INSTITUTE FOR BASIC RESEARCH

Palm Harbor, Florida, November 25, 2000. Last update October 5, 2005

CURRICULUM SUMMARY OF Prof. Ruggero Maria Santilli

prepared by the staff of
The Institute for Basic Research
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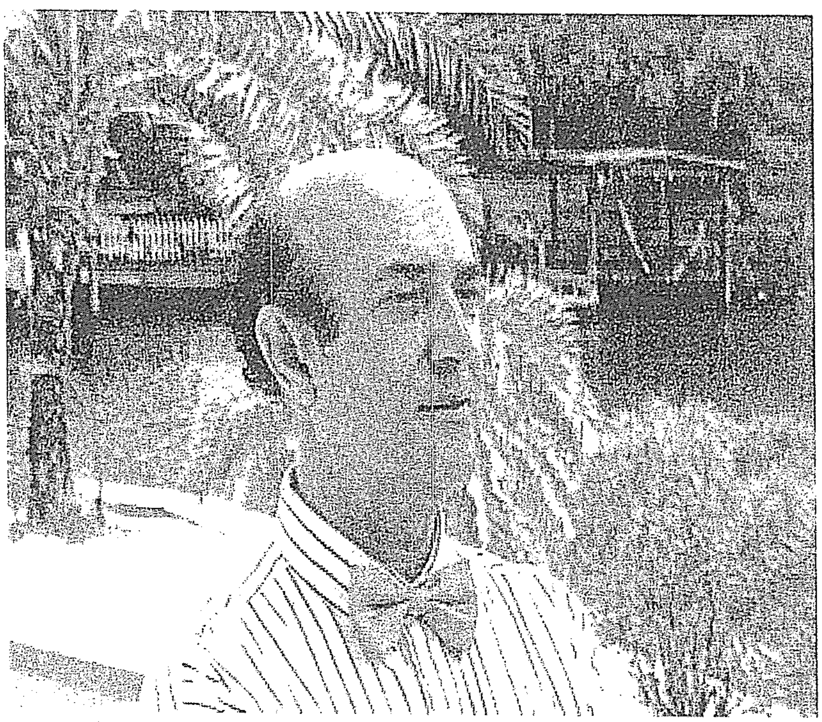

A 1995 photo of Prof. Santilli at his house in Florida

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CAREER SUMMARY

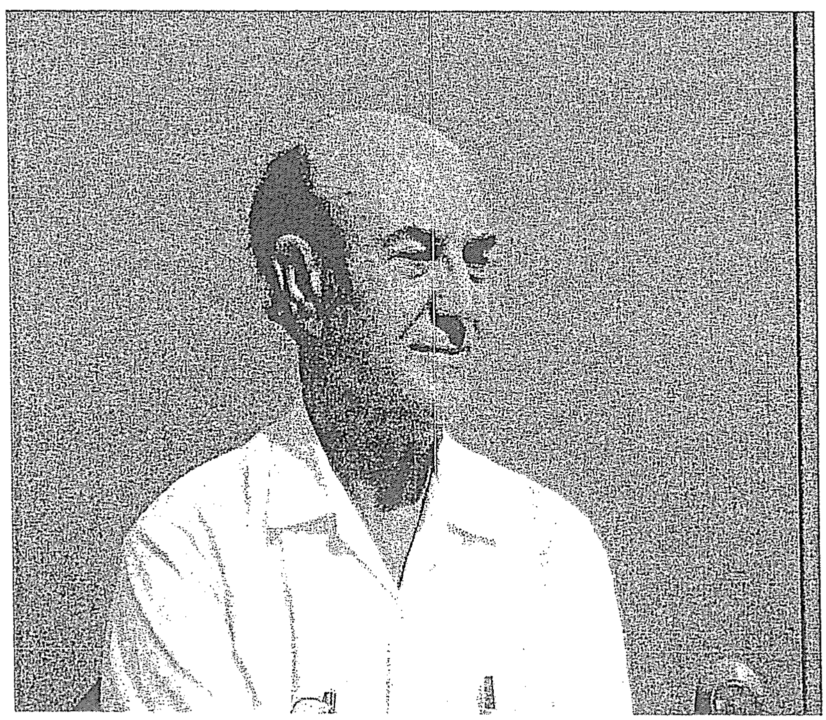
1. Santilli received the degree of Dottore in Fisica' (Physics Doctor) from the University of Naples, Italy. He subsequently attended the Graduate Shool in Physics of the University of Turin, Italy, where he obtained in 1966 the highest graduate degree in physics available at that time, corresponding to the U. S. 'Philosophical Doctor in Physics.' Jointly, Santilli held the chair of 'Professor of Nuclear Physics' at the famous A. Avogadro Institute in Turin, Italy.

2. Because of his post Ph.D. research conducted in Italy, Santilli was invited in 1967 by the University of Miami in Florida to conduct research under NASA financial support. In 1968, Santilli joined the faculty of Boston University as Associate Professor of Physics, where he taught physics and mathematics from prep-courses to post Ph.D. Seminal courses, and conducted research for the U. S. Air Force, research which led to his assuming the U. S. Citizenship.

3. In 1976 and 1977 Santilli was a visiting scholar at the Institute for Theoretical Physics of the Massachusetts Institute of Technology.

4. in 1978 Santilli joined Harvard University where he was co-principal investigator of research grants from the U. S. Department of Energy numbers ER-78-S-02-47420.A000 and AS02-78ER04742.

5. In 1983 Santilli assumed the position of President and Professor of Theoretical Physics of the newly formed Institute for Basic Research, then located at the Prescott House on Harvard Grounds, as well as Principal Investigator of DOE contracts DE-ACO2-80ER10651, DE-ACO2-80ER-10651.A001, and DE-ACO2-80ER10651.A002. The Institute for Basic Research was subsequently moved to Palm Harbor, Florida, in 1990.



A view of Prof. Santilli in 2005, age 70.

6. In 1998 Santilli assumed the additional post of Director of Research of corporations in the U.S.A.,

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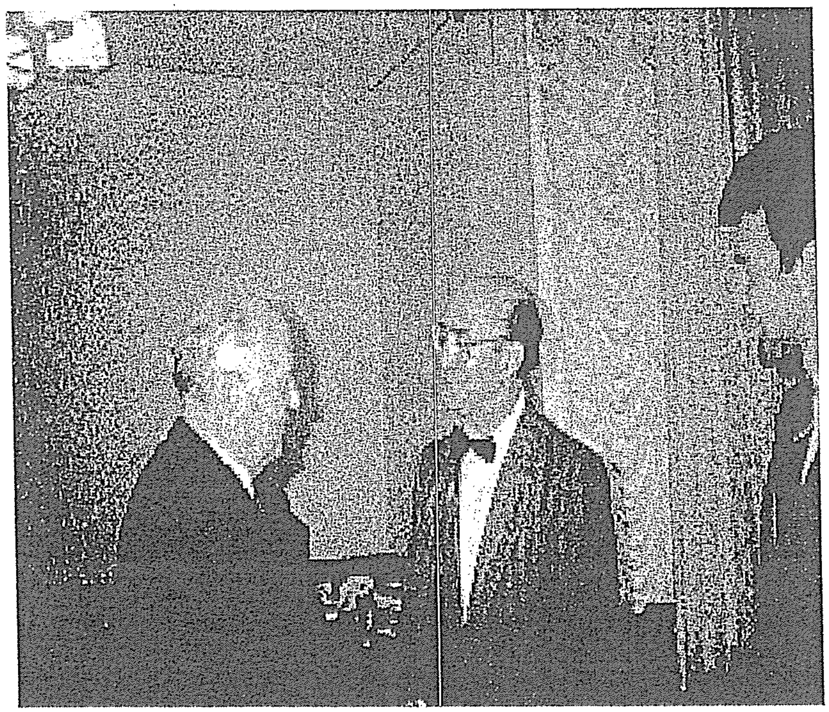
Europe and Asia developing new clean fuels with Santilli's novel magnecular structure.

7. Recently Santilli retired while remaining affiliated with a number of academic and corporate research insrtitutions around the world, including U.S.A., Ukraine, Russia, China, Italy, and Australia.

8. Santilli is the Founder and Editor in Chief of three journals, Hadronic Journal (which was initiated at Harvard University and continued for 27 years of uninterrupted publications), Hadronic Journal Supplement (with 19 years of uninterrupted publications) and Algebras, Groups and Geometries (with 20 years of uninterrupted publications).

9. Santilli is also Editor of the International Journal of PhysIcs, the Journal of the Balkan Geometry Society, the Journal of Alternative Energy and Ecology, the Journal of Dynamical Systems and Geometric Theories, and other Journals in mathematics and physics.He is also a reviewer or advisor to numerous other journals.



Prof. Santilli during a 20 minutes meeting with President Mikhail Gorbachev (and an interpreter on the right) following the collapse of the U.S.S.R. in August 1993. The late Prof. C. N. Bogoliubov, when Director of the JINR in Dubna, Russia, had been one of the founders of the *Hadronic Journal* jointly with Nobel Laureate C. N. Yang, Nobel Laureate I. Prigogine and other distinguished scholars, when the journal was organized in 1978 by Prof. Santilli then at Harvard University.

PUBLICATIONS SUMMARY

see below for complete listing<>br>

PAPERS

1. Santilli is:

The author of 19 post Ph.D. level research monographs (that is, monograph with original content)

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published by Springer-Verlag (Germany), Naukowa Dumka (Ukraine), Kluwer (The Netherlands), Springer (Holland), Hadronic Press (U.S.A.) and other highly qualified Publishing Houses,

The author of 250 technical articles in pure mathematics, applied mathematics, theoretical and experimental physics, superconductivity, chemistry, biology, astrophysics and cosmology published in refereed journals around the world, and

The editor or co-editor of about 100 volumes of confgerence p[roceedings also published by distinguished academic houses.

SOME OF LEADING JOURNALS WITH PROF. SANTILLI'S PUBLICATIONS:

PHYS. REVIEW (relativistic extension of the Galilean symmetry with P. Roman; extension of the PCT theorem to all discrete symmetries with C, N. Ktorides, inapplicability of Pauli's exclusion principle under open-nonconservative strong interactions with H. C. Myung; isotopic breaking of gauge symmetries; and several other papers);

NUOVO CIMENTO, NUOVO CIMENTO LETTERS and RIVISTA NUOVO CIMENTO (first presentation in physics - with application to dissipative systems - of Albert Lie-admissible algebras; first (p.q)-deformation of Lie algebras - 1967; first prediction that strong interactions can causally accelerate massive particles at speed greater than c; first generalizations of the Minkowski space, Lorentz-Poincare' symmetry and special relativity for arbitrary speeds of light within physical media and interactions; and several other papers published up to 1983, year of take over of the Italian Physical Society by Mr. Ricci and his group and consequential suppression of all - about 100 - submission by Santilli and his associates, all papers published elsewhere);

RENDICONTI CIRCOLO MAT. PALERMO (systematic generalizations - from numbers to spaces, functional analysis, differential calculus, topologies, etc. - of contemporary mathematics of isotopic, genotopic and hyperstructural type based on generalized units and products - used for the treatment of matter in progressive conditions of complexity - and the anti-isomorphic images of said generalized mathematics called isodual - for the treatment of antimatter; first structural generalization of Newton's equations on record since Newton's time -for which Santilli invented his generalized calculi and topologies - for the representation of extended-deformable particles under unrestricted nonlocal and nonpotential interactions; first structural generalization of Hamiltonian mechanics and related inverse problem which is directly universal for all possible discrete systems of extended-deformable particles; structural liftings of the Euclidean, symplectic and Riemannian geometries for arbitrary causal local speeds, etc.).

INTERN. J. PHYSICS and MODERN PHYS. LETTERS (first and only known "classical" theory of antimatter on scientific record - beginning from Newton's equation - whose operator image is compatible with charge conjugation; first axiomatically consistent prediction of antigravity for antimatter in the field of matter; first structural unification of the Minkowskian and Riemannian geometries permitted by the generalized calculi, with consequential geometric unification of special and general relativities; comprehensive study of the catastrophic inconsistencies of noncanonical-nonunitary theories when treated with conventional mathematics);

FOUND. PHYS. and FOUND. PHYS. LETTERS (first proposal on record - 1981 - that quarks cannot be elementary; achievement of maturity in 1976 with a comprehensive memoir on hadronic mechanics following its proposal in 1978; experimental review with Yu Arestov of deviations from the Minkowskian geometry and special relativity in the interior of hadrons; "invited" paper on the first invariant formulation of (p, q)-deformations and consequential resolution of the catastrophic inconsistencies of their current formulation; first and only known axiomatically consistent grand unifications "with a basic unifying symmetry and geometry" embedding gravity in the unity of electroweak interactions; and other papers);

COMMUN. THEOR. PHYS. (a variety of papers including: first achievement of a rigorous confinement of quarks via the incoherence of internal and external Hilbert spaces solely permitted by hadronic mechanics; first proposal of the isodual theory of antimatter holding at all level of study -rather than only in second quantization as per theories prior to Santilli's works; first proof that Heisenberg's uncertainties remain valid for nonpotential interactions in closed conditions; and several other papers);

MIT-ANNALS OF PHYSICS (comprehensive study with seven papers in the 1970s on the integrability conditions for the existence of a Lagrangian or a Hamiltonian in discrete and field mechanics; and other papers).

JINR - RAPID COMMUN. (first isotopic lifting of the SU(2)-isospin with first recovering of the exact isospin symmetry in nuclear physics; and other results);

ACTA APPL. MATH. (first nonunitary isotopies of the SU(2)-spin, first structural generalization of Pauli's matrices with hidden parameters; first proof that the nonunitary-isotopic image of Bell's inequality does indeed admit a classical counterpart contrary to popular beliefs; and other papers);

IoP-JOURNAL OF PHYSICS (first proof that the experimental data on the anomalous behavior of the meanlife of unstable particles with speed can be exactly represented by the isominkowskian geometry, published with other co-authors; and other results);

HYPERFINE INTERACTIONS ("invited paper" on the first proof that photons emitted by antimatter are different than those emitted by matter, which differences can be experimentally measured; first future possibility of ascertaining whether a far away galaxy is made up of matter or of antimatter' and other basic advances in antimatter);

INTERN. J. QUANTUM CHEMISTRY (first hadronic generalization of superconductivity and its first structural representation of the bonding-attraction of the two identical electrons in the Cooper pair, published with A. O. E. Animalu);

INTERN. J. HYDROGEN ENERGY (first nonunitary-hadronic generalization of quantum chemistry; first known model of molecular bonds with "attraction" between identical valence electrons; first achievement on record of a representation of molecular data exact to the seventh digit; and other major advances in chemistry, ;published with D. D. Shillady; the first and only new species of hydrogen with increased specific weight and energy contents due to Santilli's magnecular structure; the first and only new gaseous and combustible form of water, and other topics).);

J. NEW ENERGY (first exact-numerical representation on scientific records of all nuclear magnetic moments; a new structure model of nuclei explaining why the deuteron has spin 1; comprehensive review of the experimental verifications of hadronic mechanics in particle physics, nuclear physics, molecular physics, superconductivity, biology, astrophysics, and cosmology);

ANNALES DE LA FONDATION L. DE BROGLIE (the first and only grand unification of electroweak and gravitational interactions including a consistent gravitational treatment of antimatter; inconsistencies of Weinberg's nonlinear theory; and other topics).

NUMEROUS OTHER JOURNALS inc luding:
ADVANCES IN ALGEBRAS,
#JOURNAL OF DYNAMICAL SYSTEMS AND GEOMETRIC THEORIES,
COMMUNICATIONS IN MATHEMATICAL AND THEORETICAL PHYSICS,
CHINESE J. OF SYSTEMS ENGINEERING,
JOURNAL OF THE BALKAN GEOMETRY SOCIETY,
and others with: first axiomatically consistent reduction of macroscopic irreversibility to the ultimate level of nature, particle in interior conditions; first resolution via hadronic mechanics of the historical objection against Rutherford's conception of the neutron as a bound state of a proton and an electron;

first proposal o to utilize the the immense clean energy in the structure of the neutron via its stimulated decay; first causal spacetime machine - for isoselfdual states only; numerous proposal of new clean energies at the nuclear level; first cosmology with a universal symmetry which, for equal distribution of matter and antimatter, implies total null characteristics of the universe, with consequential lack of discontinuity at creation, thus permitting the first scientific study of creation itself; proposal and construction of the hadronic reactors capable of tapping energy within liquid molecules; theoretical prediction and vast experimental verification of the only known new -nonvalence - chemical species - called "magnecules"- on scientific record since the discovery of the valence in the 1800s, and its crucial implications for new clean fuels; and numerous other discoveries.

Prof. Santilli as a guest of Prof. A. A. Logunov, when Director of the High Energy Physics Laboratories in Protvino, Russia, in July 1994, to discuss the possible direct experimental verification in Protvino of the expected deviations from special relativity, a theory conceived for the representation of point particles in vacuum, when used in the interior of the hyperdense hadrons, a test first proposed by Prof. Santilli and still not considered in Western Laboratories for reasons of academic politics, despite known implications for much needed new clean energies and fuels.

MONOGRAPH, including:

SPRINGER-VERLAG-HEIDELBERG (two seminal monographs "Foundations of Theoretical mechanics:", Vols. I and II, in the most prestigious series of Texts and Monographs in Physics on the integrability conditions for the existence of a Lagrangian or a Hamiltonian, the Birkhoffian generalization of Hamiltonian mechanics; and a comprehensive presentation of the isotopies and genotopies of Lie's theory now called Lie-Santilli iso-, geno- and hyper theories);

UKRAINE ACADEMY OF SCIENCES- KIEV (two volumes of "Elements of Hadronic Mechanics" with the third volume currently in preparation containing a comprehensive study of the new covering mechanics, its various applications and numerous experimental verifications in various fields; "Isotopic, Genotopic and Hyperstructural Methods in Theoretical Physics", which, according to reviewers, is the most innovative monograph in biology to date, the only one representing the

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irreversibility of biological systems - since all current quantum studies are strictly reversible, thus incompatible with biological reality;

KLUWER ACADEMIC PUBLISHER, Boston-Dordrecht-London (Santilli is the author of the post Ph. D. level monograph 'Foundations of Hadronic Chemistry with Applications to New Clean Energies and Fuels', ISBN number 1-4020-0087-1, in press, which contains a systematic presentation, beginning with the discovery of new mathematics, of a structural generalization of quantum chemistry, the first capable of exact representations of experimental data on molecules, such as binding energies, electric and magnetic moments. The monograph also shows that the abandonment of theories now belonging to the past millennium in favor of new, broader scientific horizons is necessary for the development of really 'new' and 'clean' energies, as well as of really 'new' fuels capable of resolving the catastrophic environmental problems caused by fossil fuels).

KLUWER ACADEMIC PUBLISHERS, THE NETHERLANDS (the first monograph on a nonunitary yet invariant covering of quantum chemistry develped by Prof. Santilli and his collaborators under the name of *Hadronic Chemistry,* with applications to new clean fuels and energies, including a comprehensive presentation of a new chem ica;l species, the first discovered following the identification of molecules in the middle of the 19-th century, and today known as *Santilli magnecules* which new chemical species has permitted the industrial development of the first known fuels with complkete combustion, thus without toxic emissions, kn own today as *Santilli MagneGases.*)

HADRONIC PRESS-FLORIDA (two volumes of "Lie-admissible Approach to the Hadronic Structure" with the third in preparation, the first comprehensive proposal of a new structure model of hadrons with physical massive constituents in generalized interior condition which constituents can be produced free in the spontaneous decays, while achieving compatibility with composite quarks; two volumes of "Isotopic Generalization of Galilei's and Einstein's Relativities", the first and only generalizations of existing relativity for nonpotential-nonconservative forces with a basic symmetries - since all deformations have no symmetry whatever; "Foundations of Hadronic Chemistry and its Application to New Clean Energies and Fuels", in press, called by reviewers a "true scientific revolutions in chemistry", the first achieving exact representation of experimental molecular data and predicting new energies and fuels).

SPRINGER, HOLLAND (the first monograph on the novel isodual theory of antimatter with novel applications to antigravity, grand unifications and cosmology. The monograph also presents the *first known CLASSICAL theory of antimatter with a consistent operator image.*).
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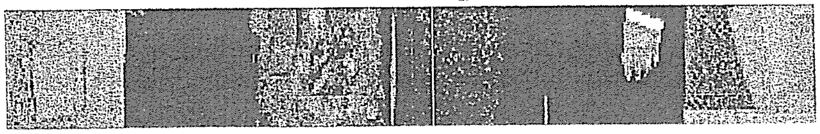

From the right, Prof. Santilli, daugther Luisa, wife Carla and son Ermanno, in July 1998.

PROCEEDINGS

Santilli has organized over TWENTY INTERNATIONAL MEETINGS, of which five at Harvard University, and the others in the U. S. A., Italy, France, Yugoslavia, Greece, Russia, the last meeting having occurred at the Academia Sinica in Beijing in 1997.

Santilli is the editor of over FIFTY VOLUME OF CONFERENCE PROCEEDINGS

HONORS

1. Santilli is the sole scientist in history who was capable of discovering a series of structural generalizations of pre-existing mathematics based on generalized units and products, and then apply them to a series of structural generalizations of physics, superconductivity, chemistry, biology, astrophysics and cosmology. By comparison, numerous other scientists discovered new "individual" mathematical structures (such as Hamilton and his quaternion, Jordan and his algebras, Lie and his theory), but not a comprehensive structural generalization of the entire mathematical and physical knowledge as achieved by Santilli. Numerous theories now carry his name, such as: Santilli's isounits and isoproducts; Santilli's iso-, geno-, and hyper-numbers and their isoduals; Hamilton-Santilli iso-, geno- and hyper mechanics; Lie-Santilli iso-, geno-, and hyper theories; Lorentz-Poincare'-Santilli iso-, geno-, and hyper-symmetry; Minkowski-Santilli iso-, geno- and hyper-geometries; Santilli's iso-, geno-, and hyper-symplectic geometries; Heisenberg-Santilli iso-, geno- and hyper equations; Pauli-Santilli iso-, geno- and hyper matrices; Schroedinger-Santilli iso-, geno- and hyper-momentum; Santilli's hadronic energy; Santilli's magnecules; Santilli's magnegas; etc. An inspection of the data-base on quotations indicate that Santilli is one of the most quoted author at this moment. Besides thousands of papers quoting Santilli, five monographs have been published by various authors with Santilli name in the title.The inclusion of vast plagiarisms of Santilli work in various scientific journals generally done in full knowledge of their editors (such as the river of papers on q-deformations without quotations of their origination by Santilli in 1967 and virtually all generalizations of Lie-quantum structures which are a particular case of Santilli's Lie-admissible structures due to their proved direct universality), there is no "individual" scientist today whose influence on contemporary science can even partially compare with that by Santilli.

2. Because of the above achievements SANTILLI has BEEN NOMINATED BY THE ESTONIA ACADEMY OF SCIENCES AMONG THE MOST ILLUSTRIOUS APPLIED MATHEMATICIANS OF ALL TIMES, jointly with Gauss, Weyerstrass, Hamilton, Jordan, Lie, etc.). In particular, Santilli is the ONLY scholar of Italian origin appearing in the entire list.

3. A Lecture Hall in a Research Institute in Australia has been called "Santilli's Lecture Hall";

4. Santilli has received a GOLD MEDAL from the University of Orleans for his achievements in Science and various similar honors from several scientific academies;

5. Santilli has been nominated for the NOBEL PRIZE IN PHYSICS by numerous scholars around the world since 1985 for his construction of Hadronic mechanics and other motivations, and he has been recently nominated for the NOBEL PRIZE IN CHEMISTRY for his construction of Hadronic chemistry and his discovery of the new chemical species of magnecules.

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A view of Prof. Santilli at the Sebring Race Track, Florida, during a track event organized by the Ferrari Club of America on April 14, 2000, racing a Ferrari 250 1959, which model won several 12 Hours Races at that track in the 1950's and 1960's.

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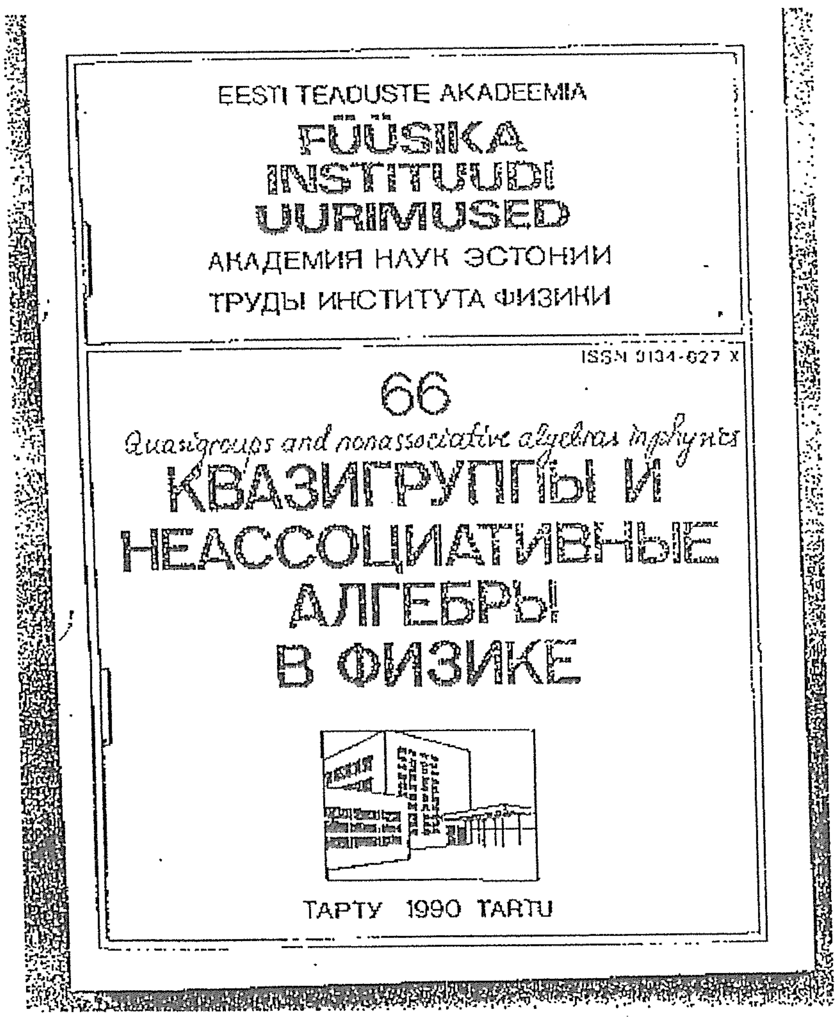
A view of the Gold Medal for Scientific Merits received by Prof. Santilli from the University of Orleans, France, on January 6, 1982.



