. | nopt, a.a. | 111, a.a. | $D_{min}$ , a.u. | itopt, a.u. |
| 0.10                             | -0.380852        | 5.167928   | 0.32      | -1.218726        | 1.614977    |
| 0.15                             | -0.571278        | 3.445291   | 0.33      | -1.256811        | 1.566041    |
| 0.20                             | -0.761704        | 2.583964   | 0.34      | -1.294896        | 1.519981    |
| 0.25                             | -0.952130        | 2.067171   | 0.35      | -1.332982        | 1.476553    |
| 0.26                             | -0.990215        | 1.987664   | 0.40      | -1.523408        | 1.291982    |
| 0.27                             | -1.028300        | 1.914050   | 0.45      | -1.713834        | 1.148428    |
| 0.28                             | -1.066385        | 1.845688   | 0.50      | -1.904260        | 1.033585    |
| 0.29                             | -1.104470        | 1.782044   | 0.75      | -2.856390        | 0.689058    |
| 0.30                             | -1.142556        | 1.722645   | 1.00      | -3.808520        | 0.516792    |
| 0.307                            | -1.169215        | 1.683367   | 1.25      | -4.760650        | 0.413434    |
| 0.308                            | -1.173024        | 1.677899   | 1.50      | -5.712780        | 0.344529    |
| 0.308381                         | -1.174475        | 1.675828   | 1.75      | -6.664910        | 0.295310    |
| 0.309                            | -1.176832        | 1.672471   | 2.00      | -7.617040        | 0.258396    |
| 0.31                             | -1.180641        | 1.667073   |           |                  |             |

Table 9.4. The minimal total energy  $E_{min}$  and the optimal internuclear distance  $R_{opt}$  of Santilli-Shillady restricted three-body isochemical model  $\hat{H}_2$  as functions of the mass M of the isoelectronium<sup>a</sup>.

 $^a$  See also Figs. 9.10 and 9.11.

Table 9.5. Summary of main data and results on the ground state energy E and the internuclear distance R.

|  | E, a.u.     | R, a.u.   |
|--|-------------|-----------|
| $H_2^+$ ion, exact theory, $N=16$ [65a]                              | -0.6026346  | 1.9971579 |
| $H_2^+$ ion, experiment [66]   | -0.6017     | 2.00      |
| 3-body $\hat{H}_2$ , $M=2m_e$ , exact theory [65a]                   | -7.617041   | 0.258399  |
| 3-body $\hat{H}_2$ , $M=2m_e$ , var. theory [64a]                    | -7.61509174 | 0.2592    |
| 3-body $\hat{H}_2$ , $M=0.381m_e$ , exact theory [65a]               | -1.174475   | 1.675828  |
| 4-body H <sub>2</sub> , $r_c$ =0.01125 a.u., $V_g$ var. theory [64a] | -1.174474   | 1.4011    |
| 4-body H <sub>2</sub> , $r_c=0.01154$ a.u., $V_e$ var. theory [65b]  | -1.144      | 1.4011    |
| 4-body H <sub>2</sub> , $r_c$ =0.08330 a.u., $V_e$ var. theory [65b] | -1.173      | 1.3184    |
| $H_2$ , experiment   | -1.174474   | 1.4011    |

With the fourth order interpolation/extrapolation, the graphical representations of Table 9.4 (see Figs. 9.10 and 9.11) show that the minimal total energy behaves as

$$E_{min}(M) \simeq -3.808M,$$
 (9.3.18)



Figure 9.10. The minimal total energy  $E_{min}(M)$  of the  $\hat{H}_2$  system as a function of the isoelectronium mass M.



Figure 9.11. The optimal internuclear distance  $R_{opt}(M)$  of the  $\hat{H}_2$  system as a function of the isoelectronium mass M.

and the optimal distance behaves as

$$R_{opt}(M) \simeq 0.517/M.$$
 (9.3.19)

One can see that at  $M = 2m_e$  we have

$$E_{min}(M) = -7.617041 \text{ a.u.}, \quad R_{opt}(M) = 0.258399 \text{ a.u.}, \quad (9.3.20)$$

which recover the values obtained in Ref. [64a]

$$E_{min} = -7.61509174 \text{ a.u.}, \quad R_{opt} = 0.2592 \text{ a.u.}, \quad (9.3.21)$$

to a remarkable accuracy.

The conclusion by Aringazin and Kucherenko is that the Santilli-Shillady restricted three-body isochemical model of the hydrogen molecule is indeed valid as suggested, that is, as in first approximation. The main data and results on  $E_{min}$  and  $R_{opt}$  are collected in Table 9.5.

An important conclusion of Ref. [65a] is, therefore, that the two valence electrons of the hydrogen molecule cannot be permanently bound inside the hadronic horizon with radius of one Fermi.

The clear understanding, stressed in Chapter 4, is that the isoelectronium must continue to exist beyond the hadronic horizon, otherwise, in its absence, we would have a violation of Pauli's exclusion principle.

# 9.3.3 Aringazin Variational Study of the Four-Body Isochemical Model of the Hydrogen Molecule

In the subsequent Ref. [65b] Aringazin applied Ritz variational method to Santilli-Shillady four-body isochemical model of molecule of the hydrogen molecule (9.1.33), i.e.

$$\left(-\frac{\hbar^2}{2m_1}\nabla_1^2 - \frac{\hbar^2}{2m_2}\nabla_2^2 - V_0 \frac{e^{-r_{12}/r_c}}{1 - e^{-r_{12}/r_c}} + \frac{e^2}{r_{12}} - \frac{e^2}{r_{1a}} - \frac{e^2}{r_{2a}} - \frac{e^2}{r_{1b}} - \frac{e^2}{r_{2b}} + \frac{e^2}{R}\right)|\psi\rangle = E|\psi\rangle, \qquad (9.3.22)$$

without restriction that the isoelectronium has the permanent dimension of about one Fermi.

In particular, Aringazin's objective was to identify the ground state energy and bond length of the H<sub>2</sub> molecule, in Born-Oppenheimer approximation, via a Gaussian screening of the Coulomb potential,  $V_g$ , the exponential screening of the Coulomb potential,

$$V_e = -\frac{Ae^{-r_{12}/r_c}}{r_{12}},\tag{9.3.23}$$

as well as the original Hulten potential  $V_h$  of the model (9.3.22). The resulting analysis is quite sophisticated, and cannot be reviewed herein the necessary detail. Readers seriously interested in this verification of the new isochemical model of the hydrogen molecule are suggested to study Aringazin's original memoir [65b].

The Coulomb and exchange integrals were calculated only for  $V_e$  while for  $V_g$  and  $V_h$  Aringazin achieved analytical results only for the Coulomb integrals because of the absence of Gegenbauer-type expansions for the latter potentials.

A conclusion is that the Ritz's variational treatment of model (9.2.45) with the potential (9.3.23) is capable to provide an exact fit of the experimental data of the hydrogen molecule in confirmation of the results obtained by Santilli and Shillady [64a] via the SASLOBE variational approach to Gaussian  $V_g$ -type model. The main data and results on the ground state energy  $E_{min}$  and internuclear distance  $R_{opt}$  are collected in Table 9.5.

Note that in the variational approach of Ref. [65b] Aringazin used a *discrete* variation of the hadronic horizon  $r_c$  and approximate exchange integral (9.3.24) that resulted in approximate fittings of the energy and distance, as shown in Table 9.5.

In addition, Ref. [65b] computed the weight of the isoelectronium phase which results to be of the order of 1% to 6% that for the case of  $V_e$  model. However, we note that this is it not the result corresponding to the original Santilli-Shillady model, which is based on the Hulten potential  $V_h$ .

An interesting result is that in order to prevent divergency of the Coulomb integral for  $V_h$  the correlation length parameter  $r_c$  should run discrete values due to Eq. (9.3.25). This condition has been used in the  $V_e$  model, although it is not a necessary one within the framework of this model.

As recalled earlier, Aringazin [*loc. cit.*] assumes that the isoelectronium undergoes an increase of length beyond the hadronic horizon, and the resulting two electrons are separated by sufficiently large distance. This leads us to problem of how to compute the effective life-time of isoelectronium.

To estimate the order of magnitude of such a life-time, Aringazin uses the ordinary formula for radioactive  $\alpha$ -decay since the total potential V(r) is of the same shape as that here considered, with very sharp decrease at  $r < r_{max}$  and Coulomb repulsion at  $r > r_{max}$ , where  $r_{max}$  corresponds to a maximum of the potential.

This quasiclassical model is a crude approximation because in reality the electrons do not leave the molecule. Moreover, the two asymptotic regimes act simultaneously, with some distribution of probability, and it would be more justified to treat the frequency of the decay process (i.e., the tunneling outside the hadronic horizon), rather than the life-time of the isoelectronium.

However, due to the assumption of the small size of isoelectronium in comparison to the molecule size, we can study an elementary process of decay separately, and use the notion of life-time. The results of Aringazin's calculations are presented in Table 9.6.

In Ritz's variational approach, the main problem is to calculate analytically the so-called *molecular integrals*. The variational molecular energy in which we are interested, is expressed in terms of these integrals. These integrals arise when using some wave function, usually a simple hydrogen-like ground state wave function, as an infinite separation asymptotic solution, in the Schrödinger

Table 9.6. Summary of Aringazin's calculations [65b] on the lifetime of the isoelectronium, where E is relative kinetic energy of the electrons, at large distance,  $r \gg r_{max}$ , in the center of mass system.

| Energy E, a.u. | eV   | $Lifetime, D_0 \cdot sec$ |
|----------------|------|---------------------------|
| 2              | 54.4 | $2.6 \cdot 10^{-18}$      |
| 1              | 27.2 | $1.6 \cdot 10^{-17}$      |
| 0.5            | 13.6 | $2.2 \cdot 10^{-16}$      |
| 0.037          | 1    | $5.1 \cdot 10^{-6}$       |
| 0.018          | 0.5  | 4.0                       |
| 0.0018         | 0.1  | $3.1 \cdot 10^{+25}$      |

equation for the diatomic molecule. The main idea of Ritz's approach is to introduce parameters into the wave function, and vary them together with the separation parameter R, to achieve a minimum of the total molecular energy, which is treated as the resulting ground state energy.

In the case under study, Aringazin [*loc. cit.*] uses two parameters,  $\gamma$  and  $\rho$ , where  $\gamma$  enters hydrogen-like ground state wave function

$$\psi(r) = \sqrt{\frac{\gamma^3}{\pi}} e^{-\gamma r}, \qquad (9.3.26)$$

and  $\rho = \gamma R$  measures internuclear distance. These parameters should be varied analytically or numerically in the final expression of the molecular energy, after the calculation is made for the associated molecular integrals.

However, the four-body Santilli-Shillady model H<sub>2</sub> suggests an additional Hulten potential interaction between the electrons, which potential contains two parameters  $V_0$  and  $r_c$ , where  $V_0$  is a general factor, and  $r_c$  is a correlation length parameter characterizing the hadronic horizon. Thus, four parameters should be varied,  $\gamma$ ,  $\rho$ ,  $V_0$ , and  $r_c$ .

The introducing of Hulten potential leads to a modification of some molecular integrals, namely, of the Coulomb and exchange integrals. The other molecular integrals remain the same as in the case of the usual model of  $H_2$ , with well-known analytic results. Normally, the Coulomb integral, which can be computed in bispherical coordinates, is much easier to resolve than the exchange integral, which is computed in bispheroidal coordinates.

Calculations of the Coulomb integral for Hulten potential  $V_h$  appeared to be quite nontrivial [2b]. Namely, in the used bispherical coordinates, several special functions, such as polylogarithmic function, Riemann zeta-function, digamma function, and Lerch function, appeared during the calculation.



Figure 9.12. The Coulomb integral  $C'_e$  as a function of  $\rho$ , at  $\lambda = 1/37$ , where  $\rho = \gamma R$ , R is the internuclear distance,  $\lambda = 2\gamma r_c$ , and  $r_c$  is the hadronic horizon.



Figure 9.13. The Coulomb integral  $C'_e$  as a function of  $r_c$ , at  $\rho = 1.67$ . For  $r_c > 0.2$  a.u., the regularized values are presented.

In order to proceed with the Santilli-Shillady approach, Aringazin [65b] invoked two different simplified potentials, the exponential screened Coulomb potential  $V_e$ , and the Gaussian screened Coulomb potential  $V_g$ , instead of the Hulten potential  $V_h$ . The former potentials both approximate well the Hulten potential at short and long range asymptotics, and each contains two parameters denoted A and  $r_c$ .

In order to reproduce the short range asymptotics of the Hulten potential, the parameter A should have the value  $A = V_0 r_c$ , for both potentials. The Coulomb integrals for these two potentials have been calculated *exactly* owing to the fact that they are much simpler than the Hulten potential.

In particular, we note that the final exact expression of the Coulomb integral for  $V_g$  contains only one special function, the error function  $\operatorname{erf}(z)$ , while for  $V_e$ it contains no special functions at all. In this way, Aringazin [65b] reaches the exact expression

$$C'_{e} = -\frac{A\lambda^{2}}{8(1-\lambda^{2})^{4}} \frac{\gamma e^{-2\rho}}{\rho} \left[ -(\rho+2\rho^{2}+\frac{4}{3}\rho^{3}) + 3\lambda^{2}(5\rho+10\rho^{2}+4\rho^{3}) - \lambda^{4}(15\rho+14\rho^{2}+4\rho^{3}) + \lambda^{6}(8+11\rho+6\rho^{2}+\frac{4}{3}\rho^{3}-8e^{2\rho-\frac{2\rho}{\lambda}}) \right], \quad (9.3.27)$$

where  $\lambda = 2\gamma r_c$ . This Coulomb integral is plotted in Figs. 9.12 and 9.13.

The most difficult part of calculations [65b] is the exchange integral. Usually, to calculate it one has to use bispheroidal coordinates, and needs in an expansion of the potential in some orthogonal polynomials, such as Legendre polynomials in bispheroidal coordinates. In Ref. [65b], only the exponential screened potential  $V_e$  is known to have such an expansion but it is formulated, however, in terms of bispherical coordinates (so called Gegenbauer expansion). Accordingly, the exchange integral  $E'_e$  for  $V_e$  at null internuclear separation, R = 0 (in which case one can use bispherical coordinates) was calculated exactly. After that, the R-dependence using the standard result for the exchange integral for Coulomb potential  $E'_C$  (celebrated Sugiura's result) was partially recovered,

$$E'_{e} \simeq \frac{A\lambda^{2}}{(1+\lambda)^{4}} \left(\frac{1}{8} + \frac{1}{2}\lambda + \frac{5}{8}\lambda^{2}\right) \frac{8}{5}E'_{C},$$
(9.3.28)

where  $\lambda = 2\gamma r_c$  (see Fig. 9.14). Thus, only some approximate expression of the exchange integral for the case of  $V_e$  has been achieved. In this way, all subsequent results apply to the approximate  $V_e$ -based model.

Inserting the so-obtained  $V_e$ -based Coulomb and exchange integrals into the total molecular energy expression, the final analytical expression containing four parameters,  $\gamma$ ,  $\rho$ , A, and  $r_c$ , was obtained. From a separate consideration of the Hulten potential case, the existence of a bound state of two electrons (which is the proper isoelectronium) leads to the following relationship between the parameters for the case of one energy level of the electron-electron system,  $V_0 = \hbar^2/(2mr_c^2)$ . Thus, using the relation  $A = V_0 r_c$  Aringazin has  $A = 1/r_c \equiv 2\gamma/\lambda$ , in atomic units ( $\hbar = m_e = c = 1$ ).



Figure 9.14. The exchange integral  $E'_e$  as a function of  $r_c$ , at  $\rho = 1.67$ .



Figure 9.15. The total energy  $E = E_{mol}$  as a function of  $\rho$ , at  $\lambda = 1/60, 1/40, 1/20, 1/10, 1/5$ . The lowest plot corresponds to  $\lambda = 1/5$ .

Note that Aringazin [65b] introduces the one-level isoelectronium characterized by the fact that the condition,

$$\lambda^{-1} = \text{ integer numbers} > 0, \qquad (9.3.29)$$

follows from the analysis of the Coulomb integral for Hulten potential.

With the above set up, minimization of the total molecular energy of the  $V_{e}$ -based model can be made. Numerical analysis shows that the  $\lambda$ -dependence does

not reveal any minimum in the interval of interest,

$$4 \le \lambda^{-1} \le 60, \tag{9.3.30}$$

while there is a minimum of the energy for some values of  $\gamma$  and  $\rho$ , at fixed  $\lambda$ .

Therefore, 56 tables have been calculated to identify the energy minima and optimal distances for different values of  $\lambda$ , in the interval (9.3.30).

Table 9.7. The total minimal energy  $E_{min}$  and the optimal internuclear distance  $R_{opt}$  as functions of the correlation length  $r_c$  for the exponential screened Coulomb potential  $V_e$ .

| $\lambda^{-1}$ | $r_c, a.u.$         | $R_{opt}, a.u.$   | $E_{min}, a.u.$    |
|----------------|---------------------|-------------------|--------------------|
| 4              | 0.10337035071618050 | 1.297162129235449 | -1.181516949656805 |
| 5              | 0.08329699109108888 | 1.318393698326879 | -1.172984902150024 |
| 6              | 0.06975270534273319 | 1.333205576478603 | -1.167271240301846 |
| 7              | 0.05999677404817234 | 1.344092354783681 | -1.163188554065554 |
| 8              | 0.05263465942162049 | 1.352417789644028 | -1.160130284706318 |
| 9              | 0.04688158804756491 | 1.358984317233049 | -1.157755960428922 |
| 10             | 0.04226204990365446 | 1.364292909163710 | -1.155860292450436 |
| 11             | 0.03847110142927672 | 1.368671725082009 | -1.154312372623724 |
| 12             | 0.03530417706681329 | 1.372344384866235 | -1.153024886026671 |
| 13             | 0.03261892720535206 | 1.375468373051375 | -1.151937408039373 |
| 14             | 0.03031323689615631 | 1.378157728092548 | -1.151006817317425 |
| 15             | 0.02831194904031777 | 1.380497017045902 | -1.150201529091051 |
| 16             | 0.02655851947236431 | 1.382550255552670 | -1.149497886394651 |
| 17             | 0.02500959113834722 | 1.384366780045693 | -1.148877823925501 |
| 18             | 0.02363136168905809 | 1.385985219224291 | -1.148327310762828 |
| 19             | 0.02239708901865092 | 1.387436244558651 | -1.147835285349041 |
| 20             | 0.02128533948435381 | 1.388744515712491 | -1.147392910500336 |
| 21             | 0.02027873303335994 | 1.389930082626193 | -1.146993041730378 |
| 22             | 0.01936302821907175 | 1.391009413196452 | -1.146629840949675 |
| 23             | 0.01852644434336641 | 1.391996158084790 | -1.146298491232105 |
| 24             | 0.01775915199935013 | 1.392901727808297 | -1.145994983116511 |
| 25             | 0.01705288514774330 | 1.393735733699196 | -1.145715952370148 |
| 26             | 0.01640064219648127 | 1.394506328745493 | -1.145458555325045 |
| 27             | 0.01579645313764336 | 1.395220473843219 | -1.145220372020229 |
| 28             | 0.01523519631632570 | 1.395884147817973 | -1.144999330178493 |
| 29             | 0.01471245291356761 | 1.396502514589167 | -1.144793644973560 |
| 30             | 0.01422439038752817 | 1.397080057337240 | -1.144601770891686 |

Aringazin's results are collected in Tables 9.7, 9.8, and Fig. 9.15. One can see that the binding energy decreases with the increase of the parameter  $r_c$ , which corresponds to an effective radius of the isoelectronium.

In conclusion, the calculation by Aringazin [65b] reviewed in this Chapter have not identified the meanlife of the isoelectronium assumed as a quasiparticle

Table 9.8. A continuation of Table 9.8.

| $\lambda^{-1}$ | $r_c, a.u.$         | $R_{opt}, a.u.$   | $E_{min}, a.u.$    |
|----------------|---------------------|-------------------|--------------------|
| 31             | 0.01376766836566138 | 1.397620687025853 | -1.144422362947838 |
| 32             | 0.01333936209977966 | 1.398127830817745 | -1.144254245203342 |
| 33             | 0.01293689977547854 | 1.398604504597664 | -1.144096385030938 |
| 34             | 0.01255801083612469 | 1.399053372836414 | -1.143947871939897 |
| 35             | 0.01220068312791624 | 1.399476798299823 | -1.143807900045981 |
| 36             | 0.01186312715793131 | 1.399876883556063 | -1.143675753475045 |
| 37             | 0.01154374612489787 | 1.400255505817128 | -1.143550794143290 |
| 39             | 0.01095393745919852 | 1.400954915288619 | -1.143320213707519 |
| 40             | 0.01068107105944273 | 1.401278573036792 | -1.143213620508321 |
| 41             | 0.01042146833640030 | 1.401586548200467 | -1.143112256673494 |
| 42             | 0.01017418516195214 | 1.401879953246168 | -1.143015746732479 |
| 43             | 0.00993836493541500 | 1.402159797887369 | -1.142923750307661 |
| 44             | 0.00971322867044429 | 1.402427000676349 | -1.142835958109381 |
| 45             | 0.00949806639934841 | 1.402682399061957 | -1.142752088467028 |
| 46             | 0.00929222969498477 | 1.402926758144872 | -1.142671884314343 |
| 47             | 0.00909512514431396 | 1.403160778323019 | -1.142595110561057 |
| 48             | 0.00890620863525624 | 1.403385101987775 | -1.142521551794315 |
| 49             | 0.00872498034101540 | 1.403600319405678 | -1.142451010262626 |
| 50             | 0.00855098030451296 | 1.403806973898863 | -1.142383304102633 |
| 51             | 0.00838378454080327 | 1.404005566419838 | -1.142318265775268 |
| 52             | 0.00822300158793934 | 1.404196559601683 | -1.142255740683024 |
| 53             | 0.00806826944722482 | 1.404380381352424 | -1.142195585944305 |
| 54             | 0.00791925286251402 | 1.404557428052374 | -1.142137669304475 |
| 55             | 0.00777564089552400 | 1.404728067404676 | -1.142081868166104 |
| 56             | 0.00763714476025456 | 1.404892640982100 | -1.142028068723488 |
| 57             | 0.00750349588477794 | 1.405051466507240 | -1.141976165188595 |
| 58             | 0.00737444417302681 | 1.405204839898059 | -1.141926059097351 |
| 59             | 0.00724975644291090 | 1.405353037106507 | -1.141877658686723 |
| 60             | 0.00712921502024112 | 1.405496315774223 | -1.141830878334298 |

of charge radius  $r_c$  of about 1 fm. As one can see in Table 9.7, the predicted meanlife varies over a rather large range of values.

The achievement of an accurate meanlife of the isoelectronium of 1 fm charge radius can be reached only after reaching a more accurate knowledge of its rest energy. As the reader will recall from Chapter 4, the value of 1 MeV should be solely considered as an upper boundary value of the rest energy of the isoelectronium, since it holds only in the absence of internal potential forces while the latter cannot be excluded. Therefore, the actual value of the rest energy of the isoelectronium is today basically unknown. The reader should also recall that the terms "meanlife of the isoelectronium when of charge radius of about 1 fm" are referring to the duration of time spent by two valence electrons at a mutual distance of 1 fm which is expected to be small. The understanding explained in Chapter 3 is that, when the restriction of the charge radius to 1 fm is removed, and orbital mutual distances are admitted, the isoelectronium must have an infinite life (for the unperturbed molecule), because any finite meanlife under the latter conditions would imply the admission of two electrons with identical features in the same orbit, and a consequential violation of Pauli's exclusion principle.

An interesting result of the Ritz variational approach to the Hulten potential studied by Aringazin [65b] is that the charge radius of the isoelectronium  $r_c$  entering the Hulten potential and the variational energy, should run discrete set of values during the variation.

In other words, this means that only some fixed values of the effective radius of the one-level isoelectronium are admitted in the Santilli-Shillady model when treated via the Ritz approach.

This result was completely unexpected and may indicate a kind of "hadronic fine structure" of the isoelectronium whose origin and meaning are unknown at this writing. It should be indicated that such a "hadronic fine structure" of the isoelectronium is solely referred to the case when  $r_c$  is restricted to be about 1 fm or less. The problem whether such a "hadronic fine structure" persists for values of  $r_c$  up to orbital distances is also unknown at this writing. It should be also indicated that this remarkable property is specific to the Hulten potential  $V_h$ , while it is absent in the  $V_e$ , or  $V_g$  models.

Moreover, Aringazin [65b] has achieved an estimation of the weight of the isoelectronium phase for the case of  $V_e$  model which appears to be of the order of 1% to 6%. This weight has been estimated from the energy contribution related to the exponentially screened potential  $V_e$ , in comparison to the contribution related to the usual Coulomb interelectron repulsive potential.

Finally, an important result of the Ritz variational four-body model studied by Aringazin [65b] is its fit to the experimental data of both the binding energy E and the bond length R of the hydrogen molecule thus providing an excellent independent confirmation of the results obtained by Santilli and Shillady [64].

# Appendix 9.A Isochemical Calculations for the Three-Body $H_2$ Molecule

This appendix contains a summary of the computer calculations conducted in Ref. [5] for the restricted three-body model of the hydrogen molecule according to isochemistry, Eq. (9.1.35), showing an exact representation of the binding energy. The calculations are based on the isoelectronium as per characteristics (9.1.25).

## Gaussian-Lobe Program for Large Molecules set up by D. Shillady and S. Baldwin Richmond Virginia 1978-1997 3 BODY H2 (Electronium)

ipear = 1, dt = 0.0, tk = 0.0, imd = 0, ntime = 60, mul = 1, iqd = 0, icor = 3, mdtim = 0, idb = 0.

| Atomic Core |       |          |       | Nuclear  |       | Coordinates |
|-------------|-------|----------|-------|----------|-------|-------------|
|             |       | Х        |       | Y        |       | Z           |
| 1.          |       | 0.000000 |       | 0.000000 |       | 0.000000    |
|             | Z1s = | 6.103    | Z2s = | 24.350   | Z2p = | 24.350      |
|             | Z3s = | 16.230   | Z3p = | 16.230   | Z3d = | -16.200     |
|             | Z4p = | 12.180   | Z4f = | 12.180   |       |             |
| 1.          |       | 0.000000 |       | 0.000000 |       | 0.259200    |
|             | Z1s = | 6.103    | Z2s = | 24.350   | Z2p = | 24.350      |
|             | Z4p = | 12.180   | Z4f = | 12.180   | Z3d = | -16.200     |

#### ELECTRONIUM-PAIR CALCULATION

Basis Size = 50 and Number of Spheres = 142 for 2 Electrons.

Distance Matrix in Angströms:

|   | Н       | Η       |
|---|---------|---------|
| Η | 0.00000 | 0.13716 |
| Η | 0.13716 | 0.00000 |

A-B-C Arcs in Degrees for 2 Atoms.

The Center of Mass is at Xm = 0.000000, Ym = 0.000000, Zm = 0.129600.

**One-Electron Energy Levels:**
| E(1) =  | -11.473116428176 | E(26) = | 28.974399759209  |
|---------|------------------|---------|------------------|
| E(2) =  | -4.103304982059  | E(27) = | 28.974400079775  |
| E(3) =  | -1.621066945385  | E(28) = | 31.002613061833  |
| E(4) =  | -1.621066909587  | E(29) = | 31.002614578175  |
| E(5) =  | 0.735166320188   | E(30) = | 35.201145239721  |
| E(6) =  | 3.760295564718   | E(31) = | 38.003259639003  |
| E(7) =  | 3.760295673022   | E(32) = | 44.948398097510  |
| E(8) =  | 4.206194459198   | E(33) = | 44.94839B118458  |
| E(9) =  | 4.813241859203   | E(34) = | 52.259825531212  |
| E(10) = | 11.2330B0571453  | E(35) = | 57.732587951875  |
| E(11) = | 15.70B645318078  | E(36) = | 57.732589021798  |
| E(12) = | 15.708645469273  | E(37) = | 68.743644612501  |
| E(13) = | 18.535761604401  | E(38) = | 68.743644649428  |
| E(14) = | 18.535761951543  | E(39) = | 73.195648957615  |
| E(15) = | 19.329445299735  | E(40) = | 79.303486379907  |
| E(16) = | 19.329445306194  | E(41) = | 85.865499885249  |
| E(17) = | 19.644048052034  | E(42) = | 85.865531919077  |
| E(18) = | 24.002368034839  | E(43) = | 127.196518644932 |
| E(19) = | 24.002368621986  | E(45) = | 130.602186113463 |
| E(20) = | 24.076849036707  | E(46) = | 130.602190550265 |
| E(21) = | 24.076853269415  | E(47) = | 137.484863078186 |
| E(22) = | 24.574406183060  | E(48) = | 158.452350229845 |
| E(23) = | 26.836031180463  | E(49) = | 205.158233049979 |
| E(25) = | 27.860752485358  | E(50) = | 446.152984041077 |

epair Energy = -7.615091736818.

# Appendix 9.B Isochemical Calculations for the Four-Body $H_2$ Molecule

In this appendix we present a summary of the computer calculations conducted in Ref. [5] for the four-body model of the hydrogen molecule, Eq. (9.1.33), according to isochemistry by using only 6G-1s orbitals for brevity. The calculations are also based on the characteristics of the isoelectronium in Eqs. (9.1.25). Note, again, the exact representation of the binding energy at -1.174447 Hartrees.

> Gaussian-Lobe Program for Large Molecules set up by D. Shillady and S. Baldwin Virginia Commonwealth University Richmond Virginia 1978-1997 Test of SASLOBE on H2

 $\begin{aligned} & \text{SANTILLI-RADIUS} = 0.01184470000000. \\ & \text{Cutoff} = (\text{A/r})^*(\exp(\text{-alp}^* r^* r)), \text{ A} = 0.20\text{E} + 01, \text{ alp} = 0.49405731\text{E} + 04. \end{aligned}$ 

| Atomic Core |       |          |       | Nuclear  |       | Coordinates |
|-------------|-------|----------|-------|----------|-------|-------------|
|             |       | Х        |       | Y        |       | Z           |
| 1.          |       | 0.000000 |       | 0.000000 |       | 0.000000    |
|             | Z1s = | 1.200    | Z2s = | 0.000    | Z2p = | 0.000       |
|             | Z3s = | 0.000    | Z3p = | 0.000    | Z3d = | 0.000       |
|             | Z4p = | 0.000    | Z4f = | 0.000    |       |             |
| 1.          |       | 0.000000 |       | 0.000000 |       | 1.401100    |
|             | Z1s = | 1.200    | Z2s = | 0.000    | Z2p = | 0.000       |
|             | Z3s = | 0.000    | Z3p = | 0.000    | Z3d = | 0.000       |
|             | Z4p = | 0.000    | Z4f = | 0.000    |       |             |

Basis Size = 2 and Number of Spheres = 12 for 2 Electrons.

Distance Matrix in Angströms:

|   | Η       | Η       |
|---|---------|---------|
| Η | 0.00000 | 0.74143 |
| Η | 0.74143 | 0.00000 |

The center of Mass is at: Xm = 0.000000, Ym = 0.000000, Zm = 0.700550.

Spherical Gaussian Basis Set:

| No. 1  | alpha = | 0.944598E + 03 at X = $0.0000$ Y = $0.0000$ Z = $0.0000$ a.u. |
|--------|---------|---|
| No. 2  | alpha = | 0.934768E+02 at X = 0.0000 Y = 0.0000 Z = 0.0000 a.u.         |
| No. 3  | alpha = | 0.798123E+01 at X = 0.0000 Y = 0.0000 Z = 0.0000 a.u.         |
| No. 4  | alpha = | 0.519961E+01 at X = 0.0000 Y = 0.0000 Z = 0.0000 a.u.         |
| No. 5  | alpha = | 0.235477E+00 at X = 0.0000 Y = 0.0000 Z = 0.0000 a.u.         |
| No. 6  | alpha = | 0.954756E+00 at X = 0.0000 Y = 0.0000 Z = 0.0000 a.u.         |
| No. 7  | alpha = | 0.1944598E+03 at X = 0.0000 Y = 0.0000 Z = 1.4011 a.u.        |
| No. 8  | alpha = | 0.7934768E+02 at X = 0.0000 Y = 0.0000 Z = 1.4011 a.u.        |
| No. 9  | alpha = | 0.40798123E+01 at X = 0.0000 Y = 0.0000 Z = 1.4011 a.u.       |
| No. 10 | alpha = | 0.11519961E+01 at X = 0.0000 Y = 0.0000 Z = 1.4011 a.u.       |
| No. 11 | alpha = | 0.37235477E+00 at X = 0.0000 Y = 0.0000 2 = 1.4011 a.u.       |
| No. 12 | alpha = | 0.12954756E+00 at X = 0.0000 Y = 0.0000 Z = 1.4011 a.u.       |

Contracted Orbital No. 1:  $0.051420^{*}(1), 0.094904^{*}(2), 0.154071^{*}(3), 0.203148^{*}(4), 0.169063^{*}(5), 0.045667^{*}(6).$ Contracted Orbital No.2:  $0.051420^{*}(7), 0.094904^{*}(8), 0.154071^{*}(9), 0.203148^{*}(10), 0.169063^{*}(11), 0.045667^{*}(12).$ 

\*\*\*\*\* Nuclear Repulsion Energy in au = 0.71372493041182. \*\*\*\*\*

Overlap Matrix:

| # |   | at-orb | 1     | 2     |
|---|---|--------|-------|-------|
| 1 | Η | 1s     | 1.000 | 0.674 |
| 2 | Η | 1s     | 0.674 | 1.000 |

S(-1/2) Matrix:

| # |   | at-orb | 1      | 2      |
|---|---|--------|--------|--------|
| 1 | Η | 1s     | 1.263  | -0.490 |
| 2 | Η | 1s     | -0.490 | 1.263  |

H-Core Matrix:

| # |   | at-orb | 1      | 2      |
|---|---|--------|--------|--------|
| 1 | Η | 1s     | -1.127 | -0.965 |
| 2 | Η | 1s     | -0.965 | -1.127 |

Initial-Guess-Eigenvectors by Column:

| # |   | at-orb | 1     | 2      |
|---|---|--------|-------|--------|
| 1 | Η | 1s     | 0.546 | 1.239  |
| 2 | Η | 1s     | 0.546 | -1.239 |

One-Electron Energy Levels: E(1) = -1.249428797385, E(2) = -0.499825553916.

| (1,1/1,1) =         | 0.75003658795676 |
|---------------------|------------------|
| minus $(1,1/1,1) =$ | 0.08506647783478 |
| total $(1,1/1,1) =$ | 0.66497011012199 |
| (1,1/1,2) =         | 0.44259146066210 |
| minus $(1,1/1,2) =$ | 0.02960554295227 |
| total $(1,1/1,2) =$ | 0.41298591770983 |
| (1,1/2,2) =         | 0.55987025041920 |
| minus $(1,1/2,2) =$ | 0.01857331166211 |
| total $(1,1/2,2) =$ | 0.54129693875709 |
| (1,2/1,2) =         | 0.30238141375547 |
| minus $(1,2/1,2) =$ | 0.01938180841827 |
| total $(1,2/1,2) =$ | 0.28299960533720 |
| (1,2/2,2) =         | 0.44259146066210 |
| minus $(1,2/2,2) =$ | 0.02960554295227 |
| total $(1,2/2,2) =$ | 0.41298591770983 |
| (2,2/2,2) =         | 0.75003658795676 |
| minus $(2,2/2,2) =$ | 0.08506647783478 |
| total $(2.2/2.2) =$ | 0.66497011012199 |

Block No. 1 Transferred to Disk/Memory. The Two-Electron Integrals Have Been Computed.

Electronic Energy = -1.88819368266525 a.u., Dif. = 1.8881936827, Electronic Energy = -1.88819368266525 a.u., Dif. = 0.0000000000. Energy Second Derivative = 0.00000000000000.

| e1a = | -2.499 | e1b = | -2.499 |        |       |
|-------|--------|-------|--------|--------|-------|
| e2a = | 0.611  | e2b = | 0.611  | e2ab = | 0.611 |

Iteration No. = 2, alpha = 0.950000. Electronic Energy = -1.88819368266525 a.u., Dif. = 0.0000000000. **Total Energy = -1.17446875 a.u.** One-Electron Energy Levels: E(1) = -0.638764885280, E(2) = 0.561205833046

Reference State Orbitals for 1 Filled Orbitals by Column:

| # |   | at-orb | 1     | 2      |
|---|---|--------|-------|--------|
| 1 | Η | 1s     | 0.546 | 1.239  |
| 2 | Н | 1s     | 0.546 | -1.239 |

Dipole Moment Components in Debyes: Dx = 0.0000000, Dy = 0.0000000, Dz = 0.0000000. Resultant Dipole Moment in Debyes = 0.0000000. Computed Atom Charges: Q(1) = 0.000, Q(2) = 0.000. Orbital Charges: 1.000000, 1.000000.

Milliken Overlap Populations:

| #     |   | at-orb | 1     | 2     |
|-------|---|--------|-------|-------|
| <br>1 | Η | 1s     | 0.597 | 0.403 |
| 2     | Η | 1s     | 0.403 | 0.597 |

Total Overlap Populations by Atom:

|   | Η        | Η        |
|---|----------|----------|
| Η | 0.597222 | 0.402778 |
| Η | 0.402778 | 0.597222 |

Orthogonalized Molecular Orbitals by Column:

| # |   | at-orb | 1     | 2      |
|---|---|--------|-------|--------|
| 1 | Η | 1s     | 0.422 | 2.172  |
| 2 | Η | 1s     | 0.422 | -2.172 |

Wiberg-Trindie Bond Indices:

| # |   | at-orb | 1     | 2     |  |
|---|---|--------|-------|-------|--|
| 1 | Η | 1s     | 0.127 | 0.127 |  |
| 2 | Η | 1s     | 0.127 | 0.127 |  |

Wiberg-Trindie Total Bond Indices by Atoms:

|   | Н        | Н        |
|---|----------|----------|
| Η | 0.127217 | 0.127217 |
| Η | 0.127217 | 0.127217 |

## Appendix 9.C Exact Solution of the Restricted Three-Body Hydrogen Molecule Calculated by Perez-Enriquez, Marin and Riera

## 9.C.1 Introduction

There exists an exact solution for the restricted three-body model of the hydrogen molecule; it was obtained by Raúl Pérez-Enríquez, José Luis Marín and Raúl Riera [68]. Their results for the three-body version of Santilli-Shillady's model [5] reproduce with high precision the values of the ground state energy as a function of the bond length as calculated by Kolos, Szalewicz and Monkhorst; these authors used a James-Coullidge type wave function with up to 259 terms (KSM curve) [69]. In the three-body approach to the hydrogen molecule, Pérez-Enríquez *et al.* assume, on the one hand, that a kind of correlated state between the electrons is present – the so-called isoelectronium state – in which these particles orbit around the nuclei in closed paths. On the other hand, they propose a hypothesis on the extension of the wave function. As a result, these authors obtain relevant results.

In an independent work, a similar kind of correlated state has been used by Pérez-Enríquez [70] to find a structural parameter that correlates linearly with the critical temperature,  $T_c$ , in the perovskite type superconductors. In this article he proposes some kind of Möbius orbital for Cooper pairs. Other contributions to the discussion about correlation between electrons have been presented. In 1993, Taut [71], by means of a pair-correlation function and density of charge for a system of two electrons in an external potential, reports that a one-particle picture may apply to systems with high charge densities.

In their approach, Pérez-Enríquez, Marín and Riera introduce as a starting point the idea that an isoelectronium is confined to a region of space; from here they work out a solution following a method similar to that of E. Ley-Koo and S. Cruz the hydrogen molecular ion inside a spheroidal box [72]; other authors have worked such a confinement for molecules under pressure [73, 74]. In this section, a brief summary of their method and its results is presented.

904

## 9.C.2 Confined Isoelectronium Approach

Taking as a point of departure Eq. (9.1.35) representing the four-body equation for the hydrogen molecule, it is possible to arrive at a couple of differential equations. In a similar way as Aringazin and Kucherenko [65], Pérez-Enríquez *et al.* find that:

$$\left\{ -\frac{\hbar^2}{2M} \nabla_{ab}^2 - \frac{\hbar^2}{2m} \nabla_{12}^2 - V \frac{e^{-r_{12}/r_c}}{1 - e^{-r_{12}/r_c}} + \frac{e^2}{r_{12}} - \frac{2e^2}{r_a} - \frac{2e^2}{r_b} + \frac{e^2}{R} \right\} \left| \hat{\psi} \right\rangle = E \left| \hat{\psi} \right\rangle.$$
(9.C.1)

An equation for the iso-electrons is obtained in terms of the distance between them:

$$-\frac{\hbar^2}{2m}\nabla_{12}^2\chi + V(r_{12})\chi = \varepsilon\chi, \qquad (9.C.2)$$

with

$$V(r_{12}) = \frac{e^2}{r_{12}} - V_0 \frac{e^{-r_{12}/r_c}}{1 - e^{-r_{12}/r_c}}.$$
(9.C.3)

Similarly, for the isoelectronium in interaction with the nuclei:

$$-\frac{\hbar^2}{2M}\nabla_{ab}^2\psi + W(r_a, r_b, R)\ \psi = (E - \varepsilon)\ \psi, \qquad (9.C.4)$$

with

$$W(r_a, r_b, R) = -\frac{2e^2}{r_a} - \frac{2e^2}{r_b} + \frac{e^2}{R}.$$
(9.C.5)

The following wave function has been used:

$$\left|\hat{\psi}\right\rangle = \chi\left(r_{12}\right)\psi\left(r_{a},r_{b}\right). \tag{9.C.6}$$

In the following paragraphs, the solution of Eq. (9.C.4) is developed after the presentation of a condition directly related to the isoelectronium definition; a condition on the extension of the isoelectronium wave function that will provide an exact representation of the hydrogen molecule as a restricted three-body model, reproducing the behavior of the ground state KSM curve in an appreciable range of distances between nuclei in the molecule.

There are two conditions that have to be mathematically represented in order to account for the properties of isoelectronium in trying to understand the kind of movement this quasi-particle follows:

a) The formation of the quasi-particle from the two electrons involves an effective mass transformation; i.e., mass and charge of isoelectronium are  $M = \nu m_e$  and q = -2e, respectively; where  $\nu$  is the effective mass parameter, also called "isorenormalization of mass" and,

b) The spatial extension of the orbits of isoelectronium is limited to a defined region of space; i.e., isoelectronium orbits in a spheroidal shaped region of space.

It is worth mentioning that the latter condition, derived from the fact that the iso-electronium is a twice charged particle which surrounds both nuclei in the molecule, would imply a different behavior to that of the electron in the molecular ion. This small but heavily charged quasi-particle would have to limit its own motion to confined orbits. The hydrogen molecule with the isoelectronium orbiting two protons would appear as a confined system.

With respect to the first condition given above, it is possible to mention that a kind of scaling has been suggested in the literature before. Not just the one proposed by Aringazin and Kucherenko but from other authors as well. In particular, Svidzinsky and collaborators [75] have recently published a paper on the role of scaling while they attempt to represent the hydrogen molecule from Bohr's model. They make a dimensional scaling of the energy in this pre-quantum mechanical description. In the present approach, scaling comes from "iso-renormalization  $\Rightarrow m'$ ", given that the central mechanism of hadronic mechanics is to transform the trivial unit 1 into a generalized quantity  $I^*$  with the consequent generalization of Plank's constant  $(h \Rightarrow h')$  and its related generalized numbers, fields, spaces and so on.

Both hypotheses can be fulfilled by using an approach similar to the one used by Ley-Koo and Cruz to solve the  $H_2^+$  molecular ion confined by a spheroidal box [72], which yields an exact solution of the differential equation using separation of variables and the condition of a vanishing wave function on the spheroidal border. The other way, whose results are reproduced here, uses a variational approach to solve Eq. (9.C.7) as it was done by Marín and Muoz [76], having the same border condition:  $\psi(\xi_0, \eta, \varphi) = 0$ , where  $\xi_0$  defines the shape of the box (the inverse of eccentricity).

## 9.C.3 Exact Values from the Confined Isoelectronium Model

The exact solution of the three-body hydrogen molecule comes from the approach proposed by Pérez-Enríquez, Marín and Riera to the three-body Santilli-Shillady model of the hydrogen molecule (modified M3CS-S). In this context, the Schrödinger equation representing the  $H_2^+$  has to be modified to include the above stated conditions on the mass,  $M = \nu m_e$ , where  $\nu$  is the effective mass parameter given by the iso-renormalization, and on the charge, q = -2e. Thus,

$$\left\{-\frac{\hbar^2}{2\nu m_e} \frac{4}{\rho^2 \left(\xi^2 - \eta^2\right)} \left[\frac{\partial}{\partial \xi} \left(\xi^2 - 1\right) \frac{\partial}{\partial \xi} + \frac{\partial}{\partial \eta} \left(1 - \eta^2\right) \frac{\partial}{\partial \eta}\right]\right\}$$

#### 906

$$+ \frac{\xi^2 - \eta^2}{(\xi^2 - 1)(1 - \eta^2)} \frac{\partial^2}{\partial \varphi^2} \bigg] - \frac{4e^2}{\rho} \cdot \frac{(Z_1 + Z_2) \xi + (Z_2 - Z_1) \eta}{\xi^2 - \eta^2} \\ + \frac{Z_1 Z_2 e^2}{\rho} \bigg\} \psi(\xi, \eta, \varphi) = E' \psi(\xi, \eta, \varphi) .$$
(9.C.7)

This equation has to be solved subject to the following restriction:

$$\psi\left(\xi_0, \eta, \varphi\right) = 0, \tag{9.C.8}$$

which specifies that there is a region of space of spheroidal shape where the isoelectronium moves ( $\xi \leq \xi_0$ ); at the border, the wave function vanishes. Due to the symmetry of the molecule in the ground state (m = 0), one can suppress the azimuth variable and reduce the problem to the z - x plane. Moreover, the following atomic units are used:

$$a_0 = \frac{\hbar^2}{m_e e^2}; \quad E' = \frac{e^2}{2a_0}E; \quad R = \frac{\rho}{a_0}.$$

Thus, the equation

$$\tilde{H}\phi = E\phi$$

is rewritten as

$$\begin{cases}
-\frac{4}{\nu R^2 (\xi^2 - \eta^2)} \left[ \frac{\partial}{\partial \xi} (\xi^2 - 1) \frac{\partial}{\partial \xi} + \frac{\partial}{\partial \eta} (1 - \eta^2) \frac{\partial}{\partial \eta} \right] \frac{8}{R} \\
\times \frac{(Z_1 + Z_2) \xi + (Z_2 - Z_1) \eta}{\xi^2 - \eta^2} \cdot \frac{2Z_1 Z_2}{R} \right\} \phi(\xi, \eta) = E \phi(\xi, \eta).$$
(9.C.9)

In order to satisfy the border conditions, a simple symmetrized variational function considering one parameter and a cut off factor can be used:

$$\phi(\alpha;\xi,\eta) = (\xi_0 - \xi) \left( \exp\left[ -\alpha \left(\xi + \eta\right) \right] + \exp\left[ -\alpha(\xi - \eta) \right] \right).$$
(9.C.10)

The minimum energy of this modified M3CS-S molecule can be obtained by minimization of the functional of energy

$$E\left(\alpha\right) = \frac{\left\langle\phi\middle|\dot{H}\middle|\phi\right\rangle}{\left\langle\phi\middle|\phi\right\rangle} \tag{9.C.11}$$

subject to the following condition

$$\left. \frac{\partial E}{\partial \alpha} \right|_{E=E_{min}} = 0. \tag{9.C.12}$$

The functional of energy depends on several parameters: the effective mass, size of the box and separation between nuclei. Then,  $E_{min}$  can be expressed as

$$E_{min} = E_{min} \left( \nu, \xi_0, R \right).$$
 (9.C.13)

907



Pérez-Marín-Riera Potential Energy Curve

Figure 9.C.1. Comparison between Kolos data and the modified three-body Santilli-Shillady model (parameters:  $\nu$  – mass;  $\xi_0$  –spheroidal shape). Figure was taken from Ref. [68].

By allowing all three parameters to change freely, a simplex optimization method, such as the Nelder-Mead method for example, yields the energy minimum (E = -7.61509174 au and R = 0.2592 bohr) as that found by Santilli-Shillady (see Table 9.1); however, one can choose the effective mass parameter and look forward to find the ground state energy of the free  $H_2$ .

Using the Nelder-Mead optimization algorithm [77] for the parameters defining the size and shape of the confining box ( $\xi_0$  and R), Pérez-Enríquez *et al.* were able to reproduce up to the fifth significant digit the ground state energy (E =-1.1744840 au) at a fixed  $\nu = 0.37039$ . This minimum was obtained for the specific values of the box parameters ( $\xi_0 = 48.46714783$ ; R = 1.41847181 bohr). It is not possible to leave this point without mentioning that the energy minimum is related to a bond length, R, that has only a 1.24% difference with respect to the experimentally observed one. The Pérez-Enríquez, Marín and Riera approach to the three-body hydrogen molecule or M3CP-M-R, may be known as the exact solution to the restricted three-body hydrogen molecule because, as shown in next subsection, it reproduces for  $R \in [0.8, 3.2]$  bohr, the KSM ground state curve up to the fourth significant digit.



Figure 9.C.2. Energy curves showing the influence of the box size parameter.

## 9.C.4 Exact Values as Compared With KSM Ground State

Once the mass parameter,  $\nu$ , and box size,  $\xi_0$ , were found for the optimal ground state energy, Perez-Enríquez *et al.* reproduce the KSM curve for the  $H_2$ ground state over a range of bond lengths. In Figure 9.C.1, the graph shows the fitness of this M3CP-M-R model (line) with the values of energy as a function of R reported by Kolos *et al.* (big points). Though the curve illustrates this fact; quantitatively, a  $\chi^2$  statistical test (1.25390 with 18 degrees of freedom) confirms that with a confidence of .9999998, both data sets are identical to each other up to the 4<sup>th</sup> significant digit.

Table 9.C.1 gathers both sets of energy data and compares them point to point, showing that this significant behavior lies within a defined range,  $R \in [0.8, 3.2]$  bohr. As can be seen while reviewing column five the difference appears at the fourth significant digit for the worst match and up to the sixth digit for the best fit, which is located at exactly R = 1.40 bohr. Both characteristics – up to five digit precision on minimum energy at the experimentally observed bond length and whole curve reproduction – support the hypothesis given for the isoelectronium movement: the orbiting of isoelectronium around the nuclei limits itself to a spheroidal region of space.

The dependence of curve matching with respect to the size of the box can be analyzed using the above mentioned  $\chi^2$  statistical test. A range of box size



Effect of Spheroidal Box Size

Figure 9.C.3. Importance of the box size parameter for reproducing the KSM curve.

parameter values going from 8.0 to 3600 were used by Pérez-Enríquez, Marín and Riera [78] to evaluate the sensitivity of the adjustment between data. In Figure 9.C.2, corresponding curves for some of the  $\xi_0$  values used are shown together with the KSM curve.

In the last figure, Figure 9.C.3, the log-log graph of  $\chi^2$  vs  $\xi_0$  is presented. As it can be seen, a point around  $\xi_0 = 50$  gives a perfect match between the KSM curve and M3CP-M-R exact solution of the three-body hydrogen molecule. There is also a well defined spheroidal region for the movement of isoelectronium.

## 9.C.5 Final Remark

The proof given by this approach to the hydrogen molecule is a good support to the Iso-Chemical model and generates confidence on hadronic mechanics and chemistry. A final remark on the Pérez-Enríquez, Marín and Riera exact solution of the restricted three-body hydrogen molecule can be stated by saying that Santilli-Shillady's orbits, the oo-shaped orbits of isoelectronium, are a necessary condition for the extension of the electron pair; the space restriction on the free movement of this quasi particle could be present in other states of paired electrons such as the Cooper pairs in superconductivity, mainly in high Tc superconductors. The physical interpretation of the isoelectronium state, in which the interaction

| $R^1$ | $\alpha^2$ | $M3CP-M^3$ | $\mathrm{Kolos}^4$ | $\mathrm{Diff.}^5$ |
|-------|------------|------------|--------------------|--------------------|
| 0.80  | 0.4188965  | -1.024900  | -1.0200565         | 0.0048435          |
| 0.90  | 0.4585059  | -1.085753  | -1.0836432         | 0.0021098          |
| 1.00  | 0.4964746  | -1.125001  | -1.1245396         | 0.0004614          |
| 1.10  | 0.5331055  | -1.149680  | -1.1500574         | 0.0003774          |
| 1.20  | 0.5686328  | -1.164305  | -1.1649352         | 0.0006302          |
| 1.30  | 0.6032813  | -1.171876  | -1.1723471         | 0.0004711          |
| 1.40  | 0.6371875  | -1.174438  | -1.1744757         | $0.0000377^{6}$    |
| 1.50  | 0.6705273  | -1.173416  | -1.1728550         | 0.0005610          |
| 1.60  | 0.7033789  | -1.169826  | -1.1685833         | 0.0012427          |
| 1.70  | 0.7358594  | -1.164397  | -1.1624586         | 0.0019384          |
| 1.80  | 0.7680469  | -1.157664  | -1.1550686         | 0.0025954          |
| 2.00  | 0.8319141  | -1.141767  | -1.1381329         | 0.0036341          |
| 2.20  | 0.8953906  | -1.124237  | -1.1201321         | 0.0041049          |
| 2.40  | 0.9589063  | -1.106267  | -1.1024226         | 0.0038444          |
| 2.60  | 1.0228130  | -1.088534  | -1.0857913         | 0.0027427          |
| 2.80  | 1.0871880  | -1.071422  | -1.0706831         | 0.0007389          |
| 3.00  | 1.1521880  | -1.055136  | -1.0573262         | 0.0021902          |
| 3.20  | 1.2179690  | -1.039776  | -1.0457995         | 0.0060235          |

Table 9.C.1. Energies from M3CP-M-R and KSM models

Notes:

<sup>1</sup> Bond length (in bohr)

<sup>2</sup> Non linear variational parameter

<sup>3</sup> Data in this work with  $\xi_0 = 48.467148$  and  $\nu = 0.37039$ 

<sup>4</sup> Data from Kolos, Szalewicz, Monhorst [69]

<sup>5</sup> Absolute value of the difference <sup>6</sup> Approximation up to  $5^{th}$  significant digit at the minimum.

between electrons takes place while being inside the hadronic horizon, is restricted to a defined region around the nuclei.