EESTI TEADUSTE AKADEEMIA

FÜÜSIKA INSTITUUDI UURIMUSED

АКАДЕМИЯ НАУК ЭСТОНИИ

ТРУДЫ ИНСТИТУТА ФИЗИКИ

ISSN 0134-627 X

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Quasigroups and nonassociative algebras in physics

КВАЗИГРУППЫ И НЕАССОЦИАТИВНЫЕ АЛГЕБРЫ В ФИЗИКЕ

ТАРТУ 1990 TARTU

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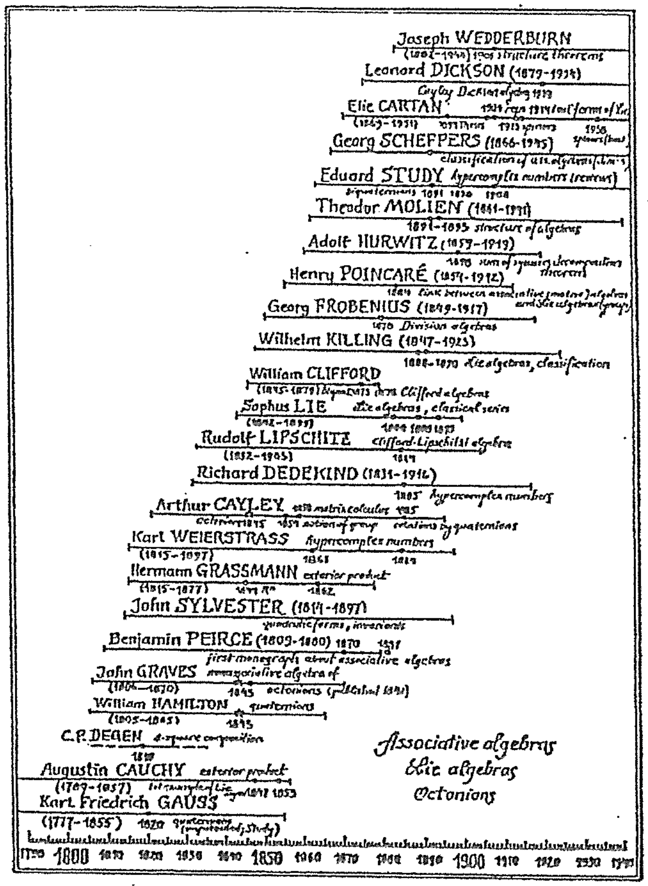
Joseph WEDDERBURN
structure theorems
Leonard DICKSON (1879-1954)
Elie CARTAN
Georg SCHEFFERS (1866-1945)
Eduard STUDY
Theodor MOLIEN
structure of algebras
Adolf HURWITZ (1859-1919)
Henry POINCARÉ (1854-1912)
Georg FROBENIUS (1849-1917)
Division algebras
Wilhelm KILLING (1847-1923)
Lie algebras, classification
William CLIFFORD
Clifford algebras
Sophus LIE
Lie algebras, classical series
Rudolf LIPSCHITZ
Clifford-Lipschitz algebra
(1832-1903)
Richard DEDEKIND (1831-1916)
hypercomplex numbers
Arthur CAYLEY
Karl WEIERSTRASS
hypercomplex numbers
(1815-1897)
Hermann GRASSMANN
exterior product
John SYLVESTER
quadratic forms, invariants
Benjamin PEIRCE
first monograph about associative algebras
John GRAVES
octonions
William HAMILTON
quaternions
(1805-1865)
C.F. DEGEN
Augustin CAUCHY
exterior product
Karl Friedrich GAUSS
(1777-1855)
Associative algebras
Lie algebras
Octonions
1800
1850
1900

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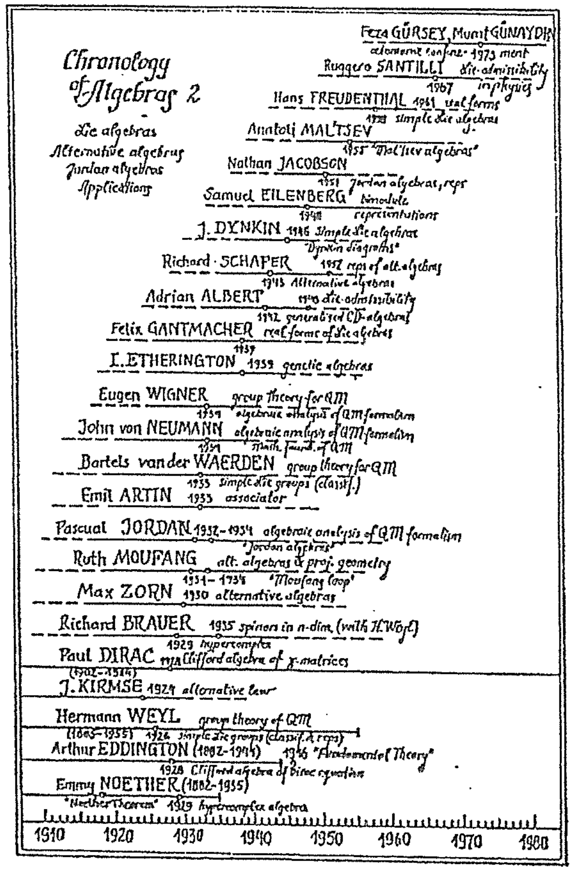

A view of the nomination dated June 9, 1990 by the Estonia Academy of Sciences of Prof. Santilli among the most illustrious applied mathematicians of all times, jointly with historical names such as Gauss, Cauchy, Hamilton, Lie, Jordan, von Neumann, and others. Note the absence in the list of Albert Einstein because he discovered no new mathematics. Note also that Prof. Santilli is the only scientist of Italian origin appearing in the list. Note finally that the nomination was for his initiation in 1967 of LIE-ADMISSIBLE ALGEBRAS in physics of which q-deformations are a particular case.

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EXTENDED CURRICULUM AND PUBLICATION LIST OF Prof. Ruggero Maria Santilli

October 2005

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Personal Data

Born on September 8, 1935 in Capracotta (Isernia), Italy
Dual citizenship, Italian and U.S. Citizenship (U. S. since June 1985)
Religion: Roman Catholic
Wife: Carla Santilli, MSW, Boston University
Daughter: Luisa, B.S. School of Management, Boston University
Son: Ermanno, B.S. School of Management, Boston College
Santilli is in excellent health, with no record of major disease

Education

High School Diploma from the town of Agnone (Isernia), Italy

Laurea in Physics with research thesis (in between the B.S. and M.S. degrees) from the Department of Theoretical Physics, University of Naples, Italy, 1959

Specializzazione in Fisica Teorica with advanced research thesis (Italian equivalent of the Ph.D. at that time) from the Institute of Theoretical Physics at the University of Turin, Italy, 1966

Academic and Industrial Affiliations

1962-1965
Assistant Professor at the San Secondo Institute (prep. school), Turin, Italy

1965-1967
Teaching Fellow at the Department of Physics, University of Turin, Italy, and

Assistant Professor and Director, Department of the Nuclear Physics Institute, A. Avogadro, Turin, Italy

1966-1967
Visiting Scientist (summers) at the International Centre for Theoretical Physics, Trieste, Italy

1967-1968
Visiting Scientist, Center for Theoretical Physics, University of Miami, Coral Gables, FL, USA, under contract with NASA and USAFOSR

1968-1970
Senior Research Associate at the Department of Physics, Boston University, Boston MA, under contract with USAFOSR

1970-1975
Assistant Professor of Physics, Department of Physics, Boston University, Boston, MA

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1975-1976 Associate Professor of Physics, Department of Physics, Boston University, Boston, MA

1976-1977 Visiting Scientist, Center for Theoretical Physics, Massachusetts Institute of Technology, Cambridge, MA

1977-1978
Honorary Research Fellow, Lyman Laboratory of Physics, Harvard University, Cambridge, MA

1978-1980
Senior Applied Mathematician at the Department of Mathematics, Harvard University as Principal Co-Investigator of DOE contracts

1980-present
Professor of Theoretical Physics and Applied Mathematics, President, The Institute for Basic Research, Cambridge, MA

1992-1993
Visiting Professor, Joint Institute for Nuclear Research, Dubna, Russia

1994-present
President, Istituto per la Ricerca di Base, Castello Principe Pignatelli, Monteroduni (Province of Isernia), Molise, Italy

1995-present
Honorary Professor of Physics, Ukraine Academy of Sciences, Kiev, Ukraine

1998-present
Director of Research at U. S. Corporations in Florida

Teaching

Santilli taught the following courses:

1962-1965
Several courses of Prep. Physics, Mathematics and Electrodynamics at the San Secondo Institute, Turin, Italy

1965-1967
Assistant to Wataghin's Chair in Physics, University of Turin, Italy, and
Taught Atomic and Nuclear Physics, Avogadro Institute, Turin, Italy

1967-1976
Taught at the Department of Physics at Boston University Boston, MA:

Undergraduate Courses:

Physics without Calculus

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Physics with Calculus
Undergraduate Mechanics

Graduate Courses:
Advanced Classical Mechanics
Advanced Quantum Mechanics
Advanced Quantum Field Theory
Mathematical Methods in Theoretical Physics
High Energy Hadron Physics

Seminar /post Ph.D. Courses:

Lie's Theory
Differential Geometry
Topology
Calculus of Variations
Theory of Systems with Constraints

1978-1979
Taught the following seminar course at Lyman Laboratory of Physics, Harvard University:

The Inverse Problem of Newtonian Mechanics and Field Theory (conditions of variational selfadjointness and Birkhoffian mechanics)

l980-l990
Taught brief seminar courses on various topics in the USA and Europe, and Supervisor of Ph. D. Theses in various institutions

Spring-l992
Taught a brief seminar course on

The Isotopies of Contemporary Algebras, Geometries and Mechanics, at Mathematical Institute G. Castelnuovo, University of Rome, Italy
Depts of Physics and Mathematics, Univ. of Bari, Italy
Mathematics Department, Howard University, Washington, D.C.
Depts of Physics and Mathematics, University of Patras, Patras, Greece
Mathematics Department, Aristotle University, Thessaloniki, Greece
Theoretical Physics Division, CERN, Geneva, Switzerland
JINR, Dubna, Russia
Universities of Jasi and Constanta, Rumania

1992-present
Taught advanced post-doctoral courses on New Mathematical Methods for Novel Treatments of Strong Interactions, Antimatter and Theoretical Biology at various institutions

Monographs

Santilli is the author of the following monographs:

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[1] Introduction to Nuclear Physics, with G. Soliani, A. Avogadro Institute, Turin, Italy, in Italian, printed by the Avogadro Institute (1952)

[2] Group Theory and Symmetries of Elementary Particles, with G. Soliani, printed by the Inst. of Theor. Phys., Univ. of Turin., Italy, in Italian, notes from lectures and seminars for the Ph.D. degree (1965)

[3] Foundations of Theoretical Mechanics, Lyman Laboratory of Physics., Harvard University, Cambridge, MA, Volume I: The Inverse Problem in Newtonian Mechanics, in the series Text and Monographs in Physics, Springer-Verlag, Heidelberg, Germany (1978)

[4] Lie-admissible Approach to the Hadronic Structure, Lyman Laboratory of Physics, Harvard University, Cambridge, MA, Volume I: Nonapplicability of the Galilei and Einstein Relativities? In the series Monographs in Theoretical Physics, Hadronic Press, Palm Harbor, Florida (1978)

[5] Lie-admissible Approach to the Hadronic Structure, Institute for Basic Research, Cambridge, MA, Volume II: Coverings of the Galilei and Einstein Relativities? In the series Monographs in Theoretical Physics, Hadronic Press, Palm Harbor, Florida (1981)

[6] Foundations of Theoretical Mechanics, Institute for Basic Research, Cambridge, MA, Volume II: Birkhoffian Generalization of Hamiltonian Mechanics, In the series Text and Monographs in Physics, Springer-Verlag, Heidelberg, Germany (1982)

[7] Il Grande Grido: Ethical Probe of Einstein's Followers in the U. S. A. : An Insider's View Institute for Basic Research, Cambridge, MA, Alpha Publishing, Newtonville, MA (1984)

[8] Documentation of Il Grande Grido, Volumes I, II and III: Institute for Basic Research, Cambridge, MA, Alpha Publishing, Newtonville, MA (1985)

[9] Isotopic Generalizations of Galilei and Einstein Relativities, Institute for Basic Research, Palm Harbor, FL, Volume I: Mathematical Foundations, Hadronic Press, Palm Harbor, Florida (1991)

[10] Isotopic Generalizations of Galilei and Einstein Relativities, Institute for Basic Research, Palm Harbor, FL, Volume II: Classical Formulations, Hadronic Press, Palm Harbor, Florida (1991)

[11] Elements of Hadronic Mechanics, The Institute for Basic Research, Palm Harbor, FL Volume I: Mathematical Foundations Naukova Dumka, Ukraine Academy of Sciences, Kiev (second edition 1995)

[12] Elements of Hadronic Mechanics, The Institute for Basic Research, Palm Harbor, FL 1994 Volume II: Theoretical Foundations Naukova Dumka, Ukraine Academy of Sciences, Kiev (second edition 1995)

[13] Foundations of Theoretical Conchology, with C.R. Illert Hadronic Press, Palm Harbor, Florida (1995)

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[14] Isotopic, Genotopic and Hyperstructural Methods in Theoretical Biology, Ukraine Academy of Sciences, Kiev (1996)

[15] The Physics of New Clean Energies and Fuels According to Hadronic Mechanics, Special issue of the Journal of New Energy, 318 pages (1999)

[16] Foundations of Hadronic Chemistry with Applications to New Clean Energies and Fuels, Institute for Basic Research, Palm Harbor, Florida, Kluwer Academic Publishers, Boston-Dordrecht-London, 397 pages (2001)
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http://i-b-r.org/docs/sanrus.pdf.zip

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Conference Proceedings

Santilli is the Editor or Co-editor of the following Conference Proceedings and Proceedings Reprints Volumes:

Proceedings of the Second Workshop on Lie-Admissible Formulations, Science Center, Harvard University, August 1 to 8 (l979)

Part I: Review Papers, Hadronic J. Vo.l. 2, no. 6, pp. 1252-2033 (l979)

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Part II: Research Papers, Hadronic J. Vol. 3, no. 1, pp. 1-725 (I980)

Proceedings of the Third Workshop on Lie-Admissible Formulations, University of Massachusetts, Boston, August 4 to 9 (I980)

Part A: Mathematics, Hadronic J. Vol. 4, issue no. 2, pp. 183-607 (I981)

Part B: Theoretical Physics, Hadronic J. Vo.4, issue no. 3, pp. 608-1165 (I981)

Part C: Experimental Physics and Bibliography Hadronic J. Vol. 4, issue no. 4, pp. 1166-1625 (I981)

Proceedings of the First International Conference on Nonpotential Interactions and their Lie-Admissible Treatment, UniversiteÂ´ d'OrleÂ´ans, France, January 5 to 9 (I982)

6) Part A: Invited Papers Hadronic J., Vol. 5, issue no. 2, pp. 245-678 (I982)

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Part C: Contributed Papers, Hadronic J. Vol. 5, issue no. 4, pp. 1194-1626 (I982)

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Proceedings of the First Workshop on Hadronic Mechanics, The Institute for Basic Research, Cambridge, MA, August 2 to 6, I983 with J. Fronteau, R. Mignani and H.C. Myung Hadronic J. Vol. 6, issue no. 6, pp. 1400-1989 (I983)

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Volume I: Hadronic J. Vol. 7, issue no. 5, pp. 911-1258 (I984)

Volume II: Hadronic J. Vol. 7, issue no. 6, pp. 1259-1759 (I984)

Fourth Workshop on Hadronic Mechanics and Nonpotential Interactions, Univ. of Skopjie, Yugoslavia, August 22 to 26 (I988) with A.D. Jannussis, R. Mignani, M. Mijatovic, H.C. Myung B. Popov and A. Tellez Arenas Nova Science, New York (I990)

Reprint Volumes

Santilli is also the Editor of the following series of reprint volumes:

: Applications of Lie-Admissible Algebras in Physics, H.C. Myung, S. Okubo and R.M. Santilli, Editors, Volume I (I978), Hadronic Press Inc., Box 0594, Tarpon Springs, FL 34688

Application of Lie-Admissible Algebras in Physics, H.C. Myung, S. Okubo and R.M. Santilli, Editors Volume II (I979), Hadronic Press, Tarpon Springs, FL

Applications of Lie-Admissible Algebras in Physics, R.M. Santilli, Editor, Volume III (I984): Direct Universality of Lie-Admissible Algebras in Newtonian, Statistical and Particle

924

Physics, Hadronic Press, Tarpon Springs, FL

Selected Papers of Italian Physicists: Piero Caldirola, E. Recami, R. Mignani and R.M. Santilli, Editors

Volume I (1986)

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7) Developments in the Quark Theory of Hadrons, D.B. Lichtenberg and S.P. Rosen, Editors Volume I: Original papers from 1964 to 1978, Hadronic Press, Tarpon Springs FL (1979)

Developments in the Quark Theory of Hadrons, Volume II: Papers from 1979 to 1989, in preparation

Developments in the Quark Theory of Hadrons, Volume III: Isotopic quark theories, Scheduled for the completion of the series

Irreversibility and Nonpotentiality in Statistical Mechanics, A. Schoeber, Editor Hadronic Press, Tarpon Springs, FL (1984)

Advances in Discrete Mathematics and Computer Sciences, D.F. Hsu, Editor

Volume I: Neofields and Combinatorial Designs, Hadronic Press, Tarpon Springs, FL (1985)

Volume II: Hadronic Press, Tarpon Springs, FL (1986)

13) Volume III: Gradient Projection Methods in Linear and Nonlinear Programming, Hadronic Press, Tarpon Springs, FL (1988)

Volume IV: In preparation

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Mathematical Studies in Lie-admissible Algebras, Volume I (1985), H.C. Myung, Editor, Hadronic Press, Tarpon Springs, FL

Volume II (1985), H.C. Myung, Editor, Hadronic Press, Tarpon Springs, FL

18) Volume III (1986), H.C. Myung, Editor, Hadronic Press, Tarpon Springs, FL

Volume IV (1986), H.C. Myung, Editor, Hadronic Press, Tarpon Springs, FL

Volume V, R.M. Santilli, Editor, In preparation

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Seminars

Santilli has delivered various seminars on advanced topics in physics and mathematics at the following institutions:

Seminars in Europe and the Middle East

International Centre for Theoretical Physics, Trieste, Italy
University of Turin, Italy
University of Milan, Italy
University of Bari, Italy
Avogadro Institute, Turin, Italy
University of Naples, Italy
Mathematical Institute Castelnuovo, Univ. of Rome, Italy
Institut voor Theoretische Mechanica Rijksuniversiteit Gent, Belgium
Institut der Theoretisce Physik der Universitat, Zurich, Switzerland
Institut H. Poincare,Â´ Paris, France
Atominstitut, Wien, Austria
Italian National Laboratories, Frascati, Italy
University of Patras, Greece
Mathematics Institute, Aristotle Univ., Thessaloniki, Greece
UniversiteÂ´ d'Orleans, France
Democritos University, Xanthi, Greece
Demokritus Institute, Athens, Greece
Ukraine Academy of Sciences, Kiev
Istituto Ricerche di Basi, Monteroduni, Italy
Estonia Academy of Sciences, Tartu
Institute for High Energy Physics, Protvino, Russia
Moscow State University
University Al.I. Cuza, Iasi, Rumania
University of Constanta, Rumania
Karaganda State University, Kazakhstan
Institute for Nuclear Physics, Alma Ata, Kazakhstan
King Saud University, Riyadh, Saudi Arabia
Academia Sinica, Beijing, China
Department of Mathematics, Hong Kong University
Joint Imstitute for Nuclear Research, Dubna, Russia
Oxford University, Oxford, England

Seminars in the USA

Center for Theoretical Studies, Univ. of Miami, FL
Ohio State University, Athens, Ohio
University of South Carolina, Columbia, SC
Boston University, Boston, MA
Brandeis University, Waltham, MA
Northeastern University, Boston, MA
University of Massachusetts, Boston, MA

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Boston College, Boston, MA
University of Rochester, Rochester, NY
Department of Physics, Howard Univ. Washington D.C.
Dept of Mathematics, Howard Univ., Washington D.C.
University of Reno, Reno, NV
University of California, Los Angeles, CA
University of Arizona, Tucson, AZ
Center for Theoretical Physics, MIT, Cambridge, MA
Lyman Laboratory of Physics, Harvard Univ., Cambridge, MA
Department of Mathematics, Harvard University, Cambridge, MA
Stanford University, Stanford, CA
National High Magnetic Field Laboratory, Tallahassee, FL

Conferences

Santilli has been the organizer or co-organizer of the following conferences, organizations and workshops:

1) First workshop on Lie-admissible Formulations, Department of Mathematics, Harvard University, Cambridge, MA August 24-25, l978

2) Second workshop on Lie-admissible formulations, Science Center, Harvard University, Cambridge, MA August 1-4, l979

3) Third workshop on Lie-admissible formulations, Science Center, Harvard University, Cambridge, MA August 4 to 9, l980

4) Fourth workshop on Lie-admissible formulations, The Institute for Basic Research, Cambridge, MA August 3-7, l981

5) Fifth workshop on Lie-admissible formulations, The Institute for Basic Research, Cambridge, MA August 2-7, l983

6) First workshop on hadronic mechanics, The Institute for Basic Research, Cambridge, MA August 2-7, l983

7) Second workshop on hadronic mechanics, Center Alessandro Volta, Villa Olmo, Como, Italy August 1-4, l984

8) Third workshop on hadronic mechanics, University of Patras, Patras, Greece August 25-30, l986

9) Fourth workshop on hadronic mechanics, University of Skopje, Yugoslavia August 22-26, l988

10) First international Conference on nonpotential interactions and their Lie- admissible treatment, UniversiteÂ´d'OrleÂ´ans, France January 5-9, l982

11) First International Workshop on New Frontiers in Hyperstructures, Istituto per la Ricerca

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di Base, Castello Principe Pignatelli, Monteroduni, Italy, August 1995

12) First International Workshop on New Frontiers in Geometries, Istituto per la Ricerca di Base, Castello Principe Pignatelli, Monteroduni, Italy, August 1995

13) First International Workshop on New Frontiers in Physics, Istituto per la Ricerca di Base, Castello Principe Pignatelli, Monteroduni, Italy, August 1995

14) First International Workshop on New Frontiers in Theoretical Biology, Istituto per la Ricerca di Base, Castello Principe Pignatelli, Monteroduni, Italy, August 1995

15) International Workshop on Open Problems on the Frontiers of Mathematics and Physics, Academia Sinica, Beijing, China, August 1997

Editorial Activities

Santilli is the founder and editor-in-chief of the following three journals:

 # HADRONIC JOURNAL

A bi-monthly journal for original and advanced research in Applied Mathematics, Theoretical and Experimental Physics in its 24-th year of regular publication;
 # HADRONIC JOURNAL SUPPLEMENT
A quarterly journal for the publication of selected and advanced long review- research papers and Ph.D. thesis at its 15-th year of regular publications; and

 # ALGEBRAS, GROUPS AND GEOMETRIES
A quarterly journal for the publication of advanced, purely mathematical research in algebras, groups and geometries at its 15-th year of regular publication

The above journals have acquired an international reputation for having provided the birth of a number of advances in mathematics and physics, such as:

Birkhoffian generalization of Hamiltonian mechanics (HJ, I978)
Hadronic generalization of quantum mechanics (HJ I978)
Isotopies of Lie's theory (HJ I978)
Genotopies of Lie's theories /Lie-admissible theories (HJ I978)
Local-diff. isotopies and genotopies of symplectic geometry (HJ 1978)
Integro-diff. isotopies and genotopies of symplectic geometry (AGG 1991)
Integro-diff. isotopies and genotopies of Riemannian geometry (AGG I991)
Classical isotopies and genotopies of Galilei's relativity (HJ I978)
Classical isotopies and genotopies of Einstein's special relativity (HJ I979, HJS I988)
Classical isotopies and genotopies of Einstein's gravitation (HJS I988)
Integro-diff. operator isotopies of Galilei's relativity (HJS I989)
Integro-diff. operator isotopies and genotopies of Einstein's special relativity (HJS I989)
Integro-diff. operator formulation of isogravitation (HJS I989)
The â¤|o particle as a compressed positronium (HJ I978)
The neutron as a compressed hydrogen atom (HJS I989 and HJ I990)

The first conception of hadronic energy (HJ I991)
Integro-diff. formulation of Bose-Einstein correlation (HJ I992)
Integro-diff. isotopies of manifolds (AGG 1992)
Antigravity for antiparticle in the field of matter (HJ1994)
Space-time machine (HJ1994)

#HADRONIC JOURNAL &
 # HADRONIC JOURNAL SUPPLEMENT

Founded at Harvard University in 1978
by R.M. Santilli and H. Georgi

Editorial Board (1996)

 # ALGEBRAS, GROUPS AND GEOMETRIES
Founded in 1984 at the IBR in Cambridge, MA
by R.M. Santilli and H.C. Myung

Editorial Board (1996)

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R. MIRON, Al. I. Cuza University, Iasi, Romania
P. NOWOSAD, Instituto de Matematica, Rio de Janeiro, Brasil
T. OCCHIAI, Dept of Math., University of Tokyo, Tokyo, Japan L. SANTHAROUBANE, Dept de Math., Univ. de Paris Sud, Orsay, France
R.M. SANTILLI, Div. of Math., IBR, Palm Harbor, FL
G.F. TSAGAS, Dept of Math., Aristotle University, Thessaloniki, Greece

Santilli is also an Editor of

BALKAN JOURNAL OF GEOMETRY,
INTERNATIONAL JOURNAL IOOF PHYSICS
JOURNAL OF ALTERNATIVE ENERGY AND ECOLOGY
JOURNAL OF DYNAMICAL SYSTEMS AND GEOMETRIC THEORIES,
and of other Journals.

Referee Tasks

Santilli has been referee of the following journals:

Physical Review Letters
Physical Review D
Annals of Physics
Hadronic Journal
Hadronic Journal Supplement
Algebras, Groups and Geometries
Journal of Algebras
Nuovo Cimento
Journal of Physics
Physics Essays
International J. of Theor. Physics
European Physics Letters
Comm. Theor. Phys.
as well as referee of U.S. Governmental Agencies for grant applications

Administration

Santilli shows a long record of administrative experience, such as:

I965-I967
Served on the Board of Directors of an Italian Corporation in Turin, Italy

1968-I972
Served on the Board of Directors of a Massachusetts Corporation

I967-I976
Provided a variety of administrative functions at Boston University

1978-I981

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Provided numerous administrative functions at Harvard University, including the function of Principal Co-Investigator of three grants from the US Department of Energy

1981- present
Founded, organized and funded The Institute for Basic Research by:

participating in the legal organization., including the structuring of the charter;
creating a Real Estate Trust for the separate administration of the IBR premises in Cambridge, MA;
securing the Tax Exempt status from the Federal Government;
supervising the International Admission Committee for the selection of members;
successfully funding all IBR operations, beginning with all initial organizational expenses to this day

1994-present
Founder and organizer of the Istituto per la Ricerca di Base, Castello Principe Pignatelli Monteroduni, Italy

1998-present
Director of Research in U. S. corporations

Honors

Santilli is the recipient of the following honors:

GOLD MEDAL (l978) from the Molise Province, Italy, for scientific achievements

GOLD MEDAL (l982) from the City of Orleans, France, for scientific achievements

Listed by the Estonian Academy of Sciences (l989) in a chart including the most illustrious applied mathematicians of all times from Gauss to this day, for his studies in Lie-admissible formulations

Hobbies
History of Classic Italian Automobiles
Secretary of the Ferrari Club of America for the Northeast from l981 to l988
Active in hiking, fishing and boating

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U. S. FEDERAL COURT MIDDLE DISTRICT OF FLORIDA TAMPA DIVISION

801 N Florida Ave, Tampa, FL 33602, U. A. S., Tel. 813-301 5400

CIVIL CASE NUMBER 8:07-CV-00308-T-23MSS

Ruggero Maria Santilli, Palm Harbor, Florida

PLAINTIFF

K. K. Phua River Edge, NJ
K. K. Phua, Registered Agent, World Scientific Publish. Co., Inc., New Jersey
Cornell University, Ithaca, NY
Fabio Cardone, Roma, Italy,
Roberto Mignani, Rome, Italy,
Alessio Marrani, Rome, Italy,
Istituto NaZionale Fisica Nucleare, Rome, Italy,
Consiglio Nazionale Ricerche, Roma, Italy,
Universita' di Roma Tre, Rome, Italy,
Universita' dell'Aquila, L'Aquila, Italy

DEFENDANTS

August 7, 2007

SCIENTIFIC BACKGROUND

FOREWORD

In a large variety of works over forty years of research, the plaintiff has developed a body of works [1-36] internationally known as *Santilli isotopies (or Lie-Santilli isotopic lifting, or generalization) of special relativity, the Minkowski space and the Lorentz symmetry (or transformations)* for physical conditions different than those in vacuum (such as in the interior of physical media not necessarily transparent to light) with the understanding that conventional formulations are assumed, of course, to be *exactly valid* in vacuum and are recovered identically and uniquely by the generalized theories when motion returns to be in vacuum.

The studies on the generalized formulations were initiated by the plaintiff as part of his Ph. D.. studies at the University of Torino,. Italy, in 1967 [2] with the first deformations of Lie's theory, $(A, B) = pAB - qBA$ and other formulations in scientific records. The studies were intensified in the late 1970s and early 1980s [3-5] when Santilli was a member of Harvard University under five contracts with the U. S. Department of Energy numbers ER-78-S-02-47420.A000, AS02-78ER04742, DE-ACO2-80ER10651; DE-ACO2-80ER-10651.A001, and DE-ACO2-80ER10651.A002; contracts, of course, administered by Harvard University.

The ultimate objective for the DOE funding of Santilli's research was, and remains to this day, the development of basically new methods permitting the conception and quantitative development of *new clean energies and fuels* so much needed by mankind for the solution of the increasingly cataclysmic climactic changes, since all possible energies and fuels permitted by Einsteinian theories and quantum mechanics had been fully identified by the middle of the 20-th century, and they all resulted to be environmentally unacceptable.

Thanks to the subsequent participation by American and European investors, the original DOE objective has been fully accomplished by Santilli, since his covering theories have indeed produced new energies and fuels currently seeing large industrial developments in the U.S.A as well as in various foreign countries (see, the new clean fuel technology in the web site www.magnegas.com and others that cannot be disclosed at this writing due to contractual obligations for industrial secrecy).

During a series of papers up to 1992 [38-45], defendants F. Cardone, R. Mignani and A. Marrani properly admitted Santilli's paternity and properly quoted the originating literature in their works. As one example among many, in work [45], defendant R. Mignani clearly identifies beginning with the Abstract "Santilli Lie-isotopic lifting of special relativity" first proposed in Ref. [5a] of 1983 published by Nuovo Cimento (a journal of the Italian Physics Society) and then said defendants continues with the proper identification of Santilli's paternity and the proper quotation of the copyrighted originating works for the rest of the paper. The same occurrence holds for all papers by defendants up to early 1992.

From the end of 1992 on, defendants Cardone, Mignani and Marrani decided to plagiarize Santilli's lifetime work under the name of "deformed special relativity, Minkowski space and Lorentz symmetry". as it is the case in works [37] and numerous other works to be identified during the discovery process of this lawsuit.

The paternity fraud initiated with the quotation of only one of the vast body of Santilli's works studiously selected to have a date following the dates of papers by said defendants. For instance, in the plagiarizing book [37a] the defendants initiated with the quotation of their works of 1992, that is per se a paternity fraud, and then continued by quoting only one of Santilli works of 1997 intermixed in purpose with others, and studiously abstained to quote Santilli originating paper of 1983 [5a].

Subsequently, any and all quotations of Santilli's lifetime of research in the field was completely ignored by the defendants. As one can verify, defendants Cardone, Mignani and Marrani published in the Cornell University arxiv (papers (identified a search under "Fabio Cardone" and appended in Exhibit G) specifically and entirely devoted to Santilli generalizations of special relativity, the Minkowski space and the Lorentz symmetry under the fraudulent name of "deformations" of the same, without any quotation whatever of Santilli copyrighted works.

The studious illusory grounds for the above posturing by defendants Cardone, Mignani and Marrani was the claim that they study the same theories developed by Santilli but formulated on a conventional numerical field, thus belonging to the field of "deformations." The paternity fraud occurs because Santilli is indeed the originator of deformation theories with papers initiated in 1967 as recalled above [2]. In any case, the original derivation of the generalized special relativity, Minkowski space and Lorentz transformations, Ref. [5a] of 1983, was indeed done over a conventional numerical field, as serious scholars in good faith can verify. The fraud was premeditated since said defendants had been Santilli's associates until 1992 and knew very well that Ref. [5a] presents "deformations" in their language. The novel iso-, geno- and hyper-numbers were discovered by Santilli only in 1993 [7e] (see

Santilli's paper in Exhibit C).

In any case, Santilli used the word "isotopies" in paper [5a] in its Greek meaning of "preserving topologies," namely, for the explicitly stated intent of honoring the memory of Einstein, Minkowski and Lorentz since their historical axioms were represented identically in Ref. [5a] and merely realized in a broader way. By comparison, the preservation of the historical axioms or the local isomorphism of the "deformed Lorentz symmetry" with the original one (stressed in Ref. [5a]) are absent in the works by defendants Cardone, Mignani and Marrani who, consequently, perpetrate a paternity fraud even against Einstein, Minkowski and Lorentz.

Also, Ref. [5a] achieved for the first time in scientific records the universal symmetry $\hat{O}(3,1)$ of the generalized line element $x^1 b_1^2 x^1 + x^2 b_2^2 x^2 + x^3 b_3^2 x^3 - x^4 b_4^2 x^4$, where $b_\rho . \rho = 1,2,3,4$ are nonsingular but otherwise arbitrary functions of any needed local variable within physical media, such as time t, coordinates r, momenta p (hence energy E), density μ, temperature, τ, etc. and the speed of light assumes the local form $C = cb_4$ or the more familiar expression $C = c/n, b_4 = 1/n$ where c is the speed in vacuum and n is the usual index of refraction. On serious scientific grounds, all other symmetries of the same line element are isomorphic to $\hat{O}(3.1)$. Period. The rest is vulgar scientific corruption.

Immediately upon receiving communications in the early 1990s by scientists in various countries of plagiarism, Santilli appealed to defendants Cardone, Mignani and Marrani for scientific ethics and decency, that can only be implemented via the quotation of Santilli's originating works, of course, jointly with others, but, also of course, IF directly relevant and IF listed in chronological order. These appeals turned out to be useless due to the unobstructed backing to the defendants by Italians institutions and universities. Hence. Santilli was forced to file in 1995 a first legal action against said defendants appended in Exhibit K, which legal action was sent in copy to presidents of all major Italian Funding agencies and universities. Defendants Cardone, Mignani and Marrani continued their paternity fraud in a totally obvious way, a posture that can only be based on full support in said paternity fraud by the Italian institutions and universities supporting the research.

The situation collapsed in 1996 when Santilli received additional alarmed communications from scientists the world over that Cornell University had permitted the uploading by defendants Cardone, Mignani and Marrani of a series of papers treating exactly the same theories, by using exactly the same words and exactly the sam e symbols of Ref. [5a], yet *without any quotation whatever of Santilli's originating works,* as the scholar in good faith can veify in Exhibit G. Additionally, serious scholars were alarmed because World Scientific had permitted the publication of a book on "Deformed Special Relativity" that constitutes paternity fraud beginning with the title because "Santilli deformations of special relativity" originated in paper [5a] of 1983 were not quoted at all in said book, despite the knowledge by the authors documented above.

The very arrogant ignorance of Santilli respectful appeals for corrections by Cornell University, World Scientific and the Italian institutions funding and supporting the defendants work, then rendered mandatory the filing of this lawsuit.

It is unreassuring that Santilli's covering theories are seeing great successes and large investments in the *industry,* while the same theories are beginning to be known in *academia* only recently, evidently due to known academic opposition to basic novelty. Yet, it is an easy prediction that the solution of the huge environmental problems afflicting our contemporary

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society will indeed require the participation by academia, and cannot be solely achieved via industrial research conducted in secrecy to avoid notorious academic oppositions.

Hence, the scholar reading this Scientific Background in good faith should always keep in mind that this lawsuit has been filed because the pursue of said vital environmental needs is severely damaged by the defendants. In fact, the gross plagiarism by defendants Cardone, Mignani and Marrani causes serious damages to environmental research because, as shown in this Scientific Background, their paternity fraud has been done improperly, thus being catastrophically inconsistent. Similarly, Cornell University organized suppression of scientific democracy in their arXiv in violation of laws pertaining to public financial support (and other violations of U. S. Federal and State Laws) is inflicting an a severe damage to qualified searches for new clean energies and fuels.

This Scientific Background is intended to offer to the serious scholars with a serious commitment to scientific ethics, decency and accountability, the necessary elements to verify that the "deformed" theories by defendants Cardone, Mignani and Marrani are indeed a trivial copy of Santilli early deformations defined over a conventional field of numbers. The rest of the presentation is intended to outline the *Theorems of Catastrophic Mathematical and Physical Inconsistencies* of noncanonical and nonunitary theories over conventional fields that are nowadays essential to distinguish between a serious theory and a scientific fraud.

The clear understanding is that the serious scholar cannot possibly achieve a serious knowledge of this new field via the sole glancing at an exhibit of a federal lawsuit, and must study in detail the post Ph. D. literature, beginning with a study of its novel mathematics, such as a study of: the two volumes of foundations of theoretical mechanics published by Springer Verlag [12]; the two volumes of generalizations of Galileo and Einstein relativities [14] of 1991; and the two volumes on the novel hadronic mathematics, mechanics and chemistry [22] under finalization available in pdf format in the web site http://www.i-b-r.org/Hadronic-Mechanics.htm

HISTORICAL NOTES

A main feature of special relativity is the constancy of the speed of light c in vacuum. This feature is technically represented by the invariance of the speed of light under transformations of space and time coordinates discovered by H. A. Lorentz in 1904 (see reference [1a] below), and today known as the Lorentz transformations or symmetry.

Additionally, Lorentz attempted the achievement of the broader transformations leaving invariant the more general case of the locally varying speed of light C = c/n within transparent physical media with index of refraction n [1b]. While Lorentz succeeded in achieving the invariance of the "constant" speed c, he failed to identify the broader transformations of space and time leaving invariant the locally variable speed C = c/n. Due to the successes of special relativity, Lorentz's latter attempt was vastly forgotten throughout the 20-th century, although said attempt did not escape Pauli's attention who quoted Lorentz work [1b] in his book on special relativity [1c].

OUTLINE OF SANTILLI RESEARCH IN DEFORMATIONS AND ISOTOPIES

Santilli has dedicated his lifetime of research to the study Lorentz's problem [1b] due to its fundamental character for all of physics. In the same way as the conventional Lorentz transformations in vacuum are the foundations of special relativity, the discovery of the broader transformations leaving invariant the locally varying speed $C = c/n$, are expected to characterize a broader relativity, this time applicable within physical media, such as those existing inside particles, nuclei and stars. In turn, the expected broader relativity was predicted to permit the conception and quantitative treatment of basically new clean energies and fuels that are simply inconceivable with special relativity, as subsequent events proved to be the case.

The above objective lead to comprehensive studies by Santilli including 250 technical papers published in journals of the American, British, Italian, Chinese, Indian, Pakistan, Iranian, Ukrainian, Russian and other physics societies [2-29], 14 post Ph. D. level monographs [12-22], as well as hundreds of technical papers by independent scientists and various monographs [23-29] carrying the name Santilli in the title. A comprehensive list of all contributions is available in the 90 pages long General Bibliography of books [22].

The outcome of these studies is given by a structural broadening of classical and quantum mechanics into a new discipline proposed by Santilli under the name of "hadronic mechanics" that includes as particular cases: a first broadening of special relativity known as "Santilli isotopies of special relativity" or "Santilli isorelativity" for time reversible dynamics within matter media; a second broadening of special relativity known as "Santilli genotopies of special relativity", or "Santilli genorelativity" for short for time irreversible dynamics within matter media; and corresponding isodual images of the iso-and geno-relativities reversible and irreversible dynamics within antimatter media; all broader relativities being, by construction, a covering of special relativity, that is, admitting the latter as a simple particular case when dynamics returns to be in empty space 12-22].

Lorentz failed to achieve the invariance of C = c/n because he used the same mathematics that had permitted him to achieve the invariance of c, the so called Lie's theory with celebrated nonassociative product [A, B] = AB - BA, where A, B are matrices and the products AB, BA are associative. By using Lie's theory, the transformation of a generic physical quantity A, for instance, its variation in time, is given by the finite Lie's group $A(t) = U(t)A(0)U(t)^{+} = [exp(IHt)]A(0)[exp(-itH)]$, with infinitesimal form given by the celebrated Heisenberg equation at the foundation of quantum mechanics $idA/dt = AH - HA$, where H is the total energy. Santilli's view since his graduate studies in the 1960s is that the invariance of C = c/n, and related broadening of special relativity, must be attempted by first broadening Lie's theory and related mathematical setting, such as vector and metric spaces, numerical fields, functional analysis, etc.

The very first papers published by Santilli in 1967-1968 as part of his graduate studies [2a, b,c] provided the first generalization of Lie algebras known in physics, that of the Lie-admissible type with product (A, B) = pAB - qBA where p and q are non-null scalars, Lie-admissibility is referred to Albert's notion of admitting Lie algebras as the attached antisymmetric product. This proposal permitted the generalized transformations $A(t) = X(t)A(0)Y(t)^{+} = [exp(iHqt)]A(0)[exp(-itpH)]$ with infinitesimal version characterizing the Heisenberg-Santilli time evolution $idA/dt = pAH - qHA$. The author then conducted comprehensive research on the mathematical studies of Lie-admissible algebras and their applications to physics [2-36].

During these studies it became evident that, even though Lie's theory was indeed broadened, the above Lie-admissible theory did not permit the achievement of the desired invariance of C = c/n. Additionally, Santilli has stated in his works that his initial Lie-admissible formulations suffered "catastrophic mathematical and physical inconsistencies"

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presented in details in [30-36]. This is due to the fact that Lorentz transformations such as $A(t) = U(t)A(0)U(t)^+$ are canonical at the classical level and unitary at the operator level in which case they preserve the basic unit in the sense that $I =>= I' = UIU^+ = U^+U = I$. In turn, this basic property implies a number of features that are crucial for the mathematical and physical consistency of any theory, such as the invariance of the basic units of measurements, the prediction of the same numerical values under the same conditions at different times (called invariance over time), verification of the causality law (the effect must follow the cause), and others.

CATASTROPHIC INCONSISTENCIES OF CARDONE-MIGNANI-MARRANI WORKS

By the mid 1970s it became known that a necessary condition to achieve the invariance of C = c/n is that the related transformations must "not" preserve the unit, i.e., $UIU^+ \neq I$, a property known as noncanonicity or nonunitarity. In fact, the desired representation requires the transition from the Minkowski metric $m = Diag.(1, 1, 1, -c^2)$ to the broader form $m^* = Diag.(1, 1, 1, -c^2/n^2)$ that is only possible via said noncanonical or nonunitary transform. In turn, the lack of conservation of the unit caused serious problems of mathematical and physical consistency today known under the name of "theorems of Catastrophic Mathematical and Physical Inconsistencies of Noncanonical and Nonunitary Theories" presented in details in papers [30-36] and monographs [22].

On mathematical grounds, the lack of invariance over time of the basic unit causes the loss over time of the basic numerical field (due to the crucial dependence of all numbers on the unit). In turn, the loss of the numerical field causes the collapse of the metric and other spaces, functional analysis, and all remaining mathematical structures. On physical grounds, the loss of the basic unit over time causes the lack of time invariance of the units of measurements, the impossibility of predicting the same numerical values under the same conditions at different times, the loss of observables, the loss of causality (the effect may precedes the cause), and other catastrophic inconsistencies [25-31].

A central technical aspect of the claim for fraud by defendants Cardone, Mignani and Marrani of this lawsuit is that, Lorentz transformations $A(t) = U(t)A(0)U(t)^+$ preserve the speed of light in vacuum at all times because they are canonical or unitary, $UU^+ = U^+U = I$, for which property we have the invariance of the Minkowski metric $m = Diag.(1, 1, 1, -c^2) => m' = UmU^+ = Diag.(1, 1, 1, -c^2) = m$ that includes as particular case the invariance of the speed of light in time $c => c' = c$. On the contrary, all generalizations of Lorentz transformations $A(t) = W(t)A(0)W(t)^+$ leaving invariant the locally varying speed $C = c/n$ are necessarily noncanonical or nonunitary, $WW^+ \neq I$. Consequently, they do not leave invariant the generalized metric $m = Diag(1, 1, 1, -c^2/n^2) => m' = WmW^+ \neq m$ and, in turn, the locally varying speed of light is not conserved over time under the same conditions $C = c/n => C' = c/n' \neq C$. The count on fraud perpetrated by defendants Cardone, Mignani and Marrani in works [37] and in numerous other works published by World Scientific and other publishers is that, in their attempt at hiding their plagiarisms of "Santilli's isotopies" into the "deformations", they formulated Santilli generalized Lorentz transformations on conventional n numbers and fields, rather than on Santilli isonumbers and isofields as needed for

the invariance illustrated below, thus being noncanonical or nonunitary. Consequently, as improperly formulated, said "deformed Lorentz transformations" do not leave the local speed of light invariant over time under the same physical conditions, $C = c/n \Rightarrow C' = c/n' \neq C$. The presentation via "deformations" is fraudulent because defendants Cardone and Mignani participated in the formulation of the known Theorems of Catastrophic Inconsistencies, Refs. [30-36] as, proved beyond credible doubt by paper [30] co-authored by defendant Mignani, and as the plaintiff will document to this Honorable Court beyond doubt. Hence, even ignoring the count on plagiarism, defendants Cardone and Mignani perpetrated an intentional, premeditated, malicious and conspiratorial fraud under the use of public funds hoping that, on such advanced topic, their institutions, publishers and readers at large would not identify the fraud due to the specialized character of the field.

CONSISTENCY OF SANTILLI'S ISOTOPIES OF SPECIAL RELATIVITY

The lesson learned is that the generalization of Lie algebras into broader algebras, such as the "deformed" Lie algebras with product AB - qBA, when formulated with the same mathematics of Lie's theory (same numerical fields, same functional analysis, etc.) are catastrophically inconsistent. That is the reason Santilli abandoned their study despite having discovered them first in 1967 [2a].

Ironically, at the same time the American Physical and Mathematical Societies, the British Physical and Mathematical Societies and other societies published a river of papers on said deformations in complete oblivion of their catastrophic inconsistencies as well as of their origination of 1967 [2a], with the exception of the Italian Physical Society that did publish indeed memoir [36] including the Theorems of Catastrophic Inconsistencies, and with the exclusion of the Italian mathematical Circle in Palermo that dedicated an entire issue of their journal in 1996 to Santilli isotopies, including memoirs [7e,5n] presenting a full treatment of said inconsistencies as well as their resolution.

Additionally, Lorentz transformations and Lie algebras in general characterize conservation laws of physical quantities in view of the totally antisymmetric character of the Lie product [A, B] = AB - BA = - [B, A] for which we have the trivial conservation of the energy i dH/dt = HH - HH = 0 and similar conservation of other total quantities. It was known since the early papers of 1967 [2a,b,c] that Santilli Lie-admissible algebras can only characterize nonconservative systems due to interaction with the external environment because the generalized product is not totally antisymmetric, $(A, B) \neq -(B, A)$. Rather than conservation laws, we have in this case the broader "time rate of variation of physical quantities", such as that for the energy i dH/dt = (p-q)HH and similar nonconservations for other quantities, for which conservation laws are a trivial particular case. This created the need for a simpler version of Santilli Lie-admissible algebras permitting the invariance of C = c/n for a fixed n, that is, for one given specific medium.

When Santilli joined Harvard University in 1978 under support of the U. S. Department of Energy, he initiated systematic research along the latter lines in papers [3a,b,c] by introducing for the first time in scientific records:

1. A first step-by-step broadening (called "lifting) of Lie' theory of the so-called isotopic type (in the sense of preserving the original axioms), including the isotopic lifting of envelop-

ing associative algebras, Lie algebras, Lie transformation groups and the Lie representation theory, today known as "Lie-Santilli isotheory" [23-29], based on the Lie-Santilli isoproduct $[A, B]^* = ATH - HTA$, Lie-Santilli isotransformation group $A(t) = WA(0)W^+ = [exp(IHTt)]A(0)[exp(-itTH)]$, and Heisenberg-Santilli isoequation idA/dt = ATH - HTA, where T is a fixed, positive-definite but otherwise arbitrary function, matrix or operator;

2. A step-by-step broadening of Lie-Santilli isotheory of the so-called genotopic type (in the sense of inducing new axioms), including a broadening of enveloping isoassociative algebras, Lie-Santilli isoalgebras, isogroups and the isorepresentation theory, today known as Lie-Santilli genotheory [23-29], based on Santilli's Lie-admissible genoproduct $(A, B)^* = A < B - B > A = A({}^{<}T)B - B(T^{>})A$, Lie-Santilli genotransformation $A(t) = [exp(iHT^{>}t)]A(0)[exp(-it^{<}TH)]$, and Heisenberg-Santilli genoequations $idA/dt = A < H - H > A = A({}^{<}T)H - H(T^{>})A$;

3. Two sequential step-by-step broadening of Galileo's relativity (see the title of [3a]) and quantum mechanics, one for the isotopic case with conventional total conservation laws characterized by the above Lie-Santilli transformations and Heisenberg-Santilli isoequation, and the second for the broader case of nonconservative systems with time-rate-of-variation of physical quantities with the above Lie-Santilli genotransformation and Heisenberg-Santilli genoequations.

In 1979, Santilli moved to Harvard's Mathematics Department where he initiated systematic studies of his isotopic and genotopic theories presented in papers [3-35] and monograph [7-15]. Following laborious efforts, Santilli achieved the following basically new mathematics, today known as "Santilli iso- and geno-mathematics" for matter and their isoduals for antimatter that are crucial for the proper formulation and treatment of the generalized relativities of isotopic, genotopic and isodual type because necessary for by-passing the theorems of catastrophic inconsistencies.

Isomathematics is based on: 1) The lifting of the trivial unit of conventional mathematics (the number 1 dating back to biblical times) into the most general possible matrix or integrodifferential operator $\hat{I} = \hat{I}(t, r, p, E, \mu.\tau, ...)$ provided that it is positive definite, thus invertible, $\hat{I} = 1/T > 0$; 2) The generalization $A\hat{\times}B = ATB$ of the conventional product AB in such a way to admit $\hat{I}$, rather than 1, as the correct left and right unit, $\hat{I}\hat{\times} = A\hat{\times}\hat{U} = A$ for all A of the set considered; and 3) the consequential generalization of the "totality" of the mathematics underlying Lorentz transformations with no exception. A crucial point of this lawsuits, for all claims of plagiarisms, fraud, deception, etc. is a technical knowledge that the lack of lifting of even "one" quantity or operation of Lorentz theory activates said theorems of catastrophic inconsistencies mentioned earlier.