## References

- Boyer, D.J.: Bonding Theory, McGraw Hill, New York (1968) [1a]. Hanna, M.W.: Quantum Mechanical Chemistry, Benjamin, New York (1965) [1b]. Pople, J.A. and Beveridge, D.L.: Approximate Molecular Orbits, McGraw Hill, New York (1970) [1c]. Schaefer, H.F.: The Electronic Structure of Atoms and Molecules, Addison-Wesley, Reading, Mass. (1972) [1d].
- [2] Santilli, R.M. and Shillady, D.D.: Ab Initio Hadronic Chemistry: Basic Methods, Hadronic J. 21, 633 (1998).
- [3] Santilli, R.M.: Rendiconti Circolo Matematico Palermo, Suppl. 42, 7 (1996) [3a]; Found. Phys. 27, 625 (1997) [3b]; Nuovo Cimento Lett. 37,545 (1983) [3c]; J. Moscow Phys. Soc.
  3, 255 (1993) [3d]; Elements of Hadronic Mechanics, Vol. I and II, Ukraine Academy of Sciences, Kiev, 2-nd Edition (1995) [3e]; Isotopic, Genotopic and Hyperstructural Methods in Theoretical Biology, Ukraine Academy of Sciences, Kiev (1996) [3f]; Intern. J. Modern Phys. A14, 3157 (1999) [3g].
- [4] Kadeisvili, J.V.: Math. Methods Applied Sciences 19, 1349 (1996) [4a]. Tsagas, Gr. and Sourlas, D.S.: Algebras, Groups and Geometries 12, 1 and 67 (1995) [4b]. Tsagas, Gr. and Sourlas, D.: Mathematical Foundations of the Lie-Santilli Theory, Ukraine Academy of Sciences, Kiev (1992) [4c]. Lôhmus, J., Paal, E. and Sorgsepp, L.: Nonassociative Algebras in Physics, Hadronic Press (1995) [4d]. Vacaru, S.: Interactions, Strings and Isotopies on Higher order Superspaces, Hadronic Press (1998) [4c].
- [5] Santilli, R.M. and Shillady, D.D.: Intern. J. Hydrogen Energy, 24, 943 (1999).
- [6] Lewis, G.N.: J. Am. Chem. Soc., 38, 762 (1916) [6a]. Langmuir, I.: J. Am. Chem. Soc., 41, 868 (1919) [6b]. Frost, A.A.: J. Chem. Phys., 47, 3707 (1967) [6c]. Bates, D.R., Ledsham, K. and Stewart, A.L.: Phil. Tran. Roy. Soc. (London) A246, 215 (1954) [6e]. Wind, H.: J. Chem. Phys. 42, 2371 (1965) [6f]. Boys, S.F.: Proc. Roy. Soc. (London) A200, 542 (1950) [6g].
- [7] Santilli, R.M.: Hadronic J. 1, 574 (1978) [7a]. Animalu, A.O.E.: Hadronic J. 17, 379 (1994) [7b]. Animalu, A.O.E. and Santilli, R.M.: Intern. J. Quantum Chemistry 29, 175 (1995) [7c].
- [8] Whitten, J.L.: J. Chem. Phys. **39**, 349 (1963); Sambe, H.: J. Chem. Phys. **42**, 1732 (1965);
  Preuss, H.: Z. Naturforsch. **11a**, 823 (1956); Whitten, J.L. and Allen, L.C.: J. Chem. Phys. **43**, S170 (1965); Harrison, J.F.: J. Chem. Phys. **46**, 1115 (1967); Frost, A.A.: J. Chem. Phys. **47**, 3707 (1967).
- [9] Le Rouzo, H. and Silvi, B.: Int. J. Quantum Chem. 13, 297, 311 (1978); Nguyen, T.T., Raychowdhury, P.N. and Shillady, D.D.: J. Comput. Chem. 5, 640 (1984).
- [10] Shavitt, I.: Methods in Computational Physics, B. Alder (ed.), Academic Press, New York (1963).
- [11] Born, M. and Oppenheimer, J.R.: Ann. Physik 84, 457 (1927).
- [12] Bates, D.R., Ledsham, K. and Stewart, A.L.: Phil. Tran. Roy. Soc. (London), A246, 215 (1954); Wind, H.: J. Chem. Phys. 42, 2371 (1965).

- [13] Boys, S.F.: Proc. Roy. Soc. (London) A200, 542 (1950).
- [14] Whitten, J.L.: J. Chem. Phys. **39**, 349 (1963). Sambe, H.: J. Chem. Phys. **42**, 1732 (1965).
  Preuss, H.: Z. Naturforsch. **11a**, 823 (1956). Whitten, J.L. and Allen, L.C.: J. Chem. Phys. **43**, S170 (1965). Harrison, J.F.: J. Chem. Phys. **46**, 1115 (1967). Frost, A.A.: J. Chem. Phys. **47**, 3707 (1967).
- [15] Le Rouzo, H. and Silvi, B.: Intern. J. Quantum Chem. 13, 297, 311 (1978). Nguyen, T.T., Raychowdhury, P.N. and Shillady, D.D.: J. Comput. Chem. 5, 640 (1984).
- [16] Shavitt, I.: Methods in Computational Physics, B. Alder, (ed.), Academic Press, New York, (1963).
- [17] Shillady, D.D. and Talley, D.B.: J. Computational Chem. 3, 130 (1982). Shillady, D.D. and Richardson, F.S.: Chem. Phys. Lett. 6, 359 (1970).
- [18] Ditchfield, R., Hehre, W.J. and Pople, J.A.: J. Chem. Phys. 52, 5001 (1970).
- [19] Davis, K.B., Mewes, M.O., Andrews, M.R., van Druten, N.J., Durfee, D.S., Kurn, D.M. and Ketterle, W.: Phys. Rev. Lett. **75**, 3969 (27 November 1995). Ketterle, W. and van Drutten, N.J.: Phys. Rev. **A54** 656 (1996).
- [20] Hylleras, E.: Z. Physik 54, 347 (1929).
- [21] Yip S.K. and Sauls, J.A.: Phys. Rev. Lett. **69** 2264 (1992). Xu, D., Yip, S.K. and Sauls, J.A.: Phys. Rev. **B51** 16233 (1955); see also the levels of "normal" H<sub>2</sub> in Symmetry and Spectroscopy, by D.C. Harris and M.D. Bertolucci, p. 345, Oxford Univ. Press. New York (1978).
- [22] Boys, S.F. and Cook, G.B.: Rev. Mod. Phys. 45, 226 (1960). Reeves, C.M.: Commun. Assoc. Comput. Mach. 9, 276 (1966); Lengsfield, B. and Liu, B.: J. Chem. Phys. 75, 478 (1981); Walch, S.P., Bauschlicher, C.W. Jr., Roos, B.O. and Nelin, C.J.: Chem. Phys. 103, 175 (1983).
- [23] Pople, J.A., Krishnan, R., Schlegel, H.B. and Binkly, J.S.: Int. J. Quantum Chem. 14, 545 (1978). Krishnan R. and Pople, J.A.: Int. J. Quantum Chem. 14, 91 (1978).
- [24] Cizek, J.: J. Chem. Phys. 45, 4256 (1966); Paldus, J., Cizek, J. and Shavitt, I.: Phys. Rev. A5, 50 (1972). Bartlett, R.J. and Purvis, G.D.: Int. J. Quantum Chem. 14, 561 (1978). Purvis, G.D. and Bartlett, R.J.: J. Chem. Phys. 76, 1910 (1982).
- [25] Schaefer, H.F.: The Electronic Structure of Atoms and Molecules, Addison-Wesley, Reading, Mass. (1972).
- [26] Kelly, H.P.: Phys. Rev. 131, 684 (1963).
- [27] Goodgame, M.M. and Goddard, W.A.: Phys. Rev. Lett. 54, 661 (1985).
- [28] Mosier, C. and Shillady, D.D.: Math. of Computation 26, 1022 (1972); cf. program LOBE140 described by D.D. Shillady and Sheryl Baldwin, Int. J. Quantum Chem., Quantum Biology Symposium 6, 105 (1979).
- [29] Bender, C.F. and Davidson, E.R.: Phys. Rev. 183, 23 (1969). Alston, P.V., Shillady, D.D. and Trindle, C.: J. Am. Chem. Soc. 97, 469 (1975).

- [30] Hammond, B.L., Lester, W.A. Jr., and Reynolds, P.J.: Monte Carlo Methods, in: Ab Initio Quantum Chemistry, World Scientific Lecture and Course Notes in Chemistry, Vol. 1, World Scientific, New Jersey, p. 67 (1994).
- [31] Miehlich, B., Savin, A., Stoll, H. and Preuss, H.: Chem. Phys. Lett. 157, 200 (1989). Becke,
   A.D.: J. Chem. Phys. 88, 1053 (1988). Lee, C.L., Yang, W. and Parr, R.G.: Phys. Rev. B37, 785 (1988).
- [32] Dunning, T.H.: J. Chem. Phys. 55, 716 (1971).
- [33] Luchow, A. and Anderson, J.B.: J. Chem. Phys. 105, 7573 (1996).
- [34] Kolos, W. and Wolniewicz, L.: J. Chem. Phys. 49, 404 (1968).
- [35] Boyd, R.J. and Yee, M.C.: J. Chem. Phys. 77, 3578 (1982).
- [36] Fois, E.S., Selloni, A., Parinello, M. and Car, R.: J. Phys. Chem. 92, 3268 (1988).
- [37] Xia, P. and Bloomfield, L.A.: Phys. Rev. Lett. 70, 1779 (1993).
- [38] Burnett Collaboration, http://eve.physics.ox.ac.uk/intense/
- [39] Moore, C.: Phys. Rev. Lett. 70, 3675 (1993). Chenciner, A. and Montgomery, R.: Annals of Math., 2001, in press. Montgomery, R.: Notices of the Am. Math. Soc. 48, 471 (2001).
- [40] Eisenberg, D. and Kauzmann, W.: The Structure and Properties of Water, Oxford University Press, New York (1969).
- [41] Santilli, R.M.: Elements of Hadronic Mechanics, Vols. I and II, Ukraine Academy of Sciences, Kiev, 2-nd ed. (1995)[2a]; Found. Phys. 27, 625 (1998)[2b]; Rendiconti Circolo Matematico Palermo, Suppl. 42, 7 (1996) [2c]; Algebras, Groups and Geometries 10, 273 (1993) [2d]; Isotopic, Genotopic and Hyperstructural Methods in Theoretical Biology, Ukraine Academy of Sciences, Kiev (1996) [2e]. Sourlas, D.S. and Tsagas, G.T.: Mathematical Foundations of the Lie-Santilli Theory, Ukraine Academy of Sciences, Kiev, (1993) [2f]. Lôhmus, J., Paal, E. and Sorgsepp, L.:Nonassociative Algebras in Physics, Hadronic Press, Palm Harbor, FL (1994) [2g].
- [42] Santilli, R.M.: Hadronic J. 1, 574 (1978); Animalu, A.O.E. and Santilli, R.M.: Int. J. Quantum Chem. 29, 175 (1995).
- [43] Santilli, R.M. and Shillady, D.D.: Intern. J. Hydrogen Energy 24, 943 (1999) [42a]; Intern.
   J. Hadrogen Energy 25, 173 (2000) [42b].
- [44] Barrow, G.M.: Physical Chemistry, 6th Edition, McGraw-Hill, New York (1996), Chapter 8.
- [45] Pourbaix, M.: Atlas of Electrochemical Equilibria in Aqueous Solutions, National Assoc. Corrosion Engr., Houston, Texas, USA, p. 99. (1974).
- [46] Boys, S.F.: Proc. Roy. Soc. (London), A200, 542 (1950).
- [47] Whitten, J.L.: J. Chem. Phys. **39**, 349 (1963); Sambe, H.: J. Chem. Phys. **42**, 1732 (1965);
   Preuss, H.: Z. Naturforsch. **11a**, 823 (1956); Whitten, J.L. and Allen, L.C.: J. Chem. Phys.

**43**, S170 (1965); Harrison, J.F.: J. Chem. Phys. **46**, 1115 (1967); Frost, A.A.: J. Chem. Phys. **47**, 3707 (1967).

- [48] Le Rouzo, H. and Silvi, B.: Int. J. Quantum Chem. 13, 297, 311 (1978); Nguyen, T.T., Raychowdhury, P.N. and Shillady, D.D.: J. Comput. Chem. 5, 640 (1984).
- [49] Zhitenev, N.B., Ashoori, R.C., Pfeiffer, L.N. and West, K.W.: Phys. Rev. Lett. 79, 2308 (1997).
- [50] Boyd, R.J. and Yee, M.C.: J. Chem. Phys. 77, 3578 (1982).
- [51] Fois, E.S., Selloni, A., Parinello, M. and Car, R.: J. Phys. Chem. 92, 3268 (1988).
- [52] March, J.: Advanced Organic Chemistry, 3rd ed., John Wiley and Sons, New York, p. 733 (1985),
- [53] Cook, D.B.: Handbook of Computational Quantum Chemistry, Oxford Science Publications, Oxford New York, pp. 285-295 and 438-441 (1998).
- [54] Goodgame, M.M. and Goddard, W.A.: Phys. Rev. Lett. 54, 661 (1985).
- [55] Schaefer, H.F.: The Electronic Structure of Atoms and Molecules, Addison-Wesley, Reading, Mass. (1972).
- [56] Shavitt, I.: Methods in Computational Physics, B. Alder (ed.), Academic Press, New York (1963).
- [57] Mosier, C. and Shillady, D.D.: Math. of Computation, 26, 1022 (1972): Program LOBE140 described by D.D. Shillady and Sheryl Baldwin, Int. J. Quantum Chem., Quantum Biology Symposium 6, 105 (1979).
- [58] Shillady D.D. and Talley, D.B.: J. Computational Chem. 3, 130 (1982); Shillady D.D. and Richardson, F.S.: Chem. Phys. Lett. 6, 359 (1970).
- [59] Dunning, T.H.: J. Chem. Phys. 53, 2823 (1970), J. Chem. Phys. 55, 716 (1971), J. Chem. Phys. 55, 3958 (1971).
- [60] Hammond, B.L., Lester, W.A. Jr., and Reynolds, P.J.: Monte Carlo Methods, in: Ab Initio Quantum Chemistry, World Scientific Lecture and Course Notes in Chemistry, Vol. 1, World Scientific, New Jersey, p. 67 (1994).
- [61] Luchow, A. and Anderson, J.B.: J. Chem. Phys. 105, 7573 (1996).
- [62] Burnett Collaboration, http://eve.physics.ox.ac.uk/INTENSE/zz.
- [63] USMagnegas, Inc., http://www.santillimagnegas.com.
- [64] Santilli, R.M. and Shillady, D.D.: Intern. J. Hydrogen Energy 24, 943 (1999) [1a]; Intern.
   J. Hadronic Energy 25, 173 (2000) [1b].
- [65] Aringazin, A.K. and Kucherenko, M.G.: Hadronic J. 23, 1 (2000). e-print physics/0001056 [2a]. Aringazin, A.K.: Hadronic J. 23, 57 (2000). e-print physics/0001057 [2b].
- [66] Flugge, Z.: Practical Quantum Mechanics, Vols. 1, 2, Springer-Verlag, Berlin (1971).

- [67] Santilli, R. M. Foundations of Hadronic Chemistry with Applications to New Clean Energies and Fuels, Kluwer Academic Publisher (2001).
- [68] R. Pérez-Enríquez, J. L. Marín, and R. Riera, Progr. Phys. 2, 34-41 (2007).
- [69] W. Kolos, K. Szalewicz, and H. J. Monkhorst, J. Chem. Phys. 84, 3278-3283 (1986).
- [70] R. Pérez-Enríquez, Rev. Mex. Fis. 48, Supl. 1, 262–267 (2002).
- [71] M. Taut, Phys. Rev. A 48, 3561–3565 (1993).
- [72] E. Ley-Koo and S. A. Cruz, J. Chem. Phys. 74, 4603–4610 (1981).
- [73] R. LeSar and D. R. Herschbach, J. Phys. Chem. 85, 2798-2804 (1981).
- [74] A. Corella-Madueo, R. Rosas, J. L. Marín, R. Riera, and G. Campoy, *Hydrogen molecule* confined within a spheroidal box. Personal communication.
- [75] A. A. Svidinsky, M. O. Scully, and D. R. Herschbach, Phys. Rev. Let. 95, 080401 (2005).
- [76] J. L. Marín and G. Muñoz, J. Mol. Struct. (TEOCHEM) 287, 281-285 (1993).
- [77] M. H. Wright, DUNDEE, 191–208 (1995).
- [78] R. Perez-Enriquez, J. L. Marín, and R. Riera, Hadronic J. (submitted).

Chapter 10

# INDUSTRIAL APPLICATIONS TO NEW CLEAN BURNING, COST COMPETITIVE FUELS

## 10.1 THE INCREASINGLY CATACLYSMIC CLIMACTIC EVENTS FACING MANKIND

## 10.1.1 Foreword

Some of the biggest needs of mankind to contain increasingly cataclysmic climactic events due to global warming and other large environmental problems are: 1) Remove and recycle carbon dioxide from our atmosphere; 2) Develop means for the processing of carbon dioxide in automotive exhaust; and 3) Develop new clean burning cost competitive fuels (see the content of this chapter for details).

The biggest threat to mankind in this field is the lack at this writing in all developed countries of political will to invest public funds in serious resolutions of our environmental problems. All governmental investments in the sector known to this author have been made for the *appearance* of favoring the environment while in reality favoring the myopic and self-destructing interests of the organized petroleum cartel, as it is the case for investment of public funds in hydrogen (see Section 11.1.3 for the huge environmental problems caused by current hydrogen production via the reformation of fossil fuels, while multiplying the profits of the petroleum cartel).

It should be stressed that the solution of large societal problems must be supported by *public* funds, since it is unethical to expect that individuals pay for the cost. Yet, all the research presented in this chapter has been supported by *private* funds due to the lack of public funds following solicitations by the author in the U.S.A., Continental Europe, Russia, China, Japan, Australia, and other developed countries.

One way to understand the gravity of environmental problems is to note that this chapter has been written during the month of September 2005 at the Institute for Basic Research in Florida, when the southern belt of the U.S.A. had been



*Figure 10.1.* A view of one of the primary responsibilities for current increasingly cataclysmic climatic events: the pollution caused by fossil fueled electric power plants.

exposed to some eighteen hurricanes and devastated by the hurricanes Kathrina and Rita, with additional hurricanes expected before the end of the 2005 season. Increasingly cataclysmic climactic events are expected in the years ahead, until the entire southern belt of the U.S.A. will become uninhabitable.<sup>1</sup>

Similar increasingly cataclysmic climactic events are occurring in the rest of the world. As an example, the mountain region of the Andes in Peru is experiencing an exodus of the local farmers toward the cities due to the lack of snow in winter, with expected major drought the following summer and consequential inability to grow crops.

Also, *The Economist* in England published in the fall of 2004 a report from the U. S. Pentagon releasing for the first time data on the slow down of the Gulf Stream due to the decreased density and salinity of the North Atlantic caused by the melting of the ice in the North Pole region. The complete halting of the Gulf Stream is now beyond scientific doubt, the only debatable issue remaining is that of the date, at which time England is expected to suffer from extreme cold in winter and extreme temperature in summer.

<sup>&</sup>lt;sup>1</sup>At the end of the 2005 hurricane season Florida was hit by *twenty two* major climactic events, so many that the U.S. Weather Bureau exhausted all 21 letters of the English alphabet and had to name the 22-nd storm from the Greek alphabet. There is no need to wait a few years to understand that the devastating climactic events expected in the next few years are due to the lack of serious political will NOW.

The list of similar increasingly cataclysmic climactic events all over the world could now be endless.

It is at this point were the efforts for the construction of hadronic mechanics, superconductivity and chemistry acquire their full light. In fact, all possibilities of resolving our huge environmental problems via the use of conventional doctrines were long exhausted, as better illustrated in this and in the next chapter, thus establishing the need for suitable covering disciplines beyond any possible doubt.

All scientists have a direct responsibility to contribute, or at least not to oppose, serious efforts toward the solution of these increasingly cataclysmic problems via the traditional scientific process of trial and errors, by implementing genuine scientific democracy, ethics and accountability vis a vis mankind, not via a formal academic parlance, but in actual deeds, the only ones having social as well as scientific value, beginning with the admission that the dominance of the entire universe by the rather limited Einsteinian doctrines is a purely political nonscientific posture, and its era has now ended in favor of covering theories for physical conditions unthinkable during Einstein's times.

## 10.1.2 Origin of the Increasingly cataclysmic Climactic Events

According to official data released by the U. S. Department of Energy<sup>2</sup>, by ignoring the world-wide consumption of natural gas and coal, we consumed in 2003 about  $74 \times 10^6$  barrels of crude oil (petroleum) per day, corresponding to the daily consumption of about  $3 \times 10^9$  gallons (g) or  $1.4 \times 10^{10}$  liters (L) of gasoline per day.

When adding the world consumption of natural gas and coal, the world consumption of fossil fuels in 2003 should be conservatively estimated to be equivalent to  $1.5 \times 10^7$  barrels per day, corresponding to the gasoline equivalent of  $7.5 \times 10^8$  gallon or  $2.8 \times 10^{11}$  liters per day.

Such a disproportionate consumption is due to the average daily use in 2003 of about 1,000,000,000 cars, 1,000,000 trucks, 100,000 planes plus an unidentifiable number of additional vehicles of military, agricultural, industrial and other nature, plus the large consumption of fossil fuels by electric power plants around the world.

The data for 2004 are not reported here because still debated, and estimated to be of the order of  $90 \times 10^6$  barrels of crude oil (petroleum) per day. Future consumption can be best illustrated by noting that, according to official data of the Chinese government, *China is building* 500,000,000 (yes, five hundred million) new cars by 2015, and that the need for petroleum, in China for the year 2006 will correspond to the world consumption for 2004, including China.

<sup>&</sup>lt;sup>2</sup>See, e.g., the web site http://www.eia.doe.gov/emeu/international/energy.html



Figure 10.2. Official data on the 2003 disproportionate consumption of fossil fuels in the U.S.A. alone.

The extremely serious environmental problems caused by the above disproportionate combustion of fossil fuels can be summarized as follows:<sup>3</sup>

(1) The combustion of fossil fuels releases in our atmosphere about sixty millions metric of tons carbon dioxide  $CO_2$  per day that are responsible for the first large environmental problem known as "global warning" or "green house effect."<sup>4</sup> Of these only 30 millions metric tons are estimated to be recycled by our ever decreasing forests. This implies the release in our atmosphere of about thirty millions metric tons of unrecycled green house gases per day, which release is the cause of the "global warming" now visible to everybody through climactic episodes such as floods, tornadoes, hurricanes, etc. of increasing catastrophic nature.

<sup>&</sup>lt;sup>3</sup>See for details the web site http://www.magnegas.com/technology/part6.htm. The reader should note that the calculations in this web site only treat the 2003 consumption of crude oil for automotive use. Consequently, the data therein should be multiplied by three to reach realistic values for 2003.

<sup>&</sup>lt;sup>4</sup>The value of 60 million tons of  $CO_2$  per day is easily obtained from the chemical reaction in the combustion of the indicated daily volume of fossil fuels (see for details http://www.magnegas.com/technology/part6.htm

(2) The combustion of fossil fuels causes the permanent removal from our atmosphere of about 21 millions metric tons of breathable oxygen per day, a second, extremely serious environmental problem known as "oxygen depletion."<sup>5</sup> Even though not disclosed by political circles and newsmedia, the very admission of an "excess"  $CO_2$  in our atmosphere (that is,  $CO_2$  no longer recycled by plants) is an admission of oxygen depletion because the " $O_2$  in the excess " $CO_2$ " was originally breathable oxygen. Hence, by recalling the atomic weight of  $CO_2$  and  $O_2$ , we have the value  $\frac{32}{44} \times 30 \times 10^6 = 21.8 \times 10^8$ tons of lost oxygen per day.

It appears that, prior the introduction of oxygen depletion by the author in 2000, everybody ignored the fact that the combustion of fossil fuels requires atmospheric oxygen. Since only the global warming is generally considered, it appears that newsmedia, governments and industries alike ignored the fact that we need oxygen to breath. Only more recently, various environmental groups, unions and other concerned groups are becoming aware that the increasing heart problems in densely populated area are indeed due to local oxygen depletion caused by excessive fossil fuel combustion.

(3) The combustion of fossil fuels releases in our atmosphere about fifteen millions metric tons of carcinogenic and toxic substances per day. This third, equally serious environmental problems is euphemistically referred to by the newsmedia as "atmospheric pollution", while in reality it refers to the primary source of the widespread increase of cancer in our societies. For instance, it has been established by various medical studies (generally suppressed by supporters of the oil cartel) that unless of genetic origin, breast cancer is due to the inhaling of carcinogenic substances in fossil fuels exhaust. These studies have gone so far as to establish that breast cells are very receptive to a particular carcinogenic substance in fossil fuel exhaust. After all, responsible citizens should remember and propagate (rather than myopically suppress) the fact that the U. S. Environmental Protection Agency has formally admitted that diesel exhaust is *carcinogenic*. A moment of reflection is sufficient for anybody in good faith to see that we inhale on a daily basis carcinogenic substances from gasoline exhaust in an amount that is ten thousands times bigger than carcinogenic substances ingested with food.

This is another serious environmental problem that has remained virtually ignored by all until recently due to the widespread misinformation by the newsmedia. However, the existence of this third major environmental problem caused by fossil fuel combustion has now propagated to environmental, union and other

<sup>&</sup>lt;sup>5</sup>The "oxygen depletion" was first introduced by the author at the 2000 Hydrogen World Conference held in Munich, Germany (see the web site http://www.magnegas.com/technology/part6.htm).



Figure 10.3. A picture of frequent environmental disasters caused by the spill of crude oil from tankers following accidents. The replacement of crude oil with a gaseous fuel will eliminate the environmental damage, with the exception of hydrogen because, in the event the cargo of this tanker had been composed of hydrogen, its release in the atmosphere, its immediate rising to the ozone layer, and its very rapid reaction with  $O_3$  would create a hole in the ozone layer of the size of the State of Rhode Island, with consequential increase of skin and other cancers on Earth (see Section 11.1.3 for details).

circles with predictable legal implications for the fossil fuel industry and its major users, unless suitable corrective measures are initiated, as it occurred for the tobacco industry.

It is hoped that people trapped in traffic, thus inhaling the carcinogenic fumes from the vehicle in front, will remember the above evidence and assume an active role in the support of environmentally acceptable fuels because it is written throughout history that people have the government and system they deserve.

There exist numerous additional environmental problems caused by the *global* study of fossil fuels, that is, not only the environmental problems caused by their combustion, but also those caused by their production and transportation. The latter problems are omitted here for brevity and also because the dimension of problems 1, 2 and 3 is a sufficient call for persons in good faith.

## 10.1.3 Serious Environmental Problems Caused by Hydrogen, Natural Gas, Ethanol, Biogases and Fuels with Molecular Structure

Whenever facing the ever increasing cataclysmic climatic events caused by fossil fuel combustion, a rather widespread belief is that the solution already exists and it is given by *hydrogen* for the large scale fuel uses of the future because hydrogen is believed to be "the cleanest fuel available to mankind."

Due to the potentially lethal implications for mankind, it is necessary to dispel this belief and indicate that, the current production and combustion of hydrogen, whether for an internal combustion engine or for a fuel cell, causes a global pollution much greater than that caused by gasoline when compared for the same energy outputs.

Hydrogen is indeed an environmentally acceptable fuel, but only when its production and use verify the following conditions:

CONDITION I: Hydrogen is produced via the electrolytic separation of water; CONDITION II: The electricity used for electrolysis originates from clean and renewable energy sources, such as those of hydric, solar or wind nature; and

CONDITION III: The oxygen produced by the electrolytic process is freely released in the environment so that the subsequent hydrogen combustion leaves unchanged the existing oxygen content of our atmosphere.

However, the reality in the production and use of hydrogen is dramatically different than the above ideal conditions. In fact, hydrogen is today produced in its greatest percentage via reformation processes of fossil fuels such as methane  $CH_4$ , via the use of highly polluting electric power plants, and no oxygen is released in the atmosphere during production.

Reformation processes are preferred over electrolysis not only because of the low efficiency of the electrolytic separation of water,<sup>6</sup> but also due to the fact that the primary drive in the current international support for hydrogen as a fuel is to permit the petroleum cartel to multiply the profits (because the profits from the sale of the hydrogen content of fossil fuels are a multiple of the profits from the direct sale of fossil fuels, as better indicated below.)

Renewable sources of electricity, even though manifectly valuable, are so minute with respect to the enormity of the demand for fuel that cannot be taken into serious consideration. Nuclear power plants also cannot be taken into serious consideration until governments finally provide serious financial support for basic research on the stimulated decay of radioactive nuclear waste by nuclear power plants themselves, rather than the currently preferred "storage" of nuclear waste

 $<sup>^{6}</sup>$ Electrolytic plants for the separation of water have an efficiency of the order of 0.8, thus yielding an efficiency for hydrogen production by volume of the order of 0.5, as compared to the efficiency in the production of magnegas discussed in the subsequent sections of this chapter that can be 10.5 in industrial recycler, that is, 21 times bigger than that of electrolysis.

in in depositories nobody wants to have near-by. These aspects begin to illustrate the reason hadronic mechanics, superconductivity and chemistry were developed, as studied in more details in the next chapter.

When inspected in real terms, the current production, transportation and use of hydrogen, if implemented in large scale such as that of fossil fuels, cause the following very serious environmental problems:

A) Alarming oxygen depletion caused by hydrogen combustion, namely, the permanent removal of breathable oxygen from our atmosphere and its conversion into water vapor  $H_2O$ . By remembering that oxygen is the very basis of life, we are here referring to one of the most serious environmental problems facing mankind that can become potentially lethal for large scale combustion of hydrogen irrespective of whether used as fuel or in fuel cells. When TV programs show water vapor coming out of car exhaust running on hydrogen, they are actually showing one of the most alarming environmental problems facing mankind.

It should be indicated that gasoline combustion causes much less oxygen depletion than hydrogen combustion, for various reasons. The first is that gasoline combustion turns atmospheric oxygen into  $CO_2$  that is food for plants, since the chlorophyll process turns  $CO_2$  into breathable  $O_2$  while maintaining C for plant growth. Therefore, the oxygen depletion caused by gasoline and fossil fuels in general is only that for the excess of  $CO_2$  that cannot be any longe recycled by plants due to their enormous daily releases, combined with the ongoing forest depletion.

By comparison, hydrogen turns breathable oxygen into water vapors. At this point equivocal technicians indicate that "plants also recycle water into oxygen,", which statement is correct because without water plants die, as well known. Nevertheless, if proffered by experts, the statement may be dishonest because they do not mention the fact that our atmosphere is full of water vapor as shown by clouds and rain. Hence, the additional water vapor originating from hydrogen combustion cannot possibly be recycled by plants. By comparison, the  $CO_2$  content in our atmosphere was less than 1% one century ago, in which case the excess due to fossil fuel combustion was, at least initially, recycled by plants, and this is the very reason the human race is still alive today despite the current immense fossil fuel consumption the world over.

Yet another reason favoring environmentally the combustion of gasoline over hydrogen is that the oxygen depletion caused by hydrogen combustion is a large multiple of that caused by gasoline combustion. This additional environmental problem can be seen as follows. Gasoline combustion is based on the synthesis of CO, one of the most escenergetic chemical reactions known to man, that releases 255 Kcal/mole, followed by the synthesis of  $CO_2$  that releases about 85 Kcal/mole, and other reactions for a total of at least 335 Kcal/mole. By comparison, the sole chemical reaction in hydrogen combustion is the synthesis of  $H_2O$  releasing about 57 Kcal/mole. A first year graduate student in chemistry can then compute the multiplier needed for the oxygen depletion caused by gasoline combustion to reach that of hydrogen combustion, of course, under the same energy output.

B) Alarming environmental problems caused by current hydrogen production. The reformation of methane and other fossil fuels for hydrogen production requires large amounts of energy because of the necessary breaking of strong molecular bonds such as  $CH_4$ . In this case, all byproducts of the reformation, such as the "green house gas"  $CO_2$ , are released into the environment. A first year graduate student in chemistry can then prove (although his/her teacher may disagree for personal academic gains) that the  $CO_2$  released in the atmosphere for hydrogen production from  $CH_4$  is a large multiple of the  $CO_2$  produced in gasoline combustion.

Hence, simple calculations establish that the current methods of hydrogen production, transportation and use release in the atmosphere carcinogenic substances, green house gases and other contaminants that are at least twenty times bigger than the contaminants releases by the gasoline production and combustion in contemporary cars with efficient catalytic converters.

In fact, the production of hydrogen requires large amounts of energy while, by comparison, gasoline production requires considerably less energy because crude oil comes out of the group at pressure without any need of electricity, while refining processes of crude oil into gasoline are mostly chemical in nature, thus requiring minimal electric energy. The global pollution caused by gasoline is therefore essentially restricted to the pollution caused by transportation and combustion.

Being an environmentalist, the author certainly does not support gasoline as the dominant fuel. Nevertheless, scientific honesty requires the admission that gasoline is much less polluting than hydrogen as currently produced when considered on a global scale including production, transportation and combustion.

C) Alarming threat to the ozone layer caused by hydrogen seepage and losses. Another serious environmental problem caused by hydrogen is due to its *seepage*, namely, the fact that, being composed by the smallest molecule on Earth, hydrogen escapes through container walls irrespective of the used material and thickness. Consequently, the large scale use of hydrogen must take into account the inevitable release of free hydrogen that, being very light, instantly rises to the upper layer of our atmosphere all the way to the *ozone layer*, resulting in its depletion because hydrogen and ozone have one of the fastest known chemical reactions

$$H_2 + O_3 \quad \rightarrow \quad H_2 O + O_2. \tag{11.1.1}$$

Again, gasoline is preferable over hydrogen also in regard to the ozone layer. In fact, gasoline is liquid and its vapors are heavy, thus being unable to reach the ozone layer. Also, all byproducts of gasoline combustion are heavy and they simply cannot rise to the ozone layer. Assuming that some tornado carries byproducts of gasoline combustion all the way up to the ozone layer, they have no known reaction with the ozone that could compare with that of hydrogen, Eq. (11.1.1).

D) Alarming environmental problems caused by the need to liquify hydrogen. Gasoline contains about 110,000 British Thermal Units (BTU) per gallon (g) while hydrogen contains about 300 BTU per standard cubic foot (scf). Consequently, the "Gasoline Gallon Equivalent' (GGE)' is given by 366 scf of hydrogen. Hence, the hydrogen equivalent of an average 20 gallon gasoline tank would require 7,320 scf of hydrogen, namely, a volume of hydrogen so big to require a trailer for its transportation in automotive uses.

This is the reason all manufacturers testing cars running on hydrogen as a fuel, such as BMW, GM, Honda, and others, have been forced to use *liquified hydrogen.* At this point the environmental problems caused by use of hydrogen as an automotive fuel become truly serious, e.g., because hydrogen liquifies close to the absolute zero degree temperature, thus requiring large amounts of electric energy for its liquefaction, with consequential multiplication of pollution. Additional significant amounts of energy are needed to maintain the liquid state because the spontaneous transition from the liquid to the gas state is explosive without any combustion (because of the rapidity of the transition when the cooling systems ceases to operate).

At the 2000 Hydrogen World Meeting held in Munich, Germany, under BMW support, a participant from Florida stated that "If one of my neighbors in Florida purchases a car operating on liquid hydrogen, I will sell my house because in the event that neighbor leaves the car parked in his driveway to spend the weekend in Las Vegas, and the cooling systems fails to operate due to the Florida summer heat, the explosion due to the transition of state back to the gaseous form will cause a crater."

E) **Prohibitive hydrogen cost.** Commercial grade hydrogen (not the pure hydrogen needed for fuel cells) currently retails in the USA at 0.18/scf. By comparison, natural gas retails at about 0.01/scf. But hydrogen contains 300BTU/scf, while natural gas contains 1,050BTU/scf. Consequently,  $\frac{1,050}{300} \times 0.18 = 0.63$ , namely, commercial grade hydrogen currently sells in the U.S.A. at sixty three times the cost of natural gas, a very high cost that is a reflection of the low efficiency of the available processes for hydrogen production.

But, unlike magnegas and natural gas, hydrogen cannot be significantly carried in a car in a compressed form, thus requiring its liquefaction that is very expensive to achieve as well as to maintain. Consequently, simple calculations establish that the actual cost of hydrogen in a liquified form for automotive use is at least 200 times the cost of fossil fuels,

| Element         | MagneGas (MG) | Natural Gas                             | Gasoline                                | <b>EPA Standards</b>                            |
|-----------------|---------------|---|---|---|
| Hydro-carbons   | 0.026 gm/mi   | 0.380 gm/mi<br>2460% of MG<br>emission  | 0.234 gm/mi<br>900% of MG<br>emission   | 0.41 gm/mi                                      |
| Carbon Monoxide | 0.262 gm/mi   | 5.494 gm/mi<br>2096% of MG<br>emission  | 1.965 gm/mi<br>750% of MG<br>emission   | 3.40 gm/mi                                      |
| Nitrogen Oxides | 0.281 gm/mi   | .732 gm/mi<br>260% of MG<br>emission    | 0.247 gm/mi<br>80% of MG<br>emission    | 1.00 gm/mi                                      |
| Carbon Dioxide  | 235 gm/mi     | 646.503 gm/mi<br>275% of MG<br>emission | 458.655 gm/mi<br>195% of MG<br>emission | No EPA standard<br>exists for Carbon<br>Dioxide |
| Oxygen          | 9%-12%        | 0.5%-0.7%<br>0.04% of MG<br>emission    | 0.5%-0.7%<br>0.04% of MG<br>emission    | No EPA standard<br>exists for Oxygen            |

Figure 10.4. Summary of comparative measurements combustion exhaust of the new magnegas fuel (described in Section 11.3 below), natural gas and gasoline conducted at the EPA accredited automotive laboratory of Liphardt & Associated of Long Island, New York in 2000 (see for details the website http://www.magnegas.com/technology/part6.htm). As one can see, contrary to popular belief, under the same conditions (same car with same weight used with the same computerized EPA routine, for the same duration of time), natural gas exhaust contains 61% "more" hydrocarbons, about 41% "more" green house gases, and about 200% "more" nitrogen oxides than gasoline exhaust.

There is no credible or otherwise scientific doubt that, under the above generally untold large problems, hydrogen has no realistic chance of becoming a serious alternative for large use without basically *new* technologies and processes.

The above refers to the use of hydrogen as an automotive fuel for internal combustion engines. The situation for the use of hydrogen in fuel cells is essentially the same, except for different efficiencies between internal combustion engines and fuel cells that have no relevance for environmental profiles.

A possible resolution, or at least alleviation, of these problems is presented in Section 11.5.

Another widespread misrepresentation existing in alternative fuels is the belief that "the combustion of natural gas (or methane) is cleaner than that of gasoline," with particular reference to a presumed reduction of carcinogenic and green house emissions. This misrepresentation is based on the visual evidence that the flame of natural gas is indeed cleaner than that of gasoline or other liquid fuels. However, natural gas is gaseous while gasoline is liquid, with an increase of density in the trantion from the former to the latter of about 1,500 units. Consequently, when the pollutants in the flame of natural gas are prorated to the density of gasoline, the much more polluting character of natural energes. In any case, recent measurements reviewed later on in this chapter have disproved the above belief because, *under identical performances*, *natural gas is much more polluting than gasoline* (see Figure 11.3).

Further widespread misrepresentations exist for *ethanol*, *biogases*, and other conventional fuels, that is, fuels possessing the conventional molecular structure, because generally presented as cleaner than gasoline. In effect, ethanol combustion exhaust is the most carcinogenic among all fuels, the pollution caused by biogases is truly alarming, and the same occur for all remaining available conventional fuels.

In addition, ethanol. biogases and otehr fuels of agricultural origin leave large carbon deposits on spark plugs, piiston rings and otehr component, by decreasing considerably the life of the engines.

Hence, the mere inspection of the tailpipe exhaust is today a view of the past millennium, if not motivated by equivocal commercial, political or academic interests. The sole approach environmentally acceptable today is the study of the global environmental profile pertaining to fuels, that including the environmental pollution causes by the production, storage, transportation, and combustion.

In closing, equivocal commercial, political and academic interests should be made aware that, following the success of the lawsuits against the tobacco industry, environmental groups in Berlin, Washington, Tokyo and other cities are apparently preparing lawsuits for trillion dollars punitive compensation against any large scale producer or user of polluting fuel. Therefore, it appears that the best way to confront supporters of hydrogen, ethanol, biofuels and other highly polluting fuels is that via a judicial process. After all, we should never forget that the future of mankind is at stake on these issues.

## **10.1.4** Basic Needs for the Survival of Mankind

The most basic need for the very survival of our contemporary societies in view of the disproportionate use of fossil fuels and the increasingly cataclysmic climactic events caused by the pollutants in their combustion exhaust can be summarized as follows:

(1) **Develop "new" processes for the nonpolluting, large scale production of electricity,** that is, processes beyond the now exhausted predictive capacities of conventional doctrines. Whether for electrolysis or other uses, electricity is and will remain the basic source of energy for the synthesis of new fuels. At the same time, hydro, thermal and wind sources of energy, even though very valuable, are dramatically insufficient to fulfill the present, let alone the future needs of clean energy. Nuclear power plants have been severely damaged by governmental obstructions, both in the U.S.A., Europe and other countries, against new processes for the stimulated decay of radioactive nuclear waste by the power plants themselves, in favor of a politically motivated storage of the radioactive

928

waste in depositories so much opposed by local societies, thus preventing nuclear power to be a viable alternative.<sup>7</sup> Additionally, both the "hot fusion' and the "cold fusion" have failed to achieve industrially viable results to date, and none is in sight at this writing. The need for basically "new" clean sources of electricity is then beyond scientific doubt. This need is addressed in the next chapter because, as we shall see, the content of this chapter is a necessary pre-requisite.

(2) Build a large number of large reactors for the large scale removal and recycling of the excess  $CO_2$  in our atmosphere. The containment of future production of  $CO_2$  is basically insufficient because the existing amount in our atmosphere is sufficient to cause increasingly cataclysmic climactic events. Therefore, another major problem facing mankind is the removal of the  $CO_2$ already existing in our atmosphere. This problem is addressed in the next subsection.

(3) it Develop "new" fuels that are not derivable from crude oil and are capable of achieving full combustion, that is, fuels structurally different than all known fuels due to their highly polluting character. The production of new fuels not derivable from crude oil is necessary in view of the exploding demand for fossil fuels expected from the construction in China of 500,000,000 new cars and other factors, as well as the expected end of the petroleum reserves. This need is addressed in this chapter. the need for fuels with a new chemical structure is set by the impossibility for all available fuels, those with conventional molecular structure, to achieve full combustion. This need is addressed in this chapter.

## 10.1.5 Removing Carbon Dioxide from our Atmosphere and Car Exhaust

Nowadays, we have in our atmosphere a large excess  $CO_2$  estimated to be from 100 to 300 times the  $CO_2$  percentage existing at the beginning of the 20-th century, which excess is responsible for the "global worming" and consequential devastating climactic events.

A typical illustration is given by the Gulf of Mexico whose waters have reached in August, 2005, such a high temperature  $(95^{\circ}F)$  to kill dolphins and other marine species. This sad environmental problem is due to the fact that  $CO_2$  is heavier than any other gas in the atmosphere, thus forming a layer on the top of the water that traps Sun light, with the resulting increase of water temperature.

All predictions establish that the current rate of  $CO_2$  release in our atmosphere will eventually cause the water of the Gulf of Mexico to reach in the summer a

<sup>&</sup>lt;sup>7</sup>For governmental politics opposing new methods for the stimulated decay of radioactive nuclear waste, one may visit the web site http://www.nuclearwasterecycling.com

steaming state, with consequential impossibility to sustain life, the only debatable aspect being the time of these lethal conditions in the absence of corrective action.

The only possible, rational solution of the problem is the removal of  $CO_2$  from our atmosphere via molecular filtration or other methods and its processing into noncontaminant gases.

Other solutions, such as the pumping of  $CO_2$  underground jointly with petroleum production as adopted by the petroleum company StatOil in Norway and other companies, are definitely unacceptable on environmental grounds because of the risk that the green house gas may resurface at some future time with catastrophic consequences. In fact, being a gas under very high pressure when under grounds, it is only a question of time for the  $CO_2$  to find its way back to the surface.<sup>8</sup>

The technology for the molecular separation of  $CO_2$  from our atmosphere is old and well established, thus requiring the construction of equipment in large sizes and numbers for installation in a sufficient number of location to yield appreciable results.

To understand the dimension for the sole Gulf of Mexico there is the need of a number of recyclers located in barges and/or in coastal area capable of processing at least 10 millions metric tons of air per day.

After clarifying that the technology for the removal of  $CO_2$  from our atmosphere is fully available (only the political will is still absent at this writing in virtually all developed nations), the next issue is the selection of the appropriate processing of  $CO_2$  into environmentally acceptable species.

According to extensive research in the problem conducted by the author and his associates, the most efficient method for recycling  $CO_2$  is that based on flowing the gas at high pressure through an electric arc [5]. In fact, the arc decomposes the  $CO_2$  molecule into carbon precipitates and breathable oxygen that can be released into the atmosphere to correct the oxygen depletion caused by fossil fuels.

Needless to say, these " $CO_2$  Recycling Plants can additionally remove from the environment circinogenic and other toxic pollutants via the use of the same technology of molecular sep[aration and processing.

Numerous other processes are also expected to be possible for the removal of the  $CO_2$  excess from our atmosphere, and their indication to the author for quotation in possible future editions of this monograph would be appreciated.

Whatever environmentally acceptable solution is suggested, the main needs for serious and responsible governments is to stop the debate and discussions and initiate action *now*, when the economies of developed countries are still somewhat solid, because, later on, increasingly cataclysmic climatic events combined with

<sup>&</sup>lt;sup>8</sup>In reality, petroleum companies pump  $CO_2$  underground to increase the pressure of release of near-by crude oil, and certainly not to help the environment.



Figure 10.5. A schematic view of a preferred embodymnent for the recycling of  $CO_2$  into C and  $O_2$  via the use the PlasmaArcFlow technology of Refs.[5]. the main principle is that, following its separation from the atmosphere, the most efficient mean for breaking down the  $CO_2$  bond is, by far, the electric arc..

increases in fossil fuel costs may eventually cause the collapse of said economies, at which points nations will not have the immense financial resources needed for the removal of the excess  $CO_2$  in our planet.

In closing, the reader should be aware that current technologies permit the large scale production, thus at low cost, of special  $CO_2$  absorbing cartridges that can be houses in conventional car exhaust pipes and replaced periodically. the removal of  $CO_2$  is done via special chemicals or other means. Additional possibilities are given by passing the exhaust through a series of arcs for the recycling of  $CO_2$  into C and breathable  $O_2$ .

In short, in this chapter we show that current technologies do indeed permit the production of environmentally acceptable fuels, while in the next chapter we shall show that other technologies permit new clean energies. Mankind is exposed to increasing cataclysmic climactic events not only because of the *lack* of political will for any action that could be considered minimally responsible at this writing (fall 2005) in any and all so-called developed countries, but also because the political will continues to serve the oil cartel, as demonstrated by the political support of hydrogen, of course, produced from fossil fuels, despite having extremely serious environmental problems identified in the preceding subsection

## 10.2 THE NEW CHEMICAL SPECIES OF MAGNECULES

## 10.2.1 Introduction

The origin of the alarming environmental problems increasingly afflicting our planet are not due to fossil fuels per se, but rather to the strength of their conventional valence bond, since that strength has prohibited the achievement of full combustion during the past one hundred years of efforts. In fact, most of the atmospheric pollution caused by fossil fuels is due to "chunks" (such as dimers) of uncombusted fuel that are carcinogenic primarily because consisting of incomplete molecules.

In view of the above occurrence, this author proposed in Ref. [1] of 1998 a new chemical species that, by central assumption, is based on a bond much *weaker* than that of valence bonds so as to permit full combustion. For certain technical reasons indicated below 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*.

In this chapter we report industrial research with the investment of several millions of dollars from private corporations that followed the proposal of Santilli magnecules [1], and resulted in the identification of three distinct new gaseous fuels with the novel magnecular structure, all achieving the original objective of full combustion without toxic substances in the exhaust. Several other substances with magnecular structure are under study and they will be reported in specialized technical journals.

This chapter is organized as follows. We shall first present the hypothesis of Santilli magnecules; we shall then study the industrial methods needed for their production, the features to be detected experimentally, and the analytic equipment needed for the detection of the new species. We shall then study three distinct gaseous fuels with magnecular structure and outline their rather vast experimental verifications. We shall finally study the experimental evidence for magnecular structures in liquids and other related aspects.

To begin, let us recall that the only chemical species with a clearly identified bond which was known prior to the advent of hadronic chemistry was that of *molecules* and related *valence bonds*, whose identification dates back to the 19-th century, thanks to the work by Avogadro (1811), Canizzaro (1858), and several others, following the achievement of scientific measurements of atomic weights. Various candidates for possible additional chemical species are also known, such as the delocalized electron bonds. However, none of them possess a clearly identified attractive force clearly distinct from the valence.

Also, various molecular clusters have been studied in more recent times, although they either are unstable or miss a precise identification of their internal attractive bond.

An example of unstable molecular cluster occurs when the internal bond is due to an *electric polarization* of atomic structures, that is, a deformation from a spherical charge distribution without a net electric charge to an ellipsoidal distribution in which there is the predominance of one electric charge at one end and the opposite charge at the other end, thus permitting atoms to attract each other with opposite electric polarities. The instability of these clusters then follows from the known property that the smallest perturbation causes nuclei and peripheral electrons to reacquire their natural configuration, with the consequential loss of the polarization and related attractive bond.

An example of molecular clusters without a clear identification of their internal attractive bond is given by *ionic clusters*. In fact, ionized molecules have the *same positive charge* and, therefore, they *repel*, rather than attract, each other. As a result, not only the internal attractive bond of ionic clusters is basically unknown at this writing, but, when identified, it must be so strong as to overcome the repulsive force among the ions constituting the clusters.

In 1998, R. M. Santilli submitted in paper [1] (and then studied in details in monograph [2]) the hypothesis of a new type of stable clusters composed of molecules, dimers and atoms under a new, clearly identified, attractive internal bond which permits their industrial and practical use. The new clusters were called **magnecules** (patents pending) because of the dominance of magnetic effects in their formation, as well as for pragmatic needs of differentiations with the ordinary molecules, with the understanding that a technically more appropriate name would be *electromagnecules*.

The following terminology will be used herein:

1) The word *atom* is used in its conventional meaning as denoting a stable atomic structure, such as a hydrogen, carbon or oxygen, irrespective of whether the atom is ionized or not and paramagnetic or not.

2) The word *dimer* is used to denote part of a molecule under a valance bond, such as H–O, H–C, *etc.*, irrespective of whether the dimer is ionized or not, and whether it belongs to a paramagnetic molecule or not;

3) The word *molecule* is used in its internationally known meaning of denoting stable clusters of atoms under conventional, valence, electron bonds, such as  $H_2$ ,  $H_2O$ ,  $C_2H_2$ , *etc.*, irrespective of whether the molecule is ionized or not, and paramagnetic or not;

4) The word magnecule is used to denote stable clusters of two or more molecules, and/or dimers and/or atoms and any combination thereof formed by a new internal attractive bond of primarily magnetic type identified in detail in this chapter; the word magnecular will be used in reference to substances with the structure or features of magnecules;

5) The words *chemical species* are used to denote an essentially pure population of stable clusters with the same internal bond, thus implying the conventional chemical species of molecules as well as that of magnecules, under the condition that each species admits an ignorable presence of the other species.

In this chapter we study the theoretical prediction permitted by hadronic mechanics and chemistry of the new chemical species of magnecules and its experimental verifications, which were apparently presented for the first time by Santilli in memoir [1] of 1998.

## 10.2.2 The Hypothesis of Santilli Magnecules

The main hypothesis, studied in details in the rest of this Chapter, can be formulated as follows:

**DEFINITION 11.2.1** [1,2] (patented and international patents pending [5]): **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. Santilli magnecules are characterized by, or can be identified via the following main features:

I) Magnecules primarily exist at large atomic weights where not expected, for instance, at atomic weights which are ten times or more the maximal atomic weight of conventional molecular constituents;

II) Magnecules are characterized by large peaks in macroscopic percentages in mass spectrography, which peaks remain unidentified following a search among all existing molecules;

III) Said peaks admit no currently detectable infrared signature for gases and no ultraviolet signature for liquids other than those of the conventional molecules and/or dimers constituting the magnecule;

IV) Said infrared and ultraviolet signatures are generally altered (a feature called "mutation") with respect to the conventional versions, thus indicating an alteration (called infrared or ultraviolet mutation) of the conventional structure of dimers generally occurring with additional peaks in the infrared or ultraviolet signatures not existing in conventional configurations;
V) Magnecules have an anomalous adhesion to other substances, which results in backgrounds (blank) following spectrographic tests which are often similar to the original scans, as well as implying the clogging of small feeding lines with consequential lack of admission into analytic instruments of the most important magnecules to be detected;

VI) Magnecules can break down into fragments under sufficiently energetic collisions, with subsequent recombination with other fragments and/or conventional molecules, resulting in variations in time of spectrographic peaks (called time mutations of magnecular weights);

VII) Magnecules can accrue or lose during collision individual atoms, dimers or molecules;

VIII) Magnecules have an anomalous penetration through other substances indicating a reduction of the average size of conventional molecules as expected under magnetic polarizations;

IX) Gas magnecules have an anomalous solution in liquids due to new magnetic bonds between gas and liquid molecules caused by magnetic induction;

X) Magnecules can be formed by molecules of liquids which are not necessarily solvable in each other;

XI) Magnecules have anomalous average atomic weights in the sense that they are bigger than that of any molecular constituent and any of their combinations;

XII) A gas with magnecular structure does not follow the perfect gas law because the number of its constituents (Avogadro number), or, equivalently, its average atomic weight, varies with a sufficient variation of the pressure;

XIII) Substances with magnecular structure have anomalous physical characteristics, such as anomalous specific density, viscosity, surface tension, etc., as compared to the characteristics of the conventional molecular constituents;

XIV) Magnecules release in thermochemical reactions more energy than that released by the same reactions among unpolarized molecular constituents;

XV) All the above characteristic features disappear when the magnecules are brought to a sufficiently high temperature, which varies from species to species, called Curie Magnecular Temperature; in particular, combustion eliminates all magnetic anomalies resulting in an exhaust without magnecular features.

Magnecules are also called:

A) elementary when only composed of two molecules;

B) magneplexes when entirely composed of several identical molecules;

C) magneclusters when composed of several different molecules.

Finally, magnecules are called:

i) **isomagnecules** when having all single-valued characteristics and being reversible in time, namely, when they are characterized by isochemistry (see Chapter 9);

ii) **genomagnecules** when having all single-valued characteristics and being irreversible in time, namely, when they are characterized by genochemistry; and

iii) **hypermagnecules** when having at least one multi-valued characteristic and being irreversible in time, namely, when they are characterized by hyperchemistry.

The primary objective of this chapter is, first, to study the characteristic features of magnecules from a theoretical viewpoint, and then present independent experimental verifications for each feature.

All magnecules studied in this chapter are, strictly speaking, isomagnecules because single valued and reversible. The reader should be aware that all correct calculations implying single-valued irreversible chemical processes, such as chemical reactions in general, should be done with genomagnecules. Finally, all biological; structure will inevitably require the use of hypermagnecules as illustrated in Chapter 5.

The reader should keep in mind that magnegas, the new, clean combustible gas developed by the author [1,2,5], of Largo, Florida, has precisely a magnecular structure from which it derives its name. Nevertheless, we shall identify in this chapter other gases, liquids and solids with a magnecular structure.

By denoting the conventional valence bond with the symbol "-" and the new magnetic bond with the symbol " $\times$ ", examples of *elementary magnecules* in gases and liquids are respectively given by

$$\{H-H\} \times \{H-H\}, \{O-O\} \times \{O-C-O\}, etc.,$$
 (11.2.1a)

$$\{C_{15}-H_{20}-O\} \times \{C_{15}-H_{20}-O\}, etc.;$$
 (8.1b)

examples of magneplexes in gases and liquids are respectively given by

$${\rm H-H} \times {\rm H-H} \times {\rm H-H} \times {\rm H-H} \times \dots, \ etc., \qquad (11.2.2a)$$

$$\{H-O-H\} \times \{H-O-H\} \times \dots, etc.; \qquad (11.2.2b)$$

and examples of *magneclusters* are given by

$$\{H - H\} \times \{C - O\} \times \{O - C - O\} \times \{C = O\} \times \dots, etc.,$$
 (11.2.3*a*)

$$\{C_{13}-H_{18}-O\} \times \{C_{14}-H_{12}-O_3\} \times \{C_{15}-H_{20}-O\} \times \dots, etc.$$
 (11.2.3b)

A generic representation of a gas magnecules requires the presence of individual atoms and dimers, such as:

$$\{H-H\} \times \{C-O\} \times H \times \{H-O-H\} \times C \times \{H-O\} \times \dots, etc.$$
(11.2.4)

One of the most important features of magnecules is their anomalous release of energy in thermochemical reactions (Feature XIV of Definition 8.2.1), in view of its evident importance for the industrial development of new clean fuels such as magnegas (Sects. 7.10 and 7.11).

As we shall see in detail later on, this feature is crucially dependent on the existence within the magnecules of individual atoms, such as H, C and O, and/or individual unpaired dimers, such as H–O and H–C. In fact, at the breakdown of the magnecules due to combustion, these individual atoms and dimers coupled themselves into conventional molecules via known exothermic reactions such as

$$\begin{array}{l} \mathrm{H} + \mathrm{H} \rightarrow \mathrm{H}_{2} + 105 \ \mathrm{Kcal/mole}, \\ \mathrm{C} + \mathrm{O} \rightarrow \mathrm{CO} + 255 \ \mathrm{Kcal/mole}, \\ \mathrm{H} - \mathrm{O} + \mathrm{H} \rightarrow \mathrm{H}_{2}\mathrm{O} + 28 \ \mathrm{Kcal/mole}, \ etc., \end{array} \tag{11.2.5}$$

with consequential release during combustion of a large amount of energy that does not exist in fuels with a conventional molecular structure.

In reading this chapter, the reader should keep in mind that, in view of the above important industrial, consumer and environmental implications, a primary emphasis of the presentation is the study of magnecules with the largest possible number of *unpaired atoms and dimers*, rather than molecules.

In inspecting the above representation of magnecules, the reader should also keep in mind that their linear formulation in a row is used mainly for practical purposes. In fact, the correct formulation should be via *columns*, rather than rows, since the bond occurs between one atom of a given molecule and an atom of another molecule, as we shall see in detail later on.

# 10.2.3 The Five Force Fields Existing in Polarized Atoms

The attractive bond responsible for the creation of magnecules originates within the structure of individual *atoms*. Therefore, it is recommendable to initiate our study via the identification of all force fields existing in a conventional atomic structure.

The sole fields in the atomic structure studied by chemists prior to Ref. [1] were the intrinsic electric and magnetic fields of electrons and nuclei (see Fig. 11.6). It was proved a century ago that these fields can only produce valence bonds, thus explaining the reason why molecules were the only form of atomic clustering with a clear bond admitted by chemistry until recently.

Santilli's [1] main contribution has been the identification of a new force field in the atomic structure, which is sufficiently strong to permit a new chemical species.

Since the inception of atomic physics, the electron of the hydrogen atom (but not necessarily peripheral electrons of more complex atoms) has been assumed to have a spherical distribution, which is indeed the case for isolated and unperturbed atomic structures (see also Fig. 811.6).



*Figure 10.6.* A schematic view of the force fields existing in the hydrogen atom. Fig. 11.6.A depicts an isolated hydrogen atom in its conventional spherical configuration when at absolute zero degree temperature, in which the sole force fields are given by the electric charges of the electron and of the proton, as well as by the intrinsic magnetic moments of the same particles. Fig. 11.6.B depicts the same hydrogen atom in which the orbit of the peripheral electron is polarized into a plane. In this case there is the emergence of a fifth field, the magnetic dipole moment caused by the rotation of the electron in its planar orbit. Fig. 11.6.C depicts the same hydrogen atom under an external magnetic field which causes the transition from the spherical distribution of the peripheral electron as in Fig. 11.6.A to a new distribution with the same cylindrical symmetry as that of the external field, and such to offer magnetic polarities opposite to the external ones. In the latter case, the polarization generally occurs within a toroid, and reaches the perfectly planar configuration of Fig. 11.6.B only at absolute zero degree temperature or under extremely strong magnetic fields.

However, electrons are charged particles, and all charges rotating in a planar orbit create a magnetic field in the direction perpendicular to the orbital plane, and such to exhibit the North polarity in the semi-space seeing a counter-clockwise rotation (see Fig. q11.6..B).

A main point of Ref. [1] is that the distribution in space of electron orbits is altered by sufficiently strong external magnetic fields. In particular, the latter cause the transition from the conventional spherical distribution to a new distribution with the same cylindrical symmetry of the external field, and such to exhibit magnetic polarities opposite to the external ones (Fig. 11.6.C).

Therefore, the magnetic fields of atoms are not solely given by the intrinsic magnetic fields of the peripheral electrons and of nuclei because, under the application of a sufficiently strong external magnetic field, atoms exhibit the additional magnetic moment caused by a polarization of the electron orbits. This third magnetic field was ignored by chemists until 1998 (although not by physicists) because nonexistent in a conventional atomic state.

As a matter of fact, it should be recalled that orbits are naturally planar in nature, as established by planetary orbits, and they acquire a spherical distribution in atoms because of various quantum effects, e.g., uncertainties. Therefore, in the absence of these, all atoms would naturally exhibit five force fields and not only the four fields currently assumed in chemistry.

On historical grounds it should be noted that theoretical and experimental studies in physics of the hydrogen atom subjected to an external (homogeneous) magnetic field date to Schrödinger's times.

### **10.2.4** Numerical Value of Magnecular Bonds

In the preceding section we have noted that a sufficiently strong external magnetic field polarizes the orbits of peripheral atomic electrons resulting in a magnetic field which does not exist in a conventional spherical distribution. Needless to say, the same external magnetic fields also polarize the intrinsic magnetic moments of the peripheral electrons and of nuclei, resulting into *three net magnetic polarities* available in an *atomic* structure for a new bond.

When considering molecules, the situation is different because valence electrons are bonded in singlet couplings to verify Pauli's exclusion principle, as per our hypothesis of the *isoelectronium* of Chapter 9. As a result, their net magnetic polarities can be assumed in first approximation as being null. In this case, only two magnetic polarities are available for new bonds, namely, the magnetic field created by the rotation of paired valence electrons in a polarized orbit plus the intrinsic magnetic field of nuclei.

It should be noted that the above results persist when the inter-electron distance of the isoelectronium assumes orbital values. In this case the total intrinsic magnetic moment of the two valence electrons is also approximately null in average due to the persistence of antiparallel spins and, therefore, antiparallel magnetic moments, in which absence there would be a violation of Pauli's exclusion principle.

The calculation of these polarized magnetic moments at absolute zero degree temperature is elementary [1]. By using rationalized units, the magnetic moment  $M_{e-\text{orb}}$  of a polarized orbit of one atomic electron is given by the general quantum mechanical law:

$$M_{\text{e-orb.}} = \frac{q}{2m} L\mu, \qquad (11.2.6)$$

where L is the angular momentum,  $\mu$  is the rationalized unit of the magnetic moment of the electron, q = -e, and  $m = m_e$ .

It is easy to see that the magnetic moment of the polarized orbit of the isoelectronium with characteristics (4.25) coincides with that of one individual electron. This is due to the fact that, in this case, in Eq. (11.2.6) the charge in the numerator assumes a double value q = -2e, while the mass in the denominator also assumes a double value,  $m = 2m_e$ , thus leaving value (8.6) unchanged.



Figure 10.7. A schematic view of the magnetic fields of the isochemical model of the hydrogen molecule with isoelectronium assumed to be a stable quasi-particle. The top view represents the molecule at absolute zero degree temperature with polarization of the orbit in a plane, while the bottom view represents the molecule at ordinary temperature with a polarization of the orbit within a toroid. In both cases there is the disappearance of the *total intrinsic* magnetic moments of the electrons because they are coupled in the isoelectronium with antiparallel spin and magnetic moments due to Pauli's exclusion principle. The *lack* of contribution of the intrinsic magnetic moments of the electrons persists even when the isoelectronium has dimension much bigger than 1 fm, because the antiparallel character of the spins and magnetic moments persists, resulting in an average null total intrinsic magnetic moment of the electrons. Therefore, the biggest magnetic moment of the hydrogen molecule which can be obtained via polarizations is that of the electrons *orbits*. Note, as recalled in Sect. 9.2, the *oo*-shaped (also called figure eight) configuration has been recently proved in mathematics to be one of the most stable solutions of the *N*-body problem.

By plotting the various numerical values for the ground state of the hydrogen atom, one obtains:

$$M_{\text{e-orb.}} = M_{\text{isoe-orb.}} = 1,859.59\mu.$$
 (11.2.7)

By recalling that in the assumed units the proton has the magnetic moment 1.4107  $\mu$ , we have the value [1]:

$$\frac{M_{\text{e-orb.}}}{M_{\text{p-intr.}}} = \frac{1,856.9590}{1.4107} = 1,316.33,$$
(11.2.8)

namely, the magnetic moment created by the orbiting in a plane of the electron in the hydrogen atom is 1,316 times bigger than the intrinsic magnetic moment of the nucleus, thus being sufficiently strong to create a bond. It is evident that the *polarized magnetic moments at ordinary temperature* are smaller than those at absolute zero degrees temperature. This is due to the fact that, at ordinary temperature, the perfect polarization of the orbit in a plane is no longer possible. In this case the polarization occurs in a *toroid*, as illustrated in Fig. 8.2, whose sectional area depends on the intensity of the external field.

As an illustrative example, under an external magnetic field of 10 Tesla, an *isolated hydrogen atom* has a total magnetic field of the following order of magnitude:

$$M_{\text{H-tot.}} = M_{\text{p-intr.}} + M_{\text{e-intr.}} + M_{\text{e-orb.}} \approx 3,000\mu, \qquad (11.2.9)$$

while the same hydrogen atom under the same conditions, when a component of a *hydrogen molecule* has the smaller value

$$M_{\rm H_2-tot.} = M_{\rm p-intr.} + M_{\rm isoe-orb.} \approx 1,500\mu,$$
 (11.2.10)

again, because of the absence of the rather large contribution from the intrinsic magnetic moment of the electrons, while the orbital contribution remains unchanged.

The above feature is particularly important for the study of magnecules and their applications because it establishes the theoretical foundations for the presence of isolated atoms in the structure of magnecules since the magnetic bonds of isolated atoms can be at least twice stronger than those of the same atoms when part of a molecule.

An accurate independent verification of the above calculations was conducted by M.G. Kucherenko and A.K. Aringazin [3], who obtained the following value via the use of alternative models,

$$\frac{M_{\text{e-orb.}}}{M_{\text{p-intr.}}} \approx 1,315\mu. \tag{11.2.11}$$

Needless to say, the quantized value of the angular momentum of the ground state of the conventional (unpolarized) hydrogen atom is null, L = 0, thus implying a null magnetic moment, M = 0. This occurrence confirms the well known feature that the magnetic moment of the orbit of the peripheral electron of a conventional (unpolarized) hydrogen atom is null.

Consequently, expressions (8.6)-(8.11) should be considered under a number of clarifications. First, said expressions refer to the orbit of the peripheral electron under an external magnetic field which implies an evident alteration of the value of the magnetic moment. Note that this external magnetic field can be either that of an electric discharge, as in the PlasmaArcFlow reactors, or that of another polarized hydrogen atom, as in a magnetule. This occurrence confirms a main aspect of the new chemical species of magnetules, namely, that the plane polarization of the orbits of the peripheral atomic electron is stable if and only

if said polarization is coupled to another because, if isolated, the plane polarization is instantly lost due to rotations with recover the conventional spheroidal distribution of the orbits.

Moreover, expressions (11.2.6)-(11.2.11) refer to the angular momentum of the orbit of the peripheral electron *polarized in a plane*, rather than that with a spherical distribution as in the conventional ground state of the hydrogen atom. The latter condition, alone, is sufficient to provide a non-null quantized orbital magnetic moment.

Finally, the value L = 1 needed for expressions (11.2.6)-(11.2.11) can be obtained via the direct quantization of the plane polarization of a classical orbit. These aspects have been studied in detail by Kucherenko and Aringazin [2] and Aringazin [8] (see Appendix 8.A). These studies clarify a rather intriguing property mostly ignored throughout the 20-th century according to which, contrary to popular beliefs, the quantized angular momentum of the ground state of the hydrogen atom is not necessarily zero, because its value depends on possible external fields.

It is important to note that the magnetic polarizations herein considered are *physical notions*, thus being best expressed and understood via *actual orbits* as treated above rather than *chemical orbitals*. This is due to the fact that *orbits* are *physical entities* actually existing in nature, and schematically represented in the figures with standing waves, in semiclassical approximation. By contrasts, *orbitals are purely mathematical notions* given by probability density. As a result, magnetic fields can be more clearly associated with orbits rather than with orbitals.

Despite the above differences, it should be stressed that, magnetic polarizations can also be derived via the *orbitals* of conventional use in chemistry. For example, consider the description of an isolated atom via the conventional Schrödinger equation

$$H|\psi\rangle = \left(\frac{p^2}{2m} + V\right)|\psi\rangle = E|\psi\rangle, \qquad (11.2.12)$$

where  $|\psi\rangle$  is a state in a Hilbert space. Orbitals are expressed in terms of the probability density  $|\langle\psi| \times |\psi\rangle|$ . The probability density of the electron of a hydrogen atom has a spherical distribution, namely, the electron of an isolated hydrogen atom can be found at a given distance from the nucleus with the same probability in any direction in space.

Assume now that the same hydrogen atom is exposed to a strong external homogeneous and static magnetic field B. This case requires the new Schrödinger equation,

$$\left(\left(p - \frac{e}{c}A\right)^2/2m + V\right)|\psi'\rangle = E'|\psi'\rangle,\tag{11.2.13}$$

where A is vector-potential of the magnetic field B. It is easy to prove that, in this case, the new probability density  $|\langle \psi' | \times |\psi' \rangle|$  possesses a cylindrical symmetry

precisely of the type indicated above, thus confirming the results obtained on physical grounds. A similar confirmation can be obtained via the use of Dirac's equation or other chemical methods.

An accurate recent review of the Schrödinger equation for the hydrogen atom under external magnetic fields is that by A.K. Aringazin [8], which study confirms the toroidal configuration of the electron orbits which is at the foundation of the new chemical species of magnecules. A review of Aringazin studies is presented in Appendix 11 .A. As one can see, under an external, strong, homogeneous, and constant magnetic fields of the order of  $10^{13}$  Gauss =  $10^7$  Tesla, the solutions of Schrödinger equation of type (8.13) imply the restriction of the electron orbits within a single, small-size toroidal configuration, while the excited states are represented by the double-splitted toroidal configuration due to parity.

Intriguingly, the binding energy of the ground state of the H atom is much higher than that in the absence of an external magnetic field, by therefore confirming another important feature of the new chemical species of magnecules, that of permitting new means of storing energy within conventional molecules and atoms, as discussed later on in this chapter.

For magnetic fields of the order of  $10^9$  Gauss, spherical symmetry begins to compete with the toroidal symmetry, and for magnetic fields of the order of  $10^5$ Gauss or less, spherical symmetry is almost completely restored by leaving only ordinary Zeeman effects. This latter result confirms that the creation of the new chemical species of magnecules in gases as per Definition 8.2.1 requires very strong magnetic fields. The situation for liquids is different, as shown later on also in this chapter.

The magnetic polarization of atoms larger than hydrogen is easily derived from the above calculations. Consider, for example, the magnetic polarization of an isolated atom of oxygen. For simplicity, assume that an external magnetic field of 10 Tesla polarizes only the two peripheral valence electrons of the oxygen. Accordingly, its total polarized magnetic field of orbital type is of the order of twice value (8.9), *i.e.*, about 6,000  $\mu$ . However, when the same oxygen atom is bonded into the water or other molecules, the maximal polarized magnetic moment is about half the preceding value.

Note the dominance of the magnetic fields due to polarized electron *orbits* over the intrinsic *nuclear* magnetic fields. This is due not only to the fact that the former are 1,316 times the latter, but also to the fact that nuclei are at a relative great distance from peripheral electrons, thus providing a contribution to the bond even smaller than that indicated. This feature explains the essential novelty of magnecules with respect to established magnetic technologies, such as that based on *nuclear magnetic resonances*.

Note also that a main mechanism of polarization is dependent on an external magnetic field and the force actually providing the bond is of magnetic type.

Nevertheless, the ultimate origin is that of charges rotating in an atomic orbit. This illustrates that, as indicated in Sect. 11.2.1, the name "magnecules" was suggested on the basis of the predominant magnetic origin, as well as for the pragmatic differentiation with molecules without using a long sentence, although a technically more appropriate name would be "electromagnecules."

Needless to say, the polarization of the orbits is not necessarily restricted to valence electrons because the polarization does not affect the quantum numbers of any given orbit, thus applying for all atomic electrons, including those of complete inner shells, of course, under a sufficiently strong external field. As a consequence, the intensity of the magnetic polarization generally increases with the number of atomic electrons, namely, the bigger is the atom, the bigger is, in general, its magnetic bond in a magnecule.

Ionizations do not affect the existence of magnetic polarizations, and they may at best affect their *intensity*. An ionized hydrogen atom is a naked proton, which acquires a polarization of the direction of its magnetic dipole moment when exposed to an external magnetic field. Therefore, an ionized hydrogen atom can indeed bond magnetically to other polarized structures. Similarly, when oxygen is ionized by the removal of one of its peripheral electrons, its remaining electrons are unchanged. Consequently, when exposed to a strong magnetic field, such an ionized oxygen atom acquires a magnetic polarization which is similar to that of an unpolarized oxygen atom, except that it lacks the contribution from the missing electron. Ionized molecules or dimers behave along similar lines. Accordingly, the issue as to whether individual atoms, dimers or molecules are ionized or not will not be addressed hereon.

The magnetic polarizations here considered are also independent as to whether the substance considered is paramagnetic or not. This is evidently due to the fact that the polarization deals with the individual orbits of individual peripheral electrons, irrespective of whether paired or unpaired, belonging to a saturate shell or not. Therefore, the issue as to whether a given substance is paramagnetic or not will be ignored hereon.

Similarly, the polarizations here considered do not require molecules to have a net total magnetic polarity, which would be possible only for paramagnetic substances, again, because they act on individual orbits of individual atomic electrons.

We should also indicate that another verification of our isochemical model of molecular structures is the resolution of the inconsistency of the conventional model in predicting that all substances are paramagnetic, as illustrated in Figs. 1.4 and 1.5.

Recall that the atoms preserve their individualities in the conventional molecular model, thus implying the *individual* acquisition of a magnetic polarization

### 944



Figure 10.8. A schematic view of the resolution for the case of the water molecule of the inconsistent prediction of the conventional molecular model that water is paramagnetic (Fig. 1.14), as permitted by the Santilli-Shillady isochemical model of water molecule (Chapter 9). As one can see, the resolution is given by the impossibility for the water molecule to acquire a net magnetic polarity. Note the complexity of the geometry of the various magnetic fields which, according to ongoing research, apparently permits the first explanation on scientific record of the 105° angle between the two H–O dimers. The corresponding resolution for the case of the hydrogen is outlined in Fig. 9.5.

under an external field, with consequential net total magnetic polarities for all molecules which is in dramatic disagreement with experimental; evidence.

By comparison, in the isochemical molecular model the valence electrons are actually bonded to each other, with consequential *oo*-shaped orbit around the respective nuclei. This implies that the rotational directions of the *o*-branches are opposite to each other. In turn, this implies that magnetic polarizations are also opposite to each other, resulting in the lack of a net magnetic polarity under an external field, in agreement with nature (see Figs. 4.5 and 8.3 for more details).

### 10.2.5 Production of Magnecules in Gases, Liquids and Solids

At its simplest, the creation of magnecules can be understood via the old method of magnetization of a paramagnetic metal by induction. Consider a paramagnetic metal which, initially, has no magnetic field. When exposed to a constant external magnetic field, the paramagnetic metal acquires a permanent magnetic field that can only be destroyed at a sufficiently high temperature varying from metal to metal and called the *Curie Temperature*.

The mechanism of the above magnetization is well known. In its natural unperturbed state, the peripheral atomic electrons of a paramagnetic metal have a space distribution that results in the lack of a total magnetic field. However, when exposed to an external magnetic field, the orbits of one or more unpaired electrons are polarized into a toroidal shape with end polarities opposite to those of the external field.

This mechanism is called magnetic induction, and results in a stable chain of magnetically polarized orbits from the beginning of the metal to its end with polarities North-South/North-South/North-South/... This chain of polarizations is so stable that it can only be destroyed by high temperatures.

The creation of magnecules can be essentially understood with a similar polarization of the peripheral electron orbits, with the main differences that: no total magnetic polarization is necessary; the polarization generally apply to all electrons, and not necessarily to unpaired electrons only; and the substance need not to be paramagnetic.

To illustrate these differences, consider a diamagnetic substance, such as the hydrogen at its gaseous state at ordinary pressure and temperature. As well known, the hydrogen molecule is then a perfect sphere whose radius is equal to the diameter of a hydrogen atom, as illustrated in Fig. 11.9.A. The creation of the needed magnetic polarization requires the use of external magnetic fields capable, first, to remove the rotation of the atoms, as illustrated in Fig. 11.9.B, and then the removal of the internal rotations of the same, resulting in a planar configuration of the orbits as illustrated in Fig. 11.9 .C.

Once the above polarization is created in two or more hydrogen molecules sufficiently near each other, they attract each other via opposite magnetic polarities, resulting in the elementary magnecules of Fig. 11.10.A. Additional elementary magnecules can then also bond to each other, resulting in clusters with a number of constituents depending on the conditions considered.

A most efficient industrial production of gas and liquid magnecules is that via the *PlasmaArcFlow Reactors* [5]. As we shall see via the experimental evidence presented below, said reactors can produce an essentially pure population of gas and liquid magnecules without appreciable percentages of molecules directly detectable in the GC- or LC-MS.



Figure 10.9. A schematic view of the main mechanism underlying the creation of magnecules, here illustrated for the case of the hydrogen molecule. It consists in the use of sufficiently strong external magnetic fields which can progressively eliminate all rotations, thus reducing the hydrogen molecule to a configuration which, at absolute zero degrees temperature, can be assumed to lie in a plane. The planar configuration of the electron orbits then implies the manifestation of their magnetic moment which would be otherwise absent. The r.h.s. of the above picture outlines the geometry of the magnetic field in the immediate vicinity of an electric arc as described in the text for the case of hadronic molecular reactors (Chapter 12). Note the circular configuration of the magnetic field lines around the electric discharge, the tangential nature of the symmetry axis of the magnetic polarization of the hydrogen atoms with respect to said circular magnetic lines, and the consideration of hydrogen atoms at orbital distances from the electric arc  $10^{-8}$  cm, resulting in extremely strong magnetic fields proportional to  $(10^{-8})^{-2} = 10^{16}$  Gauss, thus being ample sufficient to create the needed polarization (see Appendix 8.A for details).

The reason for these results is the intrinsic geometry of the PlasmaArcFlow itself. Recall that this technology deals with a DC electric arc submerged within a liquid waste to be recycled. The arc decomposes the molecules of the liquid into its atomic constituents; ionizes the same; and creates a plasma of mostly ionized H, C and O atoms at about 3,500° K. The flow of the liquid through the arc then continuously removes the plasma from the arc following its formation. Said plasma then cools down in the surrounding liquid, and a number of chemical reactions take place resulting in the formation of magnegas which bubbles to the surface of the liquid where it is collected for industrial or consumer use.

To understand the creation of a new chemical species defined according to Sect. 11.2.1 as an essentially pure population of gas magnecules, recall that mag-



Figure 10.10. A schematic view of the simplest possible bi-atomic magnecule whose bond originates from the toroidal polarization of the orbits of peripheral atomic electrons. A first main difference with conventional molecular bonds is that, under sufficiently strong external magnetic fields, the magnecular bond may occur independently from the existence or not of valence electrons. Consequently, the two polarized atoms depicted in this figure can be arbitrarily chosen, while for conventional molecular bonds the atoms are restricted to verify known valence rules. Another major difference is that, by central conception to achieve full combustion for the case of fuels (see Section 11.1), the magnecular bond is much weaker than the molecular bond. In fact, due to its magnetic origin, the bond of this picture ceases to exist at a given temperature (the Curie Temperature) that, for the case of gaseous fuels with magnecular structure, it is usually given by the flame temperature. The main industrial as well as social result is that gaseous fuels with magnecular structure do achieve indeed total combustion without any toxic substance in its exhaust, something impossible for fuels with molecular structure, as proved by various cases studied in the subsequent sections of this chapter. Another implication also of major industrial and social relevance is that fuels with magnecular structure can be synthesized in such a way to be internally rich in oxygen (usually of liquid, rather than atmospheric origin) in order to replenish the atmospheric oxygen already depleted by fossil fuels, something equally impossible for fuels with molecular structure, as also studied later on in this chapter.

netic fields are inversely proportional to the square of the distance,

$$F_{\text{magnetic}} = \frac{m_1 m_2}{r^2}.$$
 (11.2.14)

Therefore, an atom in the immediate vicinity of a DC electric arc with 1,000 A and 30 V, experiences a magnetic field which is inversely proportional to the square of the *orbital* distance  $r = 10^{-8}$  cm, resulting in a magnetic field proportional to  $10^{16}$  units.



Figure 10.11. A schematic view of the simplest possible multiatomic magnecular bonds. Case A illustrates the elementary hydrogen magnecule. The subsequent case is that of four hydrogen atoms  $(H \times H) \times (H \times H)$  (or two hydrogen molecules  $H - H) \times (H - H)$ ) under a magnecular bond that has atomic weight very close to that of the helium. Therefore, the detection in a GC-MS scan of a peak with 4 a.m.u., by no means, necessarily identifies the helium because the peak could belong to the hydrogen magnecule. Case B illustrates a magnecule composed by a molecule and a dimer. Case C illustrates the hypothesis submitted in this monograph that the structure with 3 a.m.u. generally interpreted as a conventional "molecule" H<sub>3</sub> may in reality be a magnecule between a hydrogen molecule and an isolated hydrogen atom. This is due to the fact that, once the two valence electrons of the hydrogen molecule are bonded-correlated, they cannot admit the same valence bond with a third electron for numerous physical reasons, such as: the bond cannot be stable because the former is a Boson while the latter is a Fermion; the former has charge -2e while the latter has charge -e, thus resulting in a large repulsion; etc.

No conventional space distribution of peripheral atomic electrons can exist under these extremely strong magnetic fields, which are such to generally cause the polarization of the orbits of *all* atomic electrons, and not only those of valence type, as well as their essential polarization in a plane, rather than a toroid. As soon as two or more molecules near each other possessing such an extreme magnetic polarization are created, they bond to each other via opposing magnetic polarities, resulting in the elementary magnecule of Fig. 11.8.A.

Moreover, as shown earlier, isolated atoms have a magnetic field with an intensity double that of the same atom when belonging to a molecule. Therefore, as soon as created in the immediate vicinity of the electric arc, individual polarized atoms can bond to polarized molecules without any need to belong themselves to a molecule, as illustrated in Fig. 11.10.C.

Finally, recall that the PlasmaArcFlow is intended to destroy liquid molecules such as that of water. It then follows that the plasma can also contain individual highly polarized molecular fragments, such as the dimer H–O. The notion of gas magnecules as per Definition 8.2.1 then follows as referred to stable clusters of molecules, and/or dimers, and/or isolated atoms under an internal attractive bond among opposing polarities of the magnetic polarization of the orbits of peripheral electrons, nuclei and electrons when the latter are not coupled into valence bonds.

Effective means for the creation of an essentially pure population of *liquid* magnecules are given by the same PlasmaArcFlow Reactors. In fact, during its flow through the DC arc, the liquid itself is exposed to the same extreme magnetic fields as those of the electric arc indicated above. This causes the creation of an essentially pure population of liquid magnecules composed of highly polarized liquid molecules, dimers of the same liquid, and individual atoms, as established by LC-MS/UVD tests.

One way to create an essentially pure population of *solid magnecules* is given by freezing the new chemical species at the liquid level and then verifying that the latter persists after defrosting, as confirmed by various tests. Therefore, the case of solid magnecules is ignored hereon for simplicity.

By denoting with the arrow  $\uparrow$  the vertical magnetic polarity North-South and with the arrow  $\downarrow$  the vertical polarity South-North, and by keeping the study at the absolute zero degree temperature, when exposed to the above indicated extreme magnetic fields, the hydrogen molecule H–H can be polarized into such a form that the orbit of the isoelectronium is in a plane with resulting structure  $H_{\uparrow}-H_{\downarrow}$  (Fig. 11.7).

The elementary hydrogen magnecule can then be written

$$\{\mathbf{H}^{a}_{\uparrow} - \mathbf{H}^{b}_{\downarrow}\} \times \{\mathbf{H}^{c}_{\uparrow} - \mathbf{H}^{d}_{\downarrow}\}, \qquad (11.2.15)$$

where: a, b, c, d denote different atoms; the polarized hydrogen atom  $H^a_{\uparrow}$  is bonded magnetically to the polarized atom  $H^c_{\uparrow}$  with the South magnetic pole of atom a bonded to the North pole of atom c; and the North polarity of atom b is bonded to the South polarity of atom d (see, again, Fig. 8.5.A). This results in a strong bond due to the flat nature of the atoms, the corresponding mutual distance being very small and the magnetic force being consequently very large. Moreover, unlike the case of the unstable clusters due to electric polarization discussed in Sect. 11.2.1, the above magnetic bonds are very stable because motions due to temperature apply to the bonded couple (11.2.15) as a whole.

For other magnecules we can then write

$$\{\mathbf{H}_{\uparrow} - \mathbf{H}_{\downarrow}\} \times \{\mathbf{C}_{\uparrow} - \mathbf{O}_{\downarrow}\}; \tag{11.2.16}$$

or, more generally

$$\{H_{\uparrow} - H_{\downarrow}\} \times H_{\downarrow} \times \{C_{\uparrow} - O_{\downarrow}\} \times \{H_{\uparrow} - O_{\downarrow}\} \times \{H_{\uparrow} - C_{\downarrow} - A - B - C \dots\} \times \dots, (11.2.17)$$

where A, B, and C are generic atoms in a conventional molecular chain and the atoms without an indicated magnetic polarity may indeed be polarized but are not necessarily bonded depending on the geometric distribution in space.

Magnecules can also be formed by means other than the use of external magnetic fields. For instance, magnecules can be produced by electromagnetic fields with a distribution having a cylindrical symmetry; or by microwaves capable of removing the rotational degrees of freedom of molecules and atoms, resulting in magnetic polarizations. Similarly, magnecules can be formed by subjecting a material to a pressure that is sufficiently high to remove the orbital rotations. Magnecules can also be formed by friction or by any other means not necessarily possessing magnetic or electric fields, yet capable of removing the rotational degrees of freedom within individual atomic structures, resulting in consequential magnetic polarizations.

It is, therefore, expected that a number of substances which are today listed as of unknown chemical bond, may eventually result to have a magnecular structure.

Magnecules of type (8.15) may well have been detected in past mass spectrometric measurements, but believed to be the helium (because its molecular weight is very close to that of the helium). In fact, the same happens for the "molecule" H<sub>3</sub> which, in reality may be the magnecule of Fig. 11.10.C.

The destruction of magnecules is achieved by subjecting them to a temperature greater than the magnecules Curie Temperature which varies from magnecule to magnecule.

### **10.2.6** New Molecular Internal Bonds

As indicated in Sect. 11.2.2, and verified experimentally later on, the IR signatures of conventional molecules such as  $CO_2$  are mutated due to the appearance of two new peaks which do not exist for the conventional molecule. By recalling that peaks in the IR signature generally represent bonds, this evidence indicates the capability by the  $CO_2$  molecule to acquire new internal bonds in addition to those of conventional valence type.

The magnetic polarization at the foundations of magnecules predicts the existence of these new internal bonds and permits their quantitative study. Recall



Figure 10.12. A schematic view for the cases of C=O and O-C-O of the polarization of internal atomic electrons, while preserving conventional valence bonds, and the consequential creation of new bonds in conventional molecules which are not of valence type, as later on verified experimentally via IR scans.

that external magnetic fields can polarize the orbit of valence electrons, but cannot possibly break or alter valence bonds. Recall that, consequently, sufficiently strong external magnetic fields can polarize the orbits of all atomic electrons, and not only those of the valence electrons.

Consider then a conventional molecule such as C=O. When exposed to the extreme magnetic fields as existing in the PlasmaArcFlow technology, the orbits of all internal electrons can be polarized, individually, for the carbon and the oxygen, in addition to the polarization of the two pairs of valence bonds. Note that the planes of these polarizations need not be necessarily parallel to each other, because their relative orientation dependents on the geometry at hand.

One of the various possible geometries is that in which the plane of the polarization of the internal electrons is perpendicular to that of the two pairs of valence bonds. In this case we have the birth of a new bond of magnetic origin in the interior of a conventional molecule, which is evidently given by the alignment of the two polarities North-South and North-South in the carbon and oxygen, and the consequential attraction of opposite polarities of different atoms, as illustrated in Fig. 11.11.A.

For the case of the O–C–O molecule we can evidently have two internal bonds of magnetic type in addition to the valence bonds, which are also given by the alignment of the magnetic polarities, resulting in one new bond for the O–C dimer and a second one for the C–O dimer, as illustrated in Fig. 11.11.B.

As we shall see later on, the above new internal molecular bonds have major industrial and consumer implications, inasmuch as they permit the production of fuels capable of releasing under combustion anomalous amounts of energy, with consequential reduction of pollutants in the exhaust, as already proved by magnegas.

Needless to say, the creation of new internal bonds is an extreme case of IR mutation. In reality, numerous other weaker forms of mutations without the appearance of new peaks are possible and their study is left to the interested reader.

## **10.2.7** Main Features for the Detection of Magnecules

The experimental detection of gas magnecules requires the verification of a number of characteristic features of magnecules identified in Definition 8.2.1. In the following we focus the reader's attention on the main features of gas magnecules which must be verified via GC-MS tests. The remaining features will be considered later on.

### Feature 1: Appearance of unexpected heavy MS peaks.

Gas magnecules are generally heavier than the heaviest molecule in a given gas. Peaks in the GC-MS are, therefore, expected in macroscopic percentages with atomic weights bigger than the heaviest molecule. As a concrete example, the heaviest molecule in magnegas in macroscopic percentage is  $CO_2$  with 44 a.m.u. Therefore, GC-MS scans should only show background noise if set for over 44 a.m.u. On the contrary, peaks in macroscopic percentages have been detected in magnegas all the way to 1,000 a.m.u.

### Feature 2: Unknown character of the unexpected MS heavy peaks.

To provide the initial premises for the detection of magnecules, all MS peaks of feature 1 should result in being "unknown" following the computer search among all known molecules, usually including a minimum of 150,000 molecules. Evidently, this lack of identification of the peaks, *per se*, does not guarantee the presence of a new chemical species.

### Feature 3: Lack of IR signature of the unknown MS peaks.

Another necessary condition to claim the detection of magnecules is that the unknown MS peaks of feature 1 should have no IR signature other than that of the molecules and/or dimers constituents. This feature guarantees that said heavy peaks cannot possibly represent molecules, thus establishing the occurrence of a new chemical species. In fact, only very few and very light molecules can have such a perfect spherical symmetry to avoid IR detection, while such a perfect spherical symmetry is manifestly impossible for large clusters. In regard to the constituents we are referring to IR signatures, e.g., of the CO<sub>2</sub> at 44 a.m.u. in a cluster having 458 a.m.u.

### Feature 4: Mutation of IR signatures.

The infrared signatures of conventional molecules constituting magnecules are expected to be *mutated*, in the sense that the shape of their peaks is not the conventional one. As indicated in the preceding section, the mutations most important for industrial applications are those due to the presence of *new IR peaks* representing new internal bonds. Nevertheless, various other forms of IR mutations are possible.

### Feature 5: Mutation of magnecular weights.

While molecules preserve their structure and related atomic weight at conventional temperatures and pressures, this is not the case for gas magnecules, which can *mutate* in time, that is, change their atomic weight with consequential change of the shape and location of their MS peaks. Since we are referring to gases whose constituents notoriously collide with each other, magnecules can break-down during collisions into fragments which can then recombine with other fragments or other magnecules to form new clusters.

# Feature 6: Accretion or emission of individual atoms, dimers or molecules.

Magnecules are expected to experience accretion or emission of individual atoms, dimer or molecules without necessarily breaking down into parts. It follows that the peaks of Feature 1 are not expected to remain the same over a sufficient period of time for the same gas under the same conditions.

#### Feature 7: Anomalous adhesion.

Magnetically polarized gases have anomalous adhesion to walls of disparate nature, not necessarily of paramagnetic character, as compared to the same unpolarized gas. This is due to the well-known property that magnetism can be propagated by induction, according to which a magnetically polarized molecule with a sufficiently intense magnetic moment can induce a corresponding polarization of valence and/or other electrons in the atoms constituting the wall surface. Once such a polarization is created by induction, magnecules can have strong magnetic bonds to the indicated walls. In turn, this implies that the background of GC-MS following scans and conventional flushing are often similar to the scan themselves. As a matter of fact, backgrounds following routine flushing are often used to identify the most dominant magnecules. Notice that the magnetic polarization here considered does not require that the walls of the instrument are of paramagnetic type, since the polarization occurs for the orbits of arbitrary atoms.

Magnetically polarized gases additionally have mutated physical characteristics and behavior because the very notion of polarization of electron orbits implies physical alterations of a variety of characteristics, such as average size. Mutations of other characteristics are then consequential.

We should finally recall that the above features are expected to disappear at a sufficiently high temperature, evidently varying from gas to gas (Curie Temperature), while the features are expected to be enhanced at lower temperature and at higher pressure, and survive liquefaction.

# 10.3 THE UNAMBIGUOUS DETECTION OF MOLECULES AND MAGNECULES

## **10.3.1** Selection of Analytic Instruments

Current technologies offer an impressive variety of analytic instruments (see, e.g., Ref. [4]), which include: Gas Chromatography (GC), Liquid Chromatography (LC), Capillary Electrophoresis Chromatography (CEC), Supercritical Chromatography (SCC), Ion Chromatography (IC), Infrared Spectroscopy (IR), Raman Spectroscopy (RS), Nuclear Magnetic Resonance Spectroscopy (NMRS), X-Ray Spectroscopy (XRS), Atomic Absorption Spectroscopy (AAS), Mass Spectrometry (MS), Laser Mass Spectrometry (LMS), Flame Ionization Spectrometry (FIS), and others.

Only some of these instruments are suitable for the detection of magnecules and, when applicable, their set-up and use are considerably different than those routinely used with great success for molecules.

Among all available chromatographic equipment, that suitable for the detection of gas magnecules is the GC with column having ID of at least 0.32 mm operated according to certain criteria outlined below. By comparison, other chromatographs do not appear to permit the entrance of large magnecules, such as the CEC, or be potentially destructive of the magnecules to be detected, such as the IC.

Among all available spectroscopic equipment, that preferable is the IR, with the understanding that such an instrument is used in a *negative* way, that is, to verify that the magnecule considered has no IR signature. The RS may also result in being preferable in various cases, while other instruments, such as the NMRS do not appear to be capable of detecting magnecules despite their magnetic nature, evidently because NMRS are most effective for the detection of microscopic magnetic environment of H-nuclei rather than large structures. Other spectroscopic instruments have not been studied at this writing. In regard to spectrometric equipment, the most recommendable one is the low ionization MS due to the fact that other instruments seemingly destroy magnecules at the time of their detection. The study of other spectrometric equipment is left to interested researchers. Chemical analytical methods (i.e. via chemical reactions) to *detect* gas magnecules are probably not very effective since they necessarily destroy the magnecules in reaction.

As it is well known, when used individually, the above suggested instruments have considerable limitations. For instance, the GC has a great resolution of a substance into its constituent, but it has very limited capabilities to identify them. By comparison, the MS has great capabilities to identify individual species, although it lacks the ability to separate them.

For these reasons, some of the best analytic instruments are given by the combination of two different instruments. Among them, the most recommendable one is the GC combined with the MS, and denoted GC-MS. A similar occurrence holds for the IR combined to the GC-MS. As indicated since the early parts of this Chapter, the best instrument for the detection of both molecules and magnecules in gases is the GC-MS equipped with the IRD denoted GC-MS/IRD while that for liquids is the LC-MS equipped with UVD and denoted LC-MS/UVD.

Among a large variety of GC-MS instruments, only a few are truly effective for the detection of gas magnecules for certain technical reasons identified below. The instrument which has permitted the first identification of magnecules and remains the most effective at this writing (despite its considerable age for contemporary standards) is the GC Hewlett-Packard (HP) model 5890 combined with the MS HP model 5972 equipped with a large ID column and feeding line operated at the lowest temperature permitted by the instrument (about  $10^{\circ}$  C) and the longest elusion time (about 25 min).

A secondary function of the IRD is that of identifying the *dimers constituting* a magnecule, a task which can be fulfilled by various IRD. That which was used for the original discovery of magnecules and still remains effective (again, despite its age by current standards) is the IRD HP model 5965, when operated with certain criteria identified below.

A most insidious aspect in the detection of magnecule is the protracted use of any given instrument with great success in the detection of conventional molecules, and the consequential expectation that the same instrument should work equally well for the detection of magnecules, resulting in an analysis without any real scientific value because:

i) the species to be detected may not even have entered the instrument, as it is routinely the case for small syringes and feeding lines particularly for liquid magnecules (which can be so big as to be visible to the naked eye, as shown later on in this chapter); ii) the species to be detected may have been destroyed by the measurement itself, as it is routinely the case for instruments operated at very high temperature, or flame ionization instruments which, when used for combustible gases with magnecular structure, cause the combustion of magnecules at the very time of their detection; or

iii) the detection itself may create magnecules which do not exist in the original species, as it is the case of peaks with 3 a.m.u. discussed in Fig. 11.10.

In conclusion, the separation between a true scientific measurement and a personal experimental belief requires extreme scientific caution in the selection of the analytic instrument, its use, and the interpretation of the results.

### **10.3.2** Unambiguous Detection of Molecules

As it is well known, a gas molecule is identifiable by unique and unambiguous GC-MS peaks, which are distinctly different from those of any other gas molecule. In addition, this GC-MS identification can be confirmed by IRD peaks and related resonating frequencies, which are also distinctly different for different gas molecule. Additional confirmations are possible using other analytic methods, such as those based on average molecular weight, chemical reactions and other procedures.

The advent of the new chemical species of magnecules suggests a re-examination of these analytic methods and procedures so as to separate personal opinions from actual scientific identifications. Such a re-examination is warranted by the fact that, due to extended use, claims of specific molecular identifications are nowadays generally voiced via the use of only one analytic detector.

As an illustration, most contemporary analytic laboratories conduct chemical analyses on gases via the sole use of the IRD. However, infrared detectors do not identify complete molecules, since they can only identify the bond in their dimers. For instance, for the case of  $H_2O$ , the IRD does not identify the complete molecule, but only its dimer H–O.

This method of identification of molecules is certainly acceptable for gases whose lack of magnetic polarization has been verified by the analysts. However, the same method is highly questionable for gases of unknown origin. In fact, we shall soon show experimental evidence of clear IR signatures for molecules which have no MS identification at all, in which case the claim of such a molecule evidently has no scientific value.

The inverse occurrence is equally questionable, namely, the claim of a given molecule from its sole identification in the MS without a confirmation of exactly the same peak in the IRD. In fact, there are several MS peaks in magnetically polarized gases which may be easily identified with one or another molecule, but which have no IR signature at all at the MS value of the atomic weight, in which case the claim of molecular identification evidently has no scientific value. Note that the great ambiguities in the separate use of disjoint GC-MS and IRD. In fact, in this case there is no guarantee or visible evidence that exactly the same peak is jointly inspected under the MS and, separately, the IRD. In fact, a given molecule can be tentatively identified in the MS at a given a.m.u., while the same molecule may indeed appear in the IRD, although at a different value of a.m.u., in which case, again, the claim to have detected a given molecule is a personal experimental belief, rather than a scientific truth.

In conclusion, a serious scientific identification of any given molecule requires the joint use of at least two different analytic methods, both giving exactly the same result for exactly the same peak in a unique and unambiguous way, such as the detection via MS scans with unequivocal computer identifications, confirmed by IR scans without ambiguities, thus requiring the use of GC-MS equipped with IRD.

Additional ambiguities result from the rather widespread belief that molecules are the only possible chemical species in nature, in which case small deviations from exact identifications are generally ignored for the specific intent of adapting experimental evidence to pre-existing knowledge, rather than modifying old interpretations to fit new experimental evidence. This widespread tendency is also a reason why magnecules have not been identified until now.

As an illustration, suppose that: a GC-MS equipped with IRD detects a peak with 19 a.m.u.; said peak is identified by the MS search as the water molecule with 18 a.m.u.; and the IRD confirms the presence of the HO-dimer. Under these conditions, it is almost universally accepted in contemporary analytic laboratories that said peak with 19 a.m.u. represents the water molecule, and the spurious single a.m.u. is just an "impurity" or something to be ignored, in which case, however, we do not have a true scientific identification of the species.

In fact, it is well possible that the peak at 19 a.m.u. is constituted by a highly polarized water molecule magnetically bonded to one isolated hydrogen atom with structure

$$\{\mathbf{H}_{\perp} - \mathbf{O}_{\uparrow\uparrow} - \mathbf{H}_{\perp}\} \times \mathbf{H}_{\perp}.$$
 (11.3.1)

In this case, according to our terminology, the peak at 19 a.m.u. is a magnecule and *not* a molecule, even though the MS search gives 99.99% confidence and the IR search gives 100% confidence that the species is the ordinary water molecule. After all, the magnecular bond is transparent to current IR detection, then, the latter confirms an erroneous belief.

At any rate, no claim on the peak with 19 a.m.u. can be truly scientific or otherwise credibly, unless it explains in a specific and numerical way, without vague nomenclatures, how the single a.m.u. entity is attached to the water molecule.

Recall that the valence bond requires singlet couplings to verify Pauli's exclusion principle. As a consequence, coupled pairs of valence electrons are *Bosonic* states with zero spin. Under these conditions, no nomenclature suggesting one or another type of valence can credible explain the bonding of one single H atom to the H–O–H molecule because it would imply the bond of a Fermion with spin 1/2(the valence electron of the hydrogen) with a Boson (the coupled valence electron pair of the water), which bond is an impossibility well known in particle physics. By comparison, the magnecular hypothesis identifies the *attractive* character of the bond in a clear and unambiguous way, and then its numerical value (8.9).

The detection of *liquid molecules* has problems greater than those for gas molecules, because liquid magnecules can be so big to be visible by the naked eye, in which case only their conventional molecular constituents are generally permitted to enter current instruments, resulting again in a lack of real detection.

In conclusion, the separation in the identification of molecules between a true scientific process and a personal experimental belief requires extreme care before claiming that a certain peak characterizes a molecule, since possible ambiguities exist in all cases, from small to large atomic weights. In the final analysis, as stressed above, the difference between a molecule and a magnecule may be given by what is generally considered noise, or instrument malfunction.

The most unreassuring occurrence is that all GC-MS equipped with IRD identified by this author in the USA following a laborious search belong to military, governmental, or law enforcement institutions, and none of them was identified in commercial or academic laboratories. Therefore, the great majority of analytic laboratories lack the very instrument necessary for a final and unequivocal identification of a conventional *molecules*, let alone that of magnecules.

### **10.3.3** Unambiguous Detection of Magnecules

Since magnecules have properties very different from those of conventional molecules, the experimental detection of magnecules requires a special care. In particular, methods which have been conceived and developed for the detection of molecules are not necessarily effective for the detection of the different chemical species of magnecules precisely in view of the indicated differences.

The first indication of a possible gas magnecule is given by MS peaks with large atomic weight which cannot be explained via conventional molecular hypotheses. The second indication of a gas magnecule is given by the lack of identification of said heavy peaks in the MS following a search among all known molecules. A third indication of a gas magnecule then occurs when said unknown MS peak has no IR signature, except those of its constituents with much smaller atomic weight, which occurrence establishes the lack of a valence bond. Final identification of a gas magnecule requires the knowledge of the method used in the production of the gas and other evidence.

As it is the case also for molecules, a serious spectrographic analysis of magnecules requires GC-MS detectors necessarily equipped with IRD, because only such an instrument permits the direct test of the same peaks under both the MS and IR scan. Again, if the IRD operates separately from the GC-MS, the indicated joint inspection is not possible; the IRD can only detect ordinary molecular dimers; the experimental belief that the MS peak must be a molecule is then consequential.