The broader *genomathematics* is based on: 1) the assumption of a nowhere singular but nonhermitean generalization of the unit 1, resulting in this way in two generalized units $I^{>} = 1/T^{>}$ and ${}^{<}I = 1/{}^{<}T = (I^{>})^+$, one used to characterize motion forward in time and the other motion backward in time; 2) two compatible generalizations of the product $A > B = A(T^{>})B$ and $A < B = A({}^{<}T)B$; and 3) the corresponding dual generalization of the totality of the mathematics of Lorentz transformations to avoid the activation of the theorems of catastrophic inconsistencies [30-36], that is, to avoid fraud, deception and other violation of the law. Santilli's isodual mathematics will be identified below.

As indicated in the Foreword, Santilli achieved in 1983 [3a] the first known symmetry of the generalized line element $x^2 = x^{\mu}\hat{m}_{\mu\nu}x^{\nu}$ expressed in terms of the Minkowski-Santilli isometric $\hat{m} = Tm = diag(b_1^2, b_2^2, b_3^3, -b_4^2c^2) = diag.(1/n_1^2, 1/n_2^2, 1/n_3^2, -c^2/n_4^2)$, where $C = cb_4 = c/n_4$, the quantities $n_k, k = 1, 2, 3$, represent the shape of the object considered (an ellipsoid for diagonal isometrics) normalized to the Euclidean unit for the vacuum $n_k = 1, k = 1, 2, 3$, and n_4 represents the density of the medium normalized to the value $n_4 = 1$ for the vacuum. In the original paper [3a], the formulation was based on conventional fields of numbers, thus being a "deformation", the name "isotopy" being used to honor the memory of Einstein, Minkowski and Lorentz due to the preservation of their axioms.

However, subsequent to paper [3a], Santilli discovered that the original formulation was only valid as a "polaroid picture" of nature, namely, solely valid at the initial time because, under its noncanonical or nonunitary time evolution, the formulation was catastrophically inconsistent. This lead Santilli top the completion of the isotopies with the discovery in memoir [7e] of 1993 of the new iso-, geno- and hyper-numbers based on arbitrary units yet verifying all axioms of a field.

It was only following the completion of the construction of the new isomathematics that Santilli reached the first *formulation of the generalized Lorentz transformations invariant over time* that was presented for the first time at the Moscow Physical Society in memoir [5e] also of 1993. The time invariance was achieved via the lifting of the unit $I \rightarrow I^* = 1/T = diag.(1/b_1^2, 1/b_2^2, 1/b_3^2, 1/b_4^2) = diag.(n_1^2, n_2^2, n_3^2, n_4^2)$ as the *inverse* of the lifting of the metric, $m \rightarrow \hat{m} = Tm$.

In turn, the above invariance lead to the discovery of the property that, contrary to popular beliefs during the 20-th century, *the conventional Poincaré symmetry is eleven and not ten dimensional,* in view of the additional one-dimensional invariance of the line element (here expressed for simplicity in terms of a constant K) $(x^\mu m_{\mu\nu} x^\nu) \times I \equiv [x^\mu (K^{-1} m_{\mu\nu}) x^\nu) \times (KI) = (x^\mu \hat{m}_{\mu\nu} x^\nu) \times \hat{I}$ presented for the first time in paper [5e]. As expected by experts to qualify as such, a new invariance of our spacetime resulted to have fundamental novel implications for gravitation, grand unifications and other fields.

In view of the fact that, contrary to expectations, theoretical physicists are generally horrified by new mathematics (with due exceptions Einstein called "true researchers"), Santilli identified a very simple method for the construction of hadronic from quantum models and the construction of isorelativity from special relativity. It is given by the identification of isounit with a noncanonical or nonunitary transformation, $\hat{I} = UU^+$ and then the application of such a transform to the "totality" of the quantities, operations and physical laws of the original theory.

In fact, under said isotransform the unit I of the Minkowski space is lifted into the isounit of the Minkowski-Santilli isospace $I => \hat{I} = UIU^+$, the trivial product AB of the Minkowski space is lifted into Santilli's isoproduct, $AB => U(AB)U^+ = (UAU^+)(UU^+)^{-1}(UBU^+) = A'TB' = A'\hat{\times}B'$, the exponentiation is transformed into the isoexponentiation, and Lorentz transforms are lifted into the Lorentz-Santilli isotransforms under the above identified explicit realization of the isounit as the inverse of the lifting of the metric. In this way, any needed specific model or application of isorelativity can be constructed very easily with a simple method in all needed details without excuses based on lack of knowledge of "complex new mathematics."

Santilli then constructed his isorelativity for interior dynamical problems [12-22] via :1) The adoption of the above isomathematics or its construction via the indicated simple procedure; 2) The isotopies of all symmetries of special relativity; and 3) The isotopies of all axioms of special relativity. A fundamental point of this lawsuit is that Santilli has been the unquestionable first scientist to discover his isomathematics, the unquestionable first scientist to construct all isotopies of the symmetries of special relativity and the unquestionable first scientist to construct the isotopies of the axioms of special relativity, as it will be proved to this Honorable Court by experts testifying under oath. Opposing views are expected to present clear documents under oath to prevent criminal prosecution.

Following the achievement of the applicable formulation of Lie's theory, Santilli was the first to discover the isotopic lifting of "all" structural aspects of special relativity, including: the first lifting in 1983 of the Minkowski space and of the the Lorentz symmetry in its classical [3a] and operator form [3b]; the first lifting of the rotational symmetry in [3c]; the first lifting of the spin symmetry [3d]; ; the first lifting of the Poincare' symmetry [3f]; the first lifting of the spinorial covering of the Poincaré symmetry [3e]; the first lifting of the Minkowskian geometry [3i]; and the first application of the preceding liftings to the EPR argument, local realism and all that [7j] (see [3l] and [22] for reviews).

Santilli isomathematics bypasses the theorems of catastrophic inconsistencies because any noncanonical or nonunitary transform $UU^+ \neq I$ can always be rewritten $W = UT^{1/2}$ in which case it verifies the isocanonical or isounitary law $UU^+ = W\hat{\times}W^+ = W^+\hat{\times}W = \hat{I}$ where the product is, of course, isotopic, $W\hat{\times}W^+ = WTW^+$. Consequently, relativistic hadronic mechanics in general, and Santilli isospecial relativity in particular, verify the fundamental invariances $\hat{I} =>= (\hat{I})' = W\hat{\times}\hat{I}\hat{\times}W^+ \equiv \hat{I}$ and $W\hat{\times}(A\hat{\times}B)\hat{\times}W^+ = (W\hat{\times}A\hat{\times}W^+)\hat{\times}(W\hat{\times}W^+)^{-1}\hat{\times}(W\hat{\times}B\hat{\times}W^+) = A'\hat{\times}B' = A'TB'$, where one should note *the preservation over time of the numerical value of the unit and of the product, as in special relativity.*

Unlike the case for "deformations", "Santilli isotopies of Lorentz transformations and special relativity" do indeed preserve over the numerical value of the speed of light within physical media $C = c/n$. In fact, the isotransformations $A(t) = W(t)\hat{\times}A(0)\hat{\times}W(t)^+$ are isocanonical or isounitary $W\hat{\times}W^+ = W^+\hat{\times}W = \hat{I}$, in which case they do preserve the Minkowski-Santilli isometric, $\hat{m} = Tm = diag(b_1^2, b_2^2, b_3^3, -b_4^2c^2) = diag.(1/n_1^2, 1/n_2^2, 1/n_3^2,$- $-c^2/n_4^2) => \hat{m}' = W\hat{\times}m\hat{\times}W^+ \equiv \hat{m}$ and, consequently they do preserve the value $C = c/n$ over time under the same conditions, contrary the case of plagiarizing and fraudulent works [37].

The isotopies of the axioms of special relativity were first constructed by Santilli in memoirs [6] of 1988, then presented in a comprehensive way in monographs [14] of 1991. A crucial point of this lawsuit is that all these publications predate 1992, the year of initiation of plagiarism, fraud and deception by defendants Cardone, Mignani and marrani that lead to legal action.

The isotopies, namely, *broader realizations* of the original Einsteinian axioms, rather than dealing with new axioms, here expressed for simplicity in the two-dimensional space (3.4) (see monograph [14-22] for the general treatment) can be written as follows:

ISOAXIOM I: The maximal causal speed within physical media is given by $V_{max} = c(b_4/b_3) = c(n_3/n_4)$.

ISOAXIOM II: The addition of speeds within physical media follows the isotopic la $V_{tot} = (v_1 + v_2)/[1 + (v_1 n_4^2 v_2)/(c n_3^2 c)] = (v_1 + v_2)/[1 + (v_1 b_3^2 v_2)/(c b_4^2 c)]$.

ISOAXIOM III: The isodilation of time and the space isocontraction within physical media follow the isotopic laws $t' = \hat{\gamma}t, L' = L/\hat{\gamma}$, where $\hat{\gamma} = 1/(1 - \hat{\beta}^2)^{1/2}, \hat{\beta} = v_3/V_{max} =$

$v_3b_3/cb_4 = (v_3/n_3)/(c/n_4)$. Note that v_3 is always smaller than or equal to V_{max} in exactly the same ways as it happens in special relativity, nor it can be otherwise since isotopies preserves basic laws. Hence, $\hat{\gamma}$ cannot assume imaginary values, contrary to fraudulent views expressed in plagiarizing works [37].

ISOAXIOM IV: The isodoppler law within physical media is given by the expression (for the simple case of null aberration)$\omega' = \omega/\hat{\gamma}$.

ISOAXIOM V: The mass-energy isoequivalence within physical media follows the isotopic law $E = mV_{max}^2 = mc^2n_3^2/n_4^2 = c^2b_4^2/b_3^2$.

Note that Santilli isorelativity in general and its isoaxioms in particular, recover the corresponding aspects of special relativity identically and uniquely when motion returns to be in empty space. The validity of isorelativity within physical media has been verified in classical mechanics, particle physics, nuclear physics, superconductivity, chemistry and astrophysics [12-22].

One among several classical verifications is given by the consistent treatment of light propagating within transparent media such as water (see review [14] and original works quoted therein). In this case, special relativity is "inapplicable" in water (rather than "violated" because not conceived for that scope) because within such a medium electrons can propagate faster than the local speed of light $C = c/n = 2c/3$. The assumption of the speed of light in water $C = c/n$ as the maximal causal speed causes the violation of the principle of causality. The assumption of the speed of light c "in vacuum" as the maximal causal speed "in water" to salvage causality causes the violation of the basic axiom of the relativistic addition of two light speeds that does not yield the maximal causal speed as requested for consistency, resulting in the indicated inapplicability of special relativity.

These inconsistencies are readily resolved by Santilli isorelativity [14], Recall that water is isotropic and homogeneous, thus demanding that $n_3 = n_4$, in which case the maximal causal speed in water is c from Isoaxiom I. This permits the verification of causality, namely, to avoid that ordinary electron travel in water faster than the maximal causal speed. The isorelativistic sum of speeds, Isoaxioms II, is also valid, because it applies for the maximal causal speed, and not for locally varying speeds such as that of light in water.

It should be indicated that, in the a-scientific dream of maintaining the validity of special relativity under conditions it was not conceived for, organized interests on Einsteinian doctrines proffer the validity of the relativity also within water via the claimed reduction of light to photons scattering among atoms, thus propagating in vacuum at the speed c. These views have been qualified in refereed publications as being political manipulations of science for personal gains due to various reasons, such as:

1) radio waves with, say, one meter in wavelength, cannot be credibly reduced to photons just to serve personal gains;

2) the propagation of electromagnetic waves faster than the speed c in vacuum in vacuum, even though generally ignored (or dubbed as only occurring for the phase velocity) for personal gains by corrupt scientists, is today an experimental routine, in which case the reduction of light to photons scattering among atoms is non-scientific non-sense because that reduction only allows c as the maximal causal speed; and

3) physical media are generally opaque to light in which case any claim of the continued validity of special relativity is vulgar scientific corruption that should be prosecuted in criminal court when ventured under public support, because severely damaging human knowledge

for sinister personal gains.

At any rate, the first statement that the speed of light in vacuum c is a "universal constant" valid throughout the universe is a vulgar scientific corruption, particularly when proffered by experts, to be prosecuted in court because it implies that the speed c is also valid in the interior of the stares, quasars and black holes, with the resulting value of the energies for these bodies $E = mc^2$, the resulting theology of dark matter (intentionally proposed to salvage Einstein theories in the interior of astrophysical bodies), while the serious scientific position is that "we do not know".

One among several verifications of Santilli isorelativity in particle physics is given by the Bose-Einstein correlation (see review [17,22] and original works quoted therein, including works by the defendants, as well as numerous additional experimental verifications). In this case, the fit of the experimental data via special relativity requires the use of "four" unknown parameters in direct violation of the basic axiom of expectation values that, for the applicable two point correlation function, admits a maximum of "two" parameters. The use of the Lorentz-Santilli isosymmetry permits instead an exact and time invariant representation of experimental data in which $n_k, k = 1, 2, 3$, characterize the semi-axes of the elongated proton-antiproton fireball and n_4 provides a measurement of the density of the fireball normalized to the value $n_4 = 1$ for the vacuum.

One among several verifications of Santilli isorelativity in astrophysics is given by an exact representation of the large numerical differences existing in cosmological redshifts between a galaxy and a quasar when proved to be physically connected according to gamma spectroscopy and other evidence (see again [17,22] for reviews and original references including the quotation of work by defendant Mignani who applied 'Santilli Lie-isotopic lifting of special relativity [45] as recalled in the Foreword). said large difference is merely due to the fact that light travels the immense quasar chromospheres at much reduced speed than that in vacuum, thus exiting said chromospheres at a value of the Doppler-Santilli isoredshift much bigger than the corresponding one for light emitted by the connected galaxy.

Note that in Santilli isorelativity the speed of light is not, in general, the maximal causal speed with the sole exception of motion in vacuum (where the two speeds trivially coincide). This new axiomatic vista resulted to be necessary, first of all, to have a maximal causal speed applicable also to opaque media, but also for the resolution of the inconsistencies of special relativity when applied within physical media transparent to light.

The most important function of Santilli isorelativity has been the prediction and quantitative treatment of new clean energies and fuels so much needed by mankind due to the increasingly cataclysmic climactic events. First, we have the prediction, experimental verification and industrial development of a new chemical species, today called "Santilli magnecules" to distinguish them from the conventional molecules, which new species has permitted the synthesis of fuels having a full combustion, thus alleviating said environmental problems (see book [19] for a review and original references quoted therein and website www.magnegas.com).

In regard to the needed new clean energy, the neutron represent, by far, one of the biggest reservoirs of clean energy available to mankind because the neutron is unstable (when in vacuum and in certain nuclei), and decays via the release of an easily tappable, very energetic electron plus the innocuous neutrino (assuming that it exists). Since the neutron is naturally unstable, it must admit a mechanism for its stimulated decay that would allow the utilization of its clean energy. Such a stimulated decay is strongly dismissed and its study vigorously opposed by various "scientists" on grounds that special relativity and quantum mechanics do not allow it. But these disciplines were not conceived for dynamics within the hyperdense medium inside the neutron, hence qualifying said opposition as scientific corruption particularly when compared to the support of other equivocal research. Santilli isorelativity and hadronic mechanics were conceived, constructed and verified for dynamics within the hyperdense medium inside the neutron and they predict indeed the capability of stimulating its decay. This prediction has already been preliminarily confirmed but must be proved or disproved in a final form to prevent crime against society in view of the alarming environmental problems facing mankind, particularly when compared to large investment for various particle experiments without any hope of any possible value for society.

Additionally, Santilli's isorelativity predicts means for the stimulated decay of radioactive nuclear waste that could be employed within the pools of existing nuclear reactors, of course, if seeded within a responsive financial and academic environment. This possible advance, if implemented in a responsible society, would render nuclear energy environmentally acceptable because nuclear power plants would be able to recycle their nuclear waste by triggering their decay. For the non expert we recall that special relativity does not allow the variation of the meanlives of unstable nuclei because that would require the violation of its pillar, the Poincare' symmetry. By comparison, the covering Poincare'-Santilli isosymmetry and isorelativity do allow a variable meanlife, because shapes are rigid only for the politics surrounding Einsteinian doctrines while they are deformable in the physical reality. The latter feature is represented by isorelativity via the locally varying parameters $n_k, k = 1, 2, 3$, predicting a largely elongated ellipsoidal share under which any perturbation, such as proton excesses due to neutron stimulated decay and other means, said nuclei could not survive. By comparison, special relativity is historically incompatible with extended shapes and their deformation, since the latter would cause the violation of the rotational symmetry, as experts are expected to know and admit to qualify as such (see www.recyclingnuclearwaste.org for more details).

GRAVITATIONAL IMPLICATIONS

Jointly with the isotopies of special relativity, santilli also studied the isotopies of general relativity [21], but he had to abandon them because the representation of gravity on a Riemannian space is afflicted by catastrophic inconsistencies [36] usually ignored for political gains. Any time evolution of general relativity is strictly noncanonical, thus activating the theorems of catastrophic inconsistencies [so,36]. Additionally, Riemannian metrics cannot be invariant under the time evolution of the theory, $g(x) => WgW^+ = g'(x'), g' \neq g$, thus implying that curvature, and therefore gravitational attraction, change in time for the same masses at the same distance but at different times, a feature suppressed by organized interests on Einsteinian doctrines. At any rate, curvature cannot explain a central graviutational event, thje free fall of objects along a *straight* radial line. Following additional laborious studies Santilli discovered that a formulation of two relativities is not needed because gravitation is fully included in his isorelativity. This explains the single formulation "isorelativity", rather than having two formulations, "isospecial" and "isogeneral" relativities. As a matter of fact, a primary function of isorelativity is that of providing a geometric unifications of general relativity with the axioms of the special, as a condition to avoid catastrophic inconsistencies.

This important feature is due to the fact that Santilli's isotopies leave unaffected the functional dependence of the isounit. Consequently, all Riemannian line elements are a particular case of the general isoinvariant. In fact, any given Riemannian metric with signature (+, +, +, -) can be written $g(x) = T(x)m$ where T(x) is a 4x4 matrix including all gravitational features, and m is the conventional Minkowski metric. The use of the gravitational isounit $I(x) = 1/T(x)$ then allows a full representation of gravitation via the Minkowski-Santilli isogeometry [5i] since the latter admits the same machinery of the Riemannian geometry, such as covariant derivatives, Christoffel symbols, etc., trivially, because the isominkowskian metric $\hat{m}(x) = T(x)m$ now carry a dependence on spacetime coordinates. This implies the identical reformulation of the Einstein-Hilbert gravitational field equations on isominkowski spaces over isofields.

The implications of the isominkowskian reformulation of gravity are dramatic and cannot be reviewed in detail here [22]. We merely mention that: said reformulation eliminates curvature in the description of gravity (since the Minkowski-Santilli isospaces are flat as the conventional Minkowski space); gravitation admits for the first time an "invariance", that under the Poincare'-Santilli isosymmetry, rather than the usual covariance; these features permit the resolution of the catastrophic inconsistencies [36]; and, in turn, the latter has permitted the first known axiomatically consistent, operator formulation of gravity and grand unification of electroweak and gravitational interactions, although only following the proper addition of antimatter [22].

LIMITATIONS OF EINSTEINIAN THEORIES FOR ENERGY RELEASING PROCESSES

All energy releasing processes are irreversible over time, namely, their time reversal image violates the laws of causality. For instance, the time reversal image of the combustion of fossil fuels would require that smoke and ashes *spontaneously* reconstruct the original fuel, a physical impossibility. However, special relativity and quantum mechanics are structurally reversible in time, in the sense that their mathematics has no time arrow and all known Hamiltonian are indeed time reversal invariants. Consequently, any denial of the limitation of special relativity and quantum mechanics for energy rel.easing processes is nonscientific. On serious scientific grounds we can discuss the applicable *broadening* of conventional doctrines for energy releasing processes, but not their need.

On historical ground, the above limitations of special relativity and quantum mechanics is a de facto confirmation of their historical value. In fact, the disciplines were constructed for the description of [processes that are indeed time reversal invariant, such as the trajectory of an electron in an atomic structure. However, when the same discipline are applied to irreversible processes, a number of inconsistencies emerge. Consider, for instance, the synthesis of two nuclei into a third one, $N_1 + N_2 => N_3$ plus energy. In this case, Santilli's graduate students have proved, via the use of relativistic quantum mechanics, the existence of a finite probability of the *spontaneous* inverse nuclear decay $N_3 => N_1 + N_2$ less energy, that is in dramatic disagreement with nature.

This lawsuit has been filed because any obstruction against qualified studies of the *limitations* of Einsteinian doctrines, and against the laborious search for their appropriate generalizations is a threat to society in view of the need for new clean energies and fuels. In

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particular, this lawsuit has been filed against Cornell University because with their conduction of the arXiv they do indeed oppose this fundamental research need.

The broader *genorelativity,* namely, the extension of isorelativity to irreversible processes under open conditions, has been proposed by Santilli without any claim of uniqueness in the hope of stimulating research in this basic need. This broader relativity has indeed been conceived and constructed to be *structurally irreversible,* that is, to be irreversible for all possible reversible Hamiltonians, as a necessary condition to avoid the above inconsistencies. In particular, this structural irreversibility was embedded in the *new mathematics* underling its construction and application, *Santilli genomathematics.* Still in turn, the structural irreversibility was implemented at the ultimate level of quantitative science, via *two different basic units,* one for motion forward in time $I^>$ and the second for motion backward in time $^<I$. All these aspects, with some initial applications, can be studied in memoir [35] recently published by the Italian Physics Society. Extensive presentations are available in monographs [22]. Industrial applications are under way thanks to substantial investments by the industry.

LIMITATIONS OF EINSTEINIAN DOCTRINES FOR ANTIMATTER

Antimatter had yet to be discovered at the time of the inception of special relativity. Therefore, it should not be surprising that special relativity has serious limitations for the *classical* representation of antimatter. For instance, special relativity has no classical differentiation whatever between neutral matter and antimatter and even for the description of a classical antiparticle, its operator image following quantization is that of a particle with the wrong sign of the charge and definitely not that of a charge conjugated antiparticle.

The limitations of general relativity for antimatter are even more severe than those for special relativity, trivially, because of the absence of a consistent operator formulation of gravity when represented with curvature. hence, any claim that "antigravity (as the gravitational repulsion) between matter and antimatter does not exist because not predicted by Einstein theories" should be prosecuted in court, particularly when proffered under public financial support.

Santilli addressed these limitations and, without any claim of uniqueness, proposed their solution via a yet *new mathematics,* today known as *Santilli isodual conventional, iso-, geno- and hyper-mathematics* characterized by an anti-Hermitean transforms of conventional, iso-, geno and hyper-mathematics, such as the following one for an arbitrary operator $A => A^d(x, ...) - -A^+(-x^+, ...)$. These isodual mathematics permitted a fully consistent representation of antimatter at the classical level that verifies all known experimental data. At the operator level, isoduality turned out to be equivalent to charge conjugation, with consequential verification of experimental data at the operator level too, as interested reader can see in monograph [21] and quoted original works.

The above studies permitted the resolution of a large scientific imbalance of the 20-th century, the treatment of matter at all levels, from Newton to second quantization, while antimatter was solely treated at the level of second quantization. In fact, isodual theories of antimatter apply at all levels, of course, under isoduality, from the isodual Newton-Santilli equations to isodual second quantization (that coincides with conventional treatment).

In turn, these advances permitted the first axiomatically consistent grand unification of gravitation and electroweak interaction inclusive of antimatter, presented for the first time at the Marcel Grossman Meeting in Gravitation of 2002 (see [21] and large original literature).

Additionally, the studies predict, apparently for the first time, the possibility of quantitative studies as to whether a far away galaxy or quasar is made up of matter or of antimatter since the *isodual photon,* namely, the photon emitted by antimatter, is predicted to have features different than the ordinary photon, e.g., to experience gravitational repulsion in the gravitational field of matter and other new, experimentally detectable features [21].

CONCLUSION

It is hoped that these guidelines for a rather vast and specialized body of research have provided all necessary evidence for expert eyewitnesses to testify that the "deformed special relativity, Minkowski space and Lorentz symmetry" presented in various works by defendants Cardone, Mignani and Marrani, are in fact:

I) *Identical,* on grounds of derivation, equations and symbols, to the early formulations by Santilli [3a], those on conventional fields of numbers;

II) *Catastrophically inconsistent,* because constituting noncanonical or nonunitary formulations treated via the mathematics of canonical or unitary theories, and

III) *Disrespectful* of the memory of Einstein, Minkowski and Lorentz, because they do not emphasize the "isotopic", that is, their character of preserving the original historical axioms completely unchanged and merely presenting broader realizations.

Opposing views by experts are suggested to be backed by quantitative treatments (that is, with formulae, rather than mere academic parlance) and proper documentation, because the condition of our planet is such to require the termination of academic politics with whatever means, and the implementation of scientific ethics, decency, democracy and accountability, particularly when operating under public financial support, as the only possible way for a collegian resolution of our serious environmental problems.

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B27

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http://www.scientificethics.org/Mignani-Cardone-ir00001.htm

CERTIFICATE OF REGISTRATION

C1

FORM TX
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a. Preexisting Material Identify any preexisting work or works that this work is based on or incorporates. ▼

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☐ other copyright claimant
☐ owner of exclusive right(s)
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of the work identified in this application and that the statements made by me in this application are correct to the best of my knowledge.