As a concrete example verified later on with actual tests, consider the spectrographic analysis of magnegas. This is a light gas whose heaviest molecule in macroscopic percentages should be the  $CO_2$  at 44 a.m.u. Consider now an MS peak of magnegas at 481 a.m.u. It is evident that, while small deviations could be adapted to quantum chemistry, large deviations of such an order of magnitude cannot be reconciled with established knowledge in a credible way, thus permitting the hypothesis that the MS peak in a light gas with 481 a.m.u. can be a magnecule. The MS scan of the peak soon establishes the impossibility for the computer to identify the peak among all existing molecules. When the GC-MS is equipped with IRD, the analyst can scan the same peak with 481 a.m.u. under the IRD and detect no signature at the 481 a.m.u. value, the only IR signature being that at 44 a.m.u. of the  $CO_2$  as well as those of smaller molecules. The production of the gas under intense magnetic fields then confirm that the peak here considered at 481 a.m.u. is indeed a magnecule composed of a large number of ordinary light molecules, dimers and individual atoms, in accordance with Definition 8.2.1.

Note that the IRD scan in the above test has solely identified conventional molecules without any additional unknown. Yet, the conclusion that the gas considered is solely composed of molecule would be nonscientific for numerous reasons, such as: 1) magnetic bonds are transparent to IR scans with available frequencies; 2) there is no IR detection, specifically, at 481 a.m.u.; and 3) IRD do not detect molecules, but only dimers.

Therefore, even though the IRD has detected  $CO_2$  in the above test, the actual detection was for the C–O dimer, in which case the claim of the presence of the full  $CO_2$  molecule is a personal opinion, and not an experimental fact.

The anomalous energy content, weigh and other features of magnegas confirm the above conclusions, because the latter can only be explained by assuming that a certain percentage of IR counts is indeed due to complete molecules, while the remaining percentage is due to unpaired dimers trapped in the magnecules. The freeing of these dimers and atoms at the time of the combustion, and their recombination into molecules as in Eqs. (8.5) then explains the anomalous energy content.

In addition to the above basic requirements, numerous other precautions in the use of the GC-MS equipped with IRD are necessary for the detection of magnecules, such as: i) the MS equipment should permit measurements of peaks at ordinary temperature, and avoid the high temperatures of the GC-MS column successfully used for molecules;

ii) the feeding lines should be cryogenically cooled;

iii) the GC-MS/IRD should be equipped with feeding lines of at least 0.5 mm ID;

iv) the GC-MS should be set to detect peaks at large atomic weights usually not expected; and

v) the ramp time should be the longest allowed by the instrument, e.g., of at least 25 minutes.

It should be stressed that the lack of verification of any one of the above conditions generally implies the impossibility to detect magnecules. For instance, the use of a feeding line with 0.5 mm ID is un-necessarily large for a conventional light gas, while it is necessary for a gas with magnecular structure such as magnegas. This is due to the unique adhesion of the magnecules against the walls of the feeding line, resulting in occluded lines which prevent the passage of the most important magnecules to be detected, those with large atomic weight.

Similarly, it is customary for tests of conventional gases to use GC-MS with columns at high temperature to obtain readings in the shortest possible time, since conventional molecules are perfectly stable under the temperatures here considered. The use of such method would equally prevent the test of the very species to be detected, because, as indicated earlier, they have a characteristic Curie Temperature at which all magnetic features are lost. Magnecules are stable at ordinary temperatures and, consequently, they should be measured at ordinary temperatures.

Along similar lines, recall that GC-MS with a short ramp time are generally used for rapidity of results. Again, the use of such a practice, which has been proven by extensive evidence to be effective for molecules, prevents clear detection of magnecules. If the ramp time is not of the order of 25 minutes, *e.g.*, it is of the order of one minute, all the peaks of magnecules generally combine into one single large peak, as described below. In this case the analyst is generally lead to inspect an individual section of said large peak. However, in so doing, the analyst identifies conventional molecules constituting the magnecule, and not the magnecule itself.

When these detectors with short ramp times are equipped with IRD, the latter identify the infrared signatures of individual conventional molecules constituting said large unique peak, and do not identify the possible IR signature of the single large peak itself. Therefore, a GC-MS with short ramp time is basically unsuited for the detection of magnecules because it cannot separate all existing species into individual peaks. In conclusion, the experimental evidence of the above occurrences establishes the need in the detection of gas magnecules of avoiding, rather than using, techniques and equipment with a proved efficiency for molecules, thus avoiding the use of GC-MS without IRD, with short ramp time, high column temperatures, microscopic feeding lines, and other techniques. On the contrary, new techniques specifically conceived for the detection of magnecules should be worked out.

The conditions for scientific measurements of *liquid magnecules* via LC-MS/UVD are more stringent than those for gases, because of the great increase, in general, of the atomic weight of liquid magnecules which are generally much larger than the IR of conventionally used feeding lines, as shown below.

This implies the possible erroneous claim that magnecules do not exist because they are not detected by the LC-MS, while in reality the magnecule to be detected could not enter into at all into the instrument.

## 10.3.4 Apparent Magnecular Structure of H<sub>3</sub> and O<sub>3</sub>

As it is well known, chemistry has identified in GC-MS tests clusters with 3 a.m.u., which can only be constituted of three H atoms,  $H_3$ , while the familiar ozone  $O_3$  has been known since quite some time. These structures are generally assumed to be molecules, that is, to have a valence bond according to one nomenclature or another, although this author is aware of no in depth theoretical or experimental identification of the attractive force necessary to bond the third atom to a conventional molecule.

There are serious doubts as to whether such a conventional molecular interpretation will resist the test of time as well as of scientific evidence. To begin, a fundamental property of valence bonds is that valence electrons correlate in pairs. Since the  $H_3$  and  $O_3$  structures contain the molecules  $H_2$  and  $O_2$  in which all available valence electrons are already bonded in pairs, the belief that an additional third valence electron could be correlated to the preceding ones violates basic chemical knowledge on valence.

Moreover, we have stressed earlier that the assumption of a third valence electron bonded to a valence pair is in violation of basic physical knowledge, because it would require the bond of a Fermion (the third electron with spin 1/2) with a Boson (the singlet valence pair with spin 0) both possessing the same negative charge. Such a hypothetical bond under molecular conditions would violate various laws in particle physics, e.g., it would imply a necessary violation of Pauli-s exclusion principle since the assumed "triplet" of electrons would have *two* identical electrons in the same structure with the same energy.

In view of the above (as well as other) inconsistencies, we here assume that the familiar  $H_3$  and  $O_3$  clusters are magnecules consisting of a third H and O atom magnetically bonded to the conventional  $H_2$  and  $O_2$  molecules, respectively, along the structure of Fig. 11.11.C. Note that this assumption is fully in line with

962

Definition 8.2.1 according to which a magnecule also occurs when one single atom is magnetically bonded to a fully conventional molecule.

The plausibility of the above structure is easily illustrated for the case of  $O_3$ . In fact, the oxygen is known to be paramagnetic, and the ozone is known to be best created under an electric discharge. These are the ideal conditions for the creation of a magnetic polarization of the orbits of (at least) the paramagnetic electrons. The attraction of opposing magnetic polarities is then consequential, and so is the magnetic bond of the third oxygen to the oxygen molecule, resulting in the magnecule  $O_2 \times O$ .

The above magnecular interpretation of  $O_3$  is confirmed by various GC-MS detections of peaks with 32 a.m.u. in a magnetically treated gas originally composed of pure oxygen, in which case the sole possible interpretation is that of two magnetically bonded oxygen molecules, resulting in the magnecule  $O_2 \times O_2$ .

The plausibility of the magnecular interpretation is less trivial for the  $H_3$  structure since hydrogen is diamagnetic. Nevertheless, the assumption remains equally plausible by recalling that a central feature of the new chemical species of magnecules is that the magnetic polarization occurs at the level of each individual atom, and not at the level of a diamagnetic molecule, whose total magnetic moment remains null as illustrated in Fig. 11.7.

In particular, the magnecular interpretation of the MS peaks at 3 a.m.u. is numerical and without ambiguities. Recall that GC equipment works by ionizing molecules. When testing a hydrogen gas, a number of  $H_2$  molecules are separated into individual H atoms by the ionization itself. Moreover, the ionization occurs via the emission of electrons from a filament carrying current, which is very similar to that of the PlasmaArcFlow Reactors producing magnecules. Under these conditions, the filament of the GC can not only separate H-molecules but also polarize them when sufficiently close to the filament. Once such polarizations are created, their bond is a known physical law, resulting in the magnecule of Fig. 11.11, *i.e.* 

$$\{H_{\parallel} - H_{\uparrow}\} \times H_{\parallel}.$$
 (11.2.19)

As one can see, under the magnecular structure the bond is manifestly attractive, very strong, and numerically identified in Eq. (11.3.9). Other interpretations of the peak at 3 a.m.u. are here solicited, provided that, to be credible, they are not of valence type and the internal bond is identified in a clear, unambiguous, and numerical way.

The magnecular interpretation of  $H_3$  is confirmed by numerous GC-MS detections of a cluster with 4 a.m.u. in a magnetically treated gas which originally was composed by pure hydrogen, under which conditions such a peak can only be constituted by two hydrogen molecules resulting in the magnecule  $H_2 \times H_2$ illustrated in Fig. 11.11. It is an easy prediction that numerous peaks detected in contemporary GC-MS or LC-MS equipment may need a magnecular re-interpretation since, as indicated earlier, the method of detection itself can create magnecules. This is typically the case when the comparison of a given MS cluster with the actual peak of a given molecules contains additional lines.

As a specific example, when the peak representing a hexanal molecule (whose heaviest constituent has 100 a.m.u.) contains additional lines at 133 a.m.u., 166 a.m.u., and 207 a.m.u., it is evident that the latter lines cannot cluster with the hexanal molecule via valence bond. The plausibility of the magnecular interpretation is then evident.

For copies of the GC-MS scans mentioned in this section, which are not reproduced here for brevity, we suggest the interested reader to contact the author.

## 10.3.5 Need for New Analytic Methods

In closing, we should stress that the methods for the detection and identification of magnecules are at their infancy and numerous issues remain open at this writing (spring 2001). One of the open issues relates to several detections in magnegas of IR signatures apparently belonging to complex molecules, such as light hydrocarbons, while such molecules have not been identified in the MS scans. This occurrence creates the realistic possibility that certain complex magnecules may indeed have an IR signature in view of their size. More specifically, as indicated earlier, magnecules are assumed to be transparent to currently available IRD because their inter-atomic distance is expected to be 10<sup>4</sup> times smaller than the inter-atomic distance in molecules, thus requiring test frequencies which simply do not exist in currently available IRD.

However, such an argument solely applies for magnecules with small atomic weight, such as the elementary magnecules of Fig. 11.10. On the contrary, magnecules with heavy atomic weight may well have an IR signature and, in any case, the issue requires specific study.

This possibility is confirmed by the fact that magnegas is created via underliquid electric arcs whose plasma can reach up to  $10,000^{\circ}$  K. The insistence that light hydrocarbons could survive in these conditions, let alone be created, is not entirely clear. This direct observation is confirmed by the fact that no hydrocarbon has been detected in the combustion of magnegas. In fact, the cars running on magnegas (see next section) operate without catalytic converter. Direct analysis of the combustion exhaust show a *negative count* of hydrocarbons, that is, the exhaust contains less hydrocarbons than the local atmosphere which is used for basic calibration of the instrument.

In summary, we have a case in which light hydrocarbons are seemingly indicated by IR scans to exist in small percentages in magnegas, while no hydrocarbon has ever been identified in the MS scans, no hydrocarbon is expected to survive at the extreme temperatures of the electric arcs used for their production, and no hydrocarbon has been detected in the combustion exhaust.

These occurrences illustrate again that the identification of conventional molecules via the sole use of IR scans or, equivalently, the sole use of MS scans, is, in general, a mere personal opinion without scientific foundations.

## 10.4 MAGNEGASES<sup>T</sup>M, THE COMBUSTIBLE GASES WITH A MAGNECULAR STRUCTURE

# 10.4.1 PlasmaArcFlow<sup>TM</sup> Reactors for Recycling Liquid Waste into the Clean Burning Cost Competitive Magnegas Fuel

In this section we summarize the results of corporate research following the investment of several millions of dollars for the conception and industrial development by the author of the first new gaseous fuels with magnecular structure, today known as *Santilli Magnegases*<sup>TM</sup> (patented and international patents pending [5]), verifying the following main conditions:

1) Achievement of full combustion without any toxic content in the exhaust, thanks to its magnecular structure (Section 11.1.1);

2) Achievement of exhaust rich in breathable oxygen originating from liquids (rather than from our atmosphere) so as to replenish the oxygen depleted by fossil fuel combustion and converted into excess  $CO_2$ ;

3) Have a thermodynamical equivalence with natural gas so that all equipment running on natural gas (cars, electric generators, furnaces, etc.) can also run on magnegas without structural modifications;

4) Be lighter than air and have a natural scent so that in case of leaks the gas can be easily detected and rises for safety;

5) Be synthesized via the recycling of liquid waste (such as automotive liquid wastes, city, farm or ship sewage, etc.), so as to decrease the environmental problems caused by the latter;

6) Be cost competitive with respect to fossil fuels thanks to a highly efficient and non-contaminant production process;

7) Permit the achievement of fuel independence from crude oil (petroleum) thanks to the continuous local availability as feedstock, for instance, of city sewage 24 hours per day.

The term "magnegases" is today referred to all gaseous fuels possessing Santilli's magnecular structure. from now on we shall study in this section a specific type of "magnegas" obtained via a new combustion of carbon obtained via a submerged electric arc. Consequently, the type of magnegas treated in this section contains carbon. other types of magnegases without carbon will be studied in the next sections.



Figure 10.13. Picture of a 250 Kw Santilli's Hadronic Reactor (also called PlasmaArcFlow Reactor) with the panels of its completely automatic and remote controls, to recycle liquid waste into magnegas usable for any fuel application, a large amount of heat and carbonaceous precipitates used to produce the electrodes. This Reactor can produce up to 5000,000 scf (140 millions liters) of magnegas per week of 24 hours work per day corresponding to 3,000 gasoline gallon equivalent (11,000 gasoline liter equivalent) of magnegas per week computed on the basis that: 1) Gasoline contains about 110,000 BTU/g (about 29,000 BTU/liter); 2) Magnegas has the low energy content of 750 BTU/scf (26 BTU/liter); and 3) the "gasoline gallon equivalent" is given by about 150 scf of magnegas ("gasoline liter equivalent" is given by about 29 liters of magnegas). PlasmaArcFlow reactors are completely self-contained. Consequently, they release no solid, liquid or gas to the environment and cause no noise or odor pollution (see website [5b] for details).

The equipment that has been developed for the production of type of magnegas here considered is given by *Santilli's hadronic reactors of molecular type* (Class III), also known as PlasmaArcFlow<sup>TM</sup> Reactors (patented and international patents pending [5]), that were first built by the author in 1998 in Florida, U.S.A., , and are now in regular production and sale the world over (see the figures and web site [5b] for pictures).

PlasmaArcFlow Reactors use a submerged DC electric arc between carbonbase electrodes to achieve the complete recycling of essentially any type of (nonradioactive) liquid waste into the clean burning magnegas fuel, heat usable via exchangers, and carbonaceous precipitates used for the production of electrodes. The reactors are ideally suited to recycle antifreeze waste, oil waste, sewage, and other contaminated liquids, although they can also process ordinary fresh water. The best efficiency is achieved in these reactors for the recycling of carbon-rich liquids, such as crude oil or oil waste. The new PlasmaArcFlow technology is essentially based on flowing liquids through a submerged DC arc with at least one consumable carbon electrode (see Figures 11.8 and 11.9). The arc decomposes the liquid molecules and the carbon electrode into a plasma at about  $5,000^{\circ}C$ , which plasma is composed of mostly ionized H, O and C atoms. The technology moves the plasma away from the electric arc immediately following its formation, and controls the recombination of H, O and C into magnegas, that bubbles to the surface where it is collected with various means. Other solid substances generally precipitate at the bottom of the reactor where they are periodically collected.

Since magnegas is formed under the extremely intense magnetic fields at atomic distances from the electric arc, its chemical structure is that of all possible magnecules with increasing atomic mass that can be formed from the H, C and O atoms, such as

$$H - H, \quad H \times H, \quad (H - H) \times H \quad H \times H \times H;$$
  

$$C - H, \quad C \times H, \quad (C - H) \times H, \quad C - O,$$
  

$$C \times O, \quad C \times (O - O), \quad etc. \quad (11.4.1)$$

where we should note that the bond between C and O can be single, double, and triple valence type as well as of magnecular nature.

When reduced to *atomic* (rather than molecular) percentages, magnegas produced from pure water is composed of about

$$66\% H, 22\% O, 11\% C.$$
 (11.4.2)

As we shall see in this section, under GC-MS/IRD detectors magnegas shows peaks from 2 amu to 1,000 amu even when produced from pure water. To understand the anomaly ands the *necessity* of a new chemical species to avoid nonscientific beliefs, the reader should be aware that the maximal molecular species predicted by quantum chemistry for magnegas produced from water is  $CO_2$  with 44 amu.

Chemical structure (11.3.1) also explains the capability of magnegas to have combustion exhaust without any toxic components, while being rich of breathable oxygen up to 14% and more (see later on). In fact, the combustion exhaust of magnegas are given by

$$50 - 55\% H_2 O$$
,  $12 - 14\% O_2$ ,  $5 - 7\% CO_2$ , atmospheric gases. (11.4.3)

where the  $CO_2$  content originates from the combustion of conventional carbon monoxide, that of triple bonded nature  $\equiv O$  and the stochiometric ratio magnegas/atmosphere is taken into consideration.

the availability in the exhaust of a ;large percentage of breathable oxygen is primarily due to the magnecular bond of oxygen with other species that breaks



Figure 10.14. Picture of a 50 Kw Santilli's Hadronic Reactor (PlasmaArcFlow Recycler) mounted on a trailer for mobility to conduct test recycling where liquid wastes are located. This recycler can produce up to 84,000 scf (up to 2.4M liters) of magnegas per week corresponding to about 560 gasoline gallon equivalent (2,100 gasoline liter equivalent) of magnegas per week (see website [5b] for details).

down at the Magnegas Curie temperature generally coinciding with the flame temperature at which all bonds of magnetic origin cease to exhaust. consequently, magnegas exhaust is solely composed of conventional molecules without any magnecular content.

The large percentage in the exhaust of breathable oxygen is also due to the conventional single C-O and double bonded species C = O that are unstable and can decompose into gaseous oxygen and carbon precipitate when the combustion is at atmospheric pressure (because high pressure C - O and C = O can turn into  $C \equiv O$ ).

the efficiency of Santilli's hadronic reactor of Class III is very high because their primary source of energy is given by a new type of highly efficient and clean combustion of carbon, releasing energy that is at last 30 times the electric energy used by the arc.

In fact, we have the following *Scientific Efficiency* (SE) of PlasmaArcFlow Reactors that is evidently always *smaller* than one due to the conservation of the energy and the inevitable dispersions

$$SE = \frac{E_{tot}^{out}}{E_{tot}^{in}} = \frac{(E_{MG} + E_{heat})}{(Earc + E_{carbon} + E_{unknown})} < 1,$$
(11.4.4)

where  $E_{MG}$  is the combustion energy contained in magnegas,  $E_{heat}$  is the heat acquired by the liquid feedstock and the vessel, Earc is the electric energy used

by the arc,  $E_{carbon}$  is the energy produced by the combustion of carbon in the plasma, and  $E_{unknown}$  is an unknown source of energy due to the fact that the sum  $E_{arc} + E_{carbon}$  cannot explain the total energy output (see later on in this section and the next chapter).

At the same time we have the following *Commercial Efficiency* (CE) given by the preceding one *without* the inclusion of the energy produced by the carbon combustion because the carbon content of the liquid feedstock generally brings an *income*, rather than a cost, since it is contained in the liquid waste to be, and without the unknown source of energy since it also carries no cost recycled

$$CE = \frac{E_{tot}^{out}}{E_{tot}^{in}} = \frac{(E_{MG} + E_h eat)}{Earc} >> 1, \qquad (11.4.5)$$

which value is much bigger than one because, as indicated above, the energy caused by the combustion of carbon in the plasma under the electric arc and the unknown energy are a large multiple of the electric energy used by the arc.

When operated at atmospheric pressure, at 50 Kw power and at ambient temperature, the above commercial efficiency has a minimum value of about 5. However, the efficiency of Santilli's hadronic reactors increases (nonlinearly) with the increase of pressure, power and operating temperature and can assume rather high value. For instance, when operating a PlasmaArcFlow Recycler at about 150 psi (10 bars), 300 Kw and  $275^{\circ}F$  ( $125^{\circ}C$ ), the commercial efficiency can be of the order of 30, that is, per each unit of electric energy used by the arc, the reactor produces 30 times that energy in a combination of energy contained in magnegas and usable heat.

The above very high commercial efficiency of PlasmaArcFlow reactors illustrates the reason why magnegas is cost competitive with respect to all available fossil fuels.

By comparison, one should note that, in other methods based on underwater arcs, the stationary character of the plasma within the arc implies the creation of large percentages of  $CO_2$  resulting in a  $CO_2$  content of the exhaust much greater than that of gasoline and natural gas, measured by the author to be of the order of 18%. The resulting fuel is then environmentally unacceptable since  $CO_2$  is responsible for the green house effect.

Recall that the primary source of the large glow created by underwater arcs is the recombination of H and O into  $H_2O$  following its separation. This recombination is the reason for the low efficiency of underwater arcs and consequential lack of industrial development until recently.

By comparison, the PlasmaArcFlow causes the removal of H and O from the arc immediately following their creation, thus preventing their recombination into  $H_2O$ , with consequential dramatic increase of the efficiency, that is, of the volume of combustible gas produced per Kwh.



Figure 10.15. A picture of a Ferrari 308 GTSi 1980 and two Honda Civic cars converted by the author to operate with the new clean burning magnegas without catalytic converter, yet surpassing all EPA exhaust requirements, having no carcinogenic or other toxic substance in the exhaust, reducing of about 50% the  $CO_2$  emission due to gasoline combustion, reducing the operating temperature of about 25%, and emitting in the exhaust 10% to 14% breathable oxygen (see website [5b] for details).

A Ferrari 308 GTS, an SUV, two Honda and other automobiles have been converted by the author to operate on magnegas. One of these vehicles has been subjected to intensive tests at an EPA certified automotive laboratory in Long Island, New York reviewed in details in the next subsection, which tests have established that magnegas exhaust surpasses all EPA requirements without catalytic converter, and confirmed data (11.3.3).

In addition to the production of magnegas as a fuel, the PlasmaArcFlow Reactors can be viewed as the most efficient means for producing a new form of hydrogen, called MagneHydrogen<sup>TM</sup>, a carbon-free version of magnegas, with energy content and output greater than the conventional hydrogen, and at a cost smaller than that of the latter (see next section).


Figure 10.16. A picture of a Chevrolet Suburban SUV 1992 converted by the author to operate as a bifuel gasoline/magnegas with a switch on the dashboard permitting to pass from one fuel to the other while driving. Bifuel cars are produced by numerous carmakers to operate on gasoline and natural gas. The same cars can operate on magnegas (in place of natural gas) with the sole adjustment of the pressure regulator to optimize the stochiometric ratio air/fuel, since the latter for magnegas is much smaller than that for natural gas because magnegas is very rich internally in oxygen, thus requiring a fraction of the air needed by natural gas to operate. These bifuel cars are ideally suited for the magnegas technology because, when magnegas runs out, one can still reach the magnegas refilling station on gasoline (see website [5b] for details).

## 10.4.2 Surpassing by Magnegas Exhaust of EPA Requirements without Catalytic Converter

As indicated above, while the chemical composition of magnegas is new, the chemical composition of magnegas combustion exhaust is fully conventional, and it has been measured with accuracy.

The tests were conducted by an EPA accredited automotive laboratory of Long Island, new York, on a Honda Civic Natural Gas Vehicle (NGV) VIN number 1HGEN1649WL000160 (the white car of Fig. 11x10), produced in 1998 to operate with Compressed Natural Gas (CNG). The car was purchased new in 1999 and converted to operate on Compressed MagneGas (CMG) in early 2000. All tests reported in this section were done with magnegas produced by recycling antifreeze waste. The conversion from CNG to CMG was done via:

1) the replacement of CNG with CMG in a 100 liter tank at 3,600 psi which contains about 1,000 cf of magnegas;

2) the disabling of the oxygen sensor because magnegas has about 20 times more oxygen in the exhaust than natural gas, thus causing erroneous readings by the computer set for natural gas; and

3) installing a multiple spark system to improve magnegas combustion.

The rest of the vehicle was left unchanged, including its computer.

Comparative tests on performance (acceleration, full load, etc.) have established that the output power of the vehicle operating on compressed magnegas is fully equivalent to that of the same car operating on compressed natural gas.

Comparative tests on consumption also indicate similar results. In fact, measurements of magnegas consumption per hour in ordinary city driving were conducted with the following results:

| TANK CAPACITY:  | 1,096 cf at 3,500 psi, |          |
|-----------------|------------------------|----------|
| TOTAL DURATION: | about 2.5 hours,       | (11.4.6) |
| Consumption:    | about 7 cf/minute.     |          |

As one can see, a magnegas pressure tank of 1,500 cf at 5,000 psi would provide a range of about 4 hours, which is amply sufficient for all ordinary commuting and travel needs. Measurements of magnegas consumption rate per mile on highway are under way, and they are expected to yield essentially the same results holding for natural gas, namely,

Preliminary measurements of magnegas combustion exhaust were conducted by the laboratory *National Technical Systems, Inc.*, of Largo, Florida, resulting in the following exhaust composition under proper combustion:

| WATER VAPOR:<br>Oxygen:<br>Carbon dioxide: | 50% - 60%,<br>10% - 12%,<br>6% - 7%, | (11.4.8) |
|--|--------------------------------------|----------|
| BALANCE:                                   | atmospheric gases,                   | ( -)     |
| HYDROCARBONS, CARBON MONOXIDE,             |                                      |          |
| NITROGEN OXIDES:                           | in parts per million (ppm).          |          |

Detailed magnegas exhaust measurements were then conducted at the EPA Certified, Vehicle Certification Laboratory *Liphardt & Associates* of Long Island, New York, under the Directorship of *Peter di Bernardi*, via the Varied Test Procedure (VTP) as per EPA Regulation 40-CFR, Part 86.

These EPA tests consisted of three separate and sequential tests conducted in November 2000 on a computerized dynamometer, the first and the third tests using the vehicle at its maximal possible capability to simulate an up-hill travel at 60 mph, while the second test consisted in simulating normal city driving.

Three corresponding bags with the exhaust residues were collected, jointly with a fourth bag containing atmospheric contaminants. The final measurements expressed in grams/mile are given by the average of the measurements on the three EPA test bags, less the measurements of atmospheric pollutants in the fourth bag.

The following three measurements were released by Liphardt & Associates:



Figure 10.17. [8] A picture of the Magnegas Refilling Station, consisting of a standard compressor as used for natural gas and pressure bottles. The simplicity of this station should be compared with the complexity of corresponding stations for liquid hydrogen. Note that the station depicted in this figure allows current distributors of fuel, such as gasoline stations, to become fuel producers. The refill is achieved by connecting the a pressure bottle with a pressure tank in the trunk of the car; it is faster than the refill with gasoline; and it is much safer than the latter because gasoline, being liquid, spills and explodes if ignited, while magnegas, being a gas, does not spill and if ignited, burns fast in air without explosion (see website [5b] for details).

#### 1) Magnegas exhaust measurements with catalytic converter:

| Hydrocarbons:    | 0.026 grams/mile, which is $0.063$ of the EPA    |                |
|------------------|--|----------------|
|                  | standard of 0.41 grams/mile;                     |                |
| CARBON MONOXIDE: | 0.262 grams/mile, which is $0.077$ of the EPA    |                |
|                  | standard of 3.40 grams/mile;                     |                |
| NITROGEN OXIDES: | 0.281  grams/mile, which is $0.28  of the EPA$   | $(11 \ 4 \ 0)$ |
|                  | standard of 1.00 grams/mile;                     | (11.4.9)       |
| CARBON DIOXIDE:  | 235  grams/mile, corresponding to about $6%$ ;   |                |
|                  | there is no EPA standard on $CO_2$ at this time; |                |
| OXYGEN:          | 9.5% to $10%$ ; there is no EPA standard for     |                |
|                  | oxygen at this time.                             |                |

The above tests have established the important feature that magnegas exhaust with catalytic converter imply a reduction of about 1/15 of current EPA requirement.

2) Magnegas exhaust measurements without catalytic converter in the same car and under the same conditions as (1):

| Hydrocarbons:    | 0.199  grams/mile, which is $0.485  of the EPA$ |                 |
|------------------|---|-----------------|
|                  | standard of 0.41 grams/mile;                    |                 |
| CARBON MONOXIDE: | 2.750  grams/mile, which is $0.808  of the EPA$ |                 |
|                  | standard of 3.40 grams/mile;                    | $(11 \ 4 \ 10)$ |
| NITROGEN OXIDE:  | 0.642  grams/mile, which is $0.64  of the EPA$  | (11.4.10)       |
|                  | standard of 1.00 grams/mile;                    |                 |
| CARBON DIOXIDE:  | 266  grams/mile, corresponding to about $6%$ ;  |                 |
| OXYGEN:          | 9.5% to $10%$ .                                 |                 |

As a result of the latter tests, the laboratory Liphardt & Associates released the statement that magnegas exhaust surpasses the EPA requirements without the catalytic converter. As such, magnegas can be used in old cars without catalytic converter while meeting, and actually surpassing EPA emission standards.

# 3) Natural gas exhaust measurements without catalytic converter in the same car and under the same conditions as (1):

| Hydrocarbons:    | 0.380  grams/mile, which is $0.926  of the EPA$ |           |
|------------------|---|-----------|
|                  | standard of 0.41 grams/mile;                    |           |
| CARBON MONOXIDE: | 5.494  gram/mile, which is $1.615  of the EPA$  |           |
|                  | standard of 3.40 grams/mile;                    |           |
| NITROGEN OXIDES: | 0.732  grams/mile, which is $0.73  the EPA$     | (11.4.11) |
|                  | standard of 1.00 grams/mile;                    | . ,       |
| CARBON DIOXIDE:  | 646.503 grams/mile, corresponding               |           |
|                  | to about 9%;                                    |           |
| OXYGEN:          | 0.5% to $0.7%$ .                                |           |

The latter tests established the important property that the combustion of natural gas emits about 2.5 times the  $CO_2$  emitted by magnegas without catalytic converter. Note that, as well known, natural gas exhaust without catalytic converter does not meet EPA requirements.

As an additional comparison for the above measurements, a similar Honda car running on indolene (a version of gasoline) was tested in the same laboratory with the same EPA procedure, resulting in the following data:

# 4) Gasoline (indolene) exhaust measurements conducted on a two liter Honda KIA:

| Hydrocarbons:    | 0.234  grams/mile equal to  9  times      |           |
|------------------|---|-----------|
|                  | the corresponding magnegas emission;      |           |
| CARBON MONOXIDE: | 1.965  grams/mile equal to $7.5  times$   |           |
|                  | the corresponding magnegas emission;      |           |
| NITROGEN OXIDES: | 0.247  grams/mile equal to $0.86  times$  | (11.4.12) |
|                  | the corresponding magnegas emission;      |           |
| CARBON DIOXIDE:  | 458.655  grams/mile equal to  1.95  times |           |
|                  | the corresponding of magnegas emission,   |           |
| OXYGEN:          | No measurement available.                 |           |

#### 974



Figure 10.18. A picture of the readings of a 4-ways exhaust analyzer testing the exhaust of the Ferrari 308 GTSi of a preceding picture operating on magnegas "without" catalytic converter. Note: the presence of 14% breathable oxygen in the exhaust; about half the  $CO_2$  produced by the same car when running on gasoline; the very few detected hydrocarbons originate from engine oil seeping through the piston rings because magnegas "cannot" contain hydrocarbons since it is synthesized at the 5,000°C of the arc at which temperature no hydrocarbon can survive; the very small content of CO in the exhaust is due to poor combustion because CO is fuel for magnegas, while it is a byproduct of the combustion for fossil fuels, as a result of which detecting CO in the exhaust of a car running on gasoline (see website [5b] for details).

The above data establish the environmental superiority of magnegas over natural gas and gasoline. The following comments are now in order:

1) Magnegas does not contain (heavy) hydrocarbons since it is created at 3,500° K. Therefore, the measured hydrocarbons are expected to be due to combustion of oil, either originating from magnegas compression pumps (thus contaminating the gas), or from engine oil.

2) Carbon monoxide is fuel for magnegas (while being a combustion product for gasoline and natural gas). Therefore, any presence of CO in the exhaust is evidence of insufficient combustion.



Figure 10.19. An illustration of the city part of the reported EPA test according to Regulation 40-CFR, Part 86, conducted at the Vehicle Certification Laboratory Liphardt & Associates of Long Island, New York on a Honda Civic Natural Gas Vehicle converted to magnegas by the author.. The first three diagrams illustrate the very low combustion emission of magnegas in city driving, by keeping in mind that most of measured emission is due to the heavy duty, hill climbing part of the EPA test. The fourth diagram on nitrogen oxides is an indication of insufficient cooling of the engine. The bottom diagram indicates the simulated speed of the car versus time, where flat tracts simulate idle portions at traffic lights.

3) The great majority of measurements originate from the first and third parts of the EPA test at extreme performance, because, during ordinary city traffic, magnegas exhaust is essentially pollutant free [5].

4) Nitrogen oxides are not due, in general, to the fuel (whether magnegas or other fuels), but to the temperature of the engine and other factors, thus being an indication of the quality of its cooling system. Therefore, for each given fuel, including magnegas, NOx's can be decreased by improving the cooling system and via other means.

5) The reported measurements of magnegas exhaust do not refer to the best possible combustion of magnegas, but only to the combustion of magnegas in a vehicle whose carburization was developed for natural gas. Alternatively, the test was primarily intended to prove that magnegas is interchangeable with natural gas without any major automotive changes, while keeping essentially the same



Figure 10.20. It is generally ignored that cruiseships leave a trail of marine death since they release in the ocean an average of 100,000 gallons of highly contaminated liquid wastes per day. The magnegas technology [5] was developed to resolve this problem via the on board recycling of all liquid waste into purified forms reusable on board without any release in the ocean.

performance and consumption. The measurements for combustion specifically conceived for magnegas are under way.

We should also indicate considerable research efforts under way to further reduce the  $CO_2$  content of magnegas exhaust via disposable cartridges of  $CO_2$ absorbing chemical sponges placed in the exhaust system (patent pending). Additional research is under way via *liquefied magnegas* obtained via *catalytic* (and *not* conventional) liquefaction, which liquid is expected to have an anomalous energy content with respect to other liquid fuels, and an expected consequential decrease of pollutants. As a result of these efforts, the achievement of an exhaust essentially free of pollutants and  $CO_2$ , yet rich in oxygen, appears to be within technological reach.

### **10.4.3** Anomalous Chemical Composition of Magnegas

As studied in the preceding section, the chemical composition of the magnegas exhaust is conventional and, therefore, can be tested with established analytic equipment and methods. However, the chemical composition of magnegas itself cannot be successfully tested with the same equipment and methods due to its novelty.

To begin, numerous tests in various analytic laboratories reviewed in below have established that magnegas results in being characterized by large peaks in macroscopic percentage all the way to 1,000 a.m.u., which peaks remain individually unidentified by the MS computer after scanning all known molecules.

By comparison, quantum chemistry predicts that the heaviest molecule in a *light* gas such as magnegas should only have 44 a.m.u., while offering no expla-

nation whatever, not even remote or indirect on the existence of detectable teaks all the way to 1,000 a.m.u.

The above differences are so drastic to provide clear experimental evidence on the fact that the magnegas structure is characterized by a *new chemical species* not predicted or considered by quantum chemistry until now.

Besides the inability to identify the clusters composing magnegas via the computer search among all known molecules, the chemical structure of magnegas is equally unidentifiable via InfraRed Detectors (IRD), because the new peaks composing magnegas have no IR signature at all, thus establishing the presence of bonds of non-valence type (because these large clusters cannot possibly be all symmetric).

Moreover, the IR signature of conventional molecules such as CO results in being *mutated* (in the language of hadronic mechanics) with the appearance of new peaks, which evidently indicate *new* internal bonds in *conventional* molecules.

In addition to all the above, dramatic differences between the prediction of quantum chemistry and reality exist for the energy content of magnegas. For instance, when produced with PlasmaArcFlow Reactors operating an electric arc between at least one consumable electrode within pure water, quantum chemistry predicts that magnegas should be a mixture of 50% H<sub>2</sub> and 50% CO, with traces of O<sub>2</sub> and CO<sub>2</sub>.

This prediction is dramatically disproved by the fact that both the CO and the  $CO_2$  peaks do not appear in the MS scan in the predicted percentages, while they appear in the IR scan although in a mutated form.

Moreover, quantum chemistry predicts that the indicated composition consisting of 50% H<sub>2</sub> and 50% CO should have an energy content of about 315 BTU/cf, namely, an energy content insufficient to cut metal. This prediction is also disproved by the experimental evidence that magnegas cuts metal at least 50% faster than acetylene (which has 2,300 BTU/cf).

Such a performance in metal cutting is more indicative of a plasma cutting feature, such as the metal cutting via a plasma of ionized hydrogen atoms which recombine into  $H_2$  when cooling in the metal surface, thus releasing the energy needed for metal cutting. The problem is that magnegas is at room temperature when used for metal cutting, and it is subjected to ordinary combustion, thus requiring basically new approaches for its correct interpretation.

Nevertheless, the plasma cutting feature is indicative of the presence of isolated atoms and dimers in the magnegas structure which recombine under combustion, thus yielding a behavior and a performance similar to that of plasma cutters.

In fact, as also shown later on, GC-MS scans have indicated the presence in the anomalous peaks of *individual atoms of hydrogen*, oxygen, and carbon evidently in addition to individual molecules.

To conclude, the composition of magnegas in H, C and O atoms can be easily identified from the liquid used in the reactors. For instance, when magnegas is produced from water, it is composed of 50% H, 25% O, and 25% C, with corresponding percentages for other liquids such as antifreeze, crude oil, etc.

However, all attempts to reduce the chemical composition of magnegas to conventional molecules conducted by the author as well as independent chemists, have been disproved by a variety of experimental evidence.

In particular, any belief that magnegas is entirely composed by ordinary molecules, such as  $H_2$  and CO, is disproved by experimental evidence via GC-MS and IRD detectors.

The only possible scientific conclusion at this writing is that magnegas is composed of a new chemical species studied below.

## 10.4.4 GC-MS/IRD Measurements of Magnegas at the McClellan Air Force Base

Santilli [1] had predicted that gases produced from underwater electric arcs had the new chemical structure of magnecules as clusters of molecules, dimers and individual atoms as per Definition 8.2.1, in which case conventional chemical structure (8.20) is valid only in first approximation.

Following a laborious search, Santilli [*loc. cit.*] located a GC-MS equipped with IRD suitable to measure magnecules at the *McClellan Air Force Base* in North Highland, near Sacramento, California. Thanks to the invaluable assistance and financial support by *Toups Technologies Licensing*, *Inc.*, of Largo, Florida, GC-MS/IRD measurements were authorized at that facility on magnegas with conventional chemical structure (8.20).

On June 19, 1998, Santilli visited the analytic laboratory of National Technical Systems (NTS) located at said McClellan Air Force Base and using instruments belonging to that base. The measurements on magnegas were conducted by analysts Louis A. Dee, Branch Manager, and Norman Wade who operated an HP GC model 5890, an HP MS model 5972, equipped with an HP IRD model 5965. Upon inspection at arrival, the instrument met all conditions indicated in the preceding sections then, and only then, measurements were permitted.

Thanks to a professional cooperation by the NTS analysts, the equipment was set at all the unusual conditions indicated later on. In particular, the equipment was set for the analytic method VOC IRMS.M utilizing an HP Ultra 2 column 25 m long with a 0.32 mm ID and a film thickness of 0.52  $\mu$ m. It was also requested to conduct the analysis from 40 a.m.u. to the instrument limit of 500 a.m.u. This condition was necessary to avoid the expected large CO peak of magnegas at 28 a.m.u.

Moreover, the GC-MS/IRD was set at the low temperature of 10°C; the biggest possible feeding line with an ID of 0.5 mm was installed; the feeding line itself was

cryogenically cooled; the equipment was set at the longest possible ramp time of 26 minutes; and a linear flow velocity of 50 cm/sec was selected. A number of other technical requirements are available in the complete documentation of the measurements.

The analysts first secured a documentation of the *background* of the instrument prior to any injection of magnegas (also called *blank*). Following a final control that *all* requested conditions were implemented, the tests were initiated. The results, reported in part via the representative scans of Figs. 8.7 to 8.12, constitute the first direct experimental evidence of the existence of magnecules in gases.

After waiting for 26 minutes, sixteen large peaks appeared on the MS screen between 40 and 500 a.m.u. as shown in Fig. 11.21. Each of these sixteen MS peaks resulted to be "unknown," following a computer search of database on all known molecules available at *McClellan Air Force Base*, as illustrated in Fig. 11.22 No identifiable  $CO_2$  peak was detected at all in the MS spectrum between 40 and 500 a.m.u., contrary to the presence of 9% of such a molecule in magnegas as per conventional analyses (8.20).

Upon the completion of the MS measurements, exactly the same range of 40 to 500 a.m.u. was subjected to IR detection. As expected, none of the sixteen peaks had any infrared signature at all, as shown in Fig. 11.14. Furthermore, the IR scan for these MS peaks shows only one peak, that belonging to  $CO_2$ , with additional small peaks possibly denoting traces of other substances.

Note that the IR signature of the other components, such as CO or  $O_2$  cannot be detectable in this IR test because their atomic weights are below the left margin of the scan. In addition, the IR peak of  $CO_2$  is itself mutated from that of the unpolarized molecule, as shown in Fig. 11.24. Note that the mutation is due to the appearance of two new peaks which are absent in the conventional IR signature of  $CO_2$ , exactly as expected, thus confirming the hypothesis of new internal bonds as submitted in Fig. 11.12.

Note also in Fig. 24 that the computer interprets the IR signature as that belonging to CO which interpretation is evidently erroneous because CO is outside of the selected range of a.m.u.

All remaining small peaks of the IR scan resulted to be "unknown," thus being possible magnecules, following computer search in the database of IR signatures of all known molecules available at the *McClellan Air Force Base*, as illustrated in Fig. 11.25.

Following the removal of magnegas from the GC-MS/IRD, the background continued to show the same anomalous peaks of Fig. 11.21, and reached the configuration of Fig. 11.26 only after a weekend bakeout with an inert gas. Note that the latter background is itself anomalous because the slope should have been the opposite of that shown. The background finally recovered the conventional shape only after flushing the instrument with an inert gas at high temperature.

```
Information from Data File:

File : C:\HPCHEM\1\DATA\0618004.D

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
```



Figure 10.21. A reproduction of the MS peaks providing the first experimental evidence of the existence of magnecules identified on June 19, 1998, by analysts Louis A. Dee and Norman Wade of the branch of National Technical; Systems (NTS) located at the McClellan Air Force Base in North Highland, near Sacramento, California, with support from Toups Technologies Licensing, Inc. (TTL) of Largo, Florida. The scan is restricted from 40 a.m.u to 500 a.m.u. The peaks refer to magnegas produced via an electric arc between consumable carbon electrodes within ordinary tap water with conventional chemical composition (8.20). Therefore, only the  $CO_2$  peak was expected to appear in the scan with any macroscopic percentage, while no  $CO_2$  was detected at all in the MS scan.

## 10.4.5 GC-MS/IRD Tests of Magnegas at Pinellas County Forensic Laboratory

Measurements on the same sample of magnegas tested at NTS were repeated on July 25, 1998, via a GC-MS/IRD located at the *Pinellas County Forensic* 



Figure 10.22. A representation of the first experimental evidence at NTS that the peaks of Fig. 11.12 are "unknown." The peak at the top is at 8.924 minutes, and that at the bottom shows the lack of its identification by the computer search. Note that the best fit identified by the computer does not match the peak considered. Moreover, the identified substance (methylseleno) cannot possibly exist in magnegas because of the impossible presence of the necessary elements. The same situation occurred for all remaining fifteen peaks of Fig. 11.12.

Laboratory (PCFL) of Largo, Florida, with support from Toups Technologies Licensing, Inc.

The equipment consisted of a HP GC model 5890 Series II, an HP MS model 5970 and an HP IRD model 5965B. Even though similar to the equipment used at NTS, the PCFL equipment was significantly different inasmuch as the temperature had to be increased from  $10^{\circ}$ C to  $55^{\circ}$ C and the ramp time reduced from 26 to 1 minute. The latter reduction implied the cramping of all peaks of Fig. 11.17 into one single large peak, a feature confirmed by all subsequent GC-MS tests with short ramp time.



Figure 10.23. The first experimental evidence at NTS of the lack of IR signature of MS peaks. The evidence establishes the existence of large peaks in the MS that have no IR signature at all. The only identified IR signature, that for  $CO_2$ , refers to the constituents of the peaks of Fig. 11.12. In the above figure only the IR signature of  $CO_2$  appears because the scan was from 40 a.m.u. to 500 a.m.u. and, as such, could not include the IR signatures of other molecules such as  $O_2$  and CO (H<sub>2</sub> has no IR signature).

Despite these differences, the test at PCFL, reported in part via the representative scans of Figs. 8.13 to 8.18, confirmed *all* features of magnecules first detected at NTS. In addition, the tests provided the experimental evidence of additional features.

Following Santilli's request [1], the analysts conducted two MS tests of the same magnegas at different times about 30 minutes apart. As one can see in Figs. 8.13 and 8.14, the test at PCFL provided the first experimental evidence of mutation in time of the atomic weight of magnecules. In fact, the peak of Fig. 11.27e is macroscopically different than that of Fig. 11.28.

This difference provides evidence that, when colliding, magnecules can break down into ordinary molecules, atoms, and fragments of magneclusters, which then recombine with other molecules, atoms, and/or magnecules to form new clusters. The same scan provides first experimental evidence of the accretion or loss by magnecules of individual atoms, dimers and molecules, as discussed later on.

Figure 8.15 depicts the failure by the GC-MS/IRD to identify the peaks of Figs. 8.13 and 8.14 following a search in the database among all known molecules.



Figure 10.24. The first experimental evidence at NTS on the mutation of the IR signature of magnetically polarized conventional molecules, here referring to the  $CO_2$  (top) compared to the result of the computer search (bottom). Note that the known, double-lobe peak of  $CO_2$  persists in the detected peak with the correct energy, and only with decreased intensity. Jointly, there is the appearance of two new peaks, which are evidence of new internal bonds within the conventional  $CO_2$  molecule. This evidently implies an increased energy content, thus establishing experimental foundations for the new technology of magnetically polarized fuels such as magnegas [2]. Note that the computer interprets the IR signature as that of CO, which is erroneous since CO is out of the selected range of detection.

Figure 8.16 provides an independent confirmation that the IR scan of Fig. 11.23, namely, that the MS peaks, this time of Figs. 8.13 and 8.14, have no IR signature except for the single signature of the CO<sub>2</sub>. However, the latter was not detected at all in said MS scans. Therefore, the CO<sub>2</sub> detected in said IR scan is

984

Search Method for C:UHPCHEM\1\DATA\0619005.D\Peak\_7.IDS Sample Name = Peak\_7.SPC Search Data = 06-19-1998 1:50 PM Mask Used = None

Text Search = None Peak Search = Forward Full Spectrum Search = Euclidian Distance Custom Search = None



*Figure 10.25.* A reproduction of the lack of identification in the computer search of small peaks in the IR scan, which can therefore be additional magnecules, or IR signatures of the magnecules appearing in the MS scan.

a *constituent* of the new species detected in Figs. 8.13 and 8.14. The lack of IR signature of the MS peaks confirms that said peaks *do not* represent molecules.

Figure 8.17 confirms in full the mutated IR signature of  $CO_2$  previously identified in Fig. 11.24, including the important presence of two new peaks, with the sole difference that, this time, the computer correctly identifies the IR signature as that of carbon dioxide.

Figure 8.18 presents the background of the instrument after routine flushing with an inert gas, which background essentially preserves the peaks of the MS scans, thus confirming the unique adhesion of magnecules to the instrument walls.



Figure 10.26. A view of the background of the preceding tests following a weekend bakeout.

### 10.4.6 Interpretations of the Results

A few comments are now in order for the correct interpretation of the results. First, note in the GC-MS/IRD scans that the  $CO_2$  detected in the IRD has no counterpart in the MS scans, while none of the peaks in the MS have a counterpart in the IR scans. Alternatively, the  $CO_2$  peak detected in the IR scans of Figs. 8.10 and 8.17 *does not* correspond to any peak in the MS scans in Figs. 8.7, 8.13 and 8.14. Therefore, said IR peak identifies a *constituent* of the MS clusters, and not an isolated molecule.

986



*Figure 10.27.* A view of the Total Ion Count (top) and MS spectrum (below) of magnegas conducted on July 25, 1998, via a HP GC-MS/IRD at the *Pinellas County Forensic Laboratory* (PCFL) of Largo, Florida, under support from *Toups Technologies Licensing, Inc.* (TTL) also of Largo, Florida. The scan is restricted to the range 40 a.m.u to 500 a.m.u. and confirm all results of the preceding NTS tests.

Moreover, the IR scan was done for the entire range of 40 to 500 a.m.u., thus establishing that said IR peak is the sole conventional constituent in macroscopic percentage in said a.m.u. range of *all* MS peaks, namely, the single constituent identified by the IRD is a constituent of all MS peaks.



Figure 10.28. A repetition of the scan of the preceding figure conducted at PCFL in the same sample of magnegas on the same instrument and under the same conditions, but 30 minutes later. The scan provides the first experimental evidence of the mutation of atomic weight of magnecules, as one can see from the variation of the peaks of this figure compared with that of the preceding figure.

It should also be noted that, as recalled earlier, the IR only detects dimers such as C–O, H–O, *etc.*, and does not detect complete molecules. Therefore, the peak detected by the IRD is not sufficient to establish the presence of the complete molecule  $CO_2$  unless the latter is independently identified in the MS. Yet the MS scan does not identify any peak for the  $CO_2$  molecule, as indicated earlier.



*Figure 10.29.* Lack of identification by the computer of the GC-MS/IRD at PCFL of the MS peaks of the preceding two scans following search among the database on all available molecules.

Despite that, the presence in the MS peaks of complete molecules  $CO_2$  cannot be ruled out. Therefore, the most plausible conclusion is that the MS peaks represent clusters composed of a percentage of C–O dimers and another percentage of  $CO_2$  molecules, plus other dimers, and/or molecules, and/or atoms with atomic weight smaller than 40 a.m.u., thus outside the range of the considered scans.

As indicated earlier, the presence of dimers and individual atoms in magnegas is essential for a quantitative interpretation of the large excess of energy contained in this new fuel, the order of at least three times the value predicted by quantum chemistry, which energy is released during combustion. The admission of dimers and atoms as constituents of magnecules readily explains this anomalous energy content because said dimers and atoms are released at the time of the combustion, thus being able at that time to form molecules with exothermic reactions of type (8.5). In the event magnecules would not contain dimers and atoms, their only possible constituents are conventional molecules, in which case no excess energy is possible during combustion.



*Figure 10.30.* A confirmation of the lack of IR signature of the peaks of Figs. 8.13 and 8.14, as occurred for Fig. 11.14, which establishes that the MS peaks of Figs. 8.13 and 8.14 cannot have a valence bond, thus constituting a new chemical species.

The large differences of MS peaks in the two tests at NTS and at PCFL of exactly the same gas in exactly the same range from 40 to 500 a.m.u., even though done with different GC-MS/IRD equipment, illustrates the importance of having a ramp time of the order of 26 minutes. In fact, sixteen different peaks appear in the MS scan following a ramp time of 26 minutes, as illustrated by Fig. 11.12, while all these peaks collapsed into one single peak in the MS scan of Figs. 8.13 and 8.14, because the latter were done with a ramp time of about 1 minute. Therefore, the collapse of the sixteen peaks of Fig. 11.12 into the single large peak of Figs. 8.13 and 8.14 is not a feature of magnecules, but rather it is due to the insufficient ramp time of the instrument.



Figure 10.31. The independent confirmation at the PCFL of the NTS finding of Fig. 11.15 regarding the mutated IR signature of the  $CO_2$  in magnegas. Note the identical shapes of the mutated IR peak in the top of the above figure, and that in Fig. 11.15 obtained via a different instrument. Note also the appearance again of two new peaks in the IR signature of  $CO_2$ , which indicate the presence of new internal bonds not present in the conventional molecule. Note finally that the instrument now correctly identifies the signature as that of the  $CO_2$ .

# 10.4.7 Anomalous Energy Balance of Hadronic Molecular Reactors

As is well known, the *scientific efficiency* of any equipment is *under-unity* in the sense that, from the principle of conservation of the energy and the unavoidable



Figure 10.32. The first direct experimental verification at PCFL of the anomalous adhesion of magnecules. The figure reproduces the background of the instrument upon completion of the measurements, removal of magnegas, and conventional flushing. As one can see, the background results in being very similar to the MS scan during the tests, thus establishing that part of the gas had remained in the interior of the instrument. This behavior can only be explained via the induced magnetic polarization of the atoms in the walls of the instrument, with consequential adhesion of magnecules. It should be noted that this anomalous adhesion has been confirmed by all subsequent tests for both the gaseous and liquid states. The removal of magnecules in the instrument after tests required flushing with an inert gas at high temperature.

energy losses, the ratio between the total energy produced and the total energy used for its production is smaller than one.

For the case of magnegas production, the total energy produced is the sum of the energy contained in magnegas plus the heat acquired by the liquid, while the total energy available is the sum of the electric energy used for the production of magnegas plus the energy contained in the liquid recycled. Therefore, from the principle of conservation of the energy we have the scientific energy balance

$$\frac{\text{Total energy produced}}{\text{Total energy available}} = \frac{E_{mg} + E_{heat}}{E_{electr} + E_{liq}} < 1.$$
(11.4.13)

An important feature of hadronic reactors is that they are *commercially overunity*, namely, the ratio between the total energy produced and only the electric energy used for its production, is bigger than one,

$$\frac{E_{mg} + E_{liq}}{E_{electr}} > 1. \tag{11.4.14}$$

In this commercial calculation the energy contained in the liquid is not considered because liquid wastes imply an income, rather than costing money.

As a result, Santilli's hadronic molecular reactors can be viewed as reactors capable of tapping energy from liquid molecules, in much of the same way as nuclear reactors can tap energy from nuclei. An important difference is that the former reactors release no harmful radiation and leave no harmful waste, while the latter reactors do release harmful radiations and leave harmful waste.

The energy used for the production of the carbon rod, the steel of the reactors, etc. is ignored in commercial over-unity (7.34) because its numerical value per cubic foot of magnegas produced is insignificant.

The commercial over-unity of hadronic reactors is evidently important for the production of the combustible magnegas or magnetically polarized hydrogen (MagH<sup>TM</sup>) at a price competitive over conventional fossil fuels.

A first certification of the commercial over-unity (7.34) was done on September 18 and 19, 1998, for the very first, manually operated prototype of hadronic reactors by the independent laboratory *Motorfuelers, Inc.*, of Largo, Florida, and included (see [8]):

1) Calibrating the cumulative wattmeter provided by *WattWatchers, Inc.*, of Manchester, New Hampshire, which was used to measure the electric energy drawn from the power lines per each cubic foot of magnegas produced;

2) The verification of all dimensions, including the volume of the column used for gas production, the volume of the liquid used in the process, etc.;

3) Repetition of numerous measurements in the production of magnegas and its energy content, calculation of the average values, identification of the errors, etc.

During the two days of tests, *Motorfuelers* technicians activated the electric DC generator and produced magnegas, which was transferred via a hose to a transparent plexyglass tower filled up with tap water, with marks indicating the displacement of one cubic foot of water due to magnegas production.

After the production of each cubic foot, the gas was pumped out of the tower, the tower was replenished with water, and another cubic foot of magnegas was



Figure 10.33. A view of metal cutting via magnegas. Independent certifications by various users have established that: 1) magnegas has a pre-heat time at least half that by acetylene (which is currently used for metal cutting and has an energy content of 2,300 BTU/cf); 2) magnegas cuts metal at least 50% faster than acetylene; 3) the cut produced by magnegas is much smoother without edges as compared to that by acetylene; 4) magnegas exhaust does not contain carcinogenic or other toxic substances, while that of acetylene is perhaps the most carcinogenic and toxic of all fuels; 5) magnegas cutting does not produce the "flash-back" (local explosion of paint over metal) typical of acetylene; 6) magnegas is dramatically safer than acetylene, which is unstable and one of the most dangerous fuels currently used; and 7) magnegas cost about 1/2 that of acetylene.

produced. The procedure was repeated several times to have sufficient statistics. The electric energy from the electric panel required to produce each cubic foot of magnegas was measured via the previously calibrated cumulative wattmeter.

As a result of several measurements, *Motorfuelers, Inc.* certified [8] that the production of one cubic foot of magnegas with the first prototype required an average electric energy of

$$E_{electr} = 122 \text{ W/cf} = 416 \text{ BTU/cf} \pm 5\%.$$
 (11.4.15)

It should be stressed that this is the electric energy from the electric panel, thus including the internal losses of the DC rectifier. Alternatively, we can say that the arc is served by only 65% of the measured electric energy, corresponding to

$$E_{electr} = 79.3 \text{ W/cf} = 270 \text{ BTU/cf.}$$
 (11.4.16)

The energy content of magnegas was measured on a comparative basis with the BTU content of natural gas (1,050 BTU/cf). For this purpose, technicians of *Motorfuelers, Inc.*, used two identical tanks, one of natural gas and one of magnegas, at the same initial pressure of 110 psi. Both tanks were used for 5 psi pressure decreases, under the same gas flow, to increase the temperature of the same amount of water in the same pot at the same initial temperature. The ratio of the two temperature increases is evidently proportional to the ratio of the respective BTU contents.

Following several measurements, *Motorfuelers, Inc.* certified [8] that magnegas produced from the antifreeze waste used in the reactor has about 80% of the BTU content of natural gas, corresponding to

$$E_{mq} = 871 \text{ BTU/cf} \pm 5\%.$$
 (11.4.17)

All other more scientific tests of BTU content of magnegas conducted at various academic and industrial laboratories failed to yield meaningful results due to the energy content of magnegas for various reasons. Despite their empirical character, the measurement of BTU content done by *Motorfuelers, Inc.*, remains the most credible one.

It should be noted that the value of 871 BTU/cf is a lower bound. In fact, automotive tests reviewed in Sect. 7.9 have established that the energy output of internal combustion engines powered by magnegas is fully equivalent to that of natural gas, thus yielding a realistic value of about

$$E_{mg} = 1,000 \text{ BTU/cf.}$$
 (11.4.18)

During the tests, it was evident that the temperature of the liquid waste in the reactor experienced a rapid increase, to such an extent that the tests had to be stopped periodically to cool down the equipment, in order to prevent the boiling of the liquid with consequential damage to the seals.

Following conservative estimates, technicians of *Motorfuelers, Inc.*, certified [8] that, jointly with the production of 1 cf of magnegas, there was the production of heat in the liquid of 285 BTU/cf plus 23 BTU/cf of heat acquired by the metal of the reactor itself, yielding

$$E_{heat} = 308 \text{ BTU/cf.}$$
 (11.4.19)

In summary, the average electric energy of 122 W = 416 BTU calibrated from the electric panel produced one cf of magnegas with 871 BTU/cf, plus heat in the liquid conservatively estimated to be 308 BTU/cf. These independent certifications established the following *commercial over-unity* of the first, manually operated hadronic reactor within  $\pm 5\%$  error:

$$\frac{871 \text{ BTU/cf} + 308 \text{ BTU/cf}}{416 \text{ BTU/cf}} = 2.83.$$
(11.4.20)

Note that, if one considers the electric energy used by the arc itself corresponding to 79.3 W/cf = 270 BTU/cf, we have the following commercial over-unity:

$$\frac{871 \text{ BTU/cf} + 285 \text{ BTU/cf}}{270 \text{ BTU/cf}} = 4.36.$$
(11.4.21)

In releasing the above certification, *Motorfuelers, Inc.*, noted that the arc had a poor efficiency, because it was manually operated, thus resulting in large variation of voltage, at times with complete disconnection of the process and need for its reactivation.

*Motorfuelers* technicians also noted that the BTU content of magnegas, Eq. (11.4.37), is a minimum value, because measured in comparison to natural gas, not with a specially built burner, but with a commercially available burner that had large carbon residues, thus showing poor combustion, while the burner of natural gas was completely clean.

Immediately after the above certification of commercial over-unity, a number of safety and health measurements were conducted on hadronic molecular reactors, including measurements on the possible emission of neutrons, hard photons, and other radiation.

David A. Hernandez, Director of the *Radiation Protection Associates*, in Dade City, Florida conducted comprehensive measurements via a number of radiation detectors placed around the reactor, with particular reference to the only radiations that can possibly escape outside the heavy gauge metal walls, low or high energy neutrons and hard photons.

Under the presence of eyewitnesses, none of the various counters placed in the immediate vicinity of the reactor showed any measurement of any radiation at all. As a result, Radiation Protection Associates released an official Certificate stating that:

"Santilli's Plasma ArcFlow $^{TM}$  Reactors met and exceed the regulatory regulations set for th in Florida Administrative Code, Chapter 64-E. Accordingly, the reactors are declared free of radiation leakage."

Subsequent certifications of more recent hadronic reactors operating at atmospheric pressure with 50 kW and used to recycled antifreeze waste, this time done on fully automated reactors, have produced the following measurements:

$$E_{mg} = 871 \text{ BTU/cf},$$
 (11.4.22*a*)

$$E_{lig} = 326 \text{ BTU/cf},$$
 (11.4.22b)

$$E_{electr} = 100 \text{ W/cf} = 342 \text{ BTU/cf},$$
 (7.42c)

resulting in the following commercial over-unity of automatic reactors recycling antifreeze with about 50 kW and at atmospheric pressure:

$$\frac{871 \text{ BTU/cf} + 326 \text{ BTU/cf}}{342 \text{ BTU/cf}} = 3.5.$$
(11.4.23)

996

When ordinary tap water is used in the reactors, various measurements have established a commercial over-unity of about 2.78.

It should be indicated that the commercial over-unity of the hadronic reactors increases nonlinearly with the increase of the kiloWatts, pressure and temperature. Hadronic reactors with 250 kW are under construction for operation at 250 psi and  $400^{\circ}$  F. The latter reactors have a commercial over-unity considerably bigger than (7.43).

The origin of the commercial over-unity (7.43) is quite intriguing and not completely known at this writing. In fact, conventional chemical structures and reactions have been studied by Aringazin and Santilli [9] and shown not to be sufficient for a quantitative explanation, thus requiring a new chemistry.

Following Aringazin and Santilli [9], our first task is to compute the electric energy needed to create one cubic foot of plasma in the PlasmaArcFlow reactors as predicted by conventional quantum chemistry. Only after identifying the deviations of the experimental data from these predictions, the need for the covering hadronic chemistry can be properly appraised.

For these objectives we make the following assumptions. First, we consider PlasmaArcFlow reactor processing distilled water with the DC arc occurring between a consumable pure graphite cathode and a non-consumable tungsten anode. As indicated earlier, said reactors yield a commercial over-unity also when used with pure water. Therefore, quantum chemical predictions can be more effective studied in this setting without un-necessary ambiguities. We also assume that water and the solid graphite rod are initially at  $300^{\circ}$  K and that the plasma created by the DC electric arc is at  $3,300^{\circ}$  K.

The electric energy needed to create one cubic foot of plasma must perform the following transitions (see Appendix 7.A for basic units and their conversions):

1) Evaporation of water according to the known reaction

$$H_2O(liquid) \rightarrow H_2O(vapor) - 10.4 \text{ Kcal/mole},$$
 (11.4.24)

2) Separation of the water molecule,

$$H_2O \to H_2 + \frac{1}{2}O_2 - 57 \text{ Kcal/mole},$$
 (11.4.25)

3) Separation of the hydrogen molecule,

$$H_2 \rightarrow H + H - 104 \text{ Kcal/mole},$$
 (11.4.26)

4) Ionization of H and O, yielding a total of 1,197 Kcal. We then have the evaporation and ionization of the carbon rod,

$$C(solid) \rightarrow C(plasma) - 437 \text{ Kcal/mole},$$
 (11.4.27)

resulting in the total 1,634 Kcal for 4 moles of plasma, i.e.

$$408.5 \text{ Kcal/mol} = 0.475 \text{ kWh/mol} = 1621 \text{ BTU/mol} =$$
  
= 515.8 Kcal/cf = 0.600 kWh/cf = 2,047 BTU/cf, (11.4.27)

to which we have to add the electric energy needed to heat up the non-consumable tungsten anode which is estimated to be 220 BTU/cf, resulting in the total of 2,267 BTU/cf. This total, however, holds at the electric arc itself without any loss for the creation of the DC current from conventional alternative current. By assuming that rectifiers, such as the welders used in PlasmaArcFlow reactors have an efficiency of 70%, we reach the total electric energy from the source needed to produce one cubic foot of plasma

Total Electric Energy 
$$= 3,238 \text{ BTU/cf} = 949 \text{ W/cf}.$$
 (11.4.28)

We now compute the total energy produced by PlasmaArcFlow reactors according to quantum chemistry. For this purpose we assume that the gas produced is composed of 50% hydrogen and 50% carbon monoxide with ignorable traces of carbon dioxide. The latter is indeed essentially absent in PlasmaArcFlow reactors, as indicated earlier. In addition,  $CO_2$  is not combustible. Therefore, the assumption of ignorable  $CO_2$  in the gas maximizes the prediction of energy output according to quantum chemistry, as desired.

Recall that the glow of underwater arcs is mostly due to the combustion of hydrogen and oxygen back into water which is absorbed by the water surrounding the arc and it is not present in appreciable amount in the combustible gas bubbling to the surface. Therefore, any calculation of the total energy produced must make an assumption of the percentage of the original H and O which recombine into  $H_2O$  (the evidence of this recombination is established by the production of water during the recycling of any type of oil by the hadronic reactors).

In summary, the calculation of the energy produced by the PlasmaArcFlow reactors requires: the consideration of the cooling down of the plasma from  $3,300^{\circ}$  K to  $300^{\circ}$  K with consequential release of energy; the familiar reactions

$$H + H \rightarrow H_2 + 104 \text{ Kcal/mole}, \qquad (11.4.29a)$$

$$H_2 + \frac{1}{2}O_2 \to H_2O + 57 \text{ Kcal/mole},$$
 (11.4.29b)

$$C + O \rightarrow CO + 255 \text{ Kcal/mole.}$$
 (11.4.29c)

Under the assumption of 100% efficiency (that is, no recombination of water), the total energy produced is given by

$$398 \text{ Kcal/mole} = 1,994 \text{ BTU/cf.}$$
(11.4.30)

998

By assuming that the entire energy needed to heat up the non-consumable tungsten is absorbed by the liquid surrounding the electric arc in view of its continuous cooling due to the PlasmaArcFlow, we have the total heat energy of 2,254 BTU/cf.

In addition, we have the energy content of the combustible gas produced. For this purpose we recall the following known reactions:

$$H_2(mg) + \frac{1}{2}O_2(atm) \to H_2O + 57 \text{ Kcal/mole},$$
 (11.4.31*a*)

$$CO(mg) + \frac{1}{2}O_2(atm) \to CO_2 + 68.7 \text{ Kcal/mole.}$$
 (11.4.32b)

Consequently, the 50%-50% mixture of conventional gases  $\rm H_2$  and CO has the following

Conventional energy content of magnegas produced from water =

$$= 62.8 \text{ Kcal/mole} = 249.19 \text{ BTU/mole} = 315 \text{ BTU/cf.}$$
 (11.4.33)

Therefore, the total energy output of the PlasmaArcFlow Reactors is given by

$$E(mg) + E(heat) = 315 BTU/cf + 2,254 BTU/cf = 2,569 BTU/cf.$$
 (11.4.34)

It then follows that the energy efficiency of the PlasmaArcFlow reactors is underunity for the case of maximal possible efficiency,

Energy efficiency predicted by quantum chemistry =

$$= \frac{\text{Total energy out}}{\text{Electric energy in}} = \frac{E_{mg} + E_{heat}}{E_{electr}} = \frac{2,569 \text{ BTU/cf}}{3,238 \text{ BTU/cf}} = 0.79.$$
(11.4.35)

It is possible to show that, for the case of 50% efficiency (i.e., when 50% of the original H and O recombine into water) the total energy output evidently decreases. For detail, we refer the interested reader to Aringazin and Santilli [9].

### 10.4.8 Cleaning Fossil Fuel Exhaust with Magnegas Additive

Electric power plants continue to attempt the cleaning of their atmospheric pollution (see Figure 11.1) via the cleaning of their exhaust. Since the related equipment is very expensive and notoriously inefficient, these are attempts literally belonging to the past millennium. Nowadays, the exhaust of fossil fueled electric power plants can be cleaned via cost competitive improvement of the combustion.

It is known that, whether burning petroleum or coal, about 60% of the energy in the original fuel is literally thrown through the fluke, and so is the relates cost, due to the notoriously poor combustion. It is also known in chemistry that hydrogen is the best additive to improve combustion, with consequential improvement of the environmental quality of the exhaust. In fact, hydrogen has the biggest flame temperature and speed among all known fuels. Consequently, the injection of hydrogen as an additive in the flame of fossil fuels burns the uncombusted component of the exhausts in a way proportional to the used percentage of hydrogen. A reason hydrogen as currently available has not (and cannot) be used as additive in fossil fueled electric power plants is its prohibitive cost (that in the U.S.A. is of the order of 50 times the cost of natural gas per same energy content, as recalled in Section 11.1.3).

Magnegas is the best additive for the cleaning of fossil fuel exhaust known to the author  $^9$  because:

1) When produced from the recycling of water-base liquid wastes, magnegas contains about 65% hydrogen, thus qualifying as an effective additive to improve fossil fuel combustion;

2) The remaining components of magnegas are internally rich in oxygen, thus helping to alleviate the large oxygen depletion caused by fossil fuel combustion (Section 11.1); and

3) The cost of magnegas is competitive over that of fossil fuel, particularly when produced by the electric power plants themselves, because of the grossly reduced cost of electricity plus the possibility of producing magnegas from the recycling of city sewage, with a consequential income that covers most of the operating costs of PlasmaArcFlow Recyclers. Un der these conditions, the percentage of magnegas additive to be injected in the flame of fossil fuels becomes a corporate, rather than technical or financial decision.

Besides incontrovertible environmental advantages, the increase of profits for electric power plants in the use of magnegas additive are substantial, such as: the utilization of at least half of the fuel and related cost literally thrown through the fluke due to poor combustion; the capability of producing green electricity that notoriously brings bigger income; and the gaining of the so-called *Kyoto Credits* that, alone, bring millions of dollars of additional income.

Despite these trans[parent gains and numerous solicitations as well as the international exposure of the website [5b], no electric power plant nowhere in the world has expressed interest to this day (fall 2005) interest in at least inspecting the use of magnegas additive. This behavior was expected by the author because, as stated in the opening sentences of this chapter, profits are no longer the dominant drive in the contemporary corporate world. Politics is the dominant drive. Lack of interest for major environmental and financial gains is then another confirmation of the lack of political will toward serious environmental actions in all developed countries (for more details, visit the website [5b]).

1000

<sup>&</sup>lt;sup>9</sup>The documented indication of other additives comparable to magnegas would be sincerely appreciated.

## 10.4.9 Hy-Gasoline, Hy-Diesel, Hy-Ethanol, Hy-NG, Hy-Coal

Fossil fuels are sold in a disproportionate daily volumes recalled in Section 11.1, and we should expect that they will continue to be sold in ever increasing disproportionate volumes until the extinction of all petroleum reserves.

Rather than dreaming of eliminating fossil fuels from the market, scientists in general, and chemists in particular, have the ethical duty to seek additives to clean fossil fuel combustion in automotive use, namely, an usage logistically and technically different than the combustion of fossil fuels in power plants furnaces of the preceding section.

It is at this point where the irreconcilable conflict between academic interest on pre-existing theories and the societal need for new theories emerges in its full light. In fact, the best additive to clean fossil fuel combustion is, again, hydrogen (see the preceding section). However, hydrogen is a gas, while gasoline, diesel, ethanol and other fuels are liquids. Consequently, quantum chemistry provides no possibility of achieving new fuels characterized by a stable mixture of liquid fuels and gaseous hydrogen.

However, the abandonment of quantum chemistry in favor of the covering hadronic chemistry permits indeed the possible resolution of the problem. In fact. magnecular bonds are completely insensitive as to whether the constituents of a magnecular cluster partially originated from liquids and part from gases, trivially, because the bond occurs at the level of individual atoms.

The above principle has permitted the formulation of basically new *liquid* fuels known as Hy-Gasoline<sup>TM</sup>, Hy-Diesel<sup>TM</sup>, Hy-Ethanol<sup>TM</sup>, HyCoal<sup>TM</sup>, etc. (patented and international patents pending [5]), where the prefix "Hy" is used to denote a high hydrogen content. These new fuels are essentially given by ordinary fossil fuels as currently produced, subjected to a bond with magnegas or hydrogen from magnegas (see next section) via the use of special PlasmaArcFlow Reactors.

As predicted, no petroleum company has expressed to date any interest at all in even inspecting the evidence, let alone take serious initiative in these new fuels despite numerous solicitations and the transparent environmental and, therefore, financial gains, because of the origin of the current environmental problems threatening mankind: the lack of serious political will in all developed countries to this day (fall 2005), and actually the subservience of current political will to the petroleum cartel, as denounced in the opening words of this chapter (for more details, visit the website [5b]).

## 10.4.10 Catastrophic Inconsistencies of Quantum Mechanics, Superconductivity and Chemistry for Submerged Electric Arcs

In Chapter 9 we identified the *approximate* yet still applicable character of quantum mechanics and chemistry for molecular structures.

The analysis of this section has confirmed the content of section 1.2.11 to the effect that the divergences between submerged electric arcs and the predictions of conventional disciplines are so huge to be called "catastrophics inconsistencies" such as:

1) Inability by quantum chemistry to identify the chemical composition of magnegas. This occurrence is due to the fact that quantum chemistry predicts that magnegas produced via a electric arc between pure graphite electrodes submerged within distilled water is composed primarily of the molecule H - H with 2 a.m.u and C - O with 28 a.m.u, with traces of  $H_2O$  with 18 a.m.u. and  $CO_2$  with 44 a.m.u. No additional species is predicted by quantum chemistry. By comparison, magnegas is composed of fully identifiable peaks in the MS ranging from 1 a.m.u to 1,000 a.m.u. *none* of which is identifiable with the preceding molecules, resulting in catastrophic divergences in the sense that the application of quantum chemistry to magnegas would have no scientific sense, not even approximate.

2) Inability by quantum superconductivity to represent submerged electric arcs. Distilled water is known to be dielectric. In fact, the electric resistance between electrodes submerged within distilled water at large distance (open arc) can be of the order of 100 Ohms or so. However, when the electric arc is initiated the resistance collapses to fractional Ohms, resulting in a very high temperature kind of "superconductor" (since the arc has about  $5,000^{\circ}C$ ). Such a collapse of electric resistance is beyond any hope of representation by quantum superconductivity. in reality, as studied in preceding chapters, the collapse is due to the basic inapplicability of Maxwell' s equations for submerged electric arcs , thus implying the basic inapplicability of the Lorentz and Poincaré symmetry, special relativity and all that in favor of covering theories.

3) A ten-fold error in defect in the prediction of the  $CO_2$  content of magnegas exhaust. In fact, quantum chemistry predicts the presence of about 50% of CO in magnegas from distilled water resulting in about  $40\% CO_2$  in the exhaust,, while magnegas has about 1/10-th that value;

4) A ten fold error in excess in the prediction of heat generated by carbon combustion by the arc. In fact, in the preceding subsection we showed that quantum chemistry predicts about 2,250 Kcal/scf of magnegas, while the measured amount is of the order of 250 for water as feedstock. Note that the latter error confirms the preceding one.

5) A fourteen-fold error in the prediction of oxygen in the exhaust of magnegas. In fact, quantum chemistry predicts that, under full combustion in atmosphere, there is no oxygen in the exhaust, while magnegas shows up to 14% breathable oxygen in the exhaust.

an additional large inconsistency of quantum chemistry will be shown in the next section in regard to the hydrogen content of magnegas.

However, the most catastrophic inconsistencies are given by the fact that magnegas has a variable energy content, a variable specific weight, and a variable Avogadro number. The first two features are established by the fact that the energy content and density of magnegas produced from the same reactor with the same liquid feedstock increases nonlinearly with the sole increase of the operating pressure, trivially, because bigger pressures produce heavier magnecules.

The all important variation of the Avogadro number is established by the fact, verified every day in the magnegas factories around the world when compressing magnegas in high pressure bottles according to which the same increase of pressures. For instance, the transition from 20 to 120 psi requires about 40 scf, while the transition from 3,500 psi to 3,600 psi may require 70 scf of magnegas, an occurrence that can only be explained via the *decrease of the Avogadro number with the increase of pressure*.

The latter anomaly is necessary for gases with magnecular structure for the evident reason that the increase of pressure bonds different magnecules together, thus reducing the Avogadro number. Alternatively, the magnecular structure can be also interpreted as an unusual form of "semi-liquid" in the sense that the magnecular bond is much closer to the so called "h-bridges" of the liquid state of water. the increase of pressure evidently brings magnegas progressively closer to the liquid state, which continuous process can only occur for a variable Avogadro number.

on historical grounds, it should be recalled that Avogadro conceived his celebrated number as being variable with physical characteristics of pressure and temperature, a conception clearly stated on the expectation that the gaseous constituents can break down into parts due to collision and subsequent recombinations.

Subsequently, the chemistry of the time believed for decades that the Avogadro number was variable. In fact, the first measurements of the constancy of the Avogadro number maed by Canizzaro also in Italy, were initially very controversial until verified numerous times. Today we know that the constancy of the Avogadro number for gases wit molecular structure is due to the strength of the valence bond under which no breaking of molecules is possible under increasing temperature and pressure, resulting in a constant number of constituents per mole. For over one century chemistry was restricted to the study of gases with molecular structure and Avogadro original conception was forgotten until resumed by the author with his gases with magnecular structure that verify all original intuition by Avogadro.

## 10.4.11 Concluding Remarks

The first important experimental evidence presented in this section is the independent certification of hadronic reactors of molecular type as being "commercially over-unity", that is, the ratio between the total energy produced and the electric energy needed for its production can be much bigger than one, Eq. (11.4.14).

This occurrence establishes that said hadronic reactor are based on a *a new* combustion of carbon realized via the electric arc, which combustion is much cleaner and more efficient than the combustion of carbon in a conventional furnace. In fact, the new combustion of carbon occurs in the plasma surrounding the electric arc due to the presence of oxygen originating from the liquid feedstock.

Rather than producing highly polluting exhaust, as for the combustion of carbon in a furnace, the plasma combustion produced a clean burning fuel and heat without pollution. Consequently, the plasma combustion of carbon is much more efficient than conventional combustion because pollutants in the exhaust are uncombusted fuel.

The third experimental evidence presented in this section is that establishing the existence of the new chemical species of Santilli magnecules. More specifically, said experimental evidence, plus additional tests not reported here for brevity, confirm the following features of Definition 11.4.1:

I) Magnecules have been detected in MS scans at high atomic weights where no molecules are expected for the gas considered. In fact, the biggest molecule in macroscopic percentages of the magnegas tested, that produced from tap water with conventional chemical composition (8.20), is  $CO_2$  with 44 a.m.u., while peaks in macroscopic percentages have been detected with ten times such an atomic weight and more.

II) The MS peaks characterizing magnecules remain unidentified following a computer search among all known molecules. This feature has been independently verified for *each* of the sixteen peaks of Fig. 11.12, for all peaks of Figs. 8.13 and 8.14, as partially illustrated in Figs. 8.8 and 8.15, as well as for all additional MS scans not reported here for brevity.

III) The above MS peaks characterizing magnecules admit no IR signature, thus confirming that they do not have a valence bond. In fact, none of the peaks here considered had any IR signature as partially illustrated in Figs. 8.9 and 8.16, thus confirming the achievement of an essentially pure population of magnecules.

#### 1004

IV) The IR signature of the only molecule detected in macroscopic percentage, that of the  $CO_2$ , is mutated precisely with the appearance of two additional peaks, as shown in Fig. 11.15 and independently confirmed in Fig. 11.22. Since any peak in the IR signature represents an internal bond, the mutation here considered confirms the creation by the PlasmaArcFlow technology of new internal magnetic bonds within conventional molecules, as per Fig. 11.11.

V) The anomalous adhesion of magnecules is confirmed in both tests from the evidence that the background (blank) at the end of the tests following conventional flushing continued to show the presence of essentially the same magnecules detected during the tests, as illustrated in Figs. 8.12 and 8.18.

VI) The atomic weight of magnecules mutates in time because magnecules can break down into fragments due to collisions, and then form new magnecules with other fragments. This feature is clearly illustrated by the macroscopic differences of the two scans of Figs. 8.13 and 8.14 via the same instrument on the same gas under the same conditions, only taken 30 minutes apart.

VII) Magnecules can accrue or lose individual atoms, dimers or molecules. This additional feature is proved in the scans of Figs. 8.13 and 8.14 in which one can see that: the peak at 286 a.m.u. of the former becoming 287 a.m.u. in the latter, thus establishing the accretion of one hydrogen *atom*; the peak at 302 a.m.u. in the former becomes 319 a.m.u. in the latter, thus establishing the accretion of the H–O dimer; the peak at 328 a.m.u. in the former becomes 334 a.m.u. in the latter, thus establishing the accretion of one O<sub>2</sub> molecule; the peak at 299 a.m.u. in the former become 297 a.m.u. in the latter, thus exhibiting the loss of one H<sub>2</sub> molecule; *etc.* It should be indicated that these features have been confirmed by all subsequent GC-MS/IRD scans not reported here for brevity.

The other features of Definition 11.4.1 require measurements other than those via GC-MS/IRD and, as such, they will be discussed in the next section.

A most forceful implication of the experimental evidence presented in this section is that it excludes valence as the credible origin of the attractive force characterizing the detected clusters. This feature is forcefully established by the detection of peaks all the way to 1,000 a.m.u. in a gas solely composed of H, C and O atoms that are combined at the  $10,000^{\circ}F$  of the electric arc, thus excluding hydrocarbons and other standard molecules. Even more forceful experimental evidence on new non-valence bonds will be presented in the next sections.

It is easy to predict that the emergence of "new" non-valence bonds, we have called magnecular, will inevitably imply a revision of a number of current views in chemistry, the first case coming to mind being that of the so-called *H*-bridges in the liquid state of water.

As recalled in Chapter 9, this author never accepted quantum chemistry as "the final theory" for molecular structure because quantum chemistry lacks the explicit and numerical identification of the attractive force in valence bonds, besides the



Figure 10.34. A schematic view of the magnecular interpretation of the liquid state of water. Such a state requires an ATTRACTIVE FORCE between the water molecules. But the latter are electrically neutral, diamagnetic and no unbounded electron available for valance bonds. hence, a basically new, non-valence force is needed to represent the water liquid state. Quantum chemistry suggests that such liquid state is due to the so-called "H-bridges" although the latter are pure nomenclature because they do not identify at all explicitly and numerically the attractive force among water molecules. The new chemical species of Santilli magnecules resolves the problem because the H atoms in the  $H_2O$  molecule have a polarization in a plane perpendicular to the H - O - H plane, that is precisely a toroidal polarization permitting attractive forces among different H atoms identified in their attractive as well as numerical character in this section. In summary, the main hypothesis here submitted apparently for the first time is that the liquid state of water, as well as any other liquid state, is a magnecule, by illustrating in this way the prediction that magnecules can acquire macroscopic dimensions (see additional studies on magnecules in liquids later on in this chapter).

fact that, according to quantum mechanics, two identical electrons should repel, rather than attract each other, as a consequence of which the name "valence" is a mere nomenclature without sufficient scientific content.

This was essentially the situation in molecular structures such as the water molecule  $H_2O$ . Hadronic mechanics and chemistry have resolved this insufficiency by identifying explicitly and numerically the ATTRACTIVE force between IDENTICAL ELECTRONS that is responsible for the water and other molecules.

In this section we have learned that molecules admit non-valence bonds originating from toroidal polarizations of the orbitals. The magnecular origin of the H-bridges in the liquid state of water is then inevitable because, as recalled in Chapter 9, the orbitals of the H atoms in  $H_2O$  do not have a spherical distribution, but a distribution that is perpendicular to the H - O - H plane, thus being precisely of the toroidal type underlying magnecules (see Fig. 11.34 for details).

In closing the author would like to stress that the above findings, even though independently confirmed numerous times, should be considered preliminary and in need of additional independent verifications, which are here solicited under the suggestion that:

1) Only peaks in macroscopic percentages should be initially considered to avoid shifting issues of primary relevance into others of comparatively marginal importance at this time;
2) The internal *attractive* force necessary for the very existence of cluster is identified in clear numerical terms without vague nomenclatures deprived of an actual physical reality, or prohibited by physical laws; and

3) The adopted terminology is identified with care. The word "magnecule" is a mere name intended to denote a chemical species possessing the specifically identified characteristics I) to XV) of Definition 11.4.1 which are distinctly different than the corresponding characteristics of molecules. Therefore, the new species can not be correctly called molecules. The important features are these distinctly new characteristics, and not the name selected for their referral.

## 10.5 THE NEW MAGNECULAR SPECIES OF HYDROGEN AND OXYGEN WITH INCREASED SPECIFIC WEIGHT

## 10.5.1 Resolution of Hyrogen Problems Permitted by the Magnegas Technology

In Section 11.1.3 we have pointed out serious problematic aspects caused by large scale use of hydrogen, including its large oxygen depletion, vast pollution caused by its current production methods, threat to the ozone layer, seepage and excessive costs due to the need of liquefaction. It is important to note that the new chemical species of magnecules permits the resolution, or at least the alleviation of these problems.

As indicated in Section 11.3, magnegas is synthesized from liquids that are very rich in hydrogen, such as water-base or oil-base liquid wastes. Consequently, magnegas generally contains about 66% hydrogen, not in a valence bond with other atoms as it is the case for  $CH_4$ , but in a magnecular mixture with other gases, thus permitting simple methods of molecular or other separations without the need of large energies to break valence bonds. Hence, the Magnegas Technology [5b] offers the following possibilities:

A) Reduction of oxygen depletion caused by hydrogen combustion. As indicated in the preceding sections, the new magnecular bond has been developed to achieve full combustion as well as to permit the inclusion of oxygen when prohibited by valence bonds, resulting in a fuel that is internally rich in oxygen originating not from the atmosphere, but from liquid wastes. in fact, magnegas exhaust routinely contains up to 14% of breathable oxygen, and such a percentage can be increased following suitable development. It then follows that the combustion of hydrogen produced via its separation from magnegas causes dramatically less oxygen depletion than that of hydrogen originating from reformation or electrolysis, since none of the latter processes release oxygen in the atmosphere.

B) **Reduction of environmental pollution in hydrogen production.** Admittedly, the production of magnegas currently requires the use of commercially available electricity that is polluting because of generally fossil origin. However, PlasmaArcFlow Recyclers release no solid, liquid or gaseous contaminant in the environment; the electric energy used by the arc is about 1/20-th the operating energy (since the rest is given by a very clean carbon combustion via the arc); and the efficiency of PlasmaArcFlow Recyclers can be up to twenty times that of electrolysis. Consequently, the production of hydrogen from magnegas is dramatically less polluting then conventional methods, with the understanding that, when the new clean energies presented in the next chapter achieve industrial maturity, hydrogen production from magnegas will release zero environmental pollutants.

C) Reduction of the threat to the ozone layer caused by hydrogen seepage and leaks. Besides a basically new production method, a necessary condition for hydrogen to be a really viable fuel for large scale use is that of achieving a *new magnecular form of hydrogen* consisting of clusters sufficiently large to avoid seepage, as well as to prevent that, in case of leaks, hydrogen quickly rises to the ozone layer. This new species in studied in the next subsections.

D Elimination of the need for liquefaction of hydrogen. This objective is related to the preceding one. In fact, the achievement of a magnecular form of hydrogen automatically implies an increase of the specific weight over the standard value of 2.016 a.m.u. that, in turn, automatically implies the reduction of container volumes, with consequential possibility of using hydrogen in a compressed form without any need for its liquefaction. Note that, lacking such heavier form, hydrogen has no realistic possibility of large scale use due to the extreme costs and dangers of changes of state from liquid to gas.

E) **Dramatic reduction of hydrogen cost.** Magnegas produced in volumes is cost competitive with respect to fossil fuels such as natural gas. Consequently, the biggest contribution of the Magnegas Technology to the hydrogen industry is the dramatic reduction of current hydrogen production costs down to values compatible with fossil fuels costs, as shown in more details in the next subsection. Additional advantages over conventional hydrogen are permitted by its magnecular structure as shown below.

# 10.5.2 The Hypothesis of the New Chemical Species of MagneHydrogen<sup>TM</sup> and MagneOxygen<sup>TM</sup>

In paper [18] the author submitted, apparently for the first time, the hypothesis that conventional hydrogen  $H_2$  and oxygen  $O_2$  gases can be turned into a new species with magnecular structure here called *MagneHydrogen<sup>TM</sup>* and *MagneOxygen<sup>TM</sup>* 9as well as of other gases), with suggested chemical symbols *MH* and *MO*, respectively (patented and international patents pending).

The foundations of the above hypothesis are essentially those given in preceding sections. As recalled earlier, the hydrogen molecule is diamagnetic and, therefore, it cannot acquire a total net magnetic polarity. Nevertheless, the orbits of the *individual H atoms* can acquire a toroidal polarization under a sufficiently strong external magnetic field. The opposite magnetic moments of the two H atoms then explain the diamagnetic character of the hydrogen molecule as illustrated in Figure 11.7.

The aspect important for the hypothesis of MH and MO is that the toroidal polarization of the orbits of the electrons of the individual H atoms, plus the polarization of the intrinsic magnetic moments of nuclei and electrons in the  $H_2$  molecule is sufficient for the creation of the desired new chemical species with bigger specific weight, because the new bonds can occur between pairs of individual H atoms, as illustrated in Figures 11.10 and 11.11.

The creation of MO is expected to be considerably simpler than that of MH because oxygen is paramagnetic, thus having electrons free to acquire an overall magnetic polarity which is absent for the case of MH. Nevertheless, the achievement of a significant increase of the specific weight of the oxygen will require the toroidal polarization of at least some of the peripheral atomic electrons, in addition to a total magnetic polarization.

The primary technological objective is, therefore, that of achieving physical conditions and geometries suitable for the joint polarization of *atoms*, rather than molecules, in such a way to favor their coupling into chains of opposing magnetic polarities. In the final analysis, the underlying principle here is similar to the magnetization of a ferromagnet, that is also based on the polarization of the orbits of unbounded electrons. The main difference (as well as increased difficulty) is that the creation of MH requires the application of the same principle to a gaseous, rather than a solid substance.

Under the assumption that the original gases are essentially pure, MH can be schematically represented

$$(H_{\uparrow} - H_{\downarrow}) \times H_{\uparrow}, \qquad (11.5.1a)$$

$$(H_{\uparrow} - H_{\downarrow}) \times (H_{\uparrow} - H_{\downarrow}), \qquad (11.5.1b)$$

$$(H_{\uparrow} - H_{\downarrow}) \times (H_{\uparrow} - H_{\downarrow}) \times H_{\uparrow}, etc.$$
(11.5.1c)

while MagneO can be schematically represented

$$(O_{\uparrow} - O_{\downarrow}) \times O_{\uparrow},$$
 (11.5.2*a*)

$$(O_{\uparrow} - O_{\downarrow}) \times (O_{\uparrow} - O_{\downarrow}), \qquad (11.5.2b)$$

$$(O_{\uparrow} - O_{\downarrow}) \times (O_{\uparrow} - O_{\downarrow}) \times O_{\uparrow}.etc.$$
(11.5.3c)

where the arrows now indicate possible polarizations of more than one electron orbit.

By keeping in mind the content of the preceding sections, the achievement of the above magnecular structure does imply that MH and MO have specific

weight and energy content greater than the corresponding values for unpolarized gases. The numerical values of these expected increases depend on a variety of factors discussed in the next subsections, including the intensity of the external magnetic field, the pressure of the gas, the time of exposure of the gas to the external field, and other factors.

A first important feature to be subjected to experimental verification (reviewed below) is the expected increase of specific weight. By recalling that the gasoline gallon equivalent for hydrogen is about 366 scf, the achievement of a form of MH with five times the specific weight of conventional hydrogen would reduce the prohibitive volume of 7,660 scf equivalent to 20 g of gasoline to about 1,500 scf. This is a volume of MH that can be easily stored at the pressure of 4,500 psi in carbon fiber tanks essentially similar in volume and composition to that of a natural gas tank. As a result, the achievement of MH with sufficiently high specific weight can indeed eliminate the expensive liquefaction of hydrogen in automotive use, with consequential reductions of costs.

Another basic feature to be subjected to experimental verification (reviewed below) is that the combustion of MH and MO releases more energy than the combustion of conventional H and O gases. It then follows that

I) The use for internal combustion engines of MH with a sufficiently high specific weight is expected to eliminate liquefaction, yield essentially the same power as that produced with gasoline, and permit a dramatic decrease of operating costs;

II) The use of MH and MO in fuel cells is expected to yield a significant increase of voltage, power and efficiency; and

III) The use of liquefied MH and MO as fuels for rocket propulsion is expected to permit an increase of the payload, or a decrease of the boosters weight with the same payload.

Moreover, recent studies scheduled for a separate presentation have indicated that the *liquefaction of MH and MO appears to occur at temperatures bigger than those for conventional gases*, thus implying an additional reduction of costs. This expectation is due to the fact that magnecules tend to aggregate into bigger clusters with the increase of the pressure, evidently due to their magnetic polarizations, which feature evidently favors liquefaction.

It is evident that the same principles outlined above also apply for other gases, and not necessarily to H and O gases alone. In fact, the processing of any gaseous fossil fuel via the principles here considered permits the increase of its specific weight as well as of its energy output, thus permitting a consequential decrease of storage volume, increase of performance and decrease of costs.

Note that the hypothesis of MH and MO is an extension of  $H_3$  and  $O_3$  to arbitrary values  $H_n$  and  $O_m$  as permitted by local values of pressure and temperature. Alternatively, the experimental evidence on MH and MO reviewed later on in this section confirms the magnecular structure of  $H_3$  and  $O_3$  presented in Section 11.3.4.

# 10.5.3 Industrial Production of MagneHydrogen<sup>TM</sup> and MagneOxygen<sup>TM</sup>.

As indicated earlier, the magnetic polarization of the orbits of peripheral atomic electrons requires extremely strong magnetic fields of the order of billions of Gauss. These values are of simply impossible realization in our laboratories with current technologies, that is, at distances of the order of inches or centimeters. These magnetic fields cannot be realized today even with the best possible superconducting solenoids cooled with the best available cryogenic technology.

The only possible, industrially useful method of achieving magnetic fields of the needed very high intensity is that based on direct current (DC) electric arcs with currents of the order of thousands of Amperes (A) when considered at atomic distances, i.e., of the order of  $10^{-8}$  cm. As illustrated in Fig. 11.9, the magnetic field created by a rectilinear conductor with current I at a radial distance r is given by the well known law

$$B = kI/r, \tag{11.5.4}$$

where k = 1 in absolute electromagnetic units. It then follows that, for currents in the range of  $10^3$  A and distances of the order of the size of atoms  $r = 10^{-8}$  cm, the intensity of the magnetic field B is of the order of  $10^{13}$  Oersted, thus being fully sufficient to cause the magnetic polarization of the orbits of peripheral atomic electrons.

Under the above conditions schematically represented in Fig. 11.9, atoms with the toroidal polarization of their orbits find themselves aligned one next to the other with opposing polarities which attract each other, thus forming magnecules. The electric arc decomposes the original molecule, thus permitting the presence of isolated atoms or radicals in the magnecular structure as needed to increase the energy output (Section 3).

In this way, the process transforms the original gas with its conventional molecular structure into a new chemical species consisting of individual atoms, radicals and complete molecules all bonded together by attractive forces among opposite magnetic polarities of the toroidal polarization of the orbits of peripheral atomic electrons.

In the event the original gas has a simple diatomic molecular structure, such as  $H_2$ , the magnecular clusters are composed of individual polarized H atom and ordinary polarized molecules  $H_2$  as in Fig. 11.11. In the event the original gas has the more complex diatomic structure of  $O_2$ , the magnecular clusters are composed of individual polarized O atoms, O-O single bonds, and  $O_2$  molecules with additional internal bonds as in Fig. 11.12. In the event the original gas has the more complex diatomic structure CO with triple valence bonds, the magnecular clusters are more complex and are generally composed of individual C and O atoms, single bonds C-O, double bond C=O, conventional molecules CO and  $O_2$  with internal new bonds as in Fig. 11.12, plus possible C-complexes. Original gases with more complex conventional molecular structure evidently imply more complex magnecular clusters with all possible internal atomic arrangements.

It is evident that the resulting new species is not composed of all identical magnecules, and it is composed instead of a variety of magnecules from a minimum to a maximum number of atomic components, which have been measured to reach 1,000 a.m.u. and even more. The specific weight of the magnecular gas is then given by the average weight of all different magnecules, as indicated earlier.

Needless to say, a number of alternative methods for the industrial production of MH and MO are possible as identified in the existing patent applications. An alternative method worth mentioning here is the use of solenoids. The reader should however be aware that the latter cannot decompose molecules. Therefore, the MagneGases produced via the use of electric discharges and solenoids are different.

Another type of MH important for this study is that obtained from MagneGas [5]. When MagneGas is produced from a hydrogen rich liquid feedstock (such as water or liquids of fossil origin), it may contain up to 60% hydrogen in a form already polarized by the electric arc used for its production. Therefore, the hydrogen content of MagneGas is indeed a particular form of MH which can be separated via a variety of available technologies, such as filtration, cryogenic cooling and other processes.

This particular form of MH (whose features are identified in the next subsection) is particularly suited as fuel for internal combustion engines, rather than for fuel cells. This is due to the expected presence of very small C and O impurities which do not permit their use in fuel cells.

This particular type of MH derived from MagneGas has already been tested for automotive usage and proved to have a performance essentially similar to that of gasoline without any need of liquefaction, as needed instead by hydrogen vehicles currently tested by BMW, GM and other automakers. The tests were conducted via the conversion of two Honda and one Ferrari cars to operate on the new fuels (see [5] for brevity).

Above all, this particular type of MH has resulted to be cost competitive with respect to fossil fuels, of course, when produced in sufficiently large volumes. This cost competitiveness is due to a variety of factors, including (see [5] for detail):

1) the use of hydrogen rich wastes as liquid feedstock, such as city and farm sewage, antifreeze and or oil waste, etc., which implies an *income*, rather than a cost;

2) the possible utilization of steam at  $400^{\circ}$  produced by the cooling of the highly esoenergetic processes of the reactors, which steam can be used for other *income* 



Figure 10.35. A view of the main results on the measurement of specific weight on a specific form of MH produced from magnegas released by Adsorptions Research Laboratory, in Ohio, under signature by its laboratory director. It should be stressed that the high value of specific weight was due to a specific treatment not expected to be possible on a industrial basis. Therefore, the specific weight ofg MH industrially production from magnegas is expected to have about three times the specific weight of  $H_2$ , thus sufficient to render MH equivalent to natural gas as far as energy content is concerned (because natural gas contains about 1,000 BTU/scf, H2 contains about 300 BTU/scf, consequently  $MH = 3H_2$  would contain BTU/scf close to those of natural gas)

*producing applications*, such as desalting seawater via evaporation, production of electricity via turbines, heating of buildings, and other income producing uses; and

3) the unusually high efficiency of Santilli Hadronic Reactors of molecular types used for the process which brings the cost of electricity down to 0.005/scf.

Specific equipment and designs for the industrial production of MH, MO, and other magnetically polarized gases are available on request.

# 10.5.4 Experimental Evidence on MagneHydrogen<sup>TM</sup> and MagneOxygen<sup>TM</sup>

It is now important to review the experimental evidence supporting the existence of MH and MO.

The first tests were conducted with MH produced from MagneGas as indicated in the preceding subsection. MagneGas was first produced by using antifreeze waste as liquid feedstock. The combustible gas was then passed through 5 Armstrong zeolite filters, which essentially consist of a microporous molecular sieve selecting a gas via the so-called "molecular sieving," or molecular size exclusion.. The filtered gas was then subjected to the following three measurements:

1) This type of MH was first subjected to analytic measurements by a laboratory via Gas Chromatography (CG) and independent tests for confirmation were conducted via Fourier Transform Infrared Spectroscopy (FTIS). All measurements were normalized, air contamination was removed, and the lower detection limit was identified as being 0.01%. The results are reported in Fig. 11.35. As



6349 82nd Avenue North Pinellas Park, Florida 33781 Phone: (727) 545-2297 • Fax (727) 547-8024

| Component             | Gu              |
|-----------------------|-----------------|
| Hydrogen              | 99.2            |
| Carbon<br>monoxide    | None detected ' |
| Carbon<br>dioxide     | None detected   |
| Methane               | 0.78            |
| Ethane                | None detected   |
| Ethene<br>(ethylene)  | None detected   |
| Ethyne<br>(acetylene) | None detected   |

Figure 10.36. A summary view of the spectroscopic analyses conducted by Spectra lab of largo, Florida, showing 99.2% hydrogen in the species of MH here considered. Note the "experimental belief" that the species here considered contains 0.78% methane. MH produced from magnegas cannot possibly contain methane since magnegas is formed at about 10,000°F of the electric arc at which methane cannot possibly survive. in reality, the analytic instrument has detected a magnecular species with 16 a.m.u and identified that species with methane due to lack of info in the computer data banks.

one can see, these measurements indicate that this particular type of MagneH is composed of 99.2% hydrogen and 0.78% methane, while no carbon monoxide was detected.

2) The average specific weight of this type of MH was measured by two independent laboratories as being 15.06 a.m.u., while conventional pure hydrogen has the specific weight of 2.016 a.m.u., thus implying a 7.47 fold increase of the specific weight of conventional hydrogen.

3) The same type of MH used in the preceding tests was submitted to CG-MS scans via the use of a HP GC 5890 and a HP MS 5972 with operating conditions specifically set for the detection of magnecules (Section 5 and Ref. [5]). The results of these third tests are reproduced in Fig. 11.37. As one can see, by



Figure 10.37. A view of one of the numerous GC-MS scans conducted at the Toxic Analytic Laboratory in California establishing in a final form the magnecular character of the species here studied. In fact, the molecular seeving process used by Adsorption Research Laboratory could only allow the separation of hydrogen and definitely not the numerous heavy clusters identified in this scan. Since hydrogen has only one electron and, consequently can only form under valence bond  $H_2$ , the heavy species of hydrogen here considered establishes the existence of a non-valence bond beyond any possible or otherwise credible doubt.

keeping in mind the results of GC-FTIS of Fig. 11.36, the GC-MS measurements should have shown only two peaks, that for hydrogen  $H_2$  at about 2 a.m.u., and that for methane  $CH_4$  at about 16 a.m.u. On the contrary, these GC-MS tests confirm the existence of a large peak at about 2 a.m.u. evidently representing hydrogen, but do not show any peak at 16 a.m.u. proportional to the 0.78% of methane, and exhibit instead the presence of a considerable number of additional peaks in macroscopic percentages all the way to 18 a.m.u. This GC-MS scan establishes the existence beyond credible doubt of a magnecular structure in the type of MH here studied. Note, in particular, the existence of well identified peaks in macroscopic percentage with atomic weight of 3, 4, 5, 6, 7, 8 and higher values which peaks, for the gas under consideration here, can only be explained as magnecules composed of individual H atoms as well as H molecules in increasing numbers.

The above measurements 1), 2) and 3) confirm the capability to produce hydrogen with a multiple value of their standard specific weight, and consequential increased energy content.

Next, to test MO in fuel cells, the author had constructed by technicians in Florida a rudimentary apparatus based on the use of automotive sparks powered by an ordinary car battery, the system operating at about 15 psi. Two types of MO, denoted by  $MO_1$  and  $MO_2$ , were produced from pure oxygen for comparative purposes.



*Figure 10.38.* A schematic view of the voltage increase in a test fuel cell operated with ordinary pure hydrogen and the two samples of *MO* produced by rudimentary equipment.

This type of MO was tested in lieu of ordinary oxygen in a 2-cell Proton Exchange Membrane (PEM) fuel cell operated with conventional high purity hydrogen. The membrane material was Nafion 112; the catalyst in the electrodes was platinum acting on carbon; the plates for heat transfer were given by two nickel/gold plated material; the temperature of the fuel cell was kept constant via ordinary cooling means; the current was measured via a HP 6050A electronic load with a 600 W load module; a flow rate for oxygen and hydrogen was assigned for each current measurement; both oxygen and hydrogen were humidified before entering the cell; the measurements reported herein were conducted at 30 degrees C.

The results of the measurements are summarized in Figs. 11.38, 11.39 and 11.40 that report relative measurements compared to the same conditions of the cell when operated with ordinary pure oxygen. As one can see, these measurements show a clear increase of the voltage, power and efficiency of the order of 5% when the cell was operated with  $MO_1$  and  $MO_2$ . The increase was consistent for both samples except differences within statistical errors.

To appraise these results, one should note that the types of MO used in the test were produced via rudimentary equipment based on intermittent sparks operated with an ordinary automotive battery, and with the pressure limited to 15 psi. By comparison, the industrial production of MO should be done with an array of arcs each operated with continuous currents of thousands of Amperes, and at



Figure 10.39. A schematic view of the power increase in a test fuel cell operated as in Fig. 11.38 confirming the results of the latter.

pressures of thousands of psi. It is evident that the latter conditions are expected to imply a significant increase of the performance of the fuel cells when operated with MO. Still bigger increases in voltage, power and efficiency occur when the fuel cells are operated with both MO and MH for the reasons discussed in Section 3. These latter tests are under way and are contemplated for reporting in a future research.