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R.M. SANTILLI date ▶ July 12, 1999

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273-322

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Algebras, Groups & Geometries 10 1993 /

2

a NAME OF AUTHOR ▼ RUGGERO MARIA SANTILLI

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Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

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Pseudonymous? ☐ Yes ☒ No
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b NAME OF AUTHOR ▼

DATES OF BIRTH AND DEATH Year Born ▼ Year Died ▼

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AUTHOR'S NATIONALITY OR DOMICILE Name of country
OR { Citizen of ▶ / Domiciled in ▶

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2

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10

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11

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PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Number ▼ Issue Date ▼ On Pages ▼

JINR Rapid Comm. 6 1993 / 24–38

2 NAME OF AUTHOR ▼ DATES OF BIRTH AND DEATH Year Born ▼ Year Died ▼

a RUGGERO MARIA SANTILLI 1935

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE Name of Country: U.SA
OR { Citizen of ▶ U.SA / Domiciled in ▶

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
Anonymous? ☐ Yes ☒ No
Pseudonymous? ☐ Yes ☒ No
If the answer to either of these questions is "Yes," see detailed instructions.

NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼ *Description of:

Scientific theory – Entire Text

NOTE

Under the law, the "author" of a "work made for hire" is generally the employer, not the employee (see instructions). For any part of this work that was "made for hire" check "Yes" in the space provided, give the employer (or other person for whom the work was prepared) as "Author" of that part, and leave the space for dates of birth and death blank.

NAME OF AUTHOR ▼ DATES OF BIRTH AND DEATH Year Born ▼ Year Died ▼

b

Was this contribution to the work a "work made for hire"? ☐ Yes ☐ No

AUTHOR'S NATIONALITY OR DOMICILE Name of country
OR { Citizen of ▶ / Domiciled in ▶

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Pseudonymous? ☐ Yes ☐ No
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c

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OR { Citizen of ▶ / Domiciled in ▶

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3 YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED This information must be given in all cases. *1992 ◀ Year

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK Complete this information ONLY if this work has been published. Month ▶ *6 Day ▶ *2 Year ▶ *1993
◀ Na

4 COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2. ▼

R.M. SANTILLI
Box 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

APPLICATION RECEIVED JUL. 19 1999
ONE DEPOSIT RECEIVED JUL 19 1999
TWO DEPOSITS RECEIVED
REMITTANCE NUMBER AND DATE
DO NOT WRITE HERE OFFICE USE ONLY

TRANSFER If the claimant(s) named here in space 4 are different from the author(s) named in space 2, give a brief statement of how the claimant(s) obtained ownership of the copyright. ▼

C8

EXAMINED BY WMD

FORM TX

CHECKED BY

3-7

☐ CORRESPONDENCE Yes

☐ DEPOSIT ACCOUNT FUNDS USED

FOR COPYRIGHT OFFICE USE ONLY

* Amended by C.O. Authority of phone call to Ruggero Santilli on 1/13/00.

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

5

PREVIOUS REGISTRATION Has registration for this work, or for an earlier version of this work, already been made in the Copyright Office?
☐ Yes ☐ No If your answer is "Yes," why is another registration being sought? (Check appropriate box) ▼
☐ This is the first published edition of a work previously registered in unpublished form.
☒ This is the first application submitted by this author as copyright claimant.
☐ This is a changed version of the work, as shown by space 6 on this application.
If your answer is "Yes," give: Previous Registration Number ▼ Year of Registration ▼

6

DERIVATIVE WORK OR COMPILATION Complete both space 6a & 6b for a derivative work; complete only 6b for a compilation.
a. Preexisting Material Identify any preexisting work or works that this work is based on or incorporates. ▼

b. Material Added to This Work Give a brief, general statement of the material that has been added to this work and in which copyright is claimed. ▼

See instructions before completing this space.

7

MANUFACTURERS AND LOCATIONS If this is a published work consisting preponderantly of nondramatic literary material in English, the law may require that the copies be manufactured in the United States or Canada for full protection. If so, the names of the manufacturers who performed certain processes, and the places where these processes were performed must be given. See instructions for details.
Names of Manufacturers ▼ Places of Manufacture ▼

8

REPRODUCTION FOR USE OF BLIND OR PHYSICALLY HANDICAPPED INDIVIDUALS A signature on this form at space 10, and a check in one of the boxes here in space 8, constitutes a non-exclusive grant of permission to the Library of Congress to reproduce and distribute solely for the blind and physically handicapped and under the conditions and limitations prescribed by the regulations of the Copyright Office: (1) copies of the work identified in space 1 of this application in Braille (or similar tactile symbols); or (2) phonorecords embodying a fixation of a reading of that work; or (3) both.
a ☐ Copies and Phonorecords b ☐ Copies Only c ☐ Phonorecords Only

See instructions.

9

DEPOSIT ACCOUNT If the registration fee is to be charged to a Deposit Account established in the Copyright Office, give name and number of Account.
Name ▼ Account Number ▼

CORRESPONDENCE Give name and address to which correspondence about this application should be sent. Name/Address/Apt/City/State/Zip ▼
R. M. SANTILLI TEL. 727-934-9593
BOX 1577
PALM HARBOR, FL 34682
Area Code & Telephone Number ▶

Be sure to give your daytime phone ◀ number.

10

CERTIFICATION* I, the undersigned, hereby certify that I am the
Check one ▶
☐ author
☐ other copyright claimant
☐ owner of exclusive right(s)
☐ authorized agent of
Name of author or other copyright claimant, or owner of exclusive right(s) ▲
of the work identified in this application and that the statements made by me in this application are correct to the best of my knowledge.

Typed or printed name and date ▼ If this is a published work, this date must be the same as or later than the date of publication given in space 3.
R. M. SANTILLI date ▶ July 12, 1999

Handwritten signature (X) ▼
[signature]

11

MAIL CERTIFICATE TO
Name ▼
RUGGERO M. SANTILLI
Number/Street/Apartment Number ▼
BOX 1577
City/State/ZIP ▼
PALM HARBOR, FL 34682

Certificate will be mailed in window envelope

Have you:
- Completed all necessary spaces?
- Signed your application in space 10?
- Enclosed check or money order for $10 payable to *Register of Copyrights*?
- Enclosed your deposit material with the application and fee?

MAIL TO: Register of Copyrights, Library of Congress, Washington, D.C. 20559.

* 17 U.S.C. § 506(e) Any person who knowingly makes a false representation of a material fact in the application for copyright registration provided for by section 409, or in any written statement filed in connection with the application, shall be fined not more than $2,500.

CERTIFICATE OF REGISTRATION

C9

FORM TX
UNITED STATES COPYRIGHT OFFICE

3-1

OFFICIAL SEAL
UNITED STATES COPYRIGHT OFFICE ☆ THE LIBRARY OF CONGRESS ☆

This Certificate issued under the seal of the Copyright Office in accordance with title 17, United States Code, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

Marybeth Peters

REGISTER OF COPYRIGHTS
United States of America

10914319

REGISTRATION NUMBER

TX 5-032-857

EFFECTIVE DATE OF REGISTRATION

July 19 1999
Month Day Year

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

1 TITLE OF THIS WORK ▼

Relativistic Hadron Mechanics ...

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Number ▼ Issue Date ▼ On Pages ▼

Found. Phys. 27 5 June 15, 1997 625-729

2 NAME OF AUTHOR ▼

a RUGGERO MARIA SANTILLI

DATES OF BIRTH AND DEATH
Year Born ▼ 1935 Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE
Name of Country
OR { Citizen of ▶ U.SA
Domiciled in ▶ Palm Harbor, FL

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
Anonymous? ☐ Yes ☒ No
Pseudonymous? ☐ Yes ☒ No
If the answer to either of these questions is "Yes," see detailed instructions.

NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼

Scientific theory - Entire Text - DESCRIPTION *Description of:

NOTE

Under the law, the "author" of a "work made for hire" is generally the employer, not the employee (see instructions). For any part of this work that was "made for hire" check "Yes" in the space provided, give the employer (or other person for whom the work was prepared) as "Author" of that part, and leave the space for dates of birth and death blank.

NAME OF AUTHOR ▼

b

DATES OF BIRTH AND DEATH
Year Born ▼ Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☐ No

AUTHOR'S NATIONALITY OR DOMICILE
Name of country
OR { Citizen of ▶
Domiciled in ▶

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
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NAME OF AUTHOR ▼

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Year Born ▼ Year Died ▼

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Name of Country
OR { Citizen of ▶
Domiciled in ▶

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Pseudonymous? ☐ Yes ☐ No
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NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼

3 YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED This information must be given in all cases.
1996 ◀ Year

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK
Complete this information ONLY if this work has been published.
Month ▶ June Day ▶ 15 Year ▶ 1997
◀ Na'

4 COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2. ▼

R. M. SANTILLI
BOX 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

TRANSFER If the claimant(s) named here in space 4 are different from the author(s) named in space 2, give a brief statement of how the claimant(s) obtained ownership of the copyright. ▼

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JUL. 19. 1999

TWO DEPOSITS RECEIVED

REMITTANCE NUMBER AND DATE

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CHECKED BY WMD

FORM TX

3-17

* Amended by C.O. Authority of phone call to Ruggero Santilli on 1/13/00.

☐ CORRESPONDENCE Yes

☐ DEPOSIT ACCOUNT FUNDS USED

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PREVIOUS REGISTRATION Has registration for this work, or for an earlier version of this work, already been made in the Copyright Office? 5

☐ Yes ☐ No If your answer is "Yes," why is another registration being sought? (Check appropriate box) ▼

☐ This is the first published edition of a work previously registered in unpublished form.

☒ This is the first application submitted by this author as copyright claimant.

☐ This is a changed version of the work, as shown by space 6 on this application.

If your answer is "Yes," give: Previous Registration Number ▼ Year of Registration ▼

DERIVATIVE WORK OR COMPILATION Complete both space 6a & 6b for a derivative work; complete only 6b for a compilation. 6

a. Preexisting Material Identify any preexisting work or works that this work is based on or incorporates. ▼

b. Material Added to This Work Give a brief, general statement of the material that has been added to this work and in which copyright is claimed. ▼

See instructions before completing this space.

MANUFACTURERS AND LOCATIONS If this is a published work consisting preponderantly of nondramatic literary material in English, the law may require that the copies be manufactured in the United States or Canada for full protection. If so, the names of the manufacturers who performed certain processes, and the places where these processes were performed must be given. See instructions for details. 7

Names of Manufacturers ▼ Places of Manufacture ▼

Infinit - Energy USA

REPRODUCTION FOR USE OF BLIND OR PHYSICALLY HANDICAPPED INDIVIDUALS A signature on this form at space 10, and a check in one of the boxes here in space 8, constitutes a non-exclusive grant of permission to the Library of Congress to reproduce and distribute solely for the blind and physically handicapped and under the conditions and limitations prescribed by the regulations of the Copyright Office: (1) copies of the work identified in space 1 of this application in Braille (or similar tactile symbols); or (2) phonorecords embodying a fixation of a reading of that work; or (3) both. 8

a ☐ Copies and Phonorecords b ☐ Copies Only c ☐ Phonorecords Only

See instructions.

DEPOSIT ACCOUNT If the registration fee is to be charged to a Deposit Account established in the Copyright Office, give name and number of Account. 9

Name ▼ Account Number ▼

CORRESPONDENCE Give name and address to which correspondence about this application should be sent. Name/Address/Apt/City/State/Zip ▼

R. M. SANTILLI TEL. 727-9349593

BOX 1577

PALM HARBOR, FL 34682

Area Code & Telephone Number ▶

Be sure to give your daytime phone ◀ number

CERTIFICATION* I, the undersigned, hereby certify that I am the 10

Check one ▶

☐ author

☐ other copyright claimant

☐ owner of exclusive right(s)

☐ authorized agent of

Name of author or other copyright claimant, or owner of exclusive right(s) ▲

of the work identified in this application and that the statements made by me in this application are correct to the best of my knowledge.

Typed or printed name and date ▼ If this is a published work, this date must be the same as or later than the date of publication given in space 3.

R M SANTILLI date ▶ Jul 12, 1999

Handwritten signature (X) ▼

[signature]

MAIL CERTIFICATE TO 11

Name ▼ RUGGERO M. SANTILLI

Number/Street/Apartment Number ▼ BOX 1577

City/State/ZIP ▼ PALM HARBOR, FL 34682

Certificate will be mailed in window envelope

Have you:

- Completed all necessary spaces?
- Signed your application in space 10?
- Enclosed check or money order for $10 payable to *Register of Copyrights*?
- Enclosed your deposit material with the application and fee?

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CERTIFICATE OF REGISTRATION

C11

FORM TX
UNITED STATES COPYRIGHT OFFICE

REGISTRATION NUMBER

TX 5-032-858

UNITED STATES COPYRIGHT OFFICE ★ THE LIBRARY OF CONGRESS ★
OFFICIAL SEAL

This Certificate issued under the seal of the Copyright Office in accordance with title 17, United States Code, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

Marybeth Peters

REGISTER OF COPYRIGHTS
United States of America

EFFECTIVE DATE OF REGISTRATION
July 19 1999
Month Day Year

DO NOT WRITE ABOVE THIS LINE. USE A SEPARATE CONTINUATION SHEET.

1 TITLE OF THIS WORK ▼

APPARENT CONSISTECY OF RUTHERFORD'S

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Hadronic J. 13 Number ▼ Issue Date ▼ Dec. 1, 1990 On Pages ▼ 513-531

2 NAME OF AUTHOR ▼
a RUGGERO MARIA SANTILLI

DATES OF BIRTH AND DEATH
Year Born ▼ 1935 Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE
Name of Country
OR { Citizen of ▶ U.SA
Domiciled in ▶ Palm Harbor, FL

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
Anonymous? ☐ Yes ☒ No
Pseudonymous? ☐ Yes ☒ No
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Scientific theory - Entire Text - DESCRIPTION

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NAME OF AUTHOR ▼
b

DATES OF BIRTH AND DEATH
Year Born ▼ Year Died ▼

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Name of country
OR { Citizen of ▶
Domiciled in ▶

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NAME OF AUTHOR ▼
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Year Born ▼ Year Died ▼

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Name of Country
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Domiciled in ▶

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3 YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED
1989 ◀ Year
This information must be given in all cases.

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK
Complete this information ONLY if this work has been published.
Month ▶ December Day ▶ 1 Year ▶ 1990
◀ Na[tion]

4 COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2. ▼

R.M. SANTILLI
Box 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

TRANSFER If the claimant(s) named here in space 4 are different from the author(s) named in space 2, give a brief statement of how the claimant(s) obtained ownership of the copyright. ▼

DO NOT WRITE HERE — OFFICE USE ONLY
APPLICATION RECEIVED
JUL 19 1999
ONE DEPOSIT RECEIVED
JUL 19 1999
TWO DEPOSITS RECEIVED
REMITTANCE NUMBER AND DATE

MORE ON BACK ▶ • Complete all applicable spaces (numbers 5-11) on the reverse side of this page.

C12

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CHECKED BY WMD

FORM TX

2-19

* Amended by C.O. Authority of phone call to Ruggero Santilli on 1/13/00.

☒ CORRESPONDENCE Yes

☐ DEPOSIT ACCOUNT FUNDS USED

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DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

5 'REVIOUS REGISTRATION Has registration for this work, or for an earlier version of this work, already been made in the Copyright Office?

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☐ This is a changed version of the work, as shown by space 6 on this application.

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Names of Manufacturers ▼ Places of Manufacture ▼

Plenum Publ. USA

8 REPRODUCTION FOR USE OF BLIND OR PHYSICALLY HANDICAPPED INDIVIDUALS A signature on this form at space 10, and a check in one of the boxes here in space 8, constitutes a non-exclusive grant of permission to the Library of Congress to reproduce and distribute solely for the blind and physically handicapped and under the conditions and limitations prescribed by the regulations of the Copyright Office: (1) copies of the work identified in space of this application in Braille (or similar tactile symbols); or (2) phonorecords embodying a fixation of a reading of that work; or (3) both.

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See instructions.

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Name ▼ Account Number ▼

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R. M. SANTILLI TEL. 727-9349593

BOX 1577

PALM HARBOR, FL 34682

Area Code & Telephone Number ▶

Be sure to give your daytime phone ◀ number.

10 CERTIFICATION* I, the undersigned, hereby certify that I am the

Check one ▶

☐ author

☐ other copyright claimant

☐ owner of exclusive right(s)

☐ authorized agent of

Name of author or other copyright claimant, or owner of exclusive right(s) ▲

of the work identified in this application and that the statements made by me in this application are correct to the best of my knowledge.

Typed or printed name and date ▼ If this is a published work, this date must be the same as or later than the date of publication given in space 3.

R. M. SANTILLI date ▶ Feb, 12, 1999

Handwritten signature (X) ▼ [signature]

11 MAIL CERTIFICATE TO

Certificate will be mailed in window envelope

Name ▼

RUGGERO M. SANTILLI

Number/Street/Apartment Number ▼

BOX 1577

City/State/ZIP ▼

PALM HARBOR, FL 34682

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CERTIFICATE OF REGISTRATION

C13

FORM TX
UNITED STATES COPYRIGHT OFFICE 3-22

REGISTRATION NUMBER

TX 5-032-859

EFFECTIVE DATE OF REGISTRATION

July 19 1999
Month Day Year

UNITED STATES COPYRIGHT OFFICE ★ THE LIBRARY OF CONGRESS ★

OFFICIAL SEAL

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Marybeth Peters

REGISTER OF COPYRIGHTS
United States of America

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

1

TITLE OF THIS WORK ▼

Recent Theoretical and experimental...

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Number ▼ Issue Date ▼ On Pages ▼

JINR, Dubna, Russia E4-93-352 August 1, 1993 / entire mns

2

NAME OF AUTHOR ▼ **DATES OF BIRTH AND DEATH** Year Born ▼ Year Died ▼

a RUGGERO MARIA SANTILLI 1935

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE Name of Country
OR { Citizen of ► U.S.A / Domiciled in ► Palm Harbor, FL

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
Anonymous? ☐ Yes ☒ No
Pseudonymous? ☐ Yes ☒ No
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Scientific theory - Entire Text - DESCRIPTION

NOTE

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NAME OF AUTHOR ▼ **DATES OF BIRTH AND DEATH** Year Born ▼ Year Died ▼

b

Was this contribution to the work a "work made for hire"? ☐ Yes ☐ No

AUTHOR'S NATIONALITY OR DOMICILE Name of country
OR { Citizen of ► / Domiciled in ►

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
Anonymous? ☐ Yes ☐ No
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3

YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED This information must be given in all cases.

1992 ◄ Year

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK Complete this information ONLY if this work has been published.
Month ► August Day ► 1 Year ► 1993 ◄ Na

4

COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2. ▼

R. M. SANTILLI
Box 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

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JUL. 19. 1999

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REMITTANCE NUMBER AND DATE

MORE ON BACK ► • Complete all applicable spaces (numbers 5-11) on the reverse side of this page.

DO NOT WRITE HERE 2

C14

* Amended by C.O. Authority of phone call to Ruggero Santilli on 1/13/00.

EXAMINED BY [handwritten initials]

FORM TX

CHECKED BY

3-21

☒ CORRESPONDENCE Yes

FOR COPYRIGHT OFFICE USE ONLY

☐ DEPOSIT ACCOUNT FUNDS USED

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

5

PREVIOUS REGISTRATION Has registration for this work, or for an earlier version of this work, already been made in the Copyright Office?

☐ Yes ☐ No If your answer is "Yes," why is another registration being sought? (Check appropriate box) ▼

☐ This is the first published edition of a work previously registered in unpublished form.

☒ This is the first application submitted by this author as copyright claimant.

☐ This is a changed version of the work, as shown by space 6 on this application.

If your answer is "Yes," give: Previous Registration Number ▼ Year of Registration ▼

6

DERIVATIVE WORK OR COMPILATION Complete both space 6a & 6b for a derivative work; complete only 6b for a compilation.

a. Preexisting Material Identify any preexisting work or works that this work is based on or incorporates. ▼

b. Material Added to This Work Give a brief, general statement of the material that has been added to this work and in which copyright is claimed. ▼

See instructions before completing this space.

7

MANUFACTURERS AND LOCATIONS If this is a published work consisting preponderantly of nondramatic literary material in English, the law may require that the copies be manufactured in the United States or Canada for full protection. If so, the names of the manufacturers who performed certain processes, and the places where these processes were performed must be given. See instructions for details.

Names of Manufacturers ▼ Places of Manufacture ▼

Hadronic Press USA

8

REPRODUCTION FOR USE OF BLIND OR PHYSICALLY HANDICAPPED INDIVIDUALS A signature on this form at space 10, and a check in one of the boxes here in space 8, constitutes a non-exclusive grant of permission to the Library of Congress to reproduce and distribute solely for the blind and physically handicapped and under the conditions and limitations prescribed by the regulations of the Copyright Office: (1) copies of the work identified in space 1 of this application in Braille (or similar tactile symbols); or (2) phonorecords embodying a fixation of a reading of that work; or (3) both.

a ☐ Copies and Phonorecords b ☐ Copies Only c ☐ Phonorecords Only

See instructions.

9

DEPOSIT ACCOUNT If the registration fee is to be charged to a Deposit Account established in the Copyright Office, give name and number of Account.

Name ▼ Account Number ▼

CORRESPONDENCE Give name and address to which correspondence about this application should be sent. Name/Address/Apt/City/State/Zip ▼

R. M. SANTILLI Tel. 727-9349593

BOX 1577

PALM HARBOR, FL 34682

Area Code & Telephone Number ▶

Be sure to give your daytime phone ◀ number.

10

CERTIFICATION* I, the undersigned, hereby certify that I am the

Check one ▶

☐ author

☐ other copyright claimant

☐ owner of exclusive right(s)

☐ authorized agent of

Name of author or other copyright claimant, or owner of exclusive right(s) ▲

of the work identified in this application and that the statements made by me in this application are correct to the best of my knowledge.

Typed or printed name and date ▼ If this is a published work, this date must be the same as or later than the date of publication given in space 3.

Ruggero M. Santilli date ▶ July 12, 1999

Handwritten signature (X) [signature]

11

MAIL CERTIFICATE TO

Certificate will be mailed in window envelope

Name ▼

RUGGERO M. SANTILLI

Number/Street/Apartment Number ▼

BOX 1577

City/State/ZIP ▼

PALM HARBOR, FL 34682

Have you:

- Completed all necessary spaces?
- Signed your application in space 10?
- Enclosed check or money order for $10 payable to *Register of Copyrights*?
- Enclosed your deposit material with the application and fee?

MAIL TO: Register of Copyrights, Library of Congress, Washington, D.C. 20559.

* 17 U.S.C. § 506(e): Any person who knowingly makes a false representation of a material fact in the application for copyright registration provided for by section 409, or in any written statement filed in connection with the application, shall be fined not more than $2,500.

U.S. GOVERNMENT PRINTING OFFICE: 1982-361-278/58

CERTIFICATE OF REGISTRATION

C15

FORM TX
UNITED STATES COPYRIGHT OFFICE 2-24
REGISTRATION NUMBER

TX 5-032-860

UNITED STATES COPYRIGHT OFFICE · THE LIBRARY OF CONGRESS ·
OFFICIAL SEAL

This Certificate issued under the seal of the Copyright Office in accordance with title 17, United States Code, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

Marybeth Peters
REGISTER OF COPYRIGHTS
United States of America

EFFECTIVE DATE OF REGISTRATION
July 19 1999
Month Day Year

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

1

TITLE OF THIS WORK ▼
Theoretical and experimental evidence...

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼
Chinese J. Systems Engineering
If published in a periodical or serial give: Volume ▼ Number ▼ Issue Date ▼ On Pages ▼
and Electronics 6 4 July 1, 1995 177-199

2

a NAME OF AUTHOR ▼ RUGGERO MARIA SANTILLI
DATES OF BIRTH AND DEATH Year Born ▼ 1935 Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No
AUTHOR'S NATIONALITY OR DOMICILE Name of Country
OR { Citizen of ▶ U.S.A / Domiciled in ▶
WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
Anonymous? ☐ Yes ☒ No
Pseudonymous? ☐ Yes ☒ No
If the answer to either of these questions is "Yes," see detailed instructions.

NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼
Scientific theory - Entire Text - DESCRIPTION *Description of:

NOTE
Under the law, the "author" of a "work made for hire" is generally the employer, not the employee (see instructions). For any part of this work that was "made for hire" check "Yes" in the space provided, give the employer (or other person for whom the work was prepared) as "Author" of that part, and leave the space for dates of birth and death blank.

b NAME OF AUTHOR ▼
DATES OF BIRTH AND DEATH Year Born ▼ Year Died ▼

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AUTHOR'S NATIONALITY OR DOMICILE Name of country
OR { Citizen of ▶ / Domiciled in ▶
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3

YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED 1994 ◀ Year
This information must be given in all cases.

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK
Complete this information ONLY if this work has been published.
Month ▶ July Day ▶ 1 Year ▶ 1995
◀ Na

4

COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2. ▼
R.M. SANTILLI
BOX 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

TRANSFER If the claimant(s) named here in space 4 are different from the author(s) named in space 2, give a brief statement of how the claimant(s) obtained ownership of the copyright. ▼

DO NOT WRITE HERE OFFICE USE ONLY
APPLICATION RECEIVED JUL. 19. 1999
ONE DEPOSIT RECEIVED JUL. 19. 1999
TWO DEPOSITS RECEIVED
REMITTANCE NUMBER AND DATE

MORE ON BACK ▶ • Complete all applicable spaces (numbers 5-11) on the reverse side of this page.
DO NOT WRITE HERE

C6

* Amended by C.O. Authority of phone call to Ruggero Santilli on 1/13/00.

EXAMINED BY WMD

FORM TX

CHECKED BY

☒ CORRESPONDENCE Yes

☐ DEPOSIT ACCOUNT FUNDS USED

3-2

FOR COPYRIGHT OFFICE USE ONLY

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

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PREVIOUS REGISTRATION Has registration for this work, or for an earlier version of this work, already been made in the Copyright Office?

☐ Yes ☐ No If your answer is "Yes," why is another registration being sought? (Check appropriate box) ▼

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☒ This is the first application submitted by this author as copyright claimant.

☐ This is a changed version of the work, as shown by space 6 on this application.

If your answer is "Yes," give: Previous Registration Number ▼ Year of Registration ▼

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MANUFACTURERS AND LOCATIONS If this is a published work consisting preponderantly of nondramatic literary material in English, the law may require that the copies be manufactured in the United States or Canada for full protection. If so, the names of the manufacturers who performed certain processes, and the places where these processes were performed must be given. See instructions for details.

Names of Manufacturers ▼ JINR, Dubna, Russia

Places of Manufacture ▼ Russia

8

REPRODUCTION FOR USE OF BLIND OR PHYSICALLY HANDICAPPED INDIVIDUALS A signature on this form at space 10, and a check in one of the boxes here in space 8, constitutes a non-exclusive grant of permission to the Library of Congress to reproduce and distribute solely for the blind and physically handicapped and under the conditions and limitations prescribed by the regulations of the Copyright Office: (1) copies of the work identified in space 1 of this application in Braille (or similar tactile symbols); or (2) phonorecords embodying a fixation of a reading of that work; or (3) both.

a ☐ Copies and Phonorecords b ☐ Copies Only c ☐ Phonorecords Only

See instructions.

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Name ▼ Account Number ▼

CORRESPONDENCE Give name and address to which correspondence about this application should be sent. Name/Address/Apt/City/State/Zip ▼

R. M. SANTILLI Tel. 727-9349593
BOX 1577
PALM HARBOR, FL 34682

Area Code & Telephone Number ▶

Be sure to give your daytime phone ◀ number

10

CERTIFICATION* I, the undersigned, hereby certify that I am the

Check one ▶ ☐ author ☐ other copyright claimant ☐ owner of exclusive right(s) ☐ authorized agent of

Name of author or other copyright claimant, or owner of exclusive right(s) ▲

of the work identified in this application and that the statements made by me in this application are correct to the best of my knowledge.

Typed or printed name and date ▼ If this is a published work, this date must be the same as or later than the date of publication given in space 3.

R. M. SANTILLI date ▶ July 12, 1995

Handwritten signature (X) [signature]

11

MAIL CERTIFICATE TO

Certificate will be mailed in window envelope

Name ▼ RUGGERO M. SANTILLI

Number/Street/Apartment Number ▼ BOX 1577

City/State/ZIP ▼ PALM HARBOR, FL 34682

Have you:
- Completed all necessary spaces?
- Signed your application in space 10?
- Enclosed check or money order for $10 payable to *Register of Copyrights*?
- Enclosed your deposit material with the application and fee?

MAIL TO: Register of Copyrights, Library of Congress, Washington, D.C. 20559.

17 U.S.C. § 506(e): Any person who knowingly makes a false representation of a material fact in the application for copyright registration provided for by section 409, or in any written statement filed in connection with the application, shall be fined not more than $2,500.

U.S. GOVERNMENT PRINTING OFFICE: 1982-361-278/58

CERTIFICATE OF REGISTRATION

C7

FORM TX
UNITED STATES COPYRIGHT OFFICE

REGISTRATION NUMBER

TX 5-032-854

UNITED STATES COPYRIGHT OFFICE · THE LIBRARY OF CONGRESS
OFFICIAL SEAL

This Certificate issued under the seal of the Copyright Office in accordance with title 17, United States Code, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

Marybeth Peters

REGISTER OF COPYRIGHTS
United States of America

EFFECTIVE DATE OF REGISTRATION

July 19 1999
Month Day Year

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

1 TITLE OF THIS WORK ▼

Physical laws of the emerging new energies .. I

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Infinite Energy Number ▼ 22 Issue Date ▼ 1998 On Pages ▼ 33-49

2 NAME OF AUTHOR ▼

a RUGGERO MARIA SANTILLI

DATES OF BIRTH AND DEATH Year Born ▼ 1935 Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE Name of Country OR { Citizen of ▶ U.S.A Domiciled in ▶

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK Anonymous? ☐ Yes ☒ No Pseudonymous? ☐ Yes ☒ No — If the answer to either of these questions is "Yes," see detailed instructions.

NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼ Scientific theory - Entire Text *Description of:

NOTE

Under the law, the "author" of a "work made for hire" is generally the employer, not the employee (see instructions). For any part of this work that was "made for hire" check "Yes" in the space provided, give the employer (or other person for whom the work was prepared) as "Author" of that part, and leave the space for dates of birth and death blank.

NAME OF AUTHOR ▼

b

DATES OF BIRTH AND DEATH Year Born ▼ Year Died ▼

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3 YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED *1997 ◀ Year — This information must be given in all cases.

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK — Complete this information ONLY if this work has been published. Month ▶ *12 Day ▶ *15 Year ▶ *1998 ◀ Na

4 COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2. ▼

R. M. SANTILLI
Box 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

TRANSFER If the claimant(s) named here in space 4 are different from the author(s) named in space 2, give a brief statement of how the claimant(s) obtained ownership of the copyright. ▼

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APPLICATION RECEIVED JUL. 19. 1999

ONE DEPOSIT RECEIVED JUL. 19. 1999

TWO DEPOSITS RECEIVED

REMITTANCE NUMBER AND DATE

MORE ON BACK ▶ • Complete all applicable spaces (numbers 5-11) on the reverse side ...

C18

* Amended by C.O. Authority of phone call to Ruggero Santilli on 1/13/00.

EXAMINED BY
WMD
CHECKED BY

FORM TX

39

☐ CORRESPONDENCE Yes

☐ DEPOSIT ACCOUNT FUNDS USED

FOR COPYRIGHT OFFICE USE ONLY

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This is the first application submitted by this author as copyright claimant.
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Hadronic Press, Inc USA

8 EPRODUCTION FOR USE OF BLIND OR PHYSICALLY HANDICAPPED INDIVIDUALS A signature on this form at space 10, and a eck in one of the boxes here in space 8, constitutes a non-exclusive grant of permission to the Library of Congress to reproduce and distribute solely for the blind d physically handicapped and under the conditions and limitations prescribed by the regulations of the Copyright Office: (1) copies of the work identified in space of this application in Braille (or similar tactile symbols); or (2) phonorecords embodying a fixation of a reading of that work; or (3) both.
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See instructions.

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ame ▼ Account Number ▼

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R. M. SANTILLI Tel. 727-9349593
BOX 1577
PALM HARBOR, FL 34682
Area Code & Telephone Number ▶

Be sure to give your daytime phone ◀ number.

10 ERTIFICATION* I, the undersigned, hereby certify that I am the
Check one ▶
☐ author
☐ other copyright claimant
☐ owner of exclusive right(s)
☐ authorized agent of
Name of author or other copyright claimant, or owner of exclusive right(s) ▲
f the work identified in this application and that the statements made y me in this application are correct to the best of my knowledge.

Typed or printed name and date ▼ If this is a published work, this date must be the same as or later than the date of publication given in space 3.
R.M. SANTILLI date ▶ July 12, 1999

Handwritten signature (X) ▼ [signature]

11 MAIL CERTIFICATE TO
Certificate will be mailed in window envelope

Name ▼
RUGGERO M. SANTILLI
Number/Street/Apartment Number ▼
BOX 1577
City/State/ZIP ▼
PALM HARBOR, FL 34682

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- Completed all necessary spaces?
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CERTIFICATE OF REGISTRATION

C19

FORM TX
UNITED STATES COPYRIGHT OFFICE

3-14

REGISTRATION NUMBER

TX 5-032-855

UNITED STATES COPYRIGHT OFFICE ☆ THE LIBRARY OF CONGRESS ☆

OFFICIAL SEAL

This Certificate issued under the seal of the Copyright Office in accordance with title 17, United States Code, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

Marybeth Peters

REGISTER OF COPYRIGHTS
United States of America

EFFECTIVE DATE OF REGISTRATION

July 19 1999
Month Day Year

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

1

TITLE OF THIS WORK ▼
Physical laws of the energies new energies ... II

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Infinite Energy Number ▼ 23 Issue Date ▼ 1999 On Pages ▼ 69-70

2

NAME OF AUTHOR ▼
a RUGGERO MARIA SANTILLI

DATES OF BIRTH AND DEATH
Year Born ▼ 1935 Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE
Name of Country
OR { Citizen of ▶ U.S.A. / Domiciled in ▶

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
Anonymous? ☐ Yes ☒ No
Pseudonymous? ☐ Yes ☒ No
If the answer to either of these questions is "Yes," see detailed instructions.

NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼ *Description of:
Scientific theory - Entire Text

NOTE

Under the law, the "author" of a "work made for hire" is generally the employer, not the employee (see instructions). For any part of this work that was "made for hire" check "Yes" in the space provided, give the employer (or other person for whom the work was prepared) as "Author" of that part, and leave the space for dates of birth and death blank.

NAME OF AUTHOR ▼
b

DATES OF BIRTH AND DEATH
Year Born ▼ Year Died ▼

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AUTHOR'S NATIONALITY OR DOMICILE
Name of country
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3

YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED *1998 ◀ Year
This information must be given in all cases.

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK
Complete this information ONLY if this work has been published.
Month ▶ *1 Day ▶ *15 Year ▶ *1999
◀ Na'

4

COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2.▼
R.M. SANTILLI
BOX 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

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DO NOT WRITE HERE OFFICE USE ONLY

APPLICATION RECEIVED
JUL. 19.1999
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JUL. 19.1999
TWO DEPOSITS RECEIVED
REMITTANCE NUMBER AND DATE

MORE ON BACK ▶ • Complete all applicable spaces (numbers 5-11) on the reverse side of this page.

DO NOT WRITE HERE

C20

EXAMINED BY

umd

FORM TX

CHECKED BY

3-13

☐ CORRESPONDENCE Yes

FOR COPYRIGHT OFFICE USE ONLY

☐ DEPOSIT ACCOUNT FUNDS USED

* Amended by C.O. Authority of phone call to Ruggero Santilli on 1/13/00.

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R. M. SANTILLI Tel. 727-9349593
BOX 1577
PALM HARBOR, FL 34682

Area Code & Telephone Number ▶

Be sure to give your daytime phone number.

10

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Check one ▶
☐ author
☐ other copyright claimant
☐ owner of exclusive right(s)
☐ authorized agent of
Name of author or other copyright claimant, or owner of exclusive right(s) ▲

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R. M. SANTILLI date ▶ July 12, 1994

Handwritten signature (X) [signature]

11

IL ERTIFI- ATE TO

Name ▼
RUGGERO M. SANTILLI
Number/Street/Apartment Number ▼
BOX 1577
City/State/ZIP ▼
PALM HARBOR, FL 34682

rtificate l be lled in dow relope

Have you:
- Completed all necessary spaces?
- Signed your application in space 10?
- Enclosed check or money order for $10 payable to *Register of Copyrights*?
- Enclosed your deposit material with the application and fee?

MAIL TO: Register of Copyrights, Library of Congress, Washington, D.C. 20559.

U.S.C. § 506(e): Any person who knowingly makes a false representation of a material fact in the application for copyright registration provided for by section 409, or in any written statement filed in nection with the application, shall be fined not more than $2,500.

CERTIFICATE OF REGISTRATION C21

UNITED STATES COPYRIGHT OFFICE · THE LIBRARY OF CONGRESS
OFFICIAL SEAL

This Certificate issued under the seal of the Copyright Office in accordance with title 17, United States Code, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

Marybeth Peters
REGISTER OF COPYRIGHTS
United States of America

FORM TX
UNITED STATES COPYRIGHT OFFICE 3-16

REGISTRATION NUMBER

TX 5-032-856

EFFECTIVE DATE OF REGISTRATION

July 19 1999
Month Day Year

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

1 TITLE OF THIS WORK ▼

Physical laws of the emerging new energies ..., IB

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Number ▼ Issue Date ▼ On Pages ▼

Infinite Energy 25 1999 / 60-74

2 NAME OF AUTHOR ▼ DATES OF BIRTH AND DEATH Year Born ▼ Year Died ▼

a RUGGERO MARIA SANTILLI 1935

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE Name of Country OR { Citizen of ▶ U.SA Domiciled in ▶

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK Anonymous? ☐ Yes ☒ No Pseudonymous? ☐ Yes ☒ No If the answer to either of these questions is "Yes," see detailed instructions.

NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼ *Description of:

Scientific theory – Entire Text

NOTE

Under the law, the "author" of a "work made for hire" is generally the employer, not the employee (see instructions). For any part of this work that was "made for hire" check "Yes" in the space provided, give the employer (or other person for whom the work was prepared) as "Author" of that part, and leave the space for dates of birth and death blank.

b NAME OF AUTHOR ▼ DATES OF BIRTH AND DEATH Year Born ▼ Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☐ No

AUTHOR'S NATIONALITY OR DOMICILE Name of country OR { Citizen of ▶ Domiciled in ▶

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NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼

3 YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED This information must be given in all cases. *1998 ◀ Year

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK Complete this information ONLY if this work has been published. Month ▶ *3 Day ▶ *15 Year ▶ *1999 ◀ Na

4 COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2. ▼

R. M. SANTILLI
BOX 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

TRANSFER If the claimant(s) named here in space 4 are different from the author(s) named in space 2, give a brief statement of how the claimant(s) obtained ownership of the copyright. ▼

DO NOT WRITE HERE — OFFICE USE ONLY
APPLICATION RECEIVED JUL 19 1999
ONE DEPOSIT RECEIVED JUL. 19 1999
TWO DEPOSITS RECEIVED
REMITTANCE NUMBER AND DATE

C22

* Amended by C.O. Authority of phone call to Ruggero Santilli on 1/13/00.

EXAMINED BY

WMD

CHECKED BY

☐ CORRESPONDENCE Yes

☐ DEPOSIT ACCOUNT FUNDS USED

FORM TX

3-15

FOR COPYRIGHT OFFICE USE ONLY

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

PREVIOUS REGISTRATION Has registration for this work, or for an earlier version of this work, already been made in the Copyright Office? **5**

☐ Yes ☐ No If your answer is "Yes," why is another registration being sought? (Check appropriate box) ▼

☐ This is the first published edition of a work previously registered in unpublished form.

☒ This is the first application submitted by this author as copyright claimant.

☐ This is a changed version of the work, as shown by space 6 on this application.

If your answer is "Yes," give: Previous Registration Number ▼ Year of Registration ▼

DERIVATIVE WORK OR COMPILATION Complete both space 6a & 6b for a derivative work; complete only 6b for a compilation. **6**

a. Preexisting Material Identify any preexisting work or works that this work is based on or incorporates. ▼

b. Material Added to This Work Give a brief, general statement of the material that has been added to this work and in which copyright is claimed. ▼

See instructions before completing this space.

MANUFACTURERS AND LOCATIONS If this is a published work consisting preponderantly of nondramatic literary material in English, the law may require that the copies be manufactured in the United States or Canada for full protection. If so, the names of the manufacturers who performed certain processes, and the places where these processes were performed must be given. See instructions for details. **7**

Names of Manufacturers ▼ Places of Manufacture ▼

REPRODUCTION FOR USE OF BLIND OR PHYSICALLY HANDICAPPED INDIVIDUALS A signature on this form at space 10, and a check in one of the boxes here in space 8, constitutes a non-exclusive grant of permission to the Library of Congress to reproduce and distribute solely for the blind and physically handicapped and under the conditions and limitations prescribed by the regulations of the Copyright Office: (1) copies of the work identified in space 1 of this application in Braille (or similar tactile symbols); or (2) phonorecords embodying a fixation of a reading of that work; or (3) both. **8**

a ☐ Copies and Phonorecords b ☐ Copies Only c ☐ Phonorecords Only

See instructions.

DEPOSIT ACCOUNT If the registration fee is to be charged to a Deposit Account established in the Copyright Office, give name and number of Account. **9**

Name ▼ Account Number ▼

CORRESPONDENCE Give name and address to which correspondence about this application should be sent. Name/Address/Apt/City/State/Zip ▼

R. M. SANTILLI TEL. 727-9349593

BOX 1577

PALM HARBOR, FL 34682

Area Code & Telephone Number ▶

Be sure to give your daytime phone ◀ number.

CERTIFICATION* I, the undersigned, hereby certify that I am the **10**

Check one ▶

☐ author

☐ other copyright claimant

☐ owner of exclusive right(s)

☐ authorized agent of ____

Name of author or other copyright claimant, or owner of exclusive right(s) ▲

of the work identified in this application and that the statements made by me in this application are correct to the best of my knowledge.

Typed or printed name and date ▼ If this is a published work, this date must be the same as or later than the date of publication given in space 3.

R. M. SANTILLI date ▶ July 12, 1999

Handwritten signature (X) ▼ [signature]

MAIL CERTIFICATE TO **11**

Name ▼
RUGGERO M. SANTILLI

Number/Street/Apartment Number ▼
BOX 1577

City/State/ZIP ▼
PALM HARBOR, FL 34682

Certificate will be mailed in window envelope

Have you:
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- Signed your application in space 10?
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CERTIFICATE OF REGISTRATION

C23

UNITED STATES COPYRIGHT OFFICE ★ THE LIBRARY OF CONGRESS ★

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Marybeth Peters

REGISTER OF COPYRIGHTS
United States of America

FORM TX
UNITED STATES COPYRIGHT OFFICE

REGISTRATION NUMBER

TX 5-032-861 7-26

TX | TXU

EFFECTIVE DATE OF REGISTRATION

July 19 1999
Month Day Year

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

1

TITLE OF THIS WORK ▼

The Physical Laws of the emerging New Energie ---- IIA

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Number ▼ Issue Date ▼ On Pages ▼

Infinite Energy 25 March, 15 1999 / 75-85

2

NAME OF AUTHOR ▼

a RUGGERO MARIA SANTILLI

DATES OF BIRTH AND DEATH
Year Born ▼ 1935 Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE
Name of Country
OR { Citizen of ▶ USA
Domiciled in ▶ Palm Harbor, FL

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
Anonymous? ☐ Yes ☒ No
Pseudonymous? ☐ Yes ☒ No
If the answer to either of these questions is "Yes," see detailed instructions.

NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼ *Description of:

Scientific theory - Entire Text - DESCRIPTION

NOTE

Under the law, the "author" of a "work made for hire" is generally the employer, not the employee (see instructions). For any part of this work that was "made for hire" check "Yes" in the space provided, give the employer (or other person for whom the work was prepared) as "Author" of that part, and leave the space for dates of birth and death blank.

NAME OF AUTHOR ▼

b

DATES OF BIRTH AND DEATH
Year Born ▼ Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☐ No

AUTHOR'S NATIONALITY OR DOMICILE
Name of country
OR { Citizen of ▶
Domiciled in ▶

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
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NAME OF AUTHOR ▼

c

DATES OF BIRTH AND DEATH
Year Born ▼ Year Died ▼

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AUTHOR'S NATIONALITY OR DOMICILE
Name of Country
OR { Citizen of ▶
Domiciled in ▶

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
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3

YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED This information must be given in all cases.

X 1998 ◀ Year

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK Complete this information ONLY if this work has been published.

X Month ▶ March Day ▶ 15 Year ▶ 1999

◀ Na

4

COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2. ▼

R. M. SANTILLI
Box 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

APPLICATION RECEIVED
JUL 19 1999

ONE DEPOSIT RECEIVED
JUL 19 1999

TWO DEPOSITS RECEIVED

REMITTANCE NUMBER AND DATE

DO NOT WRITE HERE OFFICE USE ONLY

TRANSFER If the claimant(s) named here in space 4 are different from the author(s) named in space 2, give a brief statement of how the claimant(s) obtained ownership of the copyright. ▼

MORE ON BACK ▶ • Complete all applicable spaces (numbers 5-11) on the reverse side of this page.

DO NOT WRITE HERE

C24

EXAMINED BY (handwritten initials)

FORM TX

CHECKED BY

3.25

[X] CORRESPONDENCE Yes

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[ ] DEPOSIT ACCOUNT FUNDS USED

* Amended by C.O. Authority of phone call to Ruggero Santilli on 1/13/00.

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

5 ...VIOUS REGISTRATION Has registration for this work, or for an earlier version of this work, already been made in the Copyright Office?
...es [ ] No If your answer is "Yes," why is another registration being sought? (Check appropriate box)
...his is the first published edition of a work previously registered in unpublished form.
...his is the first application submitted by this author as copyright claimant.
...his is a changed version of the work, as shown by space 6 on this application.
...ur answer is "Yes," give: Previous Registration Number Year of Registration

6 ...IVATIVE WORK OR COMPILATION Complete both space 6a & 6b for a derivative work; complete only 6b for a compilation.
...reexisting Material Identify any preexisting work or works that this work is based on or incorporates.

...terial Added to This Work *Give a brief, general statement of the material that has been added to this work and in which copyright is claimed.*

See instructions before completing this space.

7 ...UFACTURERS AND LOCATIONS If this is a published work consisting preponderantly of nondramatic literary material in English, the law may ...e that the copies be manufactured in the United States or Canada for full protection. If so, the names of the manufacturers who performed certain ...sses, and the places where these processes were performed must be given. See instructions for details.
...s of Manufacturers: CISE&E
Places of Manufacture: China

8 ...RODUCTION FOR USE OF BLIND OR PHYSICALLY HANDICAPPED INDIVIDUALS A signature on this form at space 10, and a ... in one of the boxes here in space 8, constitutes a non-exclusive grant of permission to the Library of Congress to reproduce and distribute solely for the blind ...hysically handicapped and under the conditions and limitations prescribed by the regulations of the Copyright Office: (1) copies of the work identified in space ...is application in Braille (or similar tactile symbols); or (2) phonorecords embodying a fixation of a reading of that work; or (3) both.
a [ ] Copies and Phonorecords b [ ] Copies Only c [ ] Phonorecords Only

See instructions.

9 ...OSIT ACCOUNT If the registration fee is to be charged to a Deposit Account established in the Copyright Office, give name and number of Account.
Account Number

...RESPONDENCE Give name and address to which correspondence about this application should be sent. Name/Address/Apt/City/State/Zip
R. M. SANTILLI TEL. 727-9349593
BOX 1577
PALM HARBOR, FL 34682
Area Code & Telephone Number

Be sure to give your daytime phone number.

10 ...IFICATION* I, the undersigned, hereby certify that I am the
Check one: [ ] author [ ] other copyright claimant [ ] owner of exclusive right(s) [ ] authorized agent of
Name of author or other copyright claimant, or owner of exclusive right(s)
...work identified in this application and that the statements made in this application are correct to the best of my knowledge.

...l or printed name and date. If this is a published work, this date must be the same as or later than the date of publication given in space 3.
RM SANTILLI date: July 12, 1999

Handwritten signature (X): (signature)

11 ...TIFI...E TO ...ficate ...e ...d in ...ow ...lope

Name: RUGGERO M. SANTILLI
Number/Street/Apartment Number: BOX 1577
City/State/ZIP: PALM HARBOR, FL 34682

Have you:
- Completed all necessary spaces?
- Signed your application in space 10?
- Enclosed check or money order for $10 payable to *Register of Copyrights*?
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GOVERNMENT PRINTING OFFICE: 1983-...

RUGGERO M SANTILLI OR
CARLA SANTILLI
35246 US 19 N #115
PALM HARBOR, FL. 34684

C25

2207

DATE 7-12-99 63-9108/2631 001

PAY TO THE ORDER OF Registry of Copyright $ 30 00/100

thirty and 00/100 DOLLARS Security features included. Details on back.

Madison Bank
35388 U.S. 19 N.
Palm Harbor
Florida 34684

FOR copyright regist [signature]

⑆263191086⑆005001010340611⑈ 2207

©HARLAND

FORM TX
UNITED STATES COPYRIGHT OFFICE

REGISTRATION NUMBER

TX TXU

EFFECTIVE DATE OF REGISTRATION

Month Day Year

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

1

TITLE OF THIS WORK ▼

Isotopic lifting of the Special Relativity

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Number ▼ Issue Date ▼ On Pages ▼

Nuovo Cimento 37 1983

2

NAME OF AUTHOR ▼

a RUGGERO MARIA SANTILLI

DATES OF BIRTH AND DEATH
Year Born ▼ 1935 Year Died ▼ 545-555

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE
Name of Country
OR { Citizen of ▶ U.S.A
Domiciled in ▶

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
Anonymous? ☐ Yes ☒ No
Pseudonymous? ☐ Yes ☒ No
If the answer to either of these questions is "Yes," see detailed instructions.

NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼

Scientific theory - Entire Text

NOTE

Under the law, the "author" of a "work made for hire" is generally the employer, not the employee (see instructions). For any part of this work that was "made for hire" check "Yes" in the space provided, give the employer (or other person for whom the work was prepared) as "Author" of that part, and leave the space for dates of birth and death blank.

NAME OF AUTHOR ▼

b

DATES OF BIRTH AND DEATH
Year Born ▼ Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☐ No

AUTHOR'S NATIONALITY OR DOMICILE
Name of country
OR { Citizen of ▶
Domiciled in ▶

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK
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NAME OF AUTHOR ▼

c

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Year Born ▼ Year Died ▼

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Name of Country
OR { Citizen of ▶
Domiciled in ▶

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3

YEAR IN WHICH CREATION OF THIS WORK WAS COMPLETED This information must be given in all cases. ◀ Year

DATE AND NATION OF FIRST PUBLICATION OF THIS PARTICULAR WORK
Complete this information ONLY if this work has been published. Month ▶ Day ▶ Year ▶
◀ Nation

4

COPYRIGHT CLAIMANT(S) Name and address must be given even if the claimant is the same as the author given in space 2. ▼

R. M. SANTILLI
Box 1577
PALM HARBOR, FL 34682

See instructions before completing this space.