In summary, the systematic character of the experimental results, combined with the limited capabilities of the used equipment, appear to confirm the hypothesis of new forms of hydrogen and oxygen with magnecular structure capable of producing an industrially significant increase in voltage, power and efficiency of fuel cells. Independent measurements are here solicited for the finalization of these issues.

### 10.5.5 Conclusions

Despite the known uneasiness created by novelty, the rather vast experimental evidence, only partially reproduced in this section to avoid a prohibitive length, supports the following results:

1) The existence of a new chemical species whose bonding force is not of valence type (from the absence of infrared signature and various other evidence as in Figs. 6 and 7), which has been interpreted by this author as being due to the only fields available in a molecular structure, the electric and magnetic fields, and called



*Figure 10.40.* A schematic view of the efficiency increase in a test fuel cell operated as in Fig. 11.38, which provide additional confirmation of the latter results.

electromagnecules in general, the name Santilli magnecules being used to denote the dominance of magnetic over electric effects (Section 2). Other researchers may prefer different nomenclatures and search for esoteric fields other than the electric and magnetic fields, with the understanding that the non-valence novelty of the new species is outside scientific debate.

2) The existence of a form of hydrogen with about seven times the atomic weight of molecular hydrogen which eliminates the need for liquefaction in automotive use, while having a power output essentially similar to that of gasoline, and being cost competitive with respect to fossil fuel when produced in large scale. This is the new species of hydrogen, called by this author MagneH<sup>TM</sup> (patented and international patents pending) which is derived via filtering, cryogenic separation or other means from the new combustible fuel called Santilli MagneGas<sup>TM</sup> (international patents pending). The latter gas s is produced via DC electric arcs between carbon-base consumable electrodes submerged within a hydrogen rich liquid feedstock, such as fresh or salt water, antifreeze or oil waste, city or farm sewage, crude oil, etc.

3) The industrial capability of turning conventional hydrogen and oxygen into new species with bigger atomic weight and energy content for use in fuel cells with increased voltage, power and efficiency.

4) The existence of new forms of liquid hydrogen and oxygen for rocket propulsion with increased trust, and consequential increased payload or decreased boosters' weight with the same payload. 5) The experimental evidence of dramatic departures from quantum chemistry in support of the covering hadronic chemistry [5].

Evidently, these studies are in their infancy and much remains to be done, both scientifically and industrially. Among the existing intriguing open problems we mention:

A) The identification of *new analytic equipment specifically conceived for the detection of magnecules*. In fact, researchers in the field know well the dramatic insufficiency for tests on magnecular substances of currently available analytic equipment specifically conceived for molecular substances.

B) The identification of the possible frequency at which magnecules may have an infrared signature. For instance, the detection of methane in the MH tests of Fig. 11.36 has a mere indicative value, rather than being an actual experimental fact. In any case, the detection of methane is not confirmed by at least one second independent test to achieve final scientific character. Also, a peak at 16 a.m.u. which is necessary in the GC-MS scans of Fig. 11.27 to confirm the presence of methane (CH<sub>4</sub>), is missing. Finally, the original MagneGas is created in the 10,000° F of electric arcs at which temperature no methane can survive. In view of the above, a more plausible possibility is that the "methane" detected by the analyses of Fig. 11.37 is, in reality, the infrared signature of a magnecule.

C) The study of the liquefaction of MagneGases on a comparative basis with the liquefaction of the same gases with conventional molecular structure. This study is recommended particularly for rocket propulsion, due to the expected new species of *liquid magnecules* [5], the liquefaction itself at a temperature bigger than the conventional ones, the increase in trust and the reduction in liquefaction costs.

D) The study of the possible storage of energy in inert gases via the mechanism of internal magnetic polarization and resulting new molecular bonds illustrated in Figs. 5 and 8. In fact there exist patents as well as reported test engines operating on inert gases which are generally dismissed by academia because of the believed "inert" character of these cases. Perhaps, a more open mind is recommendable for truly basic advances.

E) The study of nonlinear deviations from the perfect gas law and the Avogadro number which are inherent in magnecular clustering since they can break down into fragments due to collision and then have different recombinations, resulting in a population with generally varying number of constituents, while keeping constant statistical averages.

Needless to say, the author solicits the independent verification of all results presented in this section without which no real scientific advance is possible.

# 10.6 HHO, THE NEW GASEOUS AND COMBUSTIBLE FORM OF WATER WITH MAGNECULAR STRUCTURE

#### 10.6.1 Introduction

Studies on the electrolytic separation of water into hydrogen and oxygen date back to the 19-th century (for a textbook on the water molecule see, e.g., Ref. [20a] and for an account on its electrolytic separation see, e.g., Ref. [20b]). More recently, there has been considerable research in the separation of water into a mixture of hydrogen and oxygen gases. These studies were initiated by Yull Brown in 1977 via equipment generally referred to as electrolyzers and the resulting gas is known as "Brown gas" (see patents [21]).

In accordance with these patents as well as the subsequent rather vast literature in the field, the Brown gas is defined as a combustible gas composed of conventional hydrogen and conventional oxygen gases having the exact stochiometric ratio of 2/3 (or 66.66% by volume) of hydrogen and 1/3 (or 33.33% by volume) of oxygen.

In this section the author (a physicist) presents to the chemistry community for its independent verification various measurements on an apparently new mixture of hydrogen and oxygen hereon referred to as the HHO gas (international patent pending) developed by Hydrogen Technology Applications, Inc., of Clearwater, Florida (www.hytechapps.com). The new HHO gas is regularly produced via a new type of electrolyzer and has resulted to be distinctly different in chemical composition than the Brown gas, even though both gases share a number of common features.

The main scope of this section is to report, apparently for the first time, new clusters of hydrogen and oxygen atoms contained in the HHO gas, which clusters appear to escape the traditional valence interpretation and constitute one of the novelties of the HHO gas over the Brown gas.

Another objective of this sec tion is to initiate quantitative studies on the rather unique features of the HHO gas that do not appear to be representable via the conventional quantum chemistry of hydrogen and oxygen gases.

Yet another objective of this section is to present a working hypothesis to initiate the understanding of the capability by the HHO electrolyzers to perform the transition of water from the liquid to a gaseous state via a process structurally different than evaporation or separation, due to the use of energy dramatically less than that required by said evaporation or separation.

The final objective of this section is the submission, apparently for the first time, of it a new form of the water molecule created by the removal of its natural electric polarization and consequential collapse of the two HO dimers, from their conventional configuration with  $105^{\circ}$  to a new configuration in which the two



*Figure 10.41.* A view of one of the GC scans on the HHO gas conducted by Adsorption Research Laboratories showing conventional as well as anomalous peaks.

dimers are collapsed one against the other due to strongly attractive opposing magnetic polarizations (see below for details and pictures).

Due to the loss of electric polarization, polymerization and other features, the above new form of the water molecule permits a plausible representation of the creation of the HHO gas from liquid water without the evaporation energy. Its unstable character also permits a plausible interpretation on the experimental measurements of all anomalous features of the HHO gas.

Independent verification by interested chemists of the various measurements reported in this section are solicited, jointly with the conduction of additional much needed tests. Samples of the HHO gas can be obtained at any time by contacting Hydrogen Technology Applications, Inc. at their website www.hytechapps.com.

### 10.6.2 Experimental Measurements on the New HHO Gas

Under visual inspection, both the HHO gas results to be odorless, colorless and lighter than air, as it is also the case for the Brown gas. Their first remarkable feature is the efficiency E of the electrolyzer for the production of the gas, here simply defined as the ratio between the volume of HHO gas produced and the number of Watts needed for its production. In fact, the electrolyzers rapidly convert water into 55 standard cubic feet (scf) of HHO gas at 35 pounds per square inch (psi) via the use of 5 Kwh, namely, an efficiency that is at least ten times the corresponding efficiency of conventional water evaporation, thus permitting low production costs.

The above efficiency establishes the existence of a transition of water from the liquid to the gaseous state that is not caused by evaporation. By keeping in mind the combustible character of the HHO gas compared to the noncombustible char-



Figure 10.42. The IR signature of a conventional  $H_2$  gas made by the PdMA laboratory.

acter of water vapor, the above efficiency suggests the existence of new chemical processes in the production of the gas that deserve quantitative studies.

A second important feature is that the HHO gas does not require oxygen for combustion since the gas contains in its interior all oxygen needed for that scope, as it is also the case for the Brown gas. By recalling that other fuels (including hydrogen) require atmospheric oxygen for their combustion, thus causing a serious environmental problem known as oxygen depletion, the capability to combust without any oxygen depletion (jointly with its low production cost) render the gas particularly important on environmental grounds.

A third feature of the gas is that it does not follow the PVT of gases with conventional molecular structure, since the gas reacquires the liquid water state at a pressure of the order of 150 psi, while conventional gases acquire the liquid state a dramatically bigger pressures. This feature suggests that the gas here considered does not possess a conventional molecular structure, namely, a structure in which the bond is of entire valence type.

A fourth feature of the gas is its anomalous adhesion (adsorption) to gases, liquids and solids, as verified experimentally below, thus rendering its use particularly effective as an additive to improve the environmental quality of other fuels, or other applications. This feature is manifestly impossible for conventional gases  $H_2$  and  $O_2$ , thus confirming again a novel chemical structure.

A fifth feature of the gas is that it exhibits a widely varying thermal content, ranging from a relatively cold flame in open air at about  $150^{\circ}C$ , to large releases of thermal energy depending on the substance to which the flame is applied to, such as the instantaneous melting of bricks requiring up to  $9,000^{\circ}C$ .

The measurements conducted by the author at various independent laboratories on the HHO gas can be summarized as follows.

On June 30, 2003, Adsorption Research Laboratory of Dublin, Ohio, measured the specific weight of the HHO gas and released a signed statement on the result-



Figure 10.43. The IR signature of a conventional  $O_2$  gas made by the PdMA laboratory.

ing value of 12.3 grams/mole. The same laboratory repeated the measurement on a different sample of the gas and confirmed the result.

The released value of 12.3 grams/mole is anomalous. In fact, the conventional separation of water into  $H_2$  and  $P_2$  produces a mixture of 2/3  $HBN_2$  and 1/3  $O_2$  that has the specific weight (2 + 2 + 32)/3 = 11.3 grams/mole.

Therefore, we have the anomaly of 12.3 - 11.2 = 1 gram/mole, corresponding to 8.8% anomalous increase in the value of the specific weight. Rather than the predicted 66.66% of  $H_2$  the gas contains only 60.79% of the species with 2 atomic mass units (amu), and rather than having 33.33% of  $O_2$  the gas contains only 30.39% of the species with 32 amu.

These measurements provide direct experimental evidence that the HHO gas is not composed of a sole mixture of  $H_2$  and  $O_2$ , but has additional *heavier* species.

Moreover, the HHO gas used in the tests was produced from distilled water. Therefore, there cannot be an excess of  $O_2$  over  $H_2$  to explain the increased specific weight. The above measurement establishes the presence in HHO of 5.87% of hydrogen and 2.94% oxygen bonded together into species heavier than water, as identified below via mass spectroscopy and other analytic measurements.

Adsorption Research Laboratory also conducted scans of the HHO gas via a Gas Chromatographer (GC) reproduced in Fig. 11.41 establishing the presence in the HHO gas of the following species here presented in order of their decreasing percentages:

1) A first major species with 2 amu expectedly representing gaseous hydrogen;

2) A second major species with 32 amu expectedly representing gaseous oxygen;

3) A large peak at 18 amu expectedly representing water vapor;

4) A significant peak with 33 amu expectedly representing a new species expectedly of non-molecular nature;

5) A smaller yet clearly identified peak at 16 amu expectedly representing atomic oxygen;

6) Another small yet fully identified peaks at 17 amu expectedly representing the radical OH whose presence in a gas is also anomalous;



Figure 10.44. The IR signature of the HHO gas made by the PdMA laboratory. When compared to the IR scans of Figures 2 and 3, this scan shows that the HHO gas is not a mixture of  $H_2$  and  $O_2$  gases.

7) A small yet fully identified peak at 34 amu expectedly representing the bond of two dimers HO that is also anomalous for a gas;

8) A smaller yet fully identified peak at 35 amu that cannot be identified in any known molecule;

9) Additional small peaks expected to be in parts per million.

It should be added that the operation of the GC detector was halted a few seconds following the injection of the HHO gas, while the same instrument was operating normally with other gases. This anomalous behavior can be best interpreted via an anomalous adhesion of the gas to the walls of the feeding line as well as of the column and other parts of the instruments, an anomalous adhesion confirmed by additional tests reviewed below.

On July 22, 2003, the PdMA Corporation in Tampa, Florida, conducted InfraRed (IR) scans reported in Figures 2, 3 and 4 via the use of a Perkin-Elmer IR scanner model 1600 with fixed point/single beam. The reported scans refer to a conventional  $H_2$  gas (Fig. 11.42), a conventional  $O_2$  gas (Fig. 11.43), and the HHO gas Fig. 11.44).

Inspection of these scans shows a substantial differences between HHO gas and  $H_2$  and  $O_2$  gases. In fact, the latter gases are symmetric molecules, thus having very low IR peaks, as confirmed by scans 2 and 3. The first anomaly of HHO is that of showing comparatively much stronger resonating peaks. Therefore, the indicated IR scans establish that the HHO gas has an asymmetric structure, which is remarkable since the same feature is absent for the conventional mixture if  $H_2$  and  $O_2$  gases.

Moreover,  $H_2$  and  $O_2$  gases can have at most two resonating frequencies each, one for the vibrations and the other for rotations. Spherical distributions of orbitals and other features imply that  $H_2$  has essentially only one IR signature as confirmed by the scan of Fig. 11.42, while  $O_2$  has one vibrational IR frequency and three rotational ones, as also confirmed by the scans of Fig. 11.43.

Inspection of the IR scans for the HHO gas in Fig. 11.44 reveals additional novelties. First, the HHO scan show the presence of at least nine different IR frequencies grouped around wavenumber 3000, plus a separate distinct frequency at around wavenumber 1500.

These measurements provide experimental evidence that the species with 18 amu detected in the GC scans of Fig. 11.41 is not water vapor, but a yet unknown bond of two hydrogen and one oxygen atoms.

In fact, water vapor has IR frequencies with wavelengths 3756, 3657, 1595, their combination and their harmonics (here ignored for simplicity). The scan for the HHO gas in Fig. 11.44 confirms the presence of an IR signature near 1595, thus confirming the molecular bond HO, but the scan shows no presence of the additional very strong signatures of the water molecules at 3756 and 3657, thus establishing the fact that the peak at 18 amu is not water as conventionally understood in chemistry.

On July 22, 2003, the laboratory of the PdMA Corporation in Tampa, Florida measured the flash point, first on commercially available diesel fuel, detecting a flash point of  $75^{\circ}C$ , and then of the same fuel following the bubbling in its interior of the HHO gas, detecting the flash point of  $79^{\circ}C$ .

The latter measurement too is anomalous because it is known that the addition of a gas to a liquid fuel *reduces* its flash point generally by half, rather than *increasing* it as in the above measurement, thus implying the expected flash value of about  $37^C$  for the mixture of diesel and HHO gas. Therefore, the anomalous increase of the flash point is not of  $4^{\circ}C$ , but of about  $42^{\circ}C$ .

Such an increase cannot be explained via the assumption that HHO is contained in the diesel in the form of a gas (otherwise the flash point would decrease), and requires the occurrence of some type of anomalous bond between the gas and the liquid that cannot possibly be of valence type.

An experimental confirmation of the latter bond was provided on August 1, 2003, by the Southwest Research Institute of Texas, that conducted mass spectrographic measurements on one sample of ordinary diesel as used for the above flash point measurements, here reported in Fig. 11.45, and another sample of the same diesel with HHO gas bubbled in its interior, here reported in Fig. 11.46.

The measurements were conducted via a Total Ion Chromatogram (TIC) and Gas Chromatography Mass Spectrometry GC-MS manufactured by Hewlett Packard with GC model 5890 series II and MS model 5972. The TIC was obtained via a Simulated Distillation by Gas Chromatography (SDGC).

The column was a HP 5MS  $30 \times 0.25$  mm; the carrier flow was provided by helium at  $50^{\circ}C$  and 5 psi; the initial temperature of the injection was  $50^{\circ}C$  with a temperature increase of  $15^{\circ}C$  per minute and the final temperature of  $275^{\circ}C$ .



Figure 10.45. A TIC of the GC-MS scans of conventionally sold diesel fuel made by Southwest Research Institute.



*Figure 10.46.* A TIC of the GC-MS scans made by Southwest Research Institute on the same diesel fuel of Figure 5 in which the HHO gas had been bubbled through, showing the alteration of the TIC both in shape as well as increased mass, thus indicating a new bond between diesel and HHO that cannot be of valence type (since HHO is gaseous and diesel is liquid. In any case, all valence electrons in both the gas and the liquid are used by conventional molecular bonds.

The chromatogram of Fig. 11.45 confirmed the typical pattern, elusion time and other feature of commercially available diesel. However, the chromatograph of the same diesel with the HHO gas bubbled in its interior of Fig. 11.46 shows large structural differences with the preceding scan, including a much stronger response, a bigger elusion time and, above all, a shift of the peaks toward bigger amu values.

Therefore, the latter measurements provide additional confirmation of the existence of an anomalous bond between the diesel and the HHO gas, precisely as predicted by the anomalous value of the flash point and the clogging up of GC feeding lines. In turn such a bond between a gas and a liquid cannot possibly be



Figure 10.47. A TIC of the GC-MS scans on the HHO gas made by Toxic LTD Laboratories showing the  $H_2$  content of the HHO gas.

of valence type, since all valence electrons are expected to be coupled in both the liquid and the gas.

Further mass spectrographic measurements on the HHO gas were done on September 10, 2003, at SunLabs, of the University of Tampa, Florida, via the use of a very recent GC-MS Clarus 500 by Perkin Elmer, one of the most sensitive instruments currently available to detect hydrogen.

Even though the column available at the time of the test was not ideally suited for the separation of all species constituting the HHO gas, the latter measurements confirmed the preceding results.

In fact, the scan of Fig. 11.50 confirms the presence in the HHO gas of a basic species with 2 amu representing hydrogen, plus a species with 5 amu that cannot admit any valence or molecular interpretation for the HHO gas even if the species is formed by the spectrometer.

In conclusion, the experimental measurements of the flash point and of the scans of Figs. 5 and 6 establish beyond doubt the capability by the HHO gas to have an anomalous bond with liquid fuels, that is, a bond that is not of valence type.

Additional analyses on the chemical composition of the HHO gas were done by Air Toxic LTD of Folsom, California, via the scans reproduced in Figs. 7, 8 and 9. These scans confirmed that  $H_2$  and  $O_2$  are the primary constituents of the HHO gas. However, the same measurements identify the following anomalous peaks:

a) A peak in the  $H_2$  scan at 7.2 minutes elusion times (Fig. 11.47);

b) A large peak in the  $O_2$  scan at 4 minutes elusion time (Fig. 11.48); and

c) An anomalous blank following the removal of the HHO gas (Fig. 11.49),

because said blank shows the preservation of the peaks of the preceding scans,



*Figure 10.48.* A TIC of the GC-MS scans on the HHO gas made by Toxic LTD Laboratories showing the peaks belonging to  $H_2$  and  $O_2$ , plus anomalous peaks.

an occurrence solely explained via anomalous adhesion of the HHO gas to the interior walls of the instrument.

The scan of Fig. 11.51 provides evidence of a species with mass 16 amu that can only be interpreted as atomic oxygen, thus providing additional indication of the presence in the HHO gas of atomic hydrogen as expected from its capabilities, although the species, again, could be separated by the spectrometer due to the expected weak nature of the bond. The latter could not be detected in the preceding scan due to the impossibility of the instrument here considered to detect a species with 1 amu. The same scan of Fig. 11.51 confirms the presence in the HHO gas of a species with 17 amu and a species with 18 amu detected in earlier tests.

The scan of Fig. 11.52 establishes the presence in the HHO gas of species with 33 and 34 amu, while the species with 35 amu detected in preceding measurements was confirmed in other scans here not reported for brevity.

The tests also confirmed the blank anomaly, namely, the fact that the blank of the instrument following the removal of the gas continues to detect the basic species constituting the gas, which blank is not reproduced here for brevity, thus confirming the anomalous adhesion of the HHO gas to the interior walls of the instrument.

In summary, the above analytic measurements establish the following properties of the HHO gas:

I) An anomalous increase in specific weight of 1 gram/mole (or 8.8% in volume) establishing the presence in the HHO gas of species heavier than the predicted mixture of  $H_2$  and  $O_2$ , thus establishing the presence in the HHO gas of new species composed of H and O atoms that cannot possibly have valence bonds.

II) The GC scans done by Adsorption Research (Fig. 11.41) confirm the presence of chemical species in the HHO gas that cannot have a valence interpre-



Figure 10.49. One of the anomalous blanks of the GC-MS scans made by Toxic LTD Laboratories following the tests of the HHO. The blank is firstly anomalous because only the background should have been detected, thus indicating a bond between the HHO gas and the walls of the instrument, whose most plausible explanation is the magnetic polarization by induction of said walls by a form of magnetic polarization of the species composing the HHO gas. the second reasons for the anomalous nature of the blank is that the substances detected cannot possibly exist in the HHO gas produced from distilled water, thus showing an accretion of bonds to the instrument walls.

tation, such as the species with 17 amu, 33 amu, 34 amu, and 35 amu, besides conventional species with 2 amu, 16 amu and 18 amu, all species independently confirmed by other tests, such as the scans of Figs. 10, 11 and 12

III) The halting of the GC instrument in the scans of Fig. 11.41 after a few seconds following the injection of the HHO gas, while the same instrument works normally for conventional gases, is experimental evidence for an anomalous adhesion by the HHO gas to the internal walls of the instrument, to such a level of occluding the column and causing the shut down of the scan;

IV) The large increase of the flash point of diesel fuel following inclusion of the HHO gas also constitutes experimental evidence of anomalous adhesion by the HHO gas, this time, to a liquid fuel that cannot also be of valence type since all valence electrons available in both the liquid and the gas are expected to be paired;

V) The mass spectrometric measurements on the mixture of diesel and HHO (Figs. 5 and 6) provide additional experimental confirmation of an anomalous bond between the HHO gas and diesel;



Figure 10.50. The scan conducted by SunLabs on the HHO gas confirming the presence of  $H_2$ , plus additional anomalous peaks, such as the species at 5 amu, that cannot possibly admit a molecular interpretation.

VI) The additional scans of Figs. 7, 8 and 9 confirm all the preceding results, including the anomalous blank following the removal of the HHO gas, thus confirming the anomalous adhesion of the HHO gas to the internal walls of the instrument;

VII) The capability by the HHO gas to melt instantaneously tungsten and bricks is the strongest evidence on the existence in the HHO gas of basically new chemical species that cannot possibly have a valance bond, since a mixture of  $2/3 H_2$  and  $1/3 O_2$  cannot melt instantly tungsten and bricks, as any interested chemist is encouraged to verify.

It should be indicated that a number of species in the HHO gas, particularly those with higher specific weight, are expected to be unstable and, as such, decomposed by the analytic instrument itself. In different terms, by no means GC, IR and other scans should be expected to detect *all* constituents of the HHO gas, since a number of them are expected to be decomposed or altered by the ionization and other processes connected to the scans themselves.

### **10.6.3** Magnecular Interpretation of the Measurements

The first experimental evidence supporting the magnecular structure of the HHO gas is its capability of instantly melting tungsten and bricks. In fact, such



Figure 10.51. The scan conducted by SunLabs on the HHO gas detecting a peak at 16 amu that confirms the presence of atomic oxygen in the HHO gas of Fig. 11.51, plus a peak at 17 amu indicating the presence of traces of the radical O - H, a peak at 18 amu indicating the presence of water vapor all three species also detected in the scan of Fig. 11.51, as well as additional anomalous peaks at 12, 14, 25, 26, 27 amu that, for the case of the HHO gas produced from distilled water cannot admit a molecular interpretation.

a capability can only be explained via the presence in the HHO gas, not only of atomic (that is, unbounded) hydrogen as depicted in the top of Fig. 11.9, but also of atomic hydrogen with the toroidal polarization of their orbitals as depicted in the bottom of Fig. 11.10.

In fact, no instantaneous melting of bricks is possible without the hydrogen contained in the HHO gas rapidly penetrating within deeper layers of the brick structure. Such a rapid penetration cannot be explained with atomic hydrogen, although it can be readily explained via the polarized hydrogen atom of the bottom of Fig. 11.10.

Besides having a smaller sectional area that favors fast penetration, polarized H-atoms cause an induced polarization of the orbitals of the atoms of the brick, their consequential attraction to the polarized H atoms, and the latter rapid penetration within deep layers of the brick structure. In turn, faster penetration within the lattice of solids implies a bigger reactivity that, in turn, causes a bigger melting temperature.



Figure 10.52. A sample of various additional scans conducted by SunLabs on the HHO gas detecting anomalous peaks at 33, 34 and 40 amu that cannot possibly have a consistent molecular interpretation. Intriguingly, the peak at 35 amu detected in other tests did not appear sequentially in this scan, and appeared instead in other scans here not reported for brevity, thus indicating that the peaks of this and of the preceding scans conducted by SunLabs are, in actuality, the constituents of the clusters composing the HHO gas, and not the actual constituents themselves.

Moreover, polarized atomic hydrogen as well as oxygen are needed to explain the anomalous adhesion of the HHO gas to internal walls of detection instruments as well as to other substances.

Note that the studies of the Brown gas [2] have indicated the need for *atomic* hydrogen. Therefore, the presence of *atomic and polarized hydrogen* is a novelty of the HHO gas.

Evidently, individual hydrogen atoms cannot maintain their polarization as in Fig. 11.9 in view of motions caused by temperature, as well known. The only known possibility for maintaining said polarization is that polarized H atoms bond themselves with opposing magnetic polarities as depicted in Fig. 11.11. In fact, rotations and vibrations due to temperature occur for such bonded H atoms as a whole, while individually preserving said polarization.

In turn, bonds of polarized atomic hydrogen constitute the very basic bond of magnecules, thus supporting the hypothesis of the magnecular structure of the HHO gas.

Note that a conventional hydrogen gas cannot acquire any magnetic polarization because the conventional hydrogen molecules is diamagnetic. However, as established in Refs. [21], the diamagnetic character refers to the hydrogen *molecule* as a whole, because quantum mechanics establishes that each individual hydrogen *atom* of a hydrogen molecule can indeed acquire a magnetic polarization under sufficiently strong external magnetic fields.

The diamagnetic character of the hydrogen molecules, as depicted in Fig. 11.10, is due to the fact that the individual magnetic polarizations of its H atoms are opposite to each other, and are at such a close mutual distances to cancel each other when inspected at sufficiently large distances.

Needless to say, the above hypothesis on the polarization of atomic hydrogen also applies to oxygen, the latter being known to be paramagnetic, resulting in atomic oxygen with the spherical distribution of orbitals, polarized atomic oxygen with the polarization of at least the valance electrons, and pairs of bonded polarized oxygen atoms as depicted in Fig. 11.11.

The first prediction of the magnecular structure of the HHO gas is that the species at 2 amu and 32 amu detected by mass spectroscopy could, in actuality, be constituted by a mixture of the conventional molecules  $H_2$  and  $O_2$  and a percentage of the same atoms although with the magnecular bond, since the latter are expected to have essentially the same atomic weight than the former.

The separation of hydrogen molecules and magnecules is possible via instruments based on magnetic resonance techniques because the conventional hydrogen molecule is diamagnetic (Fig. 11.9) while the hydrogen magnecule has a distinct magnetic polarity (Fig. 11.11).

It is easy to see that the magnecular hypothesis on the chemical structure of the HHO gas permits a quantitative interpretation of all anomalous species reported in the preceding section.

As now familiar, let us denote the conventional valence bond with the usual symbol "-" and the magnecular bond with the symbol " $\times$ ". According to this notation,  $H_2 = H - H$  represents the molecule of Fig. 11.10 while  $H \times H$  represents the magnecule of Fig. 11.11. Molecular bonds are notoriously restricted to valence pairing, in the sense that no additional atom can be bonded when all available valence pairs are coupled. By contrast, magnecular bonds do not have such a restriction, in the sense that atoms can indeed be added to a magnecule under the sole condition of the availability of opposite magnetic polarizations.

Needless to say, for the HHO gas at ambient temperature and pressure, the stability of the magnecular clusters is inversely proportional to the number of their constituents. As a result, magnecular clusters with relatively low atomic weight are expected to exist in significant percentages, while those with large atomic weight are expected to be present at best in parts per millions. The magnecular hypothesis permits the following interpretations of the species composing the HHO gas: the species with 3 amu is interpreted as a combination of the magnecules  $H \times H \times H$  or  $(H-H) \times H$ ; the species with 4 amu is interpreted as a combination of  $(H-H) \times (H-H, (H-H) \times H \times H, \text{ or } H \times H \times H \times H$ , heavier magnecular bonds solely of hydrogen atoms being unstable due to collisions; the species with 17 amu is interpreted as a combination of the traditional dimer H - O and the magnecular bond  $H \times O$ ; the species with 33 amu is interpreted as a mixture of  $(O - O) \times H$ ,  $(H - O) \times O$  and  $O \times O \times H$ ; the species with 34 amu is interpreted as a mixture of  $(H - H) \times (O - O) \times (H - H) \times H$  and similar configurations; the species with 35 amu is interpreted as a mixture of  $(O - O) \times (H - H) \times (H - H) \times H$  and equivalent configurations (see Fig. 11.11); and other magnecular species in progressively smaller percentages.

## 10.6.4 the New Gaseous and Combustible Form of Water

Besides a quantitative interpretation of the chemical structure of all species contained in the HHO gas, as well as of its anomalous thermal content and adhesion, perhaps the biggest contribution of the magnecular hypothesis is a quantitative interpretation of the formation of the HHO gas despite the lack of evaporation or separation energy.

Recall that nature has set the water molecule  $H_2O = H - O - H$  in such a way that its H atoms do not have the spherical distribution, and have instead precisely the polarized distribution of Fig. 11.10 along a toroid whose symmetry plane is perpendicular to that of the H - O - H plane, as depicted in Fig. 153, and established in the technical literature (see, e.g., Ref. [1=20a]).

It is also known that the H-O-H molecule at ambient temperature and pressure, even though with a null total charge, has a high electric polarization (namely, a deformation of electric charge distributions) with the predominance of the negative charge density localized in the O atom and the complementary predominant positive charge density localized in the H atoms [1a]. This feature causes a repulsion of the H atoms due to their predominantly positive charges, resulting in the characteristic angle of (about)  $105^{\circ}$  between the H - O and O - H dimers as depicted in Fig. 11.54.

It is well established in quantum mechanics that toroidal polarizations of the orbitals of the hydrogen atom as in the configuration of Fig. 11.11 create very strong magnetic fields with a symmetry axis perpendicular to the plane of the toroid, and with a value of said magnetic field sufficient for the creation of the new chemical species of magnecules [3].

It then follows that, in the natural configuration of the H - O - H molecule, the strong electric polarization caused by the oxygen is such to weaken the mag-

1034



Figure 10.53. A conceptual rendering of the conventional water molecule without any electric polarization. This rendering is primarily intended to illustrate the experimentally established feature that the orbitals of the two hydrogen atoms do not have a spherical distribution as in Fig. 11.413, but have instead a distribution essentially perpendicular to the H - O - H plane (see Refs. [20] for details) here conceptually represented with a toroid. The strong valence bond needed to achieve the first known exact representation of the experimental data of the water molecule achieved in Ref. [21] requires that the corresponding orbitals of the valence electrons of the oxygen have a corresponding polarized distribution here also conceptually depicted with toroids perpendicular to the H - O - H plane around the spherical core of the remaining electrons of the oxygen atom.

netic field of the toroidal polarization of the H-orbital resulting in the indicated repulsion of the two H-atoms in the H - O - H structure.

However, as soon as the strong electric polarization of the molecule H - O - H is removed, the strong attraction between opposite polarities of the magnetic fields of the polarized H atoms become dominant over the Coulomb repulsion of the charges, resulting in a new configuration of the water molecule depicted in Figs. 19 and 20 apparently presented in this section for the first time.

Therefore, a central hypothesis of this section is that the electrolyzer developed by Hydrogen Technology Applications, Inc., is such to permit the transformation



Figure 10.54. A conceptual rendering of the conventional water molecule of Fig. 16, this time with the electric polarization as occurring in nature. Note the consequential the predominance of a positive charge in the two hydrogen atoms that is responsible in part for the angle of  $105^{\circ}$  between the two H - O radicals.

of the water molecule from the conventional H - O - H configuration of Fig. 11.54 to the basically novel configuration of Fig. 11.55.

By using the above identified symbols for molecules and magnecules, the conventional water molecule is represented by H - O - H while the new configuration of Fig. 11.55 is represented by  $(H \times H) - O$ , where the symbol "-" evidently denotes double valence bond.

The plausibility of the new form of water is supported by the fact that, when H - O - H is liquid, the new species  $(H \times H) - O$  is expected to be gaseous. This is due to various reasons, such as the fact that the hydrogen is much lighter than the oxygen in the ratio 1 to 16 amu. As a result, the new species  $(H \times H) - O$  is essentially equivalent to ordinary gaseous oxygen in conformity with conventional thermodynamical laws, since the transition from the liquid to the gas state implies the increase of the entropy, as well known.

Alternatively, the loss of electric polarization in the transition from H - O - Hto  $(H \times H) - O$  is expected to cause the loss of the processes permitting the very existence of the water molecule, such as the hydrogen bridges between dimers O - H of different molecules. Transition to a gaseous form is then consequential,



Figure 10.55. A conceptual rendering of the central hypothesis submitted for the first time in this section, namely, the H - O - H molecule in which all electric polarizations have been removed, with the consequential collapse of the two polarized H-atoms one into the other due to their neutral charge and strongly attractive opposing magnetic polarities. This hypothesis permits a quantitative interpretation of the transition of state from liquid to gas achieved by the HHO electrolyzers via processes structurally different than evaporation energy. In fact, unlike the configuration of Fig. 11.11, that of this figure can only exist at the gaseous state due to the loss of the processes permitting the liquid state, such as hydrogen bridges between pairs of water molecules. It should be noted that the configuration here depicted is unstable and decomposes into atomic oxygen, as detected in the HHO gas, plus the new magnecular species  $H \times H$  that has indeed been detected but it is generally interpreted as H - H.

thus confirm the plausibility of the new form of water  $(H \times H) - O$  proposed in this section.

However, it can also be seen that the new form of water  $(H \times H) = O$  is *unstable*, and decomposes in  $H \times H$  and O. This decomposition is supported by the clear evidence in the HHO gas of atomic oxygen, as well as of the species



*Figure 10.56.* A conceptual rendering of a perspective view of the central hypothesis submitted for the first time in this section via Fig. 11.55, better illustrating the bond via opposing magnetic polarities of the two H-atoms, as well as the unstable character of the configuration due to collision with other species and intrinsic instabilities to be studied in a forthcoming section.

with 2 amu that is normally interpreted as being H - H, while we suggest the additional possibility that such a species is, at least in part,  $H \times H$ .

# 10.6.5 Contributions of Hadronic Chemistry Toward the Future Understanding of the Complexities of Water

There is no doubt that, being the foundation of life, water is by far the most complex chemical structure in nature. Any chemist who believes to have achieved a final understanding of water via quantum chemistry should be removed from the scientific community because of either mental or ethical problems, and the same holds for chemists using hadronic chemistry.

It is merely hoped that the efforts presented in this section have achieved another step in the study of water beyond those permitted by quantum chemistry, with the understanding that a serious understanding of water may well require efforts throughout this third millennium.

Recall that quantum chemistry was unable to achieve an exact and invariant representation of the main characteristics of the water molecule from unadulterated first principles despite efforts over the past century. In fact, a historical 2% has been missing in the representation of the water binding energy, while the representation of its electric and magnetic moments was embarrassingly wrong even in the signs.

An improvement of the numerical representation was achieved via the so-called "screening of the Coulomb law", that is, the multiplication of the Coulomb potential by an arbitrary function of unknown physical or chemical origin,  $\frac{q_1 \times q_2}{r} \rightarrow f(r) \times \frac{q_1 \times q_2}{r}$ . However, as indicated since Chapter 1, this type of screening implies the abandonment of the notion of "quantum" of energy, trivially, due to the loss of all quantized orbits, as well as the exiting from the basic axioms of quantum mechanics, because the transition from the Coulomb potential to its screened form requires nonunitary transforms.

Independently from these basic shortcomings, the fundamental problem of quantum chemistry, whether with or without screening processes, remains the fact that the name "valence" is a pure nomenclature, since it does not identify in explicit and numerical terms the *attractive force* needed for two hydrogen atoms to be bounded to the oxygen atom in the structure H - O - H, and electrons repel each other in any case for quantum mechanics and chemistry.

Besides fundamental insufficiencies in a numerically exact and invariant representation of the main characteristics of the water molecules, additional vast insufficiencies exist for the liquid and solid state of water. As an example, the use of the "H-bridges" to represent the liquid state of water is another case of basically ascientific nomenclature because, again, of the lack of any identification of the *attractive force* needed to explain the bond of neutral and diamagnetic water molecules in their liquid state.

When water becomes part of biological organisms, the open problems became so great to be beyond our imagination at this writing (also because most chemists believe that the water molecule remains the same).

As shown in Chapter 9, the *isotopic branch of hadronic chemistry*, or *isochemistry* for short, was first and most fundamentally focused in the identification of the *attractive force* in the singlet coupling of two valence electrons, which identification required a necessary nonunitary theory since the valence force resulted to have a contact, thus non-Hamiltonian character.

Thanks to this basic advance, the isochemistry permitted, for the first time in scientific history, the numerically exact and invariant representation not only of the binding energy but also of the electric and magnetic moments of the water molecules (Section 9.3).

Subsequently, in Section 11.5 we indicated that the liquid state of water appears to be of magnecular character since the *H*-atoms in the  $H_2O$  structure have by nature a toroidal polarization in a plane perpendicular to the H - O - H plane, thus permitting the magnecular bond between two *H* atoms of different water molecules  $H_{\uparrow} \times H \downarrow$  that is referred to as "H-bridges" (see Figure 11.34. In this section, we have shown that water admits a previously unknown gaseous and combustible state achievable from the liquid state *without* the evaporation energy believed to be necessary by quantum chemistry. In turn, such a feature indicates our basic lack of understanding of the conventional water evaporation itself, trivially, because of the lack of conventional identification of the force responsible for the liquid state.

To understand the limited character of the advances permitted by isochemistry, it is important to recall that they have been achieved via a lifting of quantum chemistry that is strictly reversible in time as the original theory.

Consequently, isochemistry is strictly inapplicable (rather than violated) for any irreversible process involving the water molecule, such as the very creation of the molecule itself

$$2 \times H + \frac{O_2}{2} \rightarrow H_2O + 57Kcal/mole.$$
 (11.6.1)

Any insistence in the use of a reversible theory, whether quantum chemistry of its isotopic covering, for the above irreversible process may imply severe scientific drawbacks. As one example among many, it is generally believed in chemistry that the above process is unique and immutable.

On the contrary, the use of the *genotopic branch of hadronic chemistry*, or *genochemistry* for short, establishes that the rate of the above process depends on the distribution of the orbitals.

Recall that the H atoms in the  $H_2$  molecule have a spherical distribution. Consequently, to achieve reaction (11.6.1), nature has to first break down the  $H_2$  molecule and then polarize the orbitals of the individual H atoms from their spherical to the above indicated toroidal polarization.

Genochemistry then predicts that basically new advances over reaction (1.6.xx) can be achieved with the combustion of H and O, firstly, if we start from *atomic* H and/or O atoms (because in this case there is no need to separate atoms prior to their new bond) and, secondly, via the use of *atomic and polarized* H and O atoms, that is, by preparing them in the form as appearing in the H - O - H molecule. Similar basic advances can be obtained in various other chemical reactions.

Despite these possibilities, genochemistry remains basically insufficient for further advances in the study of the water molecule because the theory is indeed irreversible but single-valued. It is an easy prediction that further advances in the study of water, particularly when a member of a biological structure, will require the *hyper-structural branch of hadronic chemistry*, or *hyperchemistry* for short, due to its multi-valued character. In turn, the latter broadening will inevitably require the notion of *hypermagnecule* (Definition 11.2.1).

At that point the complexities of water and its role as the basis of life appear in their full light, e.g., because of the joint need of all four directions of time (Section 2.1), each time being multivalued (Chapter 5).

1040

In summary, water is perhaps the best illustration of the fact that the human adventure in science will never end.

# 10.7 EXPERIMENTAL EVIDENCE OF MAGNECULES IN LIQUIDS AND SOLIDS

# 10.7.1 Preparation of Liquid Magnecules used in the Tests

In early 1998 Santilli [1] obtained a number of samples of fragrance oils from Givaudan-Roure Corporation (GR) with headquarters in Teaneck, New Jersey. About 50 cc of various samples of perfectly transparent fragrance oils were placed in individual glass containers. One polarity of an alnico permanent magnet with 12,000 G and dimension  $1/2'' \times 1'' \times 2''$  was immersed within said oils.

Starting with a perfect transparency, after a few days a darkening of the oils became visible, jointly with a visible increase of the viscosity, with changes evidently varying from oil to oil. Subsequently, there was the appearance of granules of dark complexes in the interior of the oil which were visible to the naked eye. Both the darkening and the viscosity increased progressively in subsequent days, to reach in certain cases a dark brown color completely opaque to light. The viscosity increased to such an extent that the oil lost all its fluidity.

It should be stressed that the above visible effects are of pure magnetic origin because of the lack of any other contribution, *e.g.*, the complete absence of any additives. After the immersion of the permanent magnets, all samples were left undisturbed at ordinary room conditions. The indicated effects remain unchanged to this day, thus showing that the changes were stable at ordinary conditions of temperature and pressure.

Santilli's [1] main hypothesis on the darkening of the oils is that their molecules acquire a magnetic polarization in the orbits of at least some of their atomic electrons (called in chemistry cyclotron resonance orbits), by therefore bonding to each other according to Definition 11.2.1 in a way similar to the corresponding occurrence for gases.

It should also be indicate that the immersion of one polarity of a permanent magnet in fragrance oils is, evidently, a rudimentary way to create magnecules in detectable percentage although not an essentially pure population of magnecules as requested for a new chemical species (see Sect. 11.2). A number of more sophisticated magnetic polarization techniques are now available with rather complex geometries. Also, as indicated in Sect. 11.6, an essentially pure population of liquid magnecules can be reached via the PlasmaArcFlow reactors described in Section 11.4.

### **10.7.2** Photographic Evidence of Magnecules in Liquids

The above alteration of the structure of fragrance oils was confirmed by photographs taken by the GR Research Laboratory in Dubendorf, Switzerland, via a microscope with minimal magnification, as illustrated in the pictures of Figs. 8.19 and 8.20.

The pictures of Fig. 11.57 refer to the GR fragrance oil received under the code "ING258AIN, Text 2" subjected to the rudimentary magnetic polarization indicated in the preceding section under the respective magnification 10X and 100X.

As one can see, these photographs establish that, under the indicated magnetic treatment, the oil has acquired a structure of the type of "brick layering" which is visible under only 10X magnification, and is per se highly anomalous for a liquid that was originally fully transparent. Note that the magnecules are not constituted by the individual "bricks," but rather by the dark substance which interlock said "bricks." This point is important to understand the size of the magnecule here considered which covers the entire 50 cc of the liquid.

The photographs in Figs. 8.20 were taken at the University of South Florida in St. Petersburg via a microscope with the same magnifications 10X and 100X, but refer to a different GR fragrance oil received under the code "Mixture 2" and magnetically treated to such a point of completely losing transparency and fluidity. As one can see, the latter picture provides confirmation that, following exposure to a 12,000 G magnetic field, fragrance oil molecules bond together into rather large clusters estimated to be well in excess of 10,000 a.m.u., that is, with an atomic weight which is dramatically bigger than that of the largest molecule composing the oil, as per Feature I) of Definition 11.2.1.

Inspection of the various photographs shows a variety of sizes of magnecules, thus establishing their lack of unique characteristics for any given liquid. This evidently confirms the *lack* of a valence bond. Inspection of the samples also show the magnecules capability of increasing their size via the accretion of further oil molecules.

Other photographic documentations of various magnecules in liquids were done, by confirming the findings of Figs. 8.19 and 8.20.

### 10.7.3 Spectroscopic Evidence of Liquid Magnecules at the Tekmar-Dohrmann Corporation

The first experimental evidence of magnecules in liquids was established on May 5, 1998, by analysts *Brian Wallace* and *Mia Burnett* at *Tekmar-Dohrmann Corporation* (TDC) in Cincinnati, Ohio, operating a *Tekmar 7000 HT Static Headspacer Autosampler* equipped with a Flame Ionization Detector (FID). The tests were repeated on May 8 and 11, 1998, by confirming the preceding results. It should be noted that the Tekmar equipment lacks the computer search as


Figure 10.57. A photographic evidence of magnecules in liquids obtained at the Givaudan-Roure Research Laboratory in Dubendorf, Switzerland, in the GR fragrance oil "ING258IN Test 2" under magnifications 10X and 100X [1].

well as the UV scan. Also, the instrument had limited capability in atomic weight. Finally, the FID was permitted in this case because the liquids were not combustible.



*Figure 10.58.* Confirmation of magnecules in GR fragrance oil "Mixture 2" under 10X and 100X obtained at the University of South Florida in St. Petersburg. Note the difference in sizes of the magnecules and their difference with those of Fig. 11.57 [1].

The measurements were done on: Sample 1, pure (magnetically untreated) GR "Fragrance Oil 2"; Sample 2, magnetically untreated tap water; and Sample 3, a magnetically treated mixture of the two.



*Figure 10.59.* A first scan done on May 5, 1998, 8.18 a.m. at *Tekmar Dohrmann Company* (TDC) in Cincinnati, Ohio, via a Tekmar 7000 HT Static Headspacer Autosampler with a Flame Ionization Detector (FID).

Despite these limitations, the results of the Tekmar tests provided the first direct spectroscopic evidence of the existence of magnecules in liquids, including the first direct experimental evidence of water magneplexes as per Definition 11.2.1. In particular, these tests established that magnecules in liquids have the same main features of the magnecules in gases.



Figure 10.60. The scan at TDC on 5/5/98 at 8.19 a.m. to check that the background is correct.

To avoid a prohibitive length we reproduce only a few representative scans in Figs. 8.21 to 8.25 [1]. Figure 8.21 reproduces the origin test of the fragrance oil without magnetic treatment. Note the dominance of three molecules denoted "Peak 1" with 24.28%, "Peak 2" with 3.19% and "Peak 3" with 70.00%. Fig-



Figure 10.61. The scan at TDC on 5/5/98 at 8.19 a.m. on the magnetically treated water which constitutes experimental evidence of magnecules in water given by the large unknown peak.

ure 8.22 depicts the background which is shown to be correct. Figure 8.23 represent the scan of magnetically treated water with a large "unknown 1" with 64.24% and "unknown 2" with 33.53% totaling 97.78%. This is evidence of the creation of magnecules in water, also called magneplexes according to Definition 11.2.1. Figure 8.24 represents a scan of the magnetically treated combination of water and fragrance oil with "unknown 1" 1.75% and "unknown 2" with 0.45%. An important information of this scan is that the original Peak 1 of Fig. 11.59



Figure 10.62. The scan on 5/5/98 at 8.21 a.m. on the magnetically treated mixture of water and fragrance oil of scan 8.21 which constitutes evidence of magnecules given by two unknown peaks.

with 24.28% and Peak 3 with 70.00% have been decreased to the values 5.33% and 68.71%, respectively. This is evidence that the missing percentages of these molecules have been used in the formation of magnecules. Figure 8.25 reproduces the background following the tests and routine flushing. As one can see, the scan



Figure 10.63. The scan at TDC on 5/5/98 at 2.26 p.m. on the background with anomalous adhesion confirming the corresponding anomalous background for gas magnecules.

preserves macroscopic percentages of the preceding scans, thus confirming the anomalous adhesion also existing in gas magnecules.

## 10.7.4 Spectroscopic Evidence of Liquid Magnecules at Florida International University

Additional comprehensive tests via a modern equipment for LC-MS equipped with UVD were conducted on the GR fragrance oil "ING258IN Test 2" of Figs. 8.19 on December 1, 1998, at the chemistry laboratory of *Florida International Uni*- *versity* (FIU) in Miami, Florida. The tests were then repeated on December 17 and 18 by confirming the preceding results.

The tests were conducted under a number of technical characterizations specifically selected to detect magnecules, among which include:

1) Total Ion Chromatogram (TIC) collected under the positive ion atmospheric pressure electrospray ionization (ESI+) mode;

2) Integrated TIC with retention times and areas for the most abundant peaks;3) Raw mass spectra for all peaks identified in item 2;

4) HP LC chromatograms collected at fixed wavelength of 254 cm; and

5) UV-visible spectra form the HPLC diode array detector with 230–700 mm. The tests were conducted on the following samples:

I) Sample GR331, the magnetically untreated, fully transparent GR fragrance oil "ING258IN Test 2";

II) Sample GR332, magnetically treated "ING258IN Test 2" with 10% Dipropylene Glycol (DPG);

III) Sample GR332S, bottom layer of the preceding sample;

IV) Sample GR335, magnetically treated mixture 4% GR fragrance oil "ING258IN Test 2", 0.4% DPG and 95% tap water; and

V) Sample GR335O, visible dark clusters in the preceding sample.

To avoid a prohibitive length of this presentation, only representative scans are reproduced in Figs. 8.26 to 8.30 [1]. As one can see, these scans provide a second experimental evidence of magnecules in liquids as evident in comparing the peaks of the untreated liquid with those of the treated one.

A few comments are in order. To understand the FIU measurements the reader should keep in mind that the liquid is that of Fig. 11.57. Consequently, the magnecules to be tested are visible to the naked eye. Therefore, only minute fragments entered the capillary feeding lines of the LC-MS/UVD instrument.

Finally, the reader should keep in mind that the magnetic polarization of the test has been minimal, and the liquid does not constitute a pure population of liquid magnecules. The latter case is available from the PlasmaArcFlow reactors of Section 11.4 whose study is here omitted.

## 10.7.5 Experimental Verification of Mutated Physical Characteristics

In addition to the preceding *chemical* features, the existence of magnecules implies the mutation of *physical* characteristics, such as increase of the specific density and viscosity. This is due to the fact that magnetic bonds among ordinary molecules imply an evident reduction of intermolecular distances, thus resulting in more molecules per unit volume, as compared to the magnetically untreated substance. The increases in density and viscosity are then consequential.

#### 1050



*Figure 10.64.* Scan on the untreated GR oil "ING258IN Test 2" of Fig. 11.56 (GR331 of the text) conducted at *Florida International University* (FIU).

A most intriguing feature of gas magnecules with important scientific and industrial implications is that the Avogadro number of a gas with magnecular structure is not constant, or, equivalently, the so-called "gas constant" R of a gas with magnecular structure is an (expectedly nonlinear) function of P, V, T,



Figure 10.65. Scan at FIU of Sample GR332.

R = R(P, V, T), resulting in the generalized gas law

$$\frac{PV}{T} = nR(P, V, T), \tag{8.21}$$

where the explicit dependence of R on P, V, and T depends on the magnecular gas considered.



Figure 10.66. Scan at FIU of Sample GR332S.

The variation of the Avogadro number for gas with magnecular structure has been proved by routine tests at *USMagnegas, Inc.*, Largo, Florida, establishing that:

1) The number of constituents of a gas with magnecular structure decreases with a sufficient increase of the pressure;



Figure 10.67. Scan at FIU of Sample GR335.

2) Given a fixed and sealed tank with volume V of a gas with magnecular structure at given pressure P and temperature T, after bringing this tank to a sufficiently higher temperature T' > T, and then returning it to the original temperature T, the pressure of the tank is not the original pressure P but a generally bigger pressure P' > P;



Figure 10.68. Scan at FIU of Sample GR335O.

3) The increase of pressure of a gas with magnecular structure requires a volume which generally increases with the pressure itself, that is, if the increase of pressure in a given tank from 100 psi to 200 psi requires V cf of magnecular gas, the same increase of pressure in the same tank via the same gas, this time from 4,000 psi to 4,100 psi at the same temperature does not require the same vol-

ume V but a volume V' of the magnecular gas bigger than the original volume, V' > V.

The above deviations from the conventional gas law are easily explained by the fact that the increase of pressure in a gas with magnecular structure generally implies the aggregation of magnecules into bigger clusters, with consequential decrease of the number of constituents. Similarly, the increase of temperature generally implies the breaking down of magnecules into smaller clusters, with consequential increase of the number of constituents and resulting anomalous increase of pressure. It then follows that, if the increase of temperature of a given fixed volume is beyond the Curie Magnecular Point (Definition 8.2.1), all magnetic polarizations are terminated with consequential increase of the number of constituents to molecules. This implies that the return of the gas to the original temperature does not restore the original magnecules, and, consequently, the return to the original temperature generally occurs at an increased pressure due to the increased number of constituents.

We now report measurements of specific density, viscosity and other characteristics of fluids with magnecular structure which confirm the above GC-MS/IRD and LC-MS/UVD tests, by providing final evidence on the existence of magnecules as per Definition 8.2.1.