APPLICATION RECEIVED

DO NOT WRITE HERE OFFICE USE ONLY

ONE DEPOSIT RECEIVED

TWO DEPOSITS RECEIVED

REMITTANCE NUMBER AND DATE

TRANSFER If the claimant(s) named here in space 4 are different from the author(s) named in space 2, give a brief statement of how the claimant(s) obtained ownership of the copyright. ▼

C26

EXAMINED BY

FORM TX

CHECKED BY

☐ CORRESPONDENCE Yes

☐ DEPOSIT ACCOUNT FUNDS USED

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PREVIOUS REGISTRATION Has registration for this work, or for an earlier version of this work, already been made in the Copyright Office? **5**

☐ Yes ☐ No If your answer is "Yes," why is another registration being sought? (Check appropriate box) ▼

☐ This is the first published edition of a work previously registered in unpublished form.

☒ This is the first application submitted by this author as copyright claimant.

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Names of Manufacturers ▼ Places of Manufacture ▼

REPRODUCTION FOR USE OF BLIND OR PHYSICALLY HANDICAPPED INDIVIDUALS A signature on this form at space 10, and a check in one of the boxes here in space 8, constitutes a non-exclusive grant of permission to the Library of Congress to reproduce and distribute solely for the blind and physically handicapped and under the conditions and limitations prescribed by the regulations of the Copyright Office: (1) copies of the work identified in space 1 of this application in Braille (or similar tactile symbols); or (2) phonorecords embodying a fixation of a reading of that work; or (3) both. **8**

a ☐ Copies and Phonorecords b ☐ Copies Only c ☐ Phonorecords Only

See instructions.

DEPOSIT ACCOUNT If the registration fee is to be charged to a Deposit Account established in the Copyright Office, give name and number of Account. **9**

Name ▼ Account Number ▼

CORRESPONDENCE Give name and address to which correspondence about this application should be sent. Name/Address/Apt/City/State/Zip ▼

R. M. SANTILLI Tel. 727-9349593

BOX 1577

PALM HARBOR, FL 34682

Area Code & Telephone Number ▶

Be sure to give your daytime phone ◀ number.

CERTIFICATION* I, the undersigned, hereby certify that I am the **10**

Check one ▶ ☐ author ☐ other copyright claimant ☐ owner of exclusive right(s) ☐ authorized agent of

Name of author or other copyright claimant, or owner of exclusive right(s) ▲

of the work identified in this application and that the statements made by me in this application are correct to the best of my knowledge.

Typed or printed name and date ▼ If this is a published work, this date must be the same as or later than the date of publication given in space 3.

R.M. SANTILLI date ▶ July 12, 1999

Handwritten signature (X) [signature]

MAIL CERTIFICATE TO **11**

Name ▼ RUGGERO M. SANTILLI

Number/Street/Apartment Number ▼ BOX 1577

City/State/ZIP ▼ PALM HARBOR, FL 34682

Certificate will be mailed in window envelope

Have you:
- Completed all necessary spaces?
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CERTIFICATE OF REGISTRATION

C27

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REGISTER OF COPYRIGHTS
United States of America

FORM TX
For a Literary Work
UNITED STATES COPYRIGHT OFFICE

REGISTRATION NUMBER

TXu 557 057

TX (TXU)

EFFECTIVE DATE OF REGISTRATION

12 24 92
Month Day Year

DO NOT WRITE ABOVE THIS LINE. IF YOU NEED MORE SPACE, USE A SEPARATE CONTINUATION SHEET.

1

TITLE OF THIS WORK ▼

"ELEMENTS OF HADRONIC MECHANICS"

PREVIOUS OR ALTERNATIVE TITLES ▼

PUBLICATION AS A CONTRIBUTION If this work was published as a contribution to a periodical, serial, or collection, give information about the collective work in which the contribution appeared. Title of Collective Work ▼

If published in a periodical or serial give: Volume ▼ Number ▼ Issue Date ▼ On Pages ▼

2

a NAME OF AUTHOR ▼ Ruggero Maria Santilli

DATES OF BIRTH AND DEATH Year Born ▼ 1935 Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☒ No

AUTHOR'S NATIONALITY OR DOMICILE Name of Country: OR { Citizen of ▶ U.S.A. / Domiciled in ▶ Palm Harbor FL }

WAS THIS AUTHOR'S CONTRIBUTION TO THE WORK Anonymous? ☐ Yes ☒ No Pseudonymous? ☐ Yes ☒ No — If the answer to either of these questions is "Yes," see detailed instructions.

NATURE OF AUTHORSHIP Briefly describe nature of the material created by this author in which copyright is claimed. ▼
New and revised text dealing with the isotopies and genotopies of the unit

b NAME OF AUTHOR ▼

DATES OF BIRTH AND DEATH Year Born ▼ Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☐ No

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c NAME OF AUTHOR ▼ ASSIGNED TO SANTILLI

DATES OF BIRTH AND DEATH Year Born ▼ Year Died ▼

Was this contribution to the work a "work made for hire"? ☐ Yes ☐ No

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R. M. SANTILLI

Imbedding of Lie Algebras in Nonassociative Structures.

1) SANTILLI'S PATERNITY OF q-DEFORMATIONS
2) ALBERT PATERNITY OF THE LIE-ADMISSIBLE CHARACTER
3) BOTH IGNORED BY DISHONEST PHYSICISTS

BOLOGNA
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1967

Imbedding of Lie Algebras in Nonassociative Structures (*).

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Istituto di Fisica dell'Università - Torino

(ricevuto il 31 Luglio 1967)

1. – As is known, there have been attempts to introduce new algebraic structures in physics other than *Lie algebras* (L.A.). One of the most interesting attempts is the Jordan investigation on the « r-number algebras », today called *(commutative) Jordan algebras* (C.J.A.) (¹), which however have not been successful in their physical applications.

We personally think that a possible reason for this disappointment in elementary-particle physics may be the want of L.A. content in the C.J.A. In other words L.A. should not be abandoned, but might be expanded. For instance the validity of L.A. for free particles is well known. It may be interesting to investigate the possible validity of new algebraic structures for an interacting or decaying region but only in such a way that the standard procedures corresponding to the free states remain unchanged, that is preserving in any case a well-defined L.A. content.

In this connection in the present paper we introduce an imbedding of L.A. in more general nonassociative structures, we choose a suitable nonassociative algebra for our extension and we briefly discuss the possibilities of physical applications.

2. – In the *imbedding*

$$L \to A \qquad (1)$$

of a given L.A. L into any algebra A, which we call the *extension* of L, a useful intermediate concept for preserving a Lie content is given by the concept of *Lie-admissible algebras* introduced by Albert (²). An algebra A with product ab is called

(*) Notes on a lecture given at the ICTP, Trieste, June 27, 1967.
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(¹) The C.J.A. are nonassociative algebras defined by the relations: i) $ab = ba$, and ii) $(a^2b)a = a^2(ba)$. They are subdivided into: i) the *special* C.J.A., which are characterized by the product $ab = \frac{1}{2}(a \cdot b + b \cdot a) = \frac{1}{2}\{a, b\}$ (we call $a \cdot b$ the associative product), and ii) the *exceptional* C.J.A., *i.e.* the algebras which are not special. For an extensive bibliography on C.J.A. see H. Braun and M. Koecher: *Jordan-Algebren* (Berlin, 1966).
(²) A. A. Albert: *Trans. A.M.S.*, 64, 552 (1948).

Lie-admissible if the algebra A^-, which is the same vector space as A with the product $ab - ba = [a, b]$, is a Lie algebra. For example, if A is an associative algebra, then A^- is the Lie algebra in the standard form known by the physicist; if A is a L.A. with product $ab = a \cdot b - b \cdot a$, then A^- is still a L.A. with product $ab - ba = 2(a \cdot b - b \cdot a)$. Hence associative and Lie algebras are Lie-admissible. On the contrary C.J.A. are trivially Lie-admissible, since A^- is always a zero algebra (*i.e.* a nilpotent algebra of degree 2).

In the following we are interested in the general case where A is a nonassociative algebra. Then, by using the Lie-admissibility concept, *the imbedding* (1) *may be performed according to*

$$L \to A^- \to A \,, \tag{2}$$

that is by imbedding the considered L.A. L in a nonassociative extension A such that A^- is isomorphic to L. The insufficiency of the C.J.A. for this type of imbedding then appears clear because of the commutativity of the product. Hence we must search for large algebraic structures.

In order of to find the explicit condition for Lie-admissibility, we note that the product of A^- is anticommutative by construction. Hence A is Lie-admissible if and only if A^- satisfies the Jacoby identity, that is

$$[a, b, c] + [b, c, a] + [c, a, b] = [c, b, a] + [b, a, c] + [a, c, b] \,, \qquad a, b, c \in A \,, \tag{3}$$

where $[a, b, c] = (ab)c - a(bc)$ is the *associator*, a quantity which represents the amount by which the elements of a nonassociative algebra fail to obey the associative law of multiplication.

If we introduce *flexibility*, a weaker condition than associativity expressed by $(ab)a = a(ba)$ for every $a, b \in A$, then the Lie-admissibility condition is given by the reduced form

$$[a, b, c] + [b, c, a] + [c, a, b] = 0 \,, \tag{4}$$

which looks like a generalization of the Jacoby identity.

There is also the *Jordan-admissibility* concept (²) which will be useful for a more exhaustive characterization of the imbedding. An algebra A with product ab is said to be Jordan-admissible if the attached algebra A^+, which is the same vector space as A with the product $\frac{1}{2}(ab + ba) = \frac{1}{2}\{a, b\}$, is a C.J.A., that is the following relaton is verified:

$$(a^2 b) a + a(ba^2) + (ba^2) a + a(a^2 b) = a^2(ba) + (ab) a^2 + a^2(ab) + (ba) a^2 \,. \tag{5}$$

We note that associative and (commutative) Jordan algebras are Jordan-admissible, but L.A. are trivially Jordan-admissible since A^+ is a zero algebra. Moreover an algebra which is (nontrivially) Lie- and Jordan-admissible is the associative algebra.

3. – Clearly there is a great number of nonassociative Lie-admissible algebras. In order that our investigation may give rise to an explicit choice with interesting physical possibilities some suitable supplementary conditions on A must be intro-

duced. In the present paper we consider the case when A is power-associative, trace-admissible and normed; then the simple nonassociative extensions A are only the *noncommutative Jordan algebras* (N.C.J.A.) (³) and among them (⁴) the most interesting Lie-admissible algebras are the (split) *quasi-associative algebras* $A(\lambda)$ (²), that is algebras characterized by the free scalar λ and the product

$$ab = \lambda a \cdot b + (1 - \lambda) b \cdot a = \lambda [a, b] + b \cdot a \,, \tag{6}$$

which constitute the basic algebras of the N.C.J.A.

Indeed (⁵) the only power-associative, simple and trace-admissible algebras are: i) the C.J.A.; ii) the quasi-associative algebras; iii) the flexible algebras of degree 2 (⁴). Furthermore (SCHAFER (1955) (³)) every N.C.J.A. is power-associative and trace-admissible, and every flexible Jordan-admissible algebra is a N.C.J.A., while (McCRIMMON (1965) (³)) every normed algebra is a separable N.C.J.A. Finally we note that (SCHAFER (1965) (³)) the radical R of a N.C.J.A. coincides with the radical of the Jordan algebra A^+, $A \ominus R$ is semi-simple and may be expressed as a direct sum of simple algebras.

The Jordan-admissibility concept has the following property (⁵): when A is power-associative and trace-admissible, then A is simple if and only if A^+ is simple. Consequently the imbedding (2) may be used for simple L.A. L

$$L \to A^- \to A \leftarrow A^+ \,; \tag{7}$$

the preservation of the simplicity for a power-associative trace-admissible extension A is guaranteed by the simplicity of A^+, A and A^+ also possessing the same radical. Our choice of power-associative trace-admissible algebras, that is the algebras of quasi-associative type, concerns algebras which are simultaneously (nontrivial) Lie- and Jordan-admissible as the associative algebras. Indeed $ab - ab = (2\lambda - 1) \cdot (a \cdot b - b \cdot a)$ and $\frac{1}{2}(ab + ba) = \frac{1}{2}(a \cdot b + b \cdot a)$. Furthermore $A(1)$ is isomorphic to an associative algebra; $A(0)$ is antiisomorphic to an associative algebra and $A(\frac{1}{2})$ is isomorphic to a special C.J.A. However in the $A(\lambda)$ algebra there is no finite value of λ to reduce the product (6) to the commutator (⁶), which lessens the physical interest. In this connection we now investigate a generalization of the $A(\lambda)$ algebras.

4. – Let A be any algebra with product ab over a field F and λ, μ be free scalars belonging to F. We define the algebra $A(\lambda, \mu)$ to be the (λ, μ)*-mutation* of the original

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(³) The N.C.J.A. are nonassociative algebras neither anticommutative nor commutative defined by the relations: i) $(ab)a = a(ba)$, and ii) $(a^2b)a = a^2(ba)$. They were first defined by R. D. SCHAFER: *Proc. A.M.S.*, **6**, 472 (1955). See also: BRAUN and KOECHER (¹); R. D. SCHAFER: *An Introduction to Nonassociative Algebras* (New York, 1966); *Proc. A.M.S.*, **9**, 110 (1958); *Trans. A.M.S.*, **94**, 310 (1960); L. A. KOKORIS: *Proc. A.M.S.*, **9**, 164 (1958); *Canad. Journ. Math.*, **12**, 448 (1960); L. J. PAIGE: *Port. Math.*, **16**, 15 (1957); R. H. OEHMKE: *Trans. A.M.S.*, **87**, 226 (1958); *Proc. A.M.S.*, **12**, 151 (1961); K. McCRIMMON: *Pacific Journ. Math.*, **15**, 925 (1965); *Proc. A.M.S.*, **17**, 1455 (1966); *Trans. A.M.S.*, **121**, 187 (1966).

(⁴) The simple N.C.J.A. of characteristic zero (we consider only algebras and fields of characteristic zero) have been classified by SCHAFER (1955) (³) according to: i) the simple C.J.A.; ii) the simple quasi-associative algebras; iii) the simple flexible algebras of degree 2.

(⁵) A. A. ALBERT: *Proc. N.A.S.*, **35**, 317 (1949).

(⁶) However, for $\lambda \to \infty$, $ab \to [a, b]$. The author is indebted to Prof. A. SALAM for this remark.

algebra, that is the same vector space as A but with the product (7)

$$(8)\qquad (a, b) = \lambda ab + \mu ba = \varrho[a, b] + \sigma\{a, b\}, \qquad \begin{cases} \lambda = \sigma + \varrho, \\ \mu = \sigma - \varrho. \end{cases}$$

ORIGIN OF q-DEFORMATIONS

We see clearly that: i) $A(1, 0)$ is isomorphic to A; ii) $A(0, 1)$ is antiisomorphic to A; iii) $A(1, -1)$ is isomorphic to A^-; iv) $A(\frac{1}{2}, \frac{1}{2})$ is isomorphic to A^+; v) $A(\lambda, 1-\lambda)$ is isomorphic to the λ-mutations of A.

Theorem 1. $A(\lambda, \mu)$ is power-associative for every $\lambda \neq -\mu$ if and only if A is power-associative and for $\lambda = -\mu$ it is trivially power-associative. *Proof*: the identities $[a, a, a] = 0$ and $[a, a, a^2] = 0$ are sufficient to guarantee the power-associativity of an algebra (for fields of characteristic zero as in our case). The power-associativity of $A(\lambda, \mu)$ is then easily reduced to the validity of the above relations for A.

Let us also note that the algebras $A(\lambda, \mu)$ satisfy the relation

$$(9)\qquad (a, a) = \gamma aa \qquad (\gamma = 2\sigma = \lambda + \mu),$$

namely powers in $A(\lambda, \mu)$ and A do not coincide for $\gamma \neq 1$. This is the first essential difference between the (λ, μ)- and λ-mutations of an algebra. If $\gamma = 1$ then the (λ, μ)- and λ-mutations are equivalent. Indeed

$$(a, b) = \varrho[a, b] + \tfrac{1}{2}\{a, b\} = (\varrho + \tfrac{1}{2})ab + (\tfrac{1}{2} - \varrho)ba = \lambda ab + (1 - \lambda)ba$$

for $\lambda = \varrho + \frac{1}{2}$.

Theorem 2. $A(\lambda, \mu)$ is flexible for every $\lambda, \mu \in F$ if and only if A is flexible *Proof*: we have

$$((a, b), a) = \lambda^2(ab)a + \lambda\mu(ba)a + \lambda\mu a(ab) + \mu^2 a(ba)$$

and

$$(a, (b, a)) = \lambda^2 a(ba) + \lambda\mu a(ab) + \lambda\mu(ba)a + \lambda\mu(ba)a + \mu^2(ab)a.$$

Hence, if $(ab)a = a(ba)$, then $((a, b), a) = (a, (a, a))$.

Theorem 3. $A(\lambda, \mu)$ is Lie-admissible for every $\lambda \neq \mu$ if and only if A is Lie-admissible. *Proof*: A^- and $[A(\lambda, \mu)]^-$ are defined by the respective products $ab - ba$ and $(a, b) - (b, a) = (\lambda - \mu)(ab - ba)$. Hence for $\lambda \neq \mu$ $[A(\lambda, \mu)]^-$ is isomorphic to the isotopic algebra A^{*-} (8) with product $a * b - b * a = (\lambda - \mu)ab - (\lambda - \mu)ba$.

For $\lambda = \mu$, $A(\lambda, \mu)$ is trivially Lie-admissible.

(7) For the case with A = associative algebra see also: R. M. SANTILLI and G. SOLIANI: *A statistics and parastatistics formal unification*, to appear.

(8) Given an algebra A with product ab and an invertible element c we can form an algebra A^*, called the *isotope* of A, with the product $a * b = acb$. As a particular case we may have $c = \alpha 1$, where α is a free (nonzero) scalar. Then the new multiplication in A^* is simply α times the old multiplication in A: $a * b = \alpha ab$.

Theorem 4. $A(\lambda, \mu)$ is Jordan-admissible for every $\lambda \neq -\mu$ if and only if A is Jordan-admissible. *Proof*: A^+ and $[A(\lambda, \mu)]^+$ are characterized by the respective products $\frac{1}{2}(ab + ba)$ and $\frac{1}{2}[(a, b) + (b, a)] = \frac{1}{2}(\lambda + \mu)(ab + ba)$. Hence $[A(\lambda, \mu)]^+$ is isomorphic to the isotopic algebra A^{*+} with product $\frac{1}{2}(a * b + b * a) = \frac{1}{2}(\lambda + \mu)(ab + ba)$.

For $\lambda = -\mu$, $A(\lambda, \mu)$ is trivially Jordan-admissible.

Theorem 5. If $U = A(\lambda, \mu)$, then, for $\lambda \neq \pm\mu$, $A = U(\alpha, \beta)$, where $\alpha = \lambda/(\lambda^2 - \mu^2)$ and $\beta = \mu/(\mu^2 - \lambda^2)$. *Proof*: since

$$(a, b) - (b, a) = (\lambda - \mu)(ab - ba) \qquad \text{and} \qquad (a, b) + (b, a) = (\lambda + \mu)(ab + ba),$$

we have

$$(10)\qquad ab = \frac{\lambda}{\lambda^2 - \mu^2}(a, b) + \frac{\mu}{\mu^2 - \lambda^2}(b, a).$$

Theorem 5 has the following consequences: as for the $A(\lambda)$ algebra (2), if R is a two-sided ideal of A, that is ba and $ab \in R$ for every $b \in R$ and $a \in A$, then (a, b) and $(b, a) \in R$. If $A = B \oplus R$, then $A(\lambda, \mu) = B(\lambda, \mu) \oplus R(\lambda, \mu)$. $R(\lambda, \mu)$ is solvable (nilpotent) if R is solvable (nilpotent), and the maximal solvable ideal of $A(\lambda, \mu)$ coincides with that of A. Hence $A(\lambda, \mu)$ is simple if A is simple, and $A(\lambda, \mu)$ can be given as a direct sum of simple algebras when the radical is zero, if the same occurs for A.

The possible interest of the (λ, μ)-mutations for physical applications is essentially given by the mutations of associative algebras A. In this case it is easy to show that $A(\lambda, \mu)$ is a realization of the N.C.J.A., since it is flexible and Jordan-admissible. Furthermore $A(\lambda, \mu)$ is an algebra of quasi-associative type (for $\lambda \neq -\mu$), indeed the associators in $A(\lambda, \mu)$ and $[A(\lambda, \mu)]^+$ are connected by the relation $[a, b, c] = (1 - \delta)[a, b, c]^+$, where $\delta = ((\lambda - \mu)/(\lambda + \mu))^2$ is the *discriminant* of the algebra (McCRIMMON (1966) (3)) (9).

The (λ, μ)-mutations of an associative algebra satisfy the following essential relations:

$$(11)\qquad \begin{cases} \text{i)} & (ab)a = a(ba), \\ \text{ii)} & (a^2 b)a = a^2(ba), \\ \text{iii)} & a^2 = \gamma a \cdot a \qquad (\gamma \in F), \\ \text{iv)} & [a, b, c] + [b, c, a] + [c, a, b] = 0, \end{cases}$$

where i) and ii) are the fundamental relations of the N.C.J.A., iii) connects powers in the associative algebra and powers in the corresponding mutation, and iv) represents the Lie-admissibility condition for flexible algebras.

(9) The author is indebted to Prof. K. McCRIMMON for a very kind letter (of June 12, 1967), where the connections between the $A(\lambda, \mu)$ and $A(\lambda)$ algebras are explicitly investigated. McCRIMMON notes that for $\varrho, \sigma \neq 0$, by putting $\tau = 2\sigma$, $\lambda' = \lambda/\tau$ and $\mu' = \mu/\tau$, we have $\lambda' + \mu' = 1$. Then $(a, b) = \lambda' \tau a \cdot b + \mu' \tau b \cdot a = \lambda' a^* \cdot b + (1 - \lambda') b^* \cdot a$. Hence $A(\lambda, \mu)$ is just the $(\lambda/2\sigma)$-mutation of the isotopic algebra A^*, *i.e.* $A(\lambda, \mu)$ is isomorphic to $A^*(\lambda/2\sigma)$. In addition we note that, since $\sigma = \lambda + \mu$, the isotopic algebra A^* characterized by the product $a^* \cdot b = (\lambda + \mu) a \cdot b$ is the zero algebra for $\lambda = -\mu$. Furthermore for $\lambda = -\mu$ $A(\lambda, \mu)$ corresponds to the ∞-mutation of the A^* (zero) algebra (see also footnote (8)). Hence the $A(\lambda, \mu)$ and $A(\lambda)$ algebras are equivalent for every $\lambda \neq -\mu$, while the case $\lambda = -\mu$ corresponds to the explicit Lie content of the $A(\lambda, \mu)$ algebras which occurs when the discriminant has the degenerate value ∞.

Theorem 6. If $A(\lambda, \mu)$ is an algebra of quasi-associative type, then $A(\lambda, \mu)$ is solvable if it is a nilalgebra and it is strongly nilpotent if it is solvable; the radical $R(\lambda, \mu)$ is the maximal solvable ideal such that $A(\lambda, \mu) \ominus R(\lambda, \mu)$ is semi-simple and has no nonzero nilideals; every semi-simple $A(\lambda, \mu)$ algebra can be given as a direct sum of simple algebras. *Proof*: The above statements hold for λ-mutations of an associative algebra (²). Hence they also hold for $[\lambda/(\lambda+\mu)]$-mutations of the isotopic algebras A^* with the product $a^* \cdot b = (\lambda+\mu) a \cdot b$.

For the case $\lambda = -\mu$ we prove the following

Theorem 7. If $\gamma = 0$, then relations (11) define a Lie algebra. *Proof*: If $\gamma = 0$, the condition $a^2 = 0$, which is the first relation for L.A., implies that the product is anticommutative, *i.e.* $ab = -ba$. Then the Lie-admissibility condition becomes the Jacoby identity, since $[a, b, c] + [b, c, a] + [c, a, b] = 2[(ab)c + (bc)a + (ca)b] = 0$. Furthermore flexibility becomes inessential since all Lie algebras are flexible, and condition ii) is trivially satisfied since $a^2 = 0$.

We conclude by noting that starting from a given Lie algebra which is the $(1, -1)$-mutation of an associative algebra, it is possible to perform an imbedding according to (7) by taking as extension the (λ, μ)-mutation of the original associative algebra, while the two-sided ideal, the derivations, the automorphisms and many other characteristics remain unchanged. In addition the given mathematical tool presents two free quantities belonging to the field which may have some physical interest. Particularly the (λ, μ)-product may be used: i) in the general form $(a, b) = \varrho[a, b] + \sigma\{a, b\}$, *i.e.* with two free scalars; ii) in the reduced form $(a, b) = \cos\alpha[a, b] + \sin\alpha\{a, b\}$, *i.e.* with the supplementary condition $\varrho^2 + \sigma^2 = 1$; iii) in the contracted form $(a, b) = [a, b] + \sigma\{a, b\}$, *i.e.* $\varrho = 1$ and only the scalar σ is free for « perturbation » of the Lie content.

Further investigations on the $A(\lambda, \mu)$ algebras particularly for what concerns the explicit construction of the basis, the classification of the matrix representations and the Pierce decomposition are in progress.

5. – Let us now discuss the possibilities of physical applications. At *a classical level* for nonconservative systems (¹⁰) there is already a physical application of imbedding (2) given by pseudo-Hamiltonian mechanics, introduced by DUFFIN, where the Poisson bracket may be imbedded in the more general Lie-admissible form (¹¹) $(a, b)_C = \sum_{i=1}^{n} \left(\lambda(\partial a/\partial q_i)(\partial b/\partial p_i) + \mu(\partial a/\partial p_i)(\partial b/\partial q_i)\right)$.

At *a quantum-mechanical level* for elementary-particle interacting or decaying regions (¹²) there are many problems to be investigated in order to evaluate the possibilities of application of the given procedure. Among these problems one of the most crucial is the possibility that imbedding implies a change of the statistical Bose or Fermi character of the particles in interaction or decay (¹¹·¹³).

(¹⁰) Clearly for conservative systems the Hamiltonian mechanics and Lie algebra are completely satisfactory.

(¹¹) R. M. SANTILLI: *Some remarks on pseudo-Hamiltonian mechanics*, to appear.

(¹²) Of course for free states Lie algebras are completely satisfactory. Their validity however becomes problematic for the same particles in interactions of for problems like the relativistic extension of the internal symmetries where infinite parameter Lie algebras occurs. See for instance: J. FORMÁNEK: *Czech. Journ. Phys.*, B 16, 1, 281 (1966).

(¹³) For instance, in the decay $\pi \to \mu + \nu$ there in the transition from bosons to fermions, which leaves open the problem of characterization of the decaying region from a statistical viewpoint (⁷).

In this connection the following approaches are being attempted:

i) $\varrho \to 1$, $\sigma \to 0$ (or the « angle » $\alpha \to 0$). In this case it is possible to investigate the connection between the given procedure and the approximation methods or the « neighbouring algebras » by SEGAL (¹⁴).

ii) ϱ, σ = *fixed quantities* (or α = fixed « angle »). In this case, by recalling that the fundamental representations of the SU_n Lie algebras are closed under both commutators and anticommutators (hence they are closed also for the $A(\lambda, \mu)$ algebra), it may be interesting to investigate the imbedding of the SU_3 (or SU_6) model in order to see if the given procedure may give a contribution to the problem of the (non) observability of the quarks and a more exact mathematical characterization of the physical numbers. Clearly it may be interesting also to investigate the imbedding of the equal-time commutation relations, current algebra and sum rules.

iii) ϱ, σ = *variable quantities* (or α = variable « angle »). In this case it is possible, for instance, to consider a physical region with σ everywhere zero (*i.e.* we have L.A. everywhere) and only a well-defined (and limited) region of validity of the imbedding with $\sigma \neq 0$ (or $\alpha \neq 0$). In this last case the physical acceptance of the procedure might be allowed by the indetermination principle.

* * *

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(¹⁴) I. E. SEGAL: *Duke Math. Journ.*, 18, 221 (1951).

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Lie-Isotopic Lifting of the Special Relativity for Extended Deformable Particles.

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Summary. – We recall the variation of the speed of light with the local physical conditions of the material media in which it propagates, and identify a corresponding class of generalized metrics. The underlying group of isometries is constructed via a Lie-isotopic lifting of the envelope, algebra and group structure of Lorentz transformations. It is shown that the generalized transformations, called Lorentz-isotopic, are apparently capable of characterizing an isotopic lifting of the special relativity for extended, and therefore deformable particles. The current experimental information on the apparent approximate character of the conventional Lorentz transformations in particle physics are reviewed, and a number of direct tests suitable for the resolution of the issue are indicated.

As is known, the constancy of the speed of light, the underlying Lorentz's invariant in Minkowski space

$$x^2 = x^t \eta x = x^\mu \eta_{\mu\nu} x^\nu = x^1 x^1 + x^2 x^2 + x^3 x^3 - x^4 c_0^2 x^4\,, \qquad x^4 = t \tag{1}$$

and the special relativity at large, were specifically conceived for motion in vacuum (intended as empty space), as limpidly stated in the historical contributions by LORENTZ, POINCARÉ, EINSTEIN, and others (1).

Nevertheless, it is known that the speed of light is not an absolute constant through the Universe, but possesses a rather complex functional dependence on the characteristics of light itself (*e.g.*, wave-length) and on the local quantities of the physical medium in which it propagates (*e.g.*, time, co-ordinates, velocity, index of refraction, density, etc.). Thus a more adequate invariant should express the local functional dependence of the speed of light, $c = c(t, r, \dot{r}, \dots)$, as well as the general inhomogenuity and unisotropy

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(1) An excellent account still remains that by W. PAULI: *Relativitätstheorie* (Lipsia, 1921).

NOTE FOR LAWSUIT THE FORMULATION BY CONVENTIONAL NUMBERS & FIELDS

UNQUESTIONABLE PATERNITY OF "SANTILLI" GENERALIZATION OF SPECIAL RELATIVITY, THE MINKOWSKI SPACE AND LORENTZ TRANSFORMS of material media, *e.g.*, it should be of the type

$$x^{\hat{2}} = x^t g x = x^\mu g_{\mu\nu}(x, \dot{x}, \ldots) x^\nu = x^1 b_1^2 x^1 + x^2 b_2^2 x^2 + x^3 b_3^2 x^3 - x^4 c^2 x^4 , \tag{2}$$

which preserves the topological structure of (1). Further generalizations, *e.g.* via a metric with a functional dependence of the type $g_{kk} = f_{kk}(b)$, $g_{44} = f_{44}(c)$, should not be excluded.

In regard to the motion of particles, the hystorical contributions ([1]) also stated, quite limpidly, that the applicability of invariant (1) should be restricted to pointlike particles moving in empty space ([2]). In fact, it was known that, whenever particles cannot be effectively approximated as massive points, their motion does not generally occur in empty space, but rather in material media. Even though not necessarily unique, a measure of the extended character of particles moving in material media is therefore given by a departure from the perfectly homogeneous and isotropic character of empty space, *i.e.* is provided by generalized invariants (at least) of type (2).

The validity of invariant (1) for electromagnetic interactions is now established by a truly impressive amount of experimental evidence. However, authoritative doubts on the validity of the same invariant for physical conditions of particles different than those conceived by LORENTZ, POINCARÉ, and EINSTEIN, have been expressed, since the early part of this century. For instance, in regard to the interior of strongly interacting particles and their nuclear forces, Fermi clearly expressed « doubts as to whether the usual concepts of geometry hold for such small regions of space » ([3]).

A systematic study of Fermi's legacy was suggested in ref. ([4]), and then conducted at the yearly *Workshops on Lie-admissible Formulations* ([5]). The approach is based on the notion of closed, variationally non–self-adjoint systems ([6]). These are systems which, when seen from the outside, verify conventional, total conservation laws. Nevertheless, their internal forces are generally (nonlocal and) non-Hamiltonian due to contact interactions among extended constituents for which the notion of potential energy has no physical meaning. The admission of an internal non-Hamiltonian interaction then implies the lack of exact character of the analytic, geometric and algebraic foundations of special relativity, in favour of suitable generalizations. In particular, the model implies that, while the center-of-mass motion of a hadron in vacuum is fully conformed to invariant (1), the motion of its constituents could be governed by the more general invariant (2). Thus, under the approximation of an isotropic medium with $b_1 = b_2 = b_3 = b$, invariant (2) characterizes the maximal speed

$$v_{\max} = c(t, r, \dot{r}, \ldots)/\sqrt{3}\, b(t, r, \dot{r}, \ldots) \gtreqless c_{\text{vacuum}} = c_0 \tag{3}$$

according to the hypothesis submitted in ref. ([7]), with $v_{\max} < c_0$ suggested for nuclear

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([2]) The early, well-written, treateses on special relativity stressed explicitly its restricted applicability to massive points (see, *e.g.*, the title of Chapt. VI of P. G. BERGMANN: *Introduction to Special Relativity* (Englewood Cliffs, N.J., 1942)). It is regrettable that this sound scientific caution has generally disappeared in more recent treateses on the subject.

([3]) E. FERMI: *Nuclear Physics* (Chicago, Ill., 1949), p. 111.

([4]) R. M. SANTILLI: *Hadronic J.*, **1**, 574 (1978).

([5]) *Proceedings of the Second Workshop on Lie-admissible Formulations*, Parts A and B, *Hadronic J.*, **3**, (1979); *Proceedings of the Third Workshop on Lie-admissible Formulations*, Parts A, B and C, *Hadronic J.*, **4** (1980); see also the *Proceedings of the First International Conference on Nonpotential Interactions and Their Lie-admissible treatment*, Parts A, B, C and D, *Hadronic J.*, **5** (1982).

([6]) R. M. SANTILLI: *Foundations of Theoretical Mechanics*, Vol. I (Berlin, 1978).

([7]) R. M. SANTILLI: *Lett. Nuovo Cimento*, **33**, 145 (1982).

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costituents, and $v_{max} > c_0$ suggested for hadronic constituents. Subsequent independent studies (8) within the context of unified gauge theories in a curved space have produced the first estimate for hadronic constituents $v_{max} = 75c_0$.

Possible internal deviations from invariant (1) in closed non-Hamiltonian systems, even though not directly detectable from the outside, can manifest themselves in a number of indirect ways. For instance, it has been suggested for a long time that possible nonlocal internal effects may imply deviations from standard predictions of the mean life of unstable hadrons in flight (9). A systematic study of this possibility has been conducted in ref. (10) (and quoted earlier papers) for the weak decays of hadrons within the context of unified gauge theories. The main idea is that a departure from invariant (1) occurs in the Higgs sector of spontaneous symmetry breaking according to the following particular case of (2):

$$(4)\qquad \begin{cases} x^{\hat{2}} = x^\mu g_{\mu\nu} x^\nu\,, & g_{\mu\nu} = \eta_{\mu\nu} + \chi_{\mu\nu}\,,\\ \chi_{44} = \alpha\,, & \chi_{kk} = \frac{1}{3}\alpha\,,\\ \alpha = (-3.79 \pm 1.37)\cdot 10^{-3} \quad \text{for } \pi^+\,, & \alpha = (0.61 \pm 0.17)\cdot 10^{-3} \quad \text{for } K^+ \end{cases}$$

with weighted average $\alpha = (0.54 \pm 0.17)\cdot 10^{-3}$. Subsequent independent calculations (11) give the similar value $\alpha = (3.6 \pm 5.2)\cdot 10^{-3}$, as well as predict an upper limit for experiments under way.

Deviations from invariant (1) are also at the foundation of a number of theoretical studies, such as the superluminal Lorentz transformations (12) or the Finsler treatment of local anisotropy (13), and may provide a unified interpretation of a number of experimental aspects, such as: $K^0\bar{K}^0$ regeneration experiment (14), anomalous behaviour of the magnetic moments (15), anomalous torques on electron spin (16), possible instability of the proton (17), and deviations from the discrete symmetries P (18), T (19), C (20) and PCT (21).

At any rate, the possible deformation of the charge distribution of hadrons, from the perfectly spherical shape $xx + yy + zz = 1$ into the ellipsoids $xb_1^2x + yb_2^2y + zb_3^2z = 1$, has been theoretically predicted in ref. (4) (pp. 786-797) via a Lie-admissible generalization of the enveloping algebra of SU_2, it has been quantitatively worked out in ref. (15,5), and it has been apparently confirmed via neutron interferometry to be about 1% for

(8) V. De Sabbata and M. Gasperini: *Lett. Nuovo Cimento*, **34**, 337 (1982).
(9) See, *e.g.*, D. Y. Kim: *Hadronic J.*, **1**, 1343 (1978), and quoted papers.
(10) H. B. Nielsen and I. Picek: *Nucl. Phys. B*, **211**, 269 (1983).
(11) R. Huerta-Quintanilla and J. L. Lucio: Fermilab preprint 83/18-THY (1983).
(12) E. Recami and R. Mignani: *Lett. Nuovo Cimento*, **4**, 144 (1972). For an updated review, see G. D. Maccarone and E. Recami: preprint INFN/AE-82/12 (1982), University of Catania, Italy.
(13) G. Yu. Bogoslovsky: *Nuovo Cimento B*, **40**, 99, 116 (1977); **43**, 377 (1978).
(14) S. H. Aronson, G. J. Bock, H. Y. Cheng and E. Fishback: *Phys. Rev. Lett.*, **48**, 1306 (1982).
(15) G. Eder: *Hadronic J.*, **4**, 634, 2018 (1981); **5**, 750 (1982).
(16) P. R. Phillips: *Rev. Sci. Instr.*, **50**, 1018 (1979).
(17) See, *e.g.*, A. Zee: *Phys. Rev. D*, **25**, 1864 (1982).
(18) See, *e.g.*, M. Forte, B. R. Heckel, N. F. Ramsey, K. Green, G. L. Green, J. Byrne and J. L. Pendlebury: *Phys. Rev. Lett.*, **45**, 2088 (1980).
(19) R. J. Slobodrian, C. Rioux, R. Roy, H. E. Conzett, P. von Rossen and F. Interberger: *Phys. Rev. Lett.*, **47**, 1803 (1981); C. Rioux, R. Roy, R. J. Slobodrian and H. E. Conzett: *Nucl. Phys. A*, **394** (1983); and R. A. Hardekopf, P. W. Keaton, P. W. Lisowski and L. R. Veseer: *Phys. Rev. C*, **25**, 1090 (1982).
(20) See, *e.g.*, the B.C.D.M.S. Collaboration: J.I.N.R. Preprint EI-82-656 (1982), Dubna, U.S.S.R.
(21) See, *e.g.*, I. I. Bigi: *Z. Phys. C*, **12**, 235 (1982).

neutrons in the intense fields in the vicinity of Mu-metal nuclei (see ref. [22] and quoted earlier tests). It is evident that a deformation of the charge distribution of hadrons, that is, a deformation of the space component of invariant (1) into that of (2) with consequential, manifest, rotational asymmetry, must necessarily imply the transition to the entire invariant (2). At a deeper study, it emerges that the deformation of the charge distribution of extended particles can be considered as the ultimate physical foundation of virtually all studies reviewed here. By recalling that pointlike particles cannot be deformed and that their rotational symmetry cannot be broken (irrespective of the interactions considered), the ultimate conceptual foundations of invariant (2) in particle physics can be seen in the extended character of hadrons, with a corresponding profile for classical settings.

In this letter, we shall summarize our studies on a possible generalization of the special relativity for extended particles. A detailed presentation will appear elsewhere. The hope is that all the independent, theoretical and experimental contributions considered here (as well as others not indicated for brevity) may, one day, result to be different foundations of one, single, underlying physical theory [23].

The mathematical methods used in our analysis are those of the so-called *Lie-isotopic theory* [24-27]. The term «lifting» is often used as one way to differentiate the emerging generalizations from other approaches, *e.g.*, those characterized by maps.

The generalized relativity will be constructed along lines parallel to those of the isotopic lifting of Galilei's relativity submitted in ref. [25]. We are referring to a generalized relativity characterized by a Lie symmetry whose abstract, co-ordinate-free form *coincides* with that of the conventional relativity. The generalized relativity, therefore, essentially consists of *the most general possible realization of a known abstract symmetry* [25-27]. The terms *Galilei-isotopic relativity* have been submitted in ref. [25] for the nonrelativistic case, while the terms *Lorentz-isotopic relativity* are submitted here, for the relativistic one. The understanding is that other terms are equally conceivable such as «Poincaré-isotpic» or «Einstein-isotopic».

For the reader's convenience, we recall that the Lie-isotopic theory is based on the following main aspects:

a) isotopic lifting of the universal enveloping associative algebra $\mathscr{E}$ with conventional associative product AB and unit I, $IA = AI = A$, into the form $\hat{\mathscr{E}}$ character-

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([22]) H. RAUCH: *Hadronic J.*, **5**, 729 (1982).

([23]) A possible unification of the different studies considered will inhevitably call for revisions aimed at mutual compatibility. For instance, invariant (2) and related Lorentz-asymmetry is conceived to be dependent on local physical conditions and, thus, it is expected to vary not only from the weak to the strong and to other interactions, but alsô from reaction to reaction within each type of interaction. In fact, not only the value, but even the sign of the Lorentz asymmetry parameter α of eqs. (4) is different for the π^+ and K^+ decays. As a result, to reach unification with other models along the same lines, studies aiming at a sort of «universal Lorentz asymmetry», should be revised as to admit a local dependence of the Lorentz-asymmetry, *i.e.* a local dependence of the speed of light.

([24]) The notion of isotopy is rather old in abstract algebras, although generally ignored in contemporary literature. Apparently, its first application to Lie's theory (enveloping algebras, Lie algebras, and Lie groups) was made by R. M. SANTILLI: *Hadronic J.*, **4**, 223 (1978), pp. 287-290 and 329-374, as an intermediary step toward the Lie-admissible generalization of Lie's theory. A review of the state of the art in 1982 is presented in ref. [25], pp. 148-183. Specific applications to the generalization of pseudo-Euclidean spaces have been presented in ref. [16,17]. Mathematical studies can be found in ref. [4].

([25]) R. M. SANTILLI: *Foundations of Theoretical Mechanics*, Vol. II (Berlin, 1982).

([26]) R. M. SANTILLI: *Lie-isotopic liftings of Lie's theory*. - I: *General considerations*, I.B.R. preprint DE-83-2 (1983), submitted for publication.

([27]) R. M. SANTILLI: *Lie-isotopic liftings of Lie's theory*. - II: *Lifting of rotations*, I.B.R. preprint DE-83-2 (1983), submitted for publication.

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ized by the product $A * B = A\mathcal{T}B$ and the new identity $\hat{I} = \mathcal{T}^{-1}$, $\hat{I} * A = A * \hat{I} = A$, where $\mathcal{T}$ is fixed and nonsingular;

b) isotopic lifting of the (continuous) Lie transformation group $G: x' = gx = \exp[Xu]|_{\mathscr{E}} x$, into the form $\hat{G}: x' = \hat{g} * x = \exp[Xu]|_{\hat{\mathscr{E}}} * x = \exp[X\mathcal{T}u]|_{\mathscr{E}} x$, where X and u are the generator and parameter, respectively, of the original group; and

c) isotopic lifting of the Lie algebra $G: [X_i, X_j] = X_i X_j - X_j X_i = C_{ij}^k X_k$ into the form $[X_i \hat{,} X_j] = X_i * X_j - X_j * X_i = \hat{D}_{ij}^k * X_k$, where $\hat{D} = D\hat{I}$;

with underlying methodology, such as the Lie-isotopic extension of the Poincaré-Birkhoff-Witt theorem (for the construction of a basis of $\hat{\mathscr{E}}$); of the Baker-Campbell-Hausdorff theorem (for the isotopic composition law); of Lie's first, second and third theorems (for the isotopic commutation rules); etc.

More particularly, we shall use the following property of the Lie-isotopic theory worked out in the recent paper ([26]).

Theorem 1. Let $G(m)$ be a m-parameter Lie symmetry group of the composition $z^\dagger \delta z = \bar{z}^i \delta_{ij} z^j$ of a n-dimensional Euclidean space $E(n, \delta, \mathsf{F})$ over the field F of real numbers R, complex numbers C, or quaternions Q. Then, the isotopic lifting $\hat{G}(m)$ of $G(m)$ characterized by a nonsingular, Hermitian, and sufficiently smooth metric g in the local variables, leaves invariant the generalized composition $\bar{z}^i g_{ij} z^j$ of the isotopic space $\hat{E}(n, g, \hat{\mathsf{F}})$, $\hat{\mathsf{F}} = \mathsf{F}\hat{I}$.

The theorem essentially states that, when the isotopic element $\mathcal{T}$ (characterizing all associative products) is given by the new metric $g(t, z, \dot{z}, \ldots)$, the new unit is the Casimir invariant of order zero, $\hat{I} = g^{-1}$. The form invariance of the new metric is then consequential, as the interested reader can verify without the analysis of ref. ([25]).

In the subsequent paper ([27]), we have constructed the isotope $\hat{O}_3$ of O_3, that is, the generalization of the conventional rotation group which leaves invariant all possible deformations of the sphere, $x^1 b_1^2 x^1 + x^2 b_2^2 x^2 + x^3 b_3^2 x^3 = 1$. As expected, $\hat{O}_3$ turned out to be locally isomorphic to O_3 under the assumed metric (or to $O_{2,1}$ in other cases).

In this paper, we shall construct a generalization of the Lorentz's transformations verifying the following conditions.

A) The generalized transformations act in the *Minkowski-isotopic space*, *i.e.* in the lifting $\hat{E}(4, g, \hat{\mathsf{R}})$ of $E(4, \delta, \mathsf{R})$ with points $x = (x^1, x^2, x^3, x^4 = t)$ characterized by the metric g of composition (2), according to the transformation laws

$$x' = \hat{A} * x = \hat{A} g x', \qquad x^{t\prime} = x^t * \hat{A}^t = x^t g \hat{A}^t, \tag{5}$$

under the condition that they leave invariant separation (2), *i.e.* verify the properties

$$x^{t\prime} * x' = x^t * \hat{A}^t * \hat{A} * x \equiv x^t * x = x^t g x, \tag{6a}$$

$$\hat{A}^t * \hat{A} = \hat{I}, \qquad (\det \hat{A})^2 = (\det g^{-1})^2. \tag{6b}$$

B) The transformations so defined constitute a Lie-isotopic group, *i.e.* they verify the isotopic group laws

$$\hat{A}(0) = \hat{I}, \qquad \hat{A}(u) * \hat{A}(u') = \hat{A}(u + u'), \qquad \hat{A}(u) * \hat{A}(-u) = \hat{I}, \tag{7}$$

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C) The generalized transformations characterize a covering of the conventional Lorentz transformations, in the sense that they apply to a broader physical arena (extended particles moving in material media), while admitting the conventional theory (for pointlike particles) as a particular case.

As anticipated earlier, the transformations verifying conditions A), B), C), will be called *Lorentz-isotopic* and their group, denoted with $\hat{O}_{3,1}$, will be called the *Lorentz-isotopic group*.

To simplify the construction, we use the factorizations $\hat{A} = A\hat{I} \in \hat{O}_{3,1}$ and $\hat{N} = N\hat{I} \in \hat{R}$, under which we ignore the lifting $\hat{R}$ of the field R (for which $\hat{N} * x = Nx$), while conditions (6b) assume the simpler form $A^t g A = g$, $\det A = \pm 1$. The assumption of the metric $g = \mathrm{diag}(b_1^2, b_2^2, b_3^2, -c^2)$ then implies the preservation under lifting of the connectivity properties of $O_{3,1}$, resulting in the components $\hat{O}^{\uparrow}_{\pm 3,1}$ and $\hat{O}^{\downarrow}_{\pm 3,1}$. It is possible to prove that $\hat{O}^{\uparrow}_{+3,1}$ forms a (Lie-isotopic) group, while the remaining components, which are characterized by the isotopic inversions

$$
(8)\qquad \begin{cases} x' = \hat{P} * x = Px = (-r, t)\,, \\ x' = \hat{T} * x = Tx = (r, -t)\,, \\ x' = \hat{P} * \hat{T} * x = \widehat{PT} * x = PTx = (-r, -t)\,, \end{cases}
$$

do not form a group unless combined with $\hat{O}^{\uparrow}_{+3,1}$, as in the standard case.

The construction of the Lorentz-isotopic group is, therefore, reduced to that of $\hat{O}^{\uparrow}_{+3,1}$, whose explicit form is given by

1) *The isotopic lifting of the enveloping associative algebra $\mathscr{E}$ of $O^{\uparrow}_{+3,1}$*

$$
(9)\qquad \hat{\mathscr{E}}:\quad \hat{I} = g^{-1}\,,\quad X_k\,,\quad X_i * X_j\,,\quad X_i * X_j * X_k, \ldots \qquad i<j\,,\quad i<j<k\,,
$$

where the basis X_k consists of the ordered set of the conventional 4×4 generators of O_4, say, $\boldsymbol{J}$ and $\boldsymbol{M}$, as given, *e.g.*, in ref. ([28]), p. 42, under the redefinition

$$
(10)\qquad \begin{cases} X = \{\tilde{J}_k, \tilde{M}_k\}\,, \quad \tilde{J}_1 = b_2^{-1} b_3^{-1} J_1\,, \quad \tilde{J}_2 = b_1^{-1} b_3^{-1} J_2\,, \\ \tilde{J}_3 = b_1^{-1} b_2^{-1} J_3\,, \quad X^{\dagger} = -X\,, \quad \tilde{M}_k = b_k^{-1} M_k\,, \quad k = 1, 2, 3\,. \end{cases}
$$

2) *The isotopic lifting of the proper Lorentz group* characterized by the following expansions in $\hat{\mathscr{E}}$

$$
(11)\qquad \hat{O}^{\uparrow}_{+3,1}:\quad \hat{A}_g(\theta, u) = \left(\prod_{k=1}^{3}{}^{*} \exp[\tilde{J}_k \theta_k]|_{\hat{\mathscr{E}}}\right) * \left(\prod_{k=1}^{3}{}^{*} \exp[\tilde{M}_k u_k]|_{\hat{\mathscr{E}}}\right) =
$$
$$
= \left(\prod_{k=1}^{3} \exp[\tilde{J}_k g \theta_k]\right)\left(\prod_{k=1}^{3} \exp[\tilde{M}_k g u_k]\right)\hat{I}\,,
$$

where the θ's and u's are the conventional parameters of $O^{\uparrow}_{+3,1}$, and the last exponentials are the conventional ones.

([28]) P. ROMAN: *Theory of Elementary Particles* (Amsterdam, 1964).

3) *The isotopic lifting of the Lie algebra of the Lorentz group*

$$(12)\qquad \hat{O}^{\dagger}_{+3,1}\begin{cases}[\hat{J}_i \,\hat{,}\, \hat{J}_j] = -\varepsilon_{ijk}\hat{J}_k\,,\\ [\hat{M}_i \,\hat{,}\, \hat{M}_j] = c^2\varepsilon_{ijk}\hat{J}_k\,,\\ [\hat{J}_i \,\hat{,}\, \hat{M}_j] = -\varepsilon_{ijk}\hat{M}_k\,,\end{cases}$$

with related isotopic Casimir invariants

$$(13)\qquad \begin{cases}\hat{C}_1 = \tilde{J}^{\hat{2}} - \dfrac{1}{c^2}\tilde{M}^{\hat{2}} = \sum\limits_{k=1}^{3}\left(\tilde{J}_k g\tilde{J}_k - \dfrac{1}{c^2}\tilde{M}_k g\tilde{M}_k\right) = -3\hat{I}\,,\\ \hat{C}_2 = \tilde{J} * \tilde{M} = \sum\limits_{k=1}^{3}\tilde{J}_k g\tilde{M}_k = 0\,.\end{cases}$$

It is evident that, by construction, *the groups $\hat{O}_{3,1}$ and $O_{3,1}$ coincide at the abstract, co-ordinate-free level, by therefore