All tests were done via the use of ordinary tap water and a number of GR fragrance oils. All samples here considered were prepared by conventionally mixing tap water and one fragrant oil, and then submitting that mixture to rather weak permanent magnets of 200 G (much weaker than those used for the fragrance oils of Figs. 8.18 and 8.19). All samples resulted in being very stable without any measurable change over a period of about one year, and survived freezing followed by defrosting. The various samples were numbered from 1 to 25.

The measurements of the specific density were conducted on March 9, 1998 by the U.S. Testing Company, Inc. (USTC) of Fairfield, New Jersey. The results of the tests are presented in Figs. 8.31 and 8.32.

Sample 1 is ordinary untreated tap water. Sample 2 is ordinary tap water magnetically treated for about 5 minutes. Samples 3 and 4 were tap water treated with other magnetic equipment. Sample 5 was ordinary untreated GR fragrance oil "APC Fragrance." Sample 6 was a mixture of fragrance oil 5 with tap water magnetically treated for about 5 minutes. Mixtures 7 and 8 were the same mixture 5 although treated with other equipment. Sample 17 was a magnetically treated GR oil "Air Freshener 1." Mixture 19 was Fragrance 17 with tap water 16 magnetically treated for 5 minutes. Note that all measurements were done to an accuracy of the fourth digit. Therefore, numerical results up to the third digit can be considered accurate.

In the transition from Sample 1 (untreated water) to Sample 2 (magnetically treated water) there is an increase in the specific density in the macroscopic

#### 1056

|          | 291 Fairfield Avenue<br>Fairfield, NJ 07004-3833<br>Tel: 973-575-5252<br>Fax: 973-244-1694<br>Milleonium Results  | SGS U.S. Testing Company Inc. | Report Number: 103947<br>Date: 03/09/98<br>Page: 1 of 1 |  |  |  |
|----------|---|-------------------------------|---|--|--|--|
|          | Density of  | g/mL % Char                   | nge Density vs Ordinary<br>Water                        |  |  |  |
| ĺ        | Sample #1   | 0.9805                        | 0   |  |  |  |
|          | Sample #2   | 0.9889                        | +0.86   |  |  |  |
| F        | Sample #3   | 0.9804                        | 0   |  |  |  |
| LE S     | Sample #4   | 0.3853                        | +0.49   |  |  |  |
|          | Fragrant #5   | 0.9720                        | NA  |  |  |  |
|          | Mixture #6  | 0.9967                        | +1.85   |  |  |  |
| Ö        | Mocture #7  | 0.9982                        | +1.80   |  |  |  |
|          | Mixture #8  | 0.9902                        | 0.99  |  |  |  |
|          | Treated Water #16   | 0.9893                        | 0.89  |  |  |  |
| <b>H</b> | Frag Treated # 17   | 0.9453                        | NA  |  |  |  |
| <u> </u> | Mixture #18   | 0.9902                        | 0.99  |  |  |  |
| Ū        | Müdure #19  | 0.9929                        | 1.28  |  |  |  |
| R        | Samples were transferred to a separatory funnel. The layers were allowed to separate.<br>The water layer was withdrawn into a funnel with Whatman #4 filter paper. The filtrate<br>was transferred to a preweighed 10 mL volumetric flask. The sample was weighed to<br>0.0001 grams and the density calculated.<br>When the samples were pure substances, they were transferred directly to preweighed<br>10 mL volumetric flasks.<br>Calculations:<br>Weight flash with sample - weight flask + volume of flask = g/ mL |                               |   |  |  |  |

Figure 10.69. USTC measurements of specific density on magnetically treated liquids.

Arlyn Sibille, Ph.D.



Figure 10.70. USTC measurements of viscosity on magnetically treated liquids.

amount of 0.86%, thus confirming the indicated mutation of the specific density of water under a magnetic treatment. In turn, the increase in density supports the existence of magneplexes in magnetically treated water as per the scan of Fig. 11.65.

As well known, fragrance oils are (generally) *lighter* than water, *i.e.*, the specific density of the untreated fragrance in Sample 5 is *smaller* than that of the untreated water in Sample 1. According to quantum chemistry, the specific den-

sity of any mixture of the above two liquids, whether solution, suspension or dispersion, should be *in between* the lighter and heavier specific densities.

On the contrary, as one can see, the specific density of the magnetically treated mixture of GR fragrance with tap water, Sample 6, resulted in being bigger than that of the densest liquid, the water. This measurement constitutes additional, rather strong, direct experimental verification of the mutation of physical characteristics in liquids under magnetic fields.

A remarkable point is that the magnetic mutations of density are macroscopically large. In fact, they were called by an analyst "UPS-type anomalies", meaning that the shipment via UPS of a given volume of a magnetically treated liquid may require an increase of the shipping cost of the same volume of untreated liquid due to the macroscopic increase in the weight.

A further prediction of magnetically polarized liquids is the increase of its viscosity. This is evidently due to the arbitrary size of an individual magnecule, as well as the tendency of the same to bond to near-by molecules, resulting in accretions, not to mention the anomalous adhesion to the walls of the container, which has been systematically detected for all magnetically polarized liquids.

As indicated earlier, in certain cases the increase of viscosity is so large as to be first visible to the naked eye, and, when the treatment is sufficiently protracted, the increase in viscosity is such as to lose the customary liquid mobility.

Ordinary engine oils are particularly suited for magnetic treatment because, when properly treated, their increase in viscosity is so dramatic as to be visible to the naked eye jointly with a visible change in visual appearance (color, texture, opacity, *etc.*).

The measurements on viscosity are reported in Fig. 11.70. The selected engine oil was an ordinarily available 30-40 Castrol Motor Oil subjected to a particular type of magnetic treatments via two different kinds of equipment called of Type A and B. All treatments were done at ordinary conditions without any additive or change of any type. As one can see, measurement 2 shows a dramatic increase in the viscosity in the magnetically treated oil of 44.5%.

The above experimental results evidently provide additional support for the existence of magnecules.

The tests also provide evidence of the anomalous adhesion of liquids with magnecules, which is established in this case by a dramatic, macroscopic increase of adhesion of the oil to the walls of the glass container.

The same macroscopic anomaly is confirmed at the microscopic level. During the measurement of viscosity there was such an anomalous adhesion of the magnetically treated oils to the walls of the instrument that said oil could not be removed via routine cleaning with acetone and required the use of strong acids.

This anomalous adhesion is further experimental evidence of the existence of magnecules, because of their predicted capability to induce the polarization of the orbits of the valence electrons of the atoms in the walls of the container, thus resulting in anomalous adhesion via magnetic bonds due to induction.

It is evident that the mutations of density and viscosity implies the expected mutation of *all* other physical characteristics of the liquid considered. These measurements are left to the interested researchers.

The existence of mutation of *physical* characteristics then implies the mutation of *chemical* features. At this moment, we can only indicate the visual evidence reported by the analysts of USTC according to whom the reaction of magnetically treated oils with acetone is dramatically different from that with untreated oil, including mutations in color, texture and other appearances.

## 10.7.6 Concluding Remarks

The theoretical and experimental evidence presented in this Chapter establishes that the chemical species of molecules, defined as stable clusters of atoms under a valance bond, does not exhaust all possible chemical species existing in nature.

This conclusion is proved beyond scientific doubt, for instance, by macroscopic percentage of stable clusters, with atomic weight of several hundreds a.m.u., in light gases without an infrared signature where heaviest possible detected molecule is the  $CO_2$  with 44 a.m.u.; the mutation of transparent oils into a completely opaque substance without fluidity; the joint increase of the specific density for both gaseous and liquid cases; and other evidence.

Needless to say, the final characterization and detection of the new chemical species submitted in Refs. [1,2] and reviewed in this chapter will require a considerable collegial effort, since the methods presented in this chapter are manifestly preliminary, with the understanding that, again, the existence of the new chemical species is outside scientific doubts.

As a matter of fact, the proposed new chemical species of magnecules, which, according to Definition 11.2.1 includes that of molecules, cannot be considered itself as the final chemical species in nature as it is the fate proved by history for all scientific discoveries.

As an example, the reformulation of magnecules via the hyperstructural branch of hadronic chemistry implies the prediction of the broader chemical species of *hypermagnecules* which is apparently 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. The *novelty* of this possible species is then an evident consequence of its novel features. Its *need* is established by the fact that current attempts to decipher the DNA code via the numbers used for molecules and magnecules dating back to biblical times have

#### 1060

little chance of success, thus mandating the use of broader numbers, such as the hypernumbers and related multi-dimensional structures.

All in all, we can safely conclude that science is a discipline that will never admit final theories.

# Appendix 10.A

# Aringazin's Studies on Toroidal Orbits of the Hydrogen Atom under an External Magnetic Field

In the main text of this chapter we have presented the theoretical and experimental foundations of the new chemical species of magnecules which is centrally dependent on individual atoms acquiring a generally toroidal configuration of the orbits of at least the peripheral electrons when exposed to sufficiently intense external magnetic fields, as originally proposed by Santilli [1] and reviewed in the main text of this Chapter.

In this Appendix we outline the studies by Aringazin [8] on the Schrödinger equation of the hydrogen atom under a strong, external, static and uniform magnetic field which studies have confirmed the toroidal configuration of the electron orbits so crucial for the existence of the new chemical species of magnecules.

It should be stressed that when considered at orbital distances (i.e., of the order of  $10^{-8}$  cm), atoms and molecules near the electric arc of hadronic reactors (Section 11.4), and in the plasma region, are exposed to a strong magnetic field, whose intensity may be high enough to cause the needed magnetic polarization (see Fig. 11.4.D).

A weak, external, static, and uniform magnetic field B causes an anomalous Zeeman splitting of the energy levels of the hydrogen atom, with ignorably small effects on the electron charge distribution. In the case of a more intense magnetic field which is strong enough to cause decoupling of a spin-orbital interaction (in atoms),  $e\hbar B/2mc > \Delta E_{jj'} \simeq 10^{-3}$  eV, i.e., for  $B \simeq 10^5$  Gauss, a normal Zeeman effect is observed, again, with ignorably small deformation of the electron orbits.

More particularly, in the case of a weak external magnetic field B, one can ignore the quadratic term in the field B because its contribution is small in comparison with that of the other terms in Schrödinger equation, so that the *linear* approximation in the field B can be used. In such a linear approximation, the wave function of electron remains unperturbed, with the only effect being the well known Zeeman splitting of the energy levels of the H atom. In both Zeeman effects, the interaction energy of the electron with the the magnetic field is assumed to be much smaller than the binding energy of the hydrogen atom,  $e\hbar B/2mc \ll me^4/2\hbar^2 = 13.6$  eV, i.e., the intensity of the magnetic field is much smaller than some characteristic value,  $B \ll B_0 = 2.4 \cdot 10^9$  Gauss = 240000 Tesla

1062

(recall that 1 Tesla =  $10^4$  Gauss). Thus, the action of a weak magnetic field can be treated as a small perturbation of the hydrogen atom.

In the case of a very strong magnetic field,  $B \gg B_0$ , the quadratic term in the field *B* makes a great contribution and cannot be ignored. Calculations show that, in this case, a considerable deformation of the electron charge distribution in the hydrogen atom occurs. More specifically, under the influence of a very strong external magnetic field a magnetic confinement takes place, i.e., in the plane perpendicular to the direction of magnetic field (see Fig. 8.4.D), the electron dynamics is determined mainly by the action of the magnetic field, while the Coulomb interaction of the electron with the nucleus can be viewed as a small perturbation. This adiabatic approximation allows one to separate variables in the associated Schrödinger equation [9]. At the same time, in the direction of the magnetic field the motion of electron is governed both by the magnetic field and the Coulomb interaction of the electron with the nucleus.

The highest intensities of magnetic fields maintained macroscopically at large distances in modern magnet laboratories are of the order of  $10^5 - 10^6$  Gauss (~ 50 Tesla), i.e., they are much below  $B_0 = 2.4 \cdot 10^9$  Gauss (~  $10^5$  Tesla). Extremely intense external magnetic fields,  $B \ge B_c = B_0/\alpha^2 = 4.4 \cdot 10^{13}$  Gauss, correspond to the interaction energy of the order of the mass of electron,  $mc^2 = 0.5$  MeV, where  $\alpha = e^2/\hbar c$  is the fine structure constant. In this case, despite the fact that the extremely strong magnetic field does characterize a stable vacuum in respect to creation of electron-positron pairs, one should account for relativistic and quantum electrodynamics (QED) effects, and invoke Dirac or Bethe-Salpeter equation. These contributions are of interest in astrophysics, for example, in studying the atmosphere of neutron stars and white dwarfs which are characterized by  $B \simeq 10^9 \dots 10^{13}$  Gauss.

Aringazin [8] has focused his studies on magnetic fields with intensities of the order of  $2.4 \cdot 10^{10} \leq B \leq 2.4 \cdot 10^{13}$  Gauss, at which value nonrelativistic studies via the Schrödinger equation can be used to a very good accuracy, and the adiabatic approximations can be made.

Relativistic and QED effects (loop contributions), as well as effects related to finite mass, size, and magnetic moment of the nucleus, and the finite electromagnetic radius of electron, reveal themselves even at low magnetic field intensities, and can be accounted for as very small perturbations. Additional effects are related to the apparent deviation from QED of strongly correlated valence bonds as studies in Chapter 4. These effects are beyond the scope of the presented study, while being important for high precision studies, such as those on stringent tests of the Lamb shift.

It should be noted that locally high-intensity magnetic fields may arise in plasma as the result of nonlinear effects, which can lead to the creation of stable self-confined structures having nontrivial topology with knots [10]. More

particularly, Faddeev and Niemi [10] recently argued that the static equilibrium configurations within the plasma are topologically stable solitons describing knotted and linked fluxtubes of helical magnetic fields. In the region close to such fluxtubes, we suppose the magnetic field intensity may be as high as  $B_0$ . In view of this, a study of the action of strong magnetic field and the fluxtubes of magnetic fields on atoms and molecules becomes of great interest in theoretical and applicational *plasmachemistry*. Possible applications are conceivable for the new chemical species of magnetules.

As a result of the action of a very strong magnetic field, atoms attain a great binding energy as compared to the case of zero magnetic field. Even at intermediate  $B \simeq B_0$ , the binding energy of atoms greatly deviates from that of the zero-field case, and even lower field intensities may essentially affect chemical properties of molecules of heavy atoms. This occurrence permits the creation of various other bound states in molecules, clusters and bulk matter [9, 11, 12].

The paper by Lai [12] is focused on very strong magnetic fields,  $B \gg B_0$ , motivated by astrophysical applications, and provides a good survey of the early and recent studies in the field, including studies on the intermediate range,  $B \simeq B_0$ , multi-electron atoms, and H<sub>2</sub> molecule. Several papers using variational/numerical and/or analytical approaches to the problem of light and heavy atoms, ions, and H<sub>2</sub> molecule in strong magnetic field, have been published within the last years (see, e.g., references in [12]). However, highly magnetized molecules of heavy atoms have not been systematically investigated until Santilli's proposal for the new species of magnecules [1]. One of the surprising implications is that for some diatomic molecules of heavy atoms, the molecular binding energy is predicted to be several times bigger than the ground state energy of individual atom [13].

To estimate the intensity of the magnetic field which causes considerable deformation of the ground state electron orbit of the H atom, one can formally compare Bohr radius of the H atom in the ground state, in zero external magnetic field,  $a_0 = \hbar^2/me^2 \simeq 0.53 \cdot 10^{-8}$  cm = 1 a.u., with the radius of orbit of a single electron moving in the external static uniform magnetic field  $\vec{B}$ .

The mean radius of the orbital of a single electron moving in a static uniform magnetic field can be calculated exactly by using Schrödinger's equation, and it is given by

$$R_n = \sqrt{\frac{n+1/2}{\gamma}},\tag{11.A.1}$$

where  $\gamma = eB/2\hbar c$ , *B* is intensity of the magnetic field pointed along the *z* axis,  $\vec{B} = (0, 0, B)$ ,  $\vec{r} = (r, \varphi, z)$  in cylindrical coordinates, and  $n = 0, 1, \ldots$  is the principal quantum number. Thus, the radius of the orbit takes *discrete* set of values (10.A), and is referred to as Landau radius. This is in contrast to well known *classical* motion of electrons in an external magnetic field, with the radius of the orbit being of a continuous set of values.

The energy levels  $E_n$  of a single electron moving in said external magnetic field are referred to as Landau energy levels,

$$E_n = E_n^{\perp} + E_{k_z}^{\parallel} = \hbar \Omega(n + \frac{1}{2}) + \frac{\hbar^2 k_z^2}{2m}, \qquad (11.A.2)$$

where  $\Omega = eB/mc$  is so called cyclotron frequency, and  $\hbar k_z$  is a projection of the electron momentum  $\hbar \vec{k}$  on the direction of the magnetic field,  $-\infty < k_z < \infty$ , m is mass of electron, and -e is charge of electron.

Landau's energy levels  $E_n^{\perp}$  correspond to a discrete set of round orbits of the electron which are projected to the transverse plane. The energy  $E_{k_z}^{\parallel}$  corresponds to a free motion of the electron in parallel to the magnetic field (*continuous* spectrum), with a conserved momentum  $\hbar k_z$  along the magnetic field.

In regard to the above review of Landau's results, we recall that in the general case of a *uniform* external magnetic field the coordinate and spin components of the total wave function of the electron can always be separated.

The corresponding coordinate component of the total wave function of the electron, obtained as an exact solution of Schrödinger equation for a single electron moving in the external magnetic field with vector-potential chosen as  $A_r = A_z = 0, A_{\varphi} = rB/2$ ,

$$-\frac{\hbar^2}{2m}\left(\partial_r^2 + \frac{1}{r}\partial_r + \frac{1}{r^2}\partial_{\varphi}^2 + \partial_z^2 - \gamma^2 r^2 + 2i\gamma\partial_{\varphi}\right)\psi = E\psi, \qquad (11.A.3)$$

is of the following form [9]:

$$\psi_{n,s,k_z}(r,\varphi,z) = \sqrt{2\gamma} I_{ns}(\gamma r^2) \frac{e^{il\varphi}}{\sqrt{2\pi}} \frac{e^{ik_z z}}{\sqrt{L}},\qquad(II.A.4)$$

where  $I_{ns}(\rho)$  is Laguerre function,

$$I_{ns}(\rho) = \frac{1}{\sqrt{n!s!}} e^{-\rho/2} \rho^{(n-s)/2} Q_s^{n-s}(\rho); \qquad (II.A.5)$$

 $Q_s^{n-s}$  is Laguerre polynomial, L is normalization constant,  $l = 0, \pm 1, \pm 2, \ldots$  is azimuthal quantum number, s = n - l is radial quantum number, and  $\rho = \gamma r^2$ . Spin components of the total wave function are trivially given by

$$\psi(\frac{1}{2}) = \begin{pmatrix} 1\\0 \end{pmatrix}, \quad \psi(-\frac{1}{2}) = \begin{pmatrix} 0\\1 \end{pmatrix}, \quad (II.A.6)$$

with the corresponding energies  $E_{spin} = \pm \mu_0 B$ , to be added to the energy (10.A);  $\mu_0 = e\hbar/2mc$  is Bohr magneton.



Figure 10.A.1. Landau's ground state wave function of a single electron,  $\psi_{000}$  (solid curve), Eq. (10.A), in a strong external magnetic field  $B = B_0 = 2.4 \cdot 10^9$  Gauss, as function of the distance r in cylindrical coordinates, and (for a comparison) the hydrogen ground state wave function (at zero external magnetic field),  $(1/\sqrt{\pi})e^{-r/a_0}$  (dashed curve), as function of the distance r in spherical coordinates. The associated probability densities are shown in Fig. ??; 1 a.u.  $= a_0 = 0.53 \cdot 10^{-8}$  cm.



Figure 10.A.2. Probability density for the case of Landau's ground state of a single electron,  $2\pi r |\psi_{000}|^2$  (solid curve), Eq. (10.A), in a strong external magnetic field  $B = B_0 = 2.4 \cdot 10^9$  Gauss, as a function of the distance r in cylindrical coordinates, and (for a comparison) the probability density of the hydrogen atom ground state (at zero external magnetic field),  $4\pi r^2 |(1/\sqrt{\pi})e^{-r/a_0}|^2$  (dashed curve), as function of the distance r in spherical coordinates. The associated wave functions are shown in Fig. 10.A.1; 1 a.u. =  $0.53 \cdot 10^{-8}$  cm.

For the ground Landau level, i.e. at n = 0 and s = 0, and zero momentum of electron in the z-direction, i.e.  $\hbar k_z = 0$ , we have from (10.A)

$$E_0^{\perp} = \frac{e\hbar B}{2mc},\tag{II.A.7}$$

and due to Eq. (10.A) the corresponding normalized ground state wave function is

$$\psi_{000}(r,\varphi,z) = \psi_{000}(r) = \sqrt{\frac{\gamma}{\pi}} e^{-\gamma r^2/2},$$
 (II.A.8)

 $\int_0^\infty \int_0^{2\pi} r dr d\varphi \ |\psi_{000}|^2 = 1.$ 



Figure 10.A.3. Contour plot of the  $(r, \varphi)$  probability density for the case of Landau's ground state of a single electron,  $2\pi r |\psi_{000}|^2$ , Eq. (10.A), in strong external magnetic field  $B = B_0 =$  $2.4 \cdot 10^9$  Gauss, as a function of the distance in a.u. (1 a.u. =  $0.53 \cdot 10^{-8}$  cm). The lighter area corresponds to a bigger probability of finding the electron. The set of maximal values of the probability density is referred to as an "orbit".

The corresponding (smallest) Landau's radius of the orbit of electron is

$$R_0 = \sqrt{\frac{\hbar c}{eB}} \equiv \sqrt{\frac{1}{2\gamma}},\qquad(II.A.9)$$

in terms of which  $\psi_{000}$  reads

$$\psi_{000} = \sqrt{\frac{1}{2\pi R_0^2}} \ e^{-\frac{r^2}{4R_0^2}}.$$
 (II.A.10)

Figure 10.A.1 depicts Landau's ground state wave function of a single electron,  $\psi_{000}$ , in the strong external magnetic field  $B = B_0 = 2.4 \cdot 10^9$  Gauss ( $R_0 = 1$  a.u.), and (for a comparison) of the hydrogen ground state wave function, at zero external magnetic field,  $(1/\sqrt{\pi})e^{-r/a_0}$ . Figures 10.A.2 and 10.A.3 display the associated probability density of the electron as a function of the distance r from the center of the orbit, the radius of which is about 1 a.u.

The condition that Landau's radius is smaller than Bohr's radius,  $R_0 < a_0$ (which is adopted here as the condition of a considerable "deformation" of the electron orbit of the H atom) then implies

$$B > B_0 = \frac{m^2 c e^3}{\hbar^3} = 2.351 \cdot 10^9 \text{ Gauss},$$
 (II.A.11)

where *m* is mass of electron. Equivalently, this deformation condition corresponds to the case when the binding energy of the H atom,  $|E_0^{Bohr}| = |-me^4/2\hbar^2| = 0.5$  a.u. = 13.6 eV, is smaller than the ground Landau energy  $E_0^{\perp}$ .

The above critical value of the magnetic field,  $B_0$ , is naturally taken as an *atomic unit* for the strength of the magnetic field, and corresponds to the case when the pure Coulomb interaction energy of the electron with nucleus is equal to the interaction energy of the single electron with the external magnetic field,  $|E_0^{Bohr}| = E_0^{\perp} = 13.6 \text{ eV}$ , or equivalently, when Bohr radius is equal to Landau radius,  $a_0 = R_0 = 0.53 \cdot 10^{-8} \text{ cm}$ .

It should be stressed here that the characteristic parameters, Bohr's energy  $|E_0^{Bohr}|$  and Bohr's radius  $a_0$ , of the H atom have the purpose to establish a criterium for the critical strength of the external magnetic field of the hydrogen atom under the conditions here considered. For other atoms the critical value of the magnetic field may be evidently different.

After outlining the quantum dynamics of a single electron in an external magnetic field, Aringazin [8] turns to the consideration of the H atom under an external static uniform magnetic field.

In the cylindrical coordinate system  $(r, \varphi, z)$ , in which the external magnetic field is  $\vec{B} = (0, 0, B)$ , i.e., the magnetic field is directed along the z-axis, Schrödinger's equation for an electron moving around a fixed proton (Born-Oppenheimer approximation) in the presence of the external magnetic field is given by

$$-\frac{\hbar^2}{2m}\left(\partial_r^2 + \frac{1}{r}\partial_r + \frac{1}{r^2}\partial_\varphi^2 + \partial_z^2 + \frac{2me^2}{\hbar^2\sqrt{r^2 + z^2}} - \gamma^2 r^2 + 2i\gamma\partial_\varphi\right)\psi = E\psi,$$
(II.A.12)

where  $\gamma = eB/2\hbar c$ .

The main problem in the nonrelativistic study of the hydrogen atom in an external magnetic field is to solve the above Schrödinger equation and find the energy spectrum. This equation is not analytically tractable so that one is led to use approximations.

In the approximation of a very strong magnetic field,  $B \gg B_0 = 2.4 \cdot 10^9$  Gauss, Coulomb interaction of the electron with the nucleus is not important, in the transverse plane, in comparison to the interaction of the electron with external magnetic field. Therefore, in accord to the exact solution (10.A) for a single electron, one can look for an approximate ground state solution of Eq. (10.A.3) in the form of factorized transverse and longitudinal parts,

$$\psi = e^{-\gamma r^2/2} \chi(z), \qquad (II.A.13)$$

where  $\chi(z)$  is the longitudinal wave function to be found. This is so called *adiabatic approximation*. In general, the adiabatic approximation corresponds to the case when the transverse motion of electron is totally determined by the

1068

intense magnetic field, which makes the electron "dance" at its cyclotron frequency. Specifically, the radius of the orbit is then *much smaller* than Bohr radius,  $R_0 \ll a_0$ . The remaining problem is thus to find longitudinal energy spectrum, in the z direction.

Inserting the wave function (10.A.3) into the Schrödinger equation (10.A.3), multiplying it by  $\psi^*$ , and integrating over variables r and  $\varphi$  in cylindrical coordinate system, one gets the following equation characterizing the z dependence of the wave function:

$$\left(-\frac{\hbar^2}{2m}\frac{d^2}{dz^2} + \frac{\hbar^2\gamma}{m} + C(z)\right)\chi(z) = E\chi(z), \qquad (II.A.14)$$

where

$$C(z) = -\sqrt{\gamma} e^2 \int_0^\infty \frac{e^{-\rho}}{\sqrt{\rho + \gamma z^2}} d\rho = -e^2 \sqrt{\pi\gamma} e^{\gamma z^2} [1 - \operatorname{erf}(\sqrt{\gamma}|z|)], \quad (II.A.15)$$

where  $\operatorname{erf}(x)$  is the error function.

The arising effective potential C(z) is of a nontrivial form, which does not allow to solve Eq. (10.A.3) analytically, so one can approximate it by simple potentials, to make an estimation on the ground state energy and wave function of the H atom.

At high intensity of the magnetic field,  $\gamma \gg 1$  so that under the condition  $\gamma \langle z^2 \rangle \gg 1$  one can ignore  $\rho$  in the square root in the integrand in Eq. (10.A.3). Then, one can perform the simplified integral and obtain the result

$$C(z) \simeq V(z) = -\frac{e^2}{|z|}, \text{ at } \gamma \langle z^2 \rangle \gg 1,$$
 (II.A.16)

which appears to be a pure Coulomb interaction of electron with the nucleus, in the z direction. Due to the exact result (10.A.3), C(z) tends to zero as  $z \to \infty$ . However, a remarkable implication of the exact result is that C(z) is finite at z = 0, namely,  $C(0) = -\sqrt{\pi\gamma} e^2$ , so that the effective potential C(z) can not be well approximated by the Coulomb potential.

The exact potential C(z) can be well approximated by the *modified* Coulomb potential,

$$C(z) \simeq V(z) = -\frac{e^2}{|z| + z_0},$$
 (II.A.17)

where  $z_0$  is a parameter,  $z_0 \neq 0$ , which depends on the field intensity B due to

$$z_0 = -\frac{e^2}{C(0)} = \frac{1}{\sqrt{\pi\gamma}} = \sqrt{\frac{2\hbar c}{\pi e B}}.$$
 (II.A.18)

The analytic advantage of this approximation is that V(z) is finite at z = 0, being of Coulomb-type form. Therefore, Eq. (10.A.3) reduces to one-dimensional Schrödinger equation for the Coulomb-like potential,

$$\left(\frac{\hbar^2}{2m}\frac{d^2}{dz^2} + \frac{e^2}{|z|+z_0} + \frac{\hbar^2\gamma}{m} + E\right)\chi(z) = 0.$$
 (II.A.19)

In the atomic units  $(e = \hbar = m = 1)$ , using the notation

$$E' = \frac{\hbar^2 \gamma}{m} + E, \quad n^2 = \frac{1}{-2E'},$$
 (II.A.20)

introducing the new variable x = 2z/n, and dropping  $x_0 = 2z_0/n$ , to simplify representation, the above equation can be rewritten as

$$\left[\frac{d}{dx^2} + \left(-\frac{1}{4} + \frac{n}{x}\right)\right]\chi(x) = 0, \qquad (II.A.21)$$

where x > 0 is assumed. Introducing new function v(x) defined as  $\chi(x) = xe^{-x/2}v(x)$ , one gets the final form of the equation,

$$xv'' + (2-x)v' - (1-n)v = 0. (II.A.22)$$

Noting that it is a particular case of Cummer's equation,

$$xv'' + (b - x)v' - av = 0, (II.A.23)$$

the general solution is given by

$$v(x) = C_{1} F_{1}(a, b, x) + C_{2}U(a, b, x), \qquad (II.A.24)$$

where

$${}_{1}F_{1}(a,b,x) = \frac{\Gamma(b)}{\Gamma(b-a)\Gamma(a)} \int_{0}^{1} e^{xt} t^{a-1} (1-t)^{b-a-1} dt \qquad (II.A.25)$$

and

$$U(a,b,x) = \frac{1}{\Gamma(a)} \int_0^\infty e^{-xt} t^{a-1} (1+t)^{b-a-1} dt \qquad (II.A.26)$$

are the confluent hypergeometric functions, and  $C_{1,2}$  are constants; a = 1 - nand b = 2. Hence, for  $\chi(x)$  one has

$$\chi(x) = (|x|+x_0)e^{-(|x|+x_0)/2} \left[ C_1^{\pm} F_1(1-n,2,|x|+x_0) + C_2^{\pm} U(1-n,2,|x|+x_0) \right]$$
(II.A.27)

where the parameter  $x_0$  has been restored, and the "±" sign in  $C_{1,2}^{\pm}$  corresponds to the positive and negative values of x, respectively (the modulus sign is used for brevity).

1070

Let us consider first the  $x_0 = 0$  case. The first hypergeometric function  ${}_1F_1(1-n, 2, x)$  is finite at x = 0 for any n. At big x, it diverges exponentially, unless n is an integer number, n = 1, 2, ..., at which case it diverges polynomially. The second hypergeometric function U(1-n, 2, x) behaves differently, somewhat as a mirror image of the first one. In the limit  $x \to 0$ , it is finite for integer n = 1, 2, 3, ..., and diverges as 1/x for noninteger n > 1 and for  $0 \le n < 1$ . In the limit  $x \to \infty$ , it diverges polynomially for integer n, tends to zero for noninteger n > 1 and for n = 0, and diverges for noninteger 0 < n < 1.

In general, because of the prefactor  $xe^{-x/2}$  in the solution (10.A.3) which cancels some of the divergencies arising from the hypergeometric functions, we should take into account *both* of the two linearly independent solutions, to get the most general form of normalizable wave functions.

As a consequence, for  $x_0 \neq 0$  the eigenvalues may differ from those corresponding to n = 1, 2, ... (which is a counterpart of the principal quantum number in the ordinary hydrogen atom problem) so that n is allowed to take some *non-integer* values from 0 to  $\infty$ , provided that the wave function is normalizable.

For even states, in accord to the symmetry of wave function under the inversion  $z \rightarrow -z$ , one has

$$C_1^+ = C_1^-, \quad C_2^+ = C_2^-, \quad \chi'(0) = 0.$$
 (II.A.28)

Also, since n = 1 gives  $E' = -1/(2n^2) = -1/2$  a.u., one should seek normalizable wave function for n in the interval 0 < n < 1, in order to achieve lower energy value. If successful, n = 1 indeed does not characterize the ground state. Instead, it may correspond to some excited state.

Analysis shows that normalizable wave functions, as a combination of two linearly independent solutions, for the modified Coulomb potential does exist for various non-integer n. Focusing on the ground state solution, Aringazin considers values of n ranging from 0 to 1. Remind that  $E' = -1/2n^2$  so that for n < 1 the energy lower than E' = -0.5 a.u.

For n < 1, the first hypergeometric function is not suppressed by the prefactor  $xe^{-x/2}$  in the solution (10.A.3) at large x so we are led to discard it as an unphysical solution by putting  $C_1 = 0$ . A normalizable ground state wave function for n < 1 is thus may be given by the second term in the solution (10.A.3). Indeed, the condition  $\chi'(x)|_{x=0} = 0$  implies

$$\frac{1}{2}e^{-(x+x_0)/2}C_2[(2-x-x_0)U(1-n,2,x+x_0)-(II.A.29)-(2(1-n)(x+x_0)U(2-n,3,x+x_0))]_{|x=0} = 0.$$

The l.h.s of this equation depends on n and  $x_0$ , so one can select some field intensity B, calculate associated  $x_0 = x_0(B)$  and find n, from which one obtains the ground state energy E'. On the other hand, for the ground state this condition can be viewed, *vice versa*, as an equation to find  $x_0$  at some selected n.



Figure 10.A.4. A schematic view on the H atom in the ground state under a very strong external magnetic field  $\vec{B} = (0, 0, B), B \gg B_0 = 2.4 \cdot 10^9$  Gauss, due to the modified Coulomb approximation studied in the text. The electron moves on the Landau orbit of small radius  $R_0 \ll 0.53 \cdot 10^{-8}$  cm resulting in the toroidal structure used for the new chemical species of magnecules. The vertical size of the atom is comparable to  $R_0$ . The spin of the electron is antiparallel to the magnetic field.

For example, taking the noninteger value  $n = 1/\sqrt{15.58} \simeq 0.253 < 1$  Aringazin found  $x_0 = 0.140841$ . This value is in confirmation with the result  $x_0 = 0.141$ obtained by Heyl and Hernquist [14]. On the other hand,  $x_0$  is related in accord to Eq. (10.A.3) to the intensity of the magnetic field,  $x_0 = 2z_0/n$ , from which one obtains  $B \simeq 4.7 \cdot 10^{12}$  Gauss. Hence, at this field intensity the ground state energy of the hydrogen atom is determined by  $n = 1/\sqrt{15.58}$ .

The total ground state wave function is given by

$$\psi(r,\varphi,x) \simeq \sqrt{\frac{1}{2\pi R_0^2}} e^{-\frac{r^2}{4R_0^2}} (|x|+x_0) e^{(|x|+x_0)/2} U(1-n,2,|x|+x_0), \quad (II.A.30)$$

where n is determined due the above procedure, and the associated three-dimensional probability density is schematically depicted in Fig. 10.A.4.

One can see that the problem remarkably difference than the ordinary threedimensional problem of the hydrogen atom, for which the principal quantum number n must be integer to get normalizable wave functions, and the value n = 1 corresponds to the lowest energy.

The modified Coulomb potential approach provides qualitatively correct behavior, and suggests a *single* Landau-type orbit shown in Fig. 10.A.4 for the ground state charge distribution of the hydrogen atom. This is in full agreement with Santilli's study [1, 11] of the hydrogen atom in a strong magnetic field.

Accurate analytic calculation of the ground and excited hydrogen wave functions made by Heyl and Hernquist [14] in the adiabatic approximation leads to



Figure 10.A.5. The axial wavefunctions of hydrogen in an intense magnetic field (analytic calculation) for  $B = 4.7 \cdot 10^{12}$  Gauss. The first four even states with axial excitations,  $|000\rangle$  (ground state),  $|002\rangle$ ,  $|004\rangle$ , and  $|006\rangle$  (left panel), and odd states  $|001\rangle$  and  $|003\rangle$  (right panel) are depicted;  $n = 1/\sqrt{15.58}$ ,  $\zeta = 2z/n$  corresponds to x in the used notation; z in a.u., 1 a.u. =  $0.53 \cdot 10^{-8}$  cm (reproduction of Figure 3 by Heyl and Hernquist [14]).

the longitudinal parts of the wave functions shown in Fig. 10.A.5, which reproduces the original Fig. 3 of their work;  $\zeta = 2\pi\alpha z/\lambda_e$ ;  $B = 4.7 \cdot 10^{12}$  Gauss. They used the modified Coulomb potential of the type (10.A.3), and the additional set of linearly independent solutions of the one-dimensional modified Coulomb problem in the form

$$(|x|+x_m)e^{-(|x|+x_m)/2} {}_1F_1(1-n,2,|x|+x_m) \int^{|x|+x_m} \frac{e^t}{(t {}_1F_1(1-n,2,t))^2} dt,$$
(II.A.31)

where m = 0 corresponds to the ground state. For the ground state with  $n = 1/\sqrt{15.58}$ , they found  $x_0 = 0.141$ , which corresponds to  $B = 4.7 \cdot 10^{12}$  Gauss. This result is in agreement with the study made above.

One can see from Fig. 10.A.5 that the peak of the ground state wave function  $|000\rangle$  is at the point z = 0, while the largest peaks of the excited wave functions are away from the point z = 0 (as it was expected to be). Consequently, the associated longitudinal probability distributions (square modules of the wave functions multiplied by the volume factor of the chosen coordinate system) are symmetric with respect to  $z \to -z$ , and their maxima are placed in the center z = 0 for the ground state, and away from the center for the excited states. The computed ground state  $|000\rangle$  binding energy of the hydrogen atom for different field intensities are [14]:



Figure 10.A.6. A schematic view on the H atom in an excited state under a very strong external magnetic field  $\vec{B} = (0, 0, B), B \gg B_0 = 2.4 \cdot 10^9$  Gauss. One electron moves simultaneously on two toroidal orbits of radius  $R_0$  which are shown schematically as torii in the different (x, y) planes, one torus at the level  $z = -L_z$  and the other at the level  $z = +L_z$ , with the nucleus shown in the center at z = 0. Each torus represents the (x, y) probability distribution as shown in Fig. 10.A.3 but with small Landau radius,  $R_0 \ll a_0$ . The spin of electron is aligned antiparallel to the magnetic field.

| Magnetic field $B$ (Gauss)  | Binding energy, $ 000\rangle$ state (Rydberg)                 |
|---|---|
| $\begin{array}{c} 4.7\times10^{12}\\ 9.4\times10^{12}\\ 23.5\times10^{12}\\ 4.7\times10^{13}\\ 9.4\times10^{13}\\ 23.5\times10^{13}\\ 4.7\times10^{14} \end{array}$ | $15.58 \\ 18.80 \\ 23.81 \\ 28.22 \\ 33.21 \\ 40.75 \\ 47.20$ |

Heyl and Hernquist calculated the first-order perturbative corrections to the above energies and obtained the values, which are in a good agreement with the results by Ruder *et al.* [9] and Lai [12].

The associated probability density of the above excited states is evidently of a cylindrical (axial) symmetry and can be described as two Landau orbits of radius  $R_0$  in different  $(r, \varphi)$  planes, one at the level  $z = -L_z$ , and the other at the level  $z = +L_z$ , with the nucleus at z = 0, as schematically depicted in Fig. 10.A.6.

Presence of two Landau orbits occurs in accord to the excited wave functions, which is symmetrical with respect to the inversion,  $z \to -z$ , and the largest peaks of which are away from the center x = 0. The electron moves simultaneously on these two Landau orbits.

A review of approximate, variational, and numerical solutions can be found in the paper by Lai [12]. The accuracy of numerical solutions is about 3%, for the external magnetic field in the range from  $10^{11}$  to  $10^{15}$  Gauss. Particularly, due to the variational results [12], the z-size of the hydrogen atom in the ground state is well approximated by the formula  $L_z \simeq [\ln(B/B_0)]^{-1}$  a.u.; the transverse (Landau) size is  $L_{\perp} \simeq (B/B_0)^{-1/2}$  a.u.; and the ground state energy  $E \simeq -0.16[\ln(B/B_0)]^2$  a.u., with the accuracy of few percents, for  $b \equiv B/B_0$  in the range from  $10^2$  to  $10^6$ . One can see for  $B = 100B_0$ , that the variational study predicts the ground state energy E = -3.4 a.u. = -92.5 eV, the transverse size  $L_{\perp}$  of about 0.1 a.u. =  $0.53 \cdot 10^{-9}$  cm, and the z-size  $L_z$  of about 0.22 a.u. This confirms the result of the modified Coulomb analytic approach.

Since a zero-field ground state case is characterized by perfect spherically symmetric electron charge distribution in the H atom, intermediate intensities of the magnetic field are naturally expected to imply a distorted spherical distribution. However, a deeper analysis is required for the intermediate magnetic field intensities because the adiabatic approximation is not longer valid in this case.

As to the multi-electron atoms, an interesting problem is to study action of very strong external magnetic field on He atom (see. e.g., Refs. [12, 14]) and on the multi-electrons heavy atoms, with outer electrons characterized by a nonspherical charge distribution, such as the *p*-electrons in Carbon atom, orbitals of which penetrate the orbitals of inner electrons. In fact, a very intense magnetic field would force such outer electrons to follow small round toroidal orbits. In addition to the effect of a direct action of the magnetic field on the inner electrons, a series of essential rearrangements of the whole electron structure of the atom seems to occur with the variation of the field strength. The magnetic field competes with the electron-electron interactions, including spin pairings. However, it is evident that at sufficiently strong fields, all the electron spins are aligned antiparallel to the magnetic field — fully spin polarized configuration — while at lower field intensities various partial spin polarized configurations are possible.

In accord to the numerical calculations based on the density matrix theory by Johnsen and Yngvason [13], which is in good agreement with the Hartree-Fock treatment of a very strong magnetic field, the inner domain in iron atom (26 electrons) is characterized by a slightly distorted spherically symmetric distribution, even at the intensities as high as  $B = 100B_0 \dots 1000B_0$ . The outer domain appears to be of specific, highly elongated distribution along the direction of the magnetic field as shown in Fig. 10.A.7. The possible interpretation that the inner



Figure 10.A.7. Contour plots of the (r, z) plane electronic density of iron atom according to the density matrix theory at two different magnetic field strengths,  $10^{11}$  Gauss (left) and  $10^{12}$  Gauss (right). The outermost contour encloses 99% of the negative charge, the next 90%, then 80% etc., and the two innermost 5% and 1% respectively (reproduction of Fig. 5 by Johnsen and Yngvason [13]).

electrons remain to have a spherical distribution while outer electrons undergo the squeeze seems to be not correct unless the spin state of the iron atom is verified to be partially polarized. So, we can conclude that all the electrons are in the highly magnetically polarized state (Landau state mixed a little by Coulomb interaction), and the electronic structure is a kind of *Landau multi-electron cylindrical shell*, with the spins of all the electrons being aligned antiparallel to the magnetic field (fully spin polarized configuration).

Another remark regarding Fig. 10.A.7 is that the contours indicating a nearly spherical distribution will always appear since the Coulomb center (nucleus) is not totally eliminated from the consideration (non-adiabatic approximation), and it forces a spherical distribution to some degree, which evidently depends on the distance from the center (closer to the center, more sphericity). We note that outer contours in Fig. 10.A.7 is in qualitative agreement with Fig. 10.A.6 in the sense that the predicted charge distribution reveals symmetry under the inversion  $z \rightarrow -z$ , with the characteristic z-elongated Landau-type orbits.

An interesting problem is to study  $H_2$  molecule under the action of a strong external static uniform magnetic field using Schrödinger's equation. However, prior to that study, it would be useful to investigate the simpler two-center  $H_2^+$ ion, since it can give valuable information on the features of the full hydrogen molecule under the action of a strong magnetic field. We refer the interested reader to Refs. [12, 14, 15] for studies on  $H_2^+$  ion and  $H_2$  molecule in strong magnetic field. Figure 10.A.8 displays the ground and first excited state wave functions of  $H_2^+$  [14].



Figure 10.A.8. A schematic view of the ground and first-excited state of  $H_2^+$  ion. The solid line traces  $|000\rangle$ , and the dashed line follows  $|0-10\rangle$ . The triangles give the positions of the protons for the ground state and the squares for the excited state. The magnetic field  $B = 4.7 \cdot 10^{12}$  Gauss is pointed along the internuclear axis;  $\zeta = 2\pi\alpha z/\lambda_e$  denotes z in a.u.; 1 a.u. =  $0.53 \cdot 10^{-8}$  cm (reproduction of Figure 5 by Heyl and Hernquist [14]).

# **APPENDIX 10.A**

| 1 kWh              | 860  Kcal = 3413  BTU       | 1 cf             | 28.3 liters   |
|--------------------|-----------------------------|------------------|---|
| 1 Kcal             | 3.97 BTU                    | $1 \text{ cf}^a$ | 1.263 mol   |
| 1  eV              | $3.83 \times 10^{-23}$ Kcal | $N_A$            | $6.022 \times 10^{23} \text{ mol}^{-1}$                           |
| 1 cal              | 4.18 J                      | $N_A k/2$        | 1  cal/(mol·K)  |
| $1 \text{ mole}^a$ | 22.4  liters = 0.792  cf    | R                | $8.314 \text{ J/(mol \cdot K)} = 1.986 \text{ cal/(mol \cdot K)}$ |

 $^{a}$  An ideal gas, at normal conditions.

Table 10.A.2. Specific heat capacities. p = 1 atm,  $T = 25^{\circ}$  C.

| $H_2(gas)$       | 29.83  J/(mol·K)                 | 7  cal/(mol·K)                    |                 |
|------------------|----------------------------------|-----------------------------------|-----------------|
| $H_2O$ (liquid)  | $4.18 \text{ J/(gram \cdot K)}$  | $1 \text{ cal/(gram \cdot K)}$    | 18  cal/(mol·K) |
| Graphite (solid) | $0.71 \text{ J/(gram \cdot K)}$  | $0.17 \text{ cal/(gram \cdot K)}$ | 2  cal/(mol·K)  |
| $O_2$ (gas)      | $29.36 \text{ J/(gram \cdot K)}$ | $7 \text{ cal/(gram \cdot K)}$    |                 |
| H (gas)          | $14.3 \text{ J/(gram \cdot K)}$  | $3.42 \text{ cal/(gram \cdot K)}$ |                 |
| O (gas)          | $0.92 \text{ J/(gram \cdot K)}$  | $0.22 \text{ cal/(gram \cdot K)}$ |                 |
| Fe (solid)       | $0.45 \text{ J/(gram \cdot K)}$  | $0.11 \text{ cal/(gram \cdot K)}$ | 6  cal/(mol·K). |

|     | Kcal/mol    |              | Kcal/mol    |     | Kcal/mol    |
|-----|-------------|--------------|-------------|-----|-------------|
| H–H | $104.2^{a}$ | C=O          | $192.0^{d}$ | 0=0 | $119.1^{b}$ |
| C-C | 82.6        | O–H          | 110.6       | C=C | 145.8       |
| C–O | 85.5        | $C \equiv C$ | 199.6       | C=O | $255.8^{c}$ |

Table 10.A.3. Average binding energies, at  $T=25^{\circ}$  C.

<sup>a</sup> in H<sub>2</sub>; <sup>b</sup> in O<sub>2</sub>; <sup>c</sup> in carbon monoxide; <sup>d</sup> in carbon dioxide.

Table 10.A.4. Evaporation heats and first ionization potentials.

|          | Kcal/mol | Atoms | eV    |
|----------|----------|-------|-------|
| Water    | 10.4     | Н     | 13.6  |
| Graphite | 171.7    | С     | 11.26 |
|          |          | 0     | 13.6  |

## References

- [1] Santilli, R.M.: Hadronic J. 21, 789 (1998).
- R. M. Santilli, Foundations of Hadronic Chemistry with Applications to New Clean Energies and Fuels, Kluwer Academic Publishers (2001) (Russian translation available in pdf file at http://www.i-b-r.org)
- [3] Kucherenko, M.G. and Aringazin, A.K.: Hadronic J. 21, 895 (1998).
- Settle, F.A.: Editor, Handbook of Instrumental Techniques for Analytic Chemistry, Prentice Hall, Upper Saddle River, New Jersey (1997).
- [5] R. M. santilli, U.S. patents numbers 6,926,872; 6,673,322; 6,663,752; 6,540,966; and 6,183,604
   [5a]. Magnegas website http://www.magnegas.com
   [5b].
- [6] Sachse, T.I. and Kleinekathöfer, U.: "Generalized Heitler–London Theory for H<sub>3</sub>: A Comparison of the Surface Integral Method with Perturbation Theory", e-print arXiv: physics/0011058 (November 2000).
- [7] Kadomtsev, B.B. and Kudryavtsev, V.S.: Pis'ma ZhETF 13, 15, 61 (1971); Sov. Phys. JETP Lett. 13, 9, 42 (1971) (English Translation); ZhETF 62, 144 (1972); Sov. Phys. JETP 35, 76 (1972) (English Translation). Ruderman, M.: Phys. Rev. Lett. 27, 1306 (1971); in: IAU Symposium 53, *Physics of Dense Matter*, C.J. Hansen (ed.), Dordrecht, Reidel (1974). Lai, D., Salpeter, E. and Shapiro, S.L.: Phys. Rev. A45, 4832 (1992). Lai, D. and Salpeter, E.: Phys. Rev. A52, 2611 (1995); Phys. Rev. A53, 152 (1996); Astrophys. J. 491, 270 (1997).
- [8] A. K. Aringazin, Yayli and E. Soyturk, Hadronic Journal 24, 395 (2001).
- [9] Sokolov A.A., Ternov I.M., and Zhukovskii, V.Ch.: Quantum mechanics, Nauka, Moscow, 1979 (in Russian). Landau, L.D. and Lifshitz E.M.: Quantum Mechanics: Non-Relativistic Theory, 3rd ed., Pergamon, Oxford, 1989. Ruder, H., Wunner, G., Herold, H. Geyer, F.:
Atoms in Strong Magnetic Fields, Springer, Berlin-Heidelberg-New York, 1994. Kadomtsev, B.B.: Soviet Phys. JETP **31** 945 (1970). Kadomtsev, B.B. and Kudryavtsev, V.S.: JETP **13** 42 (1971); JETP Lett. **13** 9 (1971).

- [10] Faddeev, L. and Niemi, A.J.: Magnetic geometry and the confinement of electrically conducting plasmas, physics/0003083, April 2000. R. Battye, R., Sutcliffe, P.: Phys. Rev. Lett. 81, 4798 (1998); and Proc. R. Soc. Lond. A455, 4305 (1999). Hietarinta, J, Salo, P.: Phys. Lett. B451, 60 (1999); and The ground state in the Faddeev-Skyrme model, University of Turku preprint, 1999; for video animations, see http://users.utu.fi/hietarin/knots/index.html
- [11] Santilli, R.M.: The Physics of New Clean Energies and Fuels According to Hadronic Mechanics, Journal of New Energy 4, Special Edition, No. 1 (1999), 318 pages. Santilli, R.M. and Shillady, D.D.: Intern. J. Hydrogen Energy 24, 943 (1999); Intern. J. Hadrogen Energy 25, 173 (2000).
- [12] Lai, D.: Matter in strong magnetic fields, chem-ph/0009333, September 2000.
- [13] Johnsen, K. and Yngvason, J.: Density Matrix Functional Calculations for Matter in Strong Magnetic Fields: I. Atomic Properties, chem-ph/9603005, March 1996.
- [14] Heyl, J.S. and Hernquist, L.: Hydrogen and Helium Atoms and Molecules in an Intense Magnetic Field, chem-ph/9806040, June 1998. Jones, M.D., Ortiz, G., and Ceperley, D.M.: Spectrum of Neutral Helium in Strong Magnetic Fields, chem-ph/9811041, November 1998.
- [15] Lopez, J.C., Hess, P., and Turbiner, A.: H<sub>2</sub><sup>+</sup> ion in strong magnetic field: a variational study, Preprint ICN-UNAM 97-06, chem-ph/9707050. Turbiner, A., Lopez, J.C., and Solis, U.: H<sub>3</sub><sup>++</sup> molecular ions can exist in strong magnetic fields, Preprint ICN-UNAM 98-05, chemph/9809298. Lopez, J.C. and Turbiner, A.: One-electron linear systems in a strong magnetic field, Preprint ICN-UNAM 99-03, chem-ph/9911535.
- [16] R. M. Santilli, Alarming oxygen depletion caused by oxygen produced from regenerating methods, Contributed paper, International Hydrogen Energy Forum 2000, Munich, Germany, September 11-15, 2000, http://www.magnegas.com/technology/part4.htm
- [17] Liphardt and Associates: Certification of MagneGas Exhaust http://www.magnegas.com/technology/part5.htm
- [18] R. M. Santilli, Intern. J. Hydrogen Energy 28, 177 (2003)
- [19] R. M. Santilli, "A new gaseous and combustible form of water", Intern. J. Hydrogen Energy, in press (2006).
- [20] D. Eisenberg and W. Kauzmann, The Structure and Properties of Water, Oxford University Press, Oxford (1969) [1a]. J. A. Plambeck, Electroanalytical Chemistry, Principles and Applications, 2-nd edition, Wiley & Sons, New York (1982) [1b].
- [21] Yull Brown, U. S. patent number 4,014,777 issued issued on March 29, 1977, and U. S. patent number 4,081,656 issued on March 28, 1978.

Chapter 11

# INDUSTRIAL APPLICATIONS TO NEW CLEAN ENERGIES

# 11.1 IN PREPARATION - NOVEMBER 1, 2005

For a summary of the content of this chapter, consult

The Physics of New Clean Energies and Fuels According to Hadronic Mechanics, R. M. Santilli, Special issue of the Journal of New Energy, 318 pages (1998).

Foundations of Hadronic Chemistry with Applications to New Clean Energies and Fuels, R. M. santilli, Kluwer Academic Publishers, Boston-Dordrecht-London (2001).

Isodual Theory of Antimatter with Applications to Antigravity, Grand Unification and Cosmology, R. M. Santilli, Sprionger (in press)

# Postscript

In the present second volume of his opus magnum, Hadronic Mathematics, Mechanics and Chemistry, Professor Ruggero Maria Santilli applies the extensive advances to pure mathematics, presented in the first volume, to a plethora of basic and far-reaching issues in the natural sciences of physics and chemistry. By these means he attains theoretical results not possible to achieve without use of these new and powerful mathematical tools or the extensions of our ontological horizon of the universe associated with the establishment of the new number fields discovered by hadronic mathematics. This second volume also presents available established experimental evidence offering crucial support to predictions from the new sciences of hadronic mechanics and chemistry, sketches of experimental design for further support and theoretical refinements (or falsifications), and emergence of new and quite spectacular technology made possible from these advances in theoretical science. Some of this technology has already been constructed and is up-and-running, and constitutes matured fruits of the quite gigantic scientific enterprise initiated by Santilli four decades ago, and with growing affiliation from co-scientists world-wide throughout the years.

In the exploring spirit of the Renaissance, one might say that the first volume offers a guiding compass and the basic skills for constructing adequate maps and ships to search for unknown continents, while this second volume presents maps as well as treasures after having successfully travelled, reached and traced unknown continents on the other side of the vast ocean of the unknown.

Scientific revolutions in the sense of Thomas Kuhn do not happen often in the history of science, and with regard to physics the last ones, quantum mechanics and Einsteins relativity theory, have now reached the age of 100 year old-timers. With the rapidly increasing number of scientists and over-all significance of scientific progress for modern society, it is not too strange from a birds-eye-view of the history of science that a new revolution has found its day.

The new theory of physics as a whole, coined hadronic mechanics by Santilli, does not question the validity of the theories of quantum mechanics and relativity theory for the physical world, given the constraints formulated by the great creators of the said theories, represented by the kind of physical objects and relations being studied by the theory, and the proper simplifications in the describing and explaining models of such objects, dependent on the nature of the objects and the available mathematics. Basically, the constraints of these theories consist in their relevance being restricted to the so-called exterior physical world, which is the physical world outside the hadronic horizon of one femtometer. For interior relations, inside the hadronic horizon, the models and equations of these theories did not claim any immediate validity by their originators and, therefore, they are not scientifically legitimate to import inside the hadronic horizon, at least not without careful theoretical considerations on the basic problems therein involved, and without support from crucial experiments. Sad to say, this book offers much argument and evidence for a lot of such illegitimate import to have been the normal state of affairs during the second half of 20th century standard physics.

Assuming the strong interaction being adequately represented as the interaction between three point-like baryon quarks in the hadron, quantum mechanics did not succeed in establishing any good and experimentally testable model of the strong interaction, partly due to the complexities involved with the required non-linear mathematics to describe such a system. Largely because of these problems, the unification of the three other well-known forces with the strong force remained an open problem during 20th century standard physics. Equipped with the developed isomathematics, Santilli disposed the necessary tools to leave the assumption of interior point-quarks, and to describe shapes, as well as changes in shapes coined deformations, of particles with physical extension, to approach the problem of strong interactions inside the hadronic horizon. By means of isomathematics, Santilli was able to quantitatively model the neutron as a bound state of a proton and an electron, and hence to reestablish Rutherfords notion of the neutron as a compressed hydrogen atom. This achievement by Santilli was enthusiastically commented on by the great philosopher of science, Karl Popper, in his book from 1982, as a return to sanity, to that realism and objectivism for which Einstein stood.

The Rutherford-Santilli model of the neutron described the proton and the electron as a bound state with overlapping wave packets. Such a compression could only be imagined as a result of an external trigger, for example the role of pressure in the case of neutron synthesis in stars. For the neutron to stay in a bound state, the bound state had to be imagined as a singlet of a proton and an electron with opposite spins, according to the so-called gear model ruling out the possibilities of triplets or parallel spins. By 1990 Santilli had been able to publish such a model of the neutron as a mutated bound state with an exact quantitative representation of its physical characteristics: rest energy, mean life, charge radius, charge, charge parities, space, spin, and (anomalous) magnetic and electric moment.

Such a model would not have been possible by importing the quantum mechanics for exterior relations to the inside of the hadronic horizon, due to the idea of quantum quantization being contrary to the deep interpenetration of the wave packets inside the hadronic horizon and to the non-existence of exited hadronic states. Such excitation would imply tunneling through the hadronic horizon, which by Santilli was stated as the very mechanism of the neutrons spontaneous decay. In this way Santillis model of neutron synthesis, as well as neutron decay, did not need any assumption about existence of sub- or quasi-particles as in the notion of quarks, nor was there any need to imagine said processes to rely on a somewhat mystical notion of the two stable elementary particles of the physical world, protons and electrons, being created from and resolved into intermediary states of quark assemblies. In this regard Santillis theory of the neutron offered a much simpler picture of the situation inside the hadronic horizon as well as of the relation to the exterior physical world. Elegant and adequate simplifications are what good science should be about: the question was if the theory was to become supported by experimental evidence. Such significant support was provided when the measured density of the so-called fireball in the Einstein Bose correlation of colliding proton and antiproton was shown to be very close to the hadronic calculation of the density of the neutron, as predicted by hadronic mechanics. Crucial additional support was added from the experiments headed by Prof. Tsagas in 1996 with 319 stimulated decays of the neutron, expelling the Rutherford electron when exposed to the resonance frequency of a hard photon, in accordance with the predictions from hadronic mechanics. (Sad to say, no other laboratories in the world have so far wanted to retest these results by duplicating such experiments, in spite of the great scientific, technological and ecological significance of such confirmation.)

In analogy with the neutron model, Santilli already in 1978, the birth year of hadronic mechanics, had been able to present a model of the 0 meson as a bound state of an electron and a positron with overlapping wave packets, i.e. as a compressed positronium. Also this model was able, differently from quantum mechanics, to represent all physical characteristics of the 0 meson without any additional notion of quarks, and this in one single structural equation. However, it is important to notice that the said bound state is not a bound state of the involved particles as considered outside the hadronic horizon, since physical attributes of the particles undergo some changes in this compression. Such states are, therefore, only possible to describe by means of isomathematics and from the accordingly broader concept of isoparticles.

In general, different from quantum mechanics, hadronic mechanics represents a theory of physics equipped with concepts, models and mathematics to describe and explain relations interior to the hadronic horizon. However, to be able to succeed in this, hadronic mechanics had to be developed as a lifted theory compared to quantum mechanics, thereby providing a more general theory of physics, just as valid for exterior relations as quantum mechanics, the last being a sub-field of hadronic mechanics. Therefore, it is not adequate to consider hadronic mechanics as a supplement or a competitor to quantum mechanics, but as a theory of physics with a broader explanatory power than quantum mechanics, also being

able to adequately include interior relations, as well as relations between the interior and the exterior. This broadening-from-lifting follows the general scheme of development of basic theoretical advances in physics as analyzed in David Bohms interpretation of the modern history of physics.

The theory of hadronic superconductivity, initiated by Prof. Animalu and Santilli from 1994, constitutes an important bridge between hadronic mechanics and hadronic chemistry. In superconductivity theory, as approached by quantum mechanics, it was quite a mystery how the bound state of the Cooper pair could emerge and remain, considering that two electrons are known to be repelled by the Coulomb force. However, from hadronic mechanics this became explainable with the notion of a hitherto unknown physical force becoming activated when two particles are brought into touch from an external trigger, this fifth force inducing total overlap between the two involved wave packets. Different from the four conventional forces, this was a contact force without a potential, and thus requiring a non-Hamiltonian for its mathematical description; - hence being outside the reach of quantum mechanics. Also, the force was described by hadronic mechanics not to depend on the sign of the charge of the involved particles. Thus, the Cooper pair could be explained with this force simply being stronger than the Coulomb force. Due to deep interpenetration of the wave packets, the Cooper pair, by analogy with the cases of the neutron and the compressed positronium, had to be modeled, not as conventional electrons in the exterior, but as isoelectrons.

Further, the Cooper pair in hadronic superconductivity was modeled with an 8-shaped orbit around the two nuclei involved in the superconductivity structure. This orbit shape induces an extraordinarily strong magnetic force from each nuclei, in the hydrogen atom calculated to be 1.415 times the strength of the ordinary magnetic force from the proton, and of course in opposite directions from the two nuclei. Similar superconductivity structures could then be attracted and bound together, aligning from the orientations of the extraordinarily strong magnetic forces from the nuclei, and clustering into bigger structures of atoms (as well as with the possibility to include dimers, radicals or molecules). These clusters were coined magnecules by Santilli, and were predicted from hadronic superconductivity to be discovered by experiments. This became confirmed by independent laboratories, using adequate special apparatus for such detections, from 1998 on. Santilli also invented and patented so-called plasma-arc-flow reactors, also called hadronic reactors and sometimes ecoreactors, to produce magnecules in specified types and quantities in a controlled manner. Already at Dec. 15, 1998, Santilli presented the first constructed reactor producing such new chemical species. 1998 became the take-off year of hadronic chemistry also as a scientific discipline, with a special issue of the Hadronic Journal solely dedicated to presenting the scientific foundations of this lifted and broader chemistry.

Besides Santilli the publication included among its authors Profs. Shillady and Aringazin.

The discovery of magnecules represented the first discovery of a new chemical species since the discovery of molecules in the mid-1800s. Different from molecules, magnecules have non-valence bonds and they can form much larger structures, in superfluids sometimes even visible by the naked eye. Most scientists researching superconductivity with only quantum mechanics at their disposal, believe that superconductivity is restricted to extremely low temperatures (somewhat misleading referring to temperatures far below zero as High Tc superconductivity), while hadronic chemistry has explained hadronic superconductivity to be possible also for fluids and gases, activated by the external trigger of strong and close enough magnetic fields. It is a matter of fact that hadronic reactors have been producing such magnecular gases since 1998. This is a quite bizarre situation, and also with a somewhat macabre touch, since use of magnecular gas has been proven to have highly favorable ecological applications. Compared to molecules, magnecules have many different chemical attributes, explained in detail from hadronic chemistry and experimental evidence in the present volume. For example, when used as a fuel for vehicles, exhaust from combustion of magnecular hydrogen gas has a molecular composition very different from the exhaust of molecular hydrogen gas. The first does not contain potential carcinogens of the latter, has only half the CO<sub>2</sub> content, and adds, contrary to the latter, a significant amount (10-12

Compared to the molecular hydrogen gas, the density of the corresponding magnecular gas is about 7.5 times higher. This implies that, on the same tank volume and pressure, a car fuelled on magnecules drives 7.5 times the distance of a car fuelled on molecules. Such effective magnecular fuel is not possible to produce without hadronic reactors, which construction presupposed hadronic mechanics with related hadronic mathematics. In this way, the existing hadronic technology, and there are other examples as well, offers quite simple tests to convince any sound skeptic about the superiority of the hadronic sciences as a whole, compared to standard physics constituted inside century old paradigms.

Hadronic reactors also offer considerable advantages on the input side, because they apply either oil or water solutions as their inputs, and the degree of pollution of the inputs does not matter, insofar as they are not radioactive. In the reactor process, where the plasma reaches temperatures higher than the surface of the sun, the molecules are broken down to their constituents before being recombined as magnecules with non-valence bonds. Thereby almost all molecular polluters disappear, including for example sewage water or pharmaceutical toxins. At the output side, there is produced, along with the magnecular gas, either chemical clean water or heat that can be applied for useful purposes. Furthermore, Santilli has also succeeded in developing magnecular technology specifically

designed as an additive to coal processing in order to reduce the globally heavy load of environmental pollution from this energy technology. Also to consider among Santillis amazing inventions, is the new hadronic technology of so-called intermediate nuclear fusion.

The foundations of scientific theory behind these technological progressions, which ought to be highly welcomed in the contemporary alarming ecological situation, are not only solid, but much more extensive and by far superior to the whole disciplines of standard quantum mechanics and chemistry, as fleshed out in much detail in the present volume. It is not without good reason that Santilli in his informative mammoth article in Foundations of Physics of Sept. 2003, a journal counting eight Nobel laureates in physics in its editorial board, emphasized the discovery of magnecules as the most precious fruit of his lifelong scientific endeavor.

The radical implications of scientific revolutions are hard to overview for contemporaries, sometimes including the pioneering scientists themselves. As a prominent mathematical physicist once said to the author of this postscript: Who would have guessed, back in the 1920s, that such a bizarre theory as quantum mechanics should gain such broad applications in upcoming technology? With regard to chemistry, it appears hard to find any historic parallel to the degree of progress represented or announced by hadronic chemistry, without moving back to the discovery of the periodic table. The panorama of magnecules reveals a previously hidden landscape of a whole new chemical world. It appears nave to suppose that these landscapes are restricted to artificial creations of substances by means of human high technology. In the last sentence of his 2001 book on hadronic chemistry, Santilli predicts the discovery of hyper-magnecules in biology. Also, his hadronic theory of lightning, offering more correct calculations of its accompanied sound quantities, describes this phenomenon as basically a hadronic reaction resulting in nitrogen synthesis. This may indicate that also other phenomena in nature, including biological and physiological nature, will prove to be better understood from hadronic chemistry, especially phenomena revealing superconductivity features. Of special significance may be the research and later applications of magnecular substances for medicine and health, a field so far not systematically targeted by advanced hadronic chemistry and technology, but already with some promising accumulation of more circumstantial evidence.

From the more overarching approach of the broader hadronic chemistry Santilli, partly in cooperation with other scientists, such as Shillady and Aringazin, from the late 1990s published new models also of the much studied molecules of hydrogen and water, earlier thought to be possible to be represented exactly by means of quantum chemistry, but argued by Santilli to be given exact representation of all chemical characteristics only by means of isochemical modeling not available for quantum chemistry. In 2007 Prof. Prez-Enrquez succeeded by using hadronic chemistry to achieve a representation of the hydrogen molecule with amazingly exact matching with experimental data (among these representing the binding energy up to the 5th digit) by further developments from the Santilli-Shillady model and the Aringazin-Kucherenko approach, an achievement the preceding quantum chemistry was quite far from realizing. Also the work by Dr. Martin Cloonan has been able to reach new insights in fields of chemistry from his Cplex-isoelectronic theory by treating highly specialized knowledge in chemistry from the theoretical framework of hadronic chemistry. These recent developments may indicate an upcoming tendency to reframe specific problems of chemistry inside the broader umbrella of hadronic chemistry and thereby propel further progressions in the fields at hand, probably a challenge most suitable for the younger among talented chemists.

For many years Santilli has emphasized growing environmental concerns as a crucial motivation for his long-lasting scientific enterprise, and in the last decade also for his more recent occupation as an inventor. In spite of the many ecologically favorable applications of magnecular technology already appearing, Santilli regards the hadronic energy connected to the beta-electron released in the neutrons spontaneous decay as the most promising source for new and clean energy, likely to become harvested by upcoming hadronic technology based on hadronic mechanics. Calculations indicate that this energy is huge, without danger of radioactive radiation, and probably capable of capture by adequate trapping and shielding devices.

Considering this promising possibility judged from the theoretical advances in hadronic mechanics, and the possibly great implications for the ecosystem, it seems strange at first glance that powerful physics institutions and laboratories around the world so far have not wanted to execute crucial experiments to support or falsify predictions and earlier experiments from hadronic mechanics regarding neutron decay. The strangeness does not shrink when considering the modest amount of resources needed to execute such experiments, compared to the gigantic budgets of CERN and the like. Hadronic mechanics has already proved to be highly successful in achieving experimental verifications of new predictions from its theoretical extensions, as well as in constructing quite amazing new and ecofriendly technology outside the reach for quantum mechanics. A nave observer from outside the world of sophisticated theoretical physics may ask why it is that hadronic mechanics is being neglected, while a stream of resources is allocated to its sub-fields of quantum mechanics and relativity theory which has only been proven valid for the physical world outside the hadronic horizon. From reading semi-popular science magazines the outside observer will gain the impression that string theory is the most advanced physics around. But if so, how come that string theory, in spite of its rich inflow of mathematical talent and money resources, backed by mighty institutions, and much activity for some 25 years,

has not been successful in creating any new and favorable technology? Could it be that much of the reason is astonishingly simple, that these mathematical models have become too detached from the physical world, somewhat similar to the epicycles of the Middle Ages, constituting a self-sufficient and well fed giraffelike research community not needing to care about rising revolutionary physics claiming basic theoretical advances backed by direct experimental support, or about the de facto emergence of new technology from this scientific revolution?

Scientific revolutions are not a tea party, and perhaps even less so in our time when the rise of significantly more advanced scientific theory not only threatens mighty characters in huge established science institutions, prestige hierarchies and networks nourished by a priori subscription to century old paradigms, but also related established interests in energy technology, finance and politics. Santilli has often stressed the evolutionary approach to this quest, by seeking serious dialogue and mutual exploration of the issues at hand with conventional scientists and institutions. In spite of this, Santilli has to a large extent been met with a Berlin wall of ignorance or non-scientific rejection, as indicated by the amazing near non-existence of published scientific questioning of the achievements in the hadronic sciences, today piling up to at least a library of 30.000 pages of published articles and monographs. Given the seriousness of the quest, not only for the further development of science, but for the very survival of our civilization by applying new technologies made possible from hadronic mechanics and chemistry, it seems likely that a more turbulent confrontation with different establishments antagonistic to radical extensions and liftings of conventional physics, is no longer possible to avoid. Considering the grave proportions of the rising ecological crisis, it may not be exaggerated to compare the situation with that of Semmelweiss, but with the difference that Santilli also talks from theoretical science above, not below the mighty scientists not able to leave their dogmas in spite of the implied damage done for the planet. Already in his three volume work of 1986, Documentation of the Ethical Probe, Santilli presented much food for thought concerning far from optimal scientific ethics being conducted in influential scientific communities. During the last two decades the picture has turned more severe, and the footnotes in the present volume provide much further material for competent evaluation of the present situation with regard to ethical vs. non-ethical conduct in the global science ecology. It may very well be that upcoming historians of science will look at the remarkably slow post-war development of main stream physics, when comparing the amount of basic advances to the resources spent and to the amount of advances the preceding part of the century, as connected to obstructions from profound non-scientific influences, paradoxically becoming fortified and nourished inside scientific institutions themselves.

Switching the focus to the brighter side, and lifting it to the visionary horizon inspiring great minds of science and art, it is important to note that hadronic mechanics in its very architecture involves a whole new cosmology, opening vast new territories of the cosmos for human imagination, scientific exploration and technological endeavors.

Different from Einsteins relativity theory which doesn't treat antimatter, and different from quantum mechanics which allows the existence of antimatter only at second quantization, hadronic mechanics was able to treat matter and antimatter systematically on an equal footing, corresponding to the anti-symmetric structure in hadronic mathematics between the iso-, geno- and hyperfields vs. their respective isoduals. Hadronic mechanics comprehends our physical or Euclidean universe as a combination of two distinct universes, a matter universe and an antimatter universe. These two universes have a different anchoring in supra-spacetime, respectively in isospacetime and in isodual spacetime. However, isospacetime and isodual spacetime manifest in the same 3+1D space which they share and hence is to be comprehended as double-valued. Due to the antisymmetry of the two universes, positive mass in the matter universe will be projected as negative mass when experienced in the antimatter universe, and the same the other way around, and also the same with all other physical quantities, such as time, charge and energy. For the universe as a whole combination of the matter and the antimatter universe, all these magnitudes cancel out to zero. (This is also consistent with the key notion in the ambitious theory of universal rewrite nilpotent system recently worked out by mathematical physicist Peter Rowlands.)

This implies a comprehension of space itself as a universal substratum composed of a superposition of positive and negative energies, from which matter and antimatter galaxies are continuously created. This seems to provide an elegant solution for the mystery of from where the universe, considered as a closed system, receives its energy as a whole. If the universe has a paradoxical twin structure, the puzzle may be solved from a metabolism between the two moieties from the universal substratum, where the output energy from one moiety is received with the opposite sign as input energy for the other moiety, while the energy of the total universe remains zero or nilpotent. The philosophically quite simplistic Big Bang hypothesis, popular in much 20th century physics, is an answer to a question about the origin of the universe that does not make much sense when reframed from the more sophisticated cosmology and ontology of hadronic mechanics. Regarded from hadronic cosmology, treating antimatter with scientific democracy, as Santilli likes to put it, it is not quite the same universe anymore. According to hadronic cosmology, the universe is rather comprehended as inherently and continuously re-created, as it was by the great scientist David Bohm. On this background the Big Bang (and Crunch) hypothesis may be more adequately understood as a creation myth suitable for a conflated physicalistic and entropic world view painted in scientific cosmetics.

Hadronic cosmology constitutes a platform for much more optimistic and ambitious scientific undertakings. Santillis theory of antimatter has formulated precise predictions of antigravity phenomena, and has designed experimental tests of antigravity for positrons and isodual light. Also, hadronic mechanics includes the notion of bound states of matter and antimatter, coined isoselfdual states, which opens up the possibility for time travel in the matter universe via intermediary switching onto the antimatter universe. Furthermore, Santilli describes causal spacetime machines which is the theoretical notion of way more radical space travel than the rocket technology developed half a century ago, and which applies the principle of isogeometric propulsion without Newtonian action-reaction. Hence, the realism in developing UFO technology for space travel much faster than the speed of light in vacuum, does not seem farfetched anymore from the theoretical advances of hadronic mechanics. These advances were only possible from the broadening of the theory of physics to include antimatter on an equal footing with matter, which in its turn presupposed the development of the new isonumber fields, with corresponding isogeometry, for quantitative treatments.

It is worth noticing that such space deformations are accompanied by changes in time as we ordinarily understand it. This implies a detrivialization of the conventional time concept, where the familiar time arrow reduces to just one aspect of a more complex configuration of different types of time flows. In his pioneering studies of sea shell growth from hadronic geometry Chris Illert showed in the mid-1990s that a certain class of bifurcating sea shell followed a growth path that presupposed two non-trivial kinds of time flows, perceived as jumps forward and backward in conventional time. Such discovery of non-trivial time flows in a sufficiently profound specialist study of a complex irreversible system of nature, was exactly what was expected from the new time theory of hadronic mechanics which had added four types of non-trivial categories, so-called geno-times, to the conventional notion of time. Santilli has stated that for practical purposes there is no scientific difference between the new physical principles discovered in branching sea shells and those involved in the notion of causal spacetime machines.

Throughout the last century the quest of grand unification of gravitation with the three other conventional forces of physics remained a puzzling open problem in the struggles of standard physics. Santillis theory of grand unification from hadronic mechanics presents gravitation as a macro phenomenon aggregated (with presented equations) from quantum electrodynamics de facto rooted in energy from the vacuum or universal medium. However, such a grand unification is argued by Santilli still not to be theoretically possible without acknowledging the democratic co-existence of an antimatter universe, a theory of physics not available before the development of hadronic mechanics. Accordingly, there was no mystery that grand unification became out of reach for standard physics restricted to quantum mechanics and Einstein relativity theory. From this approach Santilli argued that grand unification was possible only as recognizing the quest as two connected grand unifications, one for the matter universe and one for the antimatter universe, to become integrated in a combined grand unification, and accordingly coined Iso-Grand-Unification, requiring isomathematics for its fulfillment.

Differently from 20th century standard physics, hadronic mechanics has provided a general scientific umbrella, sophisticated, abstract and broad enough to encompass life in its extension, at least in a much more emphatic and radical sense. This is intimately connected to the structure of the higher landscapes of hadronic mathematics, to be considered not only as tools but as structures complex enough to offer adequate maps of lifes phenomena. Due to the lack of isonumbers required to describe hadronic superconductivity, quantum mechanics was never able to catalyze much progress in chemistry, with growing disconnection between physics and chemistry as a result. For mappings of biological structures, genonumbers become crucial to grasp the fundamental irreversibility characterizing the complexity of the biological world (as well as already the behavior of stars, galaxies and quasars). After a lifting to genostructures, the whole field of isostructures, which still implied reversibility in its basic mathematical axioms, reappears only as the subfield of genostructures where reversibility constitutes a special case. The further lifting from genostructures to the much broader hyperstructures achieves not only irreversibility, but the multi-valued theory required to map even more complex structures of life. Santilli notes that when described as a multi-valued hyperstructure, the same seashell can overlap a large number of spaces and their isoduals, resulting in multi-fold formulations including the four different directions of time. The relevance of hyperstructures to describe really complex life phenomena becomes perhaps most immediately and intuitively obvious if we move to psychology and reflects on the multi-fold dynamic constellation of mind spaces and time travels involved in ordinary human thinking.

This may indicate that the top floor in the huge building of hadronic mechanics, hypermechanics, is sophisticated enough to include also mental and social phenomena. In standard physics the quest for grand unification was restricted to a unification of the four conventional physical forces, silently regarding the mental and social worlds as mystically separated from the universe or as mere epi-phenomena mirroring or emerging from the four physical forces. On this background it is highly interesting that Santilli not only presents an (iso-)grand unification of the four forces in chapter 14 of the present volume, but takes the steps all the way up to a Hyper-Grand-Unification. In the modern development of science and society, the frontier of physics has always been highly influential indirectly on other disciplines, being regarded as the most authoritative discipline concerning what is to be stated with the highest degree of scientific certainty with respect to the basic issues of our cosmos. The rise of hadronic mechanics, with

the present volume presenting a systematic overview of its most mature achievements, constitutes a much more radical scientific revolution, since the argued fruits of hypermechanics are far from being relevant only for physics, but seems directly relevant for all scientific disciplines, and this in a profound manner.

Santilli notes that all distinctions between matter and antimatter are lost at the hyperstructural level and that at this highest possible level of formulation, we have one single hyperrelativity, one single Poincar-Santilli hypersymmetry (chapter 6.1.15). In this regard the advanced science of hypermechanics is in accord with the basic notion of cosmos being a unitary whole, characterizing great natur philosophy, such as Plotinus, Kant, Hegel and Bohm. Santilli also states: The foundation of our hypercosmology on the universal hypersymmetry is the single most important result of the authors lifetime of research because it governs the totality of the events in the universe (ibid.).

Being based on symmetry, the hypercosmology of hadronic mechanics differs from Einstein gravity and other preceding cosmologies of physics. The unitary whole of the cosmos is reflected in Santilli coining this cosmology hyper-self-dual, and Santilli explicitly states the necessity of lifting the cosmology from isotopic and genotopic theories to the hypertopic level because a basic component of the universe is life (chapter 14.2) which needs multi-valued descriptions to become comprehended.

In spite of the imagined universality of the hyper-self-dual cosmology and hyper-hadronic mechanics, Santilli is careful by stating that science will never admit a final theory. This humble attitude, the complementary polarity to the visionary extreme ambition also characterizing scientific genius, differs remarkably from physicists clinging to doctrines from Einstein relativity more like religious dogma and for eternity. This was an attitude quite alien to Einstein himself who published his break-through articles without one single reference to any authority (or non-authority), and let the power of thought speak for itself.

Santilli holds Einstein in very high esteem, and declares him explicitly as the greatest scientist of the last century. However, the admiration between deeply creative and thereby related minds seems to be of another kind than that between a genius and the later followers of his established authority. One might say that Santillis admiration of Einstein is more profound, insofar as the scientific thinking of Santilli himself exposes a similar brave, original and creative line of thought. From this also follows a scientific obligation to leave home if and when the pupil reaches far enough to explore unknown higher territories in the mountains of knowledge, climbing from the shoulders of his master. Santilli is careful in the present volume, as in earlier works, to pinpoint under which constraints Einstein relativity is still to be considered valid, and at the same time to state loud and clear why the masters theories do not hold when these constraints are abandoned, and therefore was in need of a more lifted and broader theory of physics which

Santilli went out to create through forty years of hard work. Considering all the experimental evidence from the 1990s on, showing beyond serious doubt that the light speed in vacuum does not represent any ultimate barrier for velocity, explained by hadronic mechanics as a necessity inside hyper-dense hadron media, it seems quite pathetic when the authority of Einstein is mobilized as rhetoric ammunition to obstruct such theory formation and recognition.

It has been said that the real masters greatest satisfaction is when he realizes that his pupil has grown beyond the skills of himself. If allowing such an analogy for the case of clarifying proportions, Einstein ought to have every reason to evaluate his pupil Santilli with delightful satisfaction. Like Einstein, Santilli has pushed the frontier of physics far beyond earlier imagination. However, unlike Einstein, Santilli has also pushed the frontier of the whole of physics, as well as the frontiers of whole disciplines outside physics foremost chemistry and mathematics, but also theoretical biology, and with direct implications also for other disciplines, among them philosophy. So, all in all, it seems hard to doubt that history will judge Santilli as an even greater genius than Einstein.

In the history of mankind there are very few examples of scientists showing brilliance both in mathematics (whether pure or applied to physics) and in the art of invention, the Norwegian Kristian Birkeland (1867-1917) constituting one of the few worth mentioning. With his amazing patents, as well as different types of constructed hadronic reactors producing the new chemical species of magnecules, Santilli has also proven extraordinary skills as an inventor, praised by Tesla as the foremost among sciences, as well as a laboratory man. These skills, indicating intuitively precise connectedness to the rock hard and dynamic physical world, ought to give further credibility to the practical and direct relevance of the theoretical physics and chemistry of Santilli, constituting a character quite different from the more ivory tower type of mathematical physicists.

The present volume may represent a suitable closing of Santillis pioneering monographs given to the world to whom it could concern as perhaps the richest collection of scientific goodies ever presented to Mankind, whose future may depend crucially on what it does with the treasures contained in this opus magnum. With this publication, serious scientists and scholars with open and critical minds across a plethora of disciplines have been given heavy loads of precious ideas to digest and cultivate for many a year to come. In spite of Santilli often using the expression young minds of all ages, the scientific presents are doomed to primarily become appetizers to consider for the younger and most emergent upcoming among those minds, because they will become the carriers and releasers of the future, if any. Besides the thrills of discovery in absorbing the monograph itself, as well as from explorative adventures fuelled by inspiration from it, there will also be a heavy load of social responsibility and dedicated action to carry out, considering signs of rising turbulence inside as well as outside science. At Christmas time most people appreciate Santa Claus showing up to give them exclusive presents for delight. Sad to say, this is far from always being the situation in scientific communities, nor in society at large. Considering the immense obstacles to and antagonisms, be it brute or more sophisticated, against Santilli fulfilling his mission to science and to Mankind, it is quite a mystery in itself how this man has been able to keep on track, busily creating new insights with heroic energy and steady devotion seemingly greater than life, even after entering his eighth decade on the planet. The footnotes in this volume give some indication of the emotional challenge and burden involved therein, and tells of an intellectual honesty, integrity and boldness paradigmatic for any scientist, whatever degree of intelligence or idiosyncratic inclination.

Santilli holds the dream of humanity becoming able to harvest the huge clean energy connected to the beta-electron from neutron synthesis, predicted as a realistic possibility within reach from the physics of hadronic mechanics. At the same time, hadronic mechanics points out the missing energy in this synthesis when described by conventional physics, and locates the source of this energy gap to originate from the high energy density of the universal medium, by the way a statement similar to the avant-garde Russian physicist Kozyrev arguing the stars not to be fuelled by energy from their exterior. Whatever the destiny of this dream, it must be stated beyond doubt that the life work of Santilli represents quite a neutron synthesis in itself, fuelled from beyond the stars, with the present monograph constituting a new and clean hadronic energy of parachuting fruits from the tree of advanced and matured scientific knowledge, to be picked and eaten for the delight of the world. The release of this testament of Santillis science to the world ought to be honored with the uttermost gratitude and hungry attention. Science is nothing if not living science, so I find it irresponsible not to declare the historic proportions of the Santilli legacy, as to the best of my knowledge and judgment. Hence, on the possible behalf also of some future state of the affairs of the world and its science, I take the liberty to pass a 1001 thank you to the Great Italian - and may he stay forever young.

#### Professor Stein E. Johansen

PhD philosophy, DSc economics Institute for Basic Research, USA, Division of Physics Norwegian University of Science and Technology Department of Social Anthropology December 14, 2007

# Index

Lagrange equations, truncated, 8 Newton-Santilli genoequations for matter, 343

Action principle, 77 Action-at-a-distance interactions, 277 Aether, 280 Aethereal wind, 281 Algebra axioms, 13 Anisotropy, 294 Anti-Hydrogen atom, 149 Antigravity, 277 Antimatter, 1 Antiparticles, 145 Antiprotons, 149 Associative law, 329 Astrophysics, imbalance of, 52 Attached algebras, 330

Backward genocoordinates, 342 Backward genospeed, 342 Backward genotime, 342 Backward genounit, 334 Bilinear brackets, 329 Bimodules, 339 Binding energy, xiv Binding energy, positive, 283 Binding energy, negative, 283 Biology, xxiv, 369 Biology, imbalance of, 53 Birkhoff equations, 74 Birkhoff brackets, 75 Birkhoff tensor, 74 Birkhoffian mechanics, insufficiencies of, 244 Bistructure, 339 Bose-Einstein fireball, 32 Bose-Einstein correlation, xiv, 31 Brackets Time evolution, 329

Canonical tensor, 71 Canonical transformations, 71 Catastrophic inconsistencies, 332 causality, 88 Chaoticity parameters, xiv, 31 Charge conjugation, 142 Chemistry, insufficiency of, 38 Classical genomechanics, 98 Classical isomechanics, 98 Classical isomechanics, 98 Classical isomechanics, examples, 259 Classical isomechanics, invariance of, 260 Closed non-Hamiltonian systems, 161

Cold fusion, 278 Constancy speed of light, 285 Construction Lie-admissible theories, 350 Continuous creation, xv Coordinate genounit, 342 Cosmology, xxvi Cosmology, imbalance of, 52 Curvature, 64 Darboux theorem, 12 Deformed brackets, 83 Deformed Hamilton equations, 83 Deformed Hamilton's equations, 330 deformed Heisenberg equation, 331 Deformed Heisenberg equations, 85 Dimensionless particles, 277 Dirac equation, 139, 360 Dirac equation, isoselfduality, 139 Dirac equation, spin inconsistency, 139 Dirac-Santilli genoequations, 362 Dirac-Santilli isoequation, 298 Direct universality, 86, 288, 332, 356 Distributive law, 13 Doppler-Santilli forward hyperlaw, 376 Dunning-Davies Lie-admissible thermodynamics, 364 Dunning-Davies thermodynamics, 133 Einstein field equations, 58Einstein special relativity, 281 Electromagnetic interactions, 360 Electron, 282, 283 Electrons, 149 Energy equivalence, 52 Energy isoequivalence, 297 Energy nonconservation, 331 Ether, 280 Ethereal wind, 281 Euclid-Santilli genospace, 343 Euclid-Santilli isodual genospace, 343 Extended, nonspherical, deformable shapes, 164 Exterior dynamical problems, 7 Exterior isogravity, 304 External terms, insufficiencies, 243 Extraterrestial life, 284 Feynman diagrams limitations, 5

Forward genocoordinates, 342 Forward genospeed, 342 Forward genotime, 342

#### RUGGERO MARIA SANTILLI

Forward hyperdilation, 376 Forward hyperenergy, 376 Forward hypermass, 376 Forward hyperspeed, 376 Four time directions, 119 Freud identity, 63 Galileo symmetry, dimension of, 185 Galileo symmetry, inapplicability of, 18 Galileo-Roman boosts, 318 Galileo-Roman relativity, 317 Galileo-Roman symmetry, 317 Galileo-Roman time translation, 318 Galileo-Santilli isodual relativity, 125 General relativity, xxv, 277 General relativity, inconsistencies of, 54 Geno-Minkowskian geometry, 362 Geno-Riemannian geometry, 362 Genoaction principle, 345 Genocoordinates, 342 Genodifferential calculus, xxvii Genoexpectation values, 348 Genofields, 335 Genofunctional analysis, 335 Genogeometries, 337 Genomechanics, 98 Genomomentum, 348 Genonumbers, 335 Genoproducts, 333 genorelativity, 280 Genospacetime, 362 Genospeed, 342 Genosymmetries, 339 Genotime, 342 Genotopic liftings, 280 Genotopies, 280 Genounits, 333 Geometric locomotion, 362 Grand Unifications, 2 Grand unified theories, 363 Gravitational source, 56 Hadronic chemistry, xix Hadronic energies, xvii Hadronic genomechanics, 347 Hadronic isodual genomechanics, 347 Hadronic mechanics, fundamental assumption, 168 Hadronic mechanics, xvi, 97 Hadronic mechanics, classification, 98 Hadronic mechanics, invariance of, 276 Hadronic mechanics, simple construction of, 274Hadronic mechanics, universality of, 268 Hadrons, xiv

Hamilton equations, true, 9, 242 Hamilton equations, truncated, 8, 241 Hamilton true equations, 158 Hamilton's legacy, 327, 328 Hamilton-Jacobi-Santilli equations, 262 Hamilton-Jacobi-Santilli genoequations, 345 Hamilton-Santilli genomechanics, 344 Hamilton-Santilli isodual equations, 124 Hamilton-Santilli isodual genomechanics, 344 Hamilton-Santilli isoequations, 254 Hamilton-Santilli isomechanics, 251 Hamiltonian, 327 Hamiltonian mechanics, 98 Hamiltonian theory, 277 Heisenberg equation, 275 Heisenberg equations, 332 Heisenberg-Santilli genoequations, xvi, 348 Heisenberg-Santilli isodual equations, 139 Heisenberg-Santilli isodual genoequations, 348 Heisenberg-Santilli isoequations, xvi, 267 Hot fusion, 278 Hydrogen atom, 149 Hydrogen molecule, 38 Hyperalgebras, 373 Hyperaxioms, 376 Hyperbeta, 377 Hypercoordinates, 374 Hyperdifferential calculus, 373 hyperdifferential calculus, xxvii Hyperfunctional analysis, 373 hypergamma, 377 Hyperinterval, 375 Hypermechanics, 100, 372 Hyperproduct to the left, 372 Hyperproduct to the right, 372 Hyperspaces, 373 Hyperstructures, 371 hyperstructures, xxiv Hypertimes, 374

Inconsistency theorem, classical, 76 Inconsistency theorems, operator, 86 Inconsistent theories, 90 Index of refraction, 285 Inertia, 282 Inhomogeneity, 294 Integravility conditions for a potential, 161 Interior dynamical problems, 7 Interior isogravity, 304 Invariance Lie-admissible theories, 352 Irreversibility, 49 Irreversible systems, 280, 325 Iso-Einstein isotensor,  $215\,$ Iso-Euclidean box, 203 Iso-Euclidean geometry, 202 Iso-Freud- isoidentity, 216

### 1098

Forward genounit, 334

Forward hypercontraction, 376

### INDEX

Iso-hamiltonian, 265 Iso-Heisenberg equations, 267 Iso-Hilbert spaces, 263, 266 Iso-Minkowskian cube, 211 Iso-operations, 176 Iso-Pitagorean theorem, 190 Iso-Ricci lemma, 215 Iso-Schrödinger equations, 268 Isoaberration, 296 Isoacceleration, 249 Isoaction principle, 251 Isoaxisoms, 295 Isocanonical one-isoform, 224 Isocanonical two-isoform, 224 Isocanoninity, 227 Isocoordinates, 249, 288 Isocovariant isodifferential, 214 Isoderivative, 192 Isodeterminant, 187 Isodifferential, 192 Isodifferential calculus, xxvii, 192 Isodual isodifferential calculus, 192 Isodual backward genocoordinates, 342 Isodual backward genospeed, 342 Isodual backward genotime, 342 Isodual box, 129 Isodual classical genomechanics, 98 Isodual classical hypermechanics, 100 Isodual classical isomechanics, 98 Isodual complex numbers, 109 Isodual coordinate genounits, 342 Isodual Coulomb law, 120 Isodual curvature tensor, 115 Isodual derivative, 112 Isodual differential, 112 Isodual differential calculus, 111 Isodual distance, 114 Isodual electron, 145 Isodual electrons, 149 Isodual Euclidean geometry, 113 Isodual Euclidean metric, 114 Isodual exponentiation, 111 Isodual field equations, 134 isodual field equations, 143 Isodual fields, 107 Isodual forward genocoordinates, 342 isodual forward genospeed, 342 Isodual forward genotime, 342 Isodual functional analysis, 111 Isodual Galilean relativity, 125 isodual general relativity, 134 Isodual genoaction principle, 345 Isodual genocoordinates, 342 Isodual genoexpectation values, 348 Isodual genofields, 335 Isodual genofunctional analysis, 335 Isodual genogeometries, 337

isodual genomechanics, 98 Isodual genomomentum, 348 Isodual genonumbers, 335 Isodual genospeed, 342 Isodual genotime, 342 Isodual genounits, 334 Isodual Hamiltonian mechanics, 98, 124 Isodual Heisenberg equations, 139 Isodual Hilbert spaces, 136 Isodual Hydrogen atom, 149 Isodual hyperaxioms, 376 Isodual hyperbolic functions, 111 Isodual hypermathematics, 374 Isodual hypermechanics, 100 Isodual hypernumbers, 374 Isodual hyperspaces, 374 Isodual hyperunits, 374 Isodual iso-Hilbert spaces, 263 Isodual iso-operations, 176 Isodual isofields, 175 Isodual isofunctional analysis, 186 Isodual isoinner product, 263 Isodual isoperturbation theory, 272 Isodual isoproduct, 171 Isodual isoquantization, 262 Isodual isorelativistic hadronic mechanics, 299 Isodual isorelativity, 280 Isodual isospaces, 182 Isodual isostates, 263 Isodual isosymplectic isogeometry, 223 Isodual isotopology, 199 Isodual isounit, 171 Isodual Lagrangian mechanics, 123 Isodual light cone, 129 Isodual light speed, 130 Isodual mathematics, 107 Isodual Minkowskian geometry, 115 Isodual Minkowskian metric, 115 Isodual neutron, 145 Isodual Newton equations, 121 Isodual Newtonian mechanics, 121 Isodual norm, 109 Isodual numbers, 107 Isodual operator genomechanics, 98 Isodual operator hypermechanics, 100 Isodual operator isomechanics, 98, 265 Isodual operator Lie-isotopic mechanics, 261 Isodual particles, 145 Isodual photons, 147 Isodual Poincaré symmetry, 129 Isodual power, 109 Isodual product, 107 isodual proton, 145 isodual protons, 149 Isodual quantization, 136 Isodual quantum mechanics, 98 Isodual quotient, 109

### RUGGERO MARIA SANTILLI

Isodual real numbers, 109 Isodual Riemannian geometry, 115 Isodual Riemannian space, 116 Isodual Schrödinger equation, 138 isodual spacetime inversions, 131 Isodual special relativity, xxii, 128 Isodual sphere, 114 Isodual square root, 109 Isodual theory of antiparticles, 118 Isodual time, 119 Isodual trigonometric functions, 111 Isodual unit, 107 Isoduality, 142 Isoduasl iso-Euclidean geometry, 202 Isoexpectation values, 264 Isofield, 266 Isofields, 175 Isoflatness isotensor, 215 Isofunctional analysis, 186 Isofunctions, 187 Isogamma matrices, 298 Isogravitation, 300 isoheisenberg equation, 275 isohilbert space, 263 Isoinner product, 263 Isoinvariant, 288 Isolinear isomom, entum, 268 Isolinear momentum, 196 Isolinearity, 227 Isolocality, 227 Isomechanics, 98 Isoperturbation theory, 272 isoperturbation theory, 273 Isoproduct, 171, 266 Isoquantization, 262 Isorelativistic addition of isospeeds, 296 Isorelativistic hadronic mechanics, 298 Isorelativity, 277, 280 Isorepresentation theory, 237 Isorotations, 290 Isoselfdual states, 151 Isoselfdual symmetry, 110 Isoselfduality, 138 Isospaces, 182 Isospeed, 249 Isosphere, 291 Isostates, 263 Isosymmetries, fundamental theorem, 240 Isosymplectic geometry, 223 Isotime, 249 isotopic element, 259, 271, 273 Isotopic isoscaler, 215 Isotopic transformations, 293 Isotopology, 199, 307 Isotrace, 187

Isotranslations, 292 Isotriangle, 190 Isotrigonometric functions, 188 Isounit, 171, 266, 287 isounit, 264 Isounitarity, 227 isounitary, 264 Isovector isofield, 224 Isowave equations, 298

Jordan admissible, 330 Jordan admissible algebras, 83 Jordan algebras, 330 Jordan-admissible, 88 Jpiter interior problem, 158

Kadeisvili isocontinuity, 197 Keplerian nucleus, 19 Keplerian systems, 19

Lagrange equations, true, 9, 242 Lagrange equations, truncated, 241 Lagrange true equations, 158 Lagrange's legacy, 327, 328 Lagrange-Santilli isodual equations, 123 Lagrangian, 327 Lagrangian theory, 277 Lie algebra axioms, 14 Lie algebra loss, 13 Lie Algebras, xvi Lie algebras, 330 Lie algebras unification, 238 Lie brackets, 71 Lie tensor, 71 Lie-admissible, 88 Lie-admissible algebras, xvi, 83, 330 Lie-admissible brackets, 330 Lie-admissible genogroup, 355 Lie-admissible spin, 358 Lie-isotopic branch, 157 Lie-Koenig theorem, 12 Lie-Santilli isotheory, 266 Lie-Santilli brackets, classical, 256 Lie-Santilli hypertheory, 372 Lie-Santilli isoalgebras, 233 Lie-Santilli isodual isotheory, 237 Lie-Santilli isodual theory, 112 Lie-Santilli isogroups, 234 Lie-Santilli isotheory, 266 Lifting, xxiv, 328 Light bending, 58 Light hyperspeed, 378 Light isocone, 212, 292 Light speed, 52 Longitudinal wave, 280 Lorentz-Santilli genotransformations, 362

### INDEX

Lorentz-Santilli isosymmetry, xvii, 289

Magnegases, xix Magnetic moments deviations, 33 Mass, 282 Mass isovariation, 296 Mass operator, 319 Maximal causal isospeed, 295 Metric isospaces, 183 Minkowski-Santilli genogeometry, 337 Minkowski-Santilli genospace, 337, 361 Minkowski-Santilli hyperspace, 375 Minkowski-Santilli hyperspacetimes, 375 Minkowski-Santilli isodual genogeometry, 337 Minkowski-Santilli isodual genospace, 337 Minkowski-Santilli isodual isogeometry, 207 Minkowski-Santilli isodual isospace, 207 Minkowski-Santilli isogeometry, 207 Minkowski-Santilli isogeometry, five identifies of, 216 Minkowski-Santilli isospace, 207 Multi-dimensional, 370 Multi-valued hyperunits, 372 Negative energies, 153, 284 Negative unit, 3 Neutrino conjectures, 24 Neutron, 283 Neutron structure, 363 New clean energies, 365 New energies, 326 Newton's equations, xxvi, 8, 327 Newton's legacy, 327, 328 Newton-Santilli genoequations, xxvii, 341 Newton-Santilli hyperequations, xxvii Newton-Santilli isodual equations, 121 Newton-Santilli isodual genoequations, 341 Newton-Santilli isodual genoequations for antimatter. 343 Newton-Santilli isodual isomechanmics, 246 Newton-Santilli isoequations, xxvii, 250 Newton-Santilli isomechanics, 246 No reduction theorems, 277 Nonassociative algebras, 330 Noncanonical theories, 70 Noncanonical transform, 158 Nonconservation laws, 339 Nonkeplerian systems, 19 Nonlinear theories, 91 Nonlocal interactions, 5 Nonlocal, nonlinear, nonpotential forces, 165 nonpotential interactions, 267, 271 Nonpotential forces, 75 Nonunitary theories, 70 Nonunitary transform, 82, 158 Nuclear Force, insufficiency of, 36

Nuclear Physics imbalance, 33 Observable, 329 Operatior Lie-isotomic mechanics, 261 Operator genomechanics, 98 Operator hypermechanics, 100 Operator isomechanics, 98, 265 Operator isomechanics, invariance of, 276 Operator isomechanics, simple construction of, 274Operator Lie-admissible equations, 332 p-q-deformations, 83 Parametric Lie-admissible equations, 331 Particle experiment manipulations, 30 Pauli principle, 359 Pauli-Santilli genomatrices, 359 Phase space, 71, 329 Photons, 147, 281 Physical media, 16 Poincé-Santilli isosymmetry, xvii Poincaré symmetry, dimension of, 185 Poincaré symmetry, inapplicability of, 18 Poincaré-Birkhoff-Witt-Santilli isotheorem, 231 Poincaré-Santilli hypersymmetry, 376 Poincaré-Santilli isodual symmetry, 129 Poincaré-Santilli isosymmetry, 289 Point-like abstractions, 5 Point-like antiparticles, 118 Point-like particles, 277 Poisson brackets, 71 Position operator, 319 Positive energies, 284 Positronium, 151 Positrons, 149 Proton, 283 Protons, 149 q-deformations, 83

Quantum chemistry, xvii Quantum electrodynamics, 62 Quantum mechanics, xiii, 5, 98 Quantum mechanics, limitations of, 46 Quark conjectures, 21

Reference frame, 281 Relativistic Galilean boosts, 318 Relativistic position operator, 319 Relativistic sum violation, 16 Representation isospace, 249 Reversibility, 49 Reversible systems, 278, 325 Riemann-Santilli genogeometry, 338 Riemann-Santilli isodual genogeometry, 338

Santilli genodifferential calculus, xxiv Santilli genomathematics, xxiii, 333, 334

### RUGGERO MARIA SANTILLI

Santilli genorelativity, xxiii, 280 Santilli genounits, 334 Santilli hyperdifferential calculus, xxiv Santilli hypermathematics, xxiv, 371 Santilli hypermechanics, 371 Santilli hyperrelativity, 375 Santilli isodifferential calculus, xxiv Santilli isodual genomathematics, xxiii, 333 Santilli isodual genorelativity, xxiv Santilli isodual hypermathematics, xxiv, 374 Santilli isodual hypermechanics, 374 Santilli isodual hyperrelativity, 375 Santilli isodual isomathematics, xxiii Santilli isodual isonumbers, 175 Santilli isodual isorelativity, xxiii, 280 Santilli isodual Lie-admissible theory, 338 Santilli isodual mathematics, xxii Santilli isogravitation, 300 Santilli isomathematics, xxiii, 171 Santilli isonumbers, 175 Santilli isorelativity, xvii, xxiii, 277, 280 Santilli isounit, 168 Santilli Lie-admissible equations, 85 Santilli Lie-admissible theory, 338 Santilli magnecules, xx Scalar law, 13, 329 Schrödinger equation, 262 Schrödinger-Santilli isoequations, 268 Schrödinger-Santilli genoequations, 348 Schrödinger-Santilli isodual genoequations, 348 Schrodinger-Santilli isodual equations, 138 Screened Coulomb law, 43 SETI, 284 Space, xv, 280 Space hyperunits, 374 Space isocontraction, 296 Spacetime hypercoordinates, 375 Spacetime locomotion, 285 Special relativity, xx, 5, 277, 281 Special relativity limitations, 1 Special relativity, consistency of, 55 Special relativity, inapplicability of, 15, 16, 32 Speed genounit, 342 Speed isodual genounits, 342 Speed of light, 285 Strong interactions, 360 Structurally irreversible, 280 Structurally reversible, 278

SU(3)-color classification, 360 Submerged arcs, 46 Substratum, xv Superconductivity, insufficiency of, 37 Superluminal speeds, 18 Symplectic structure, 71

Theorem of catastrophic inconsistencies, 333 Thermodynamics, 363 Thermodynamics first law, 364 Tim rate of variation, 339 Time evolution brackets, 14 Time genounit, 342 Time hyperunits, 374 Time isodilation, 296 Time isodual genounit, 342 Total conservation laws, 162 Total isofields, 249 Total isounit, 249 Totally antisymmetric brackets, 330 Totally symmetric brackets, 330 Transversal wave, 281 Truncated analytic equations, 327 Truncated Hamilton's equations, 327 Truncated Lagrange's equations, 327 TSSFN isotopology, 307 Two points function, 31

#### Unit, 287 Unitary transform, 333 Universal isoenveloping algebra, 305 Universal length, 319 Universal substratum, 280 Universality, 288, 356 Universality of Lie-admissibility, 339

Vacuum, xv, 280, 285 Variational nonselfadjoint forces, 9, 161 Variational nonselfadjointness, 327 Variational selfadjoint forces, 9, 161 Variational selfadjoint forces, 9, 161 Variational selfadjoint, 327 Variationally nonselfadjoint, 327 Variationally selfadjoint, 327 Velence bond, 294

Wave overlapping, 167 Wavepacket overlapping, 5 Weak operations, 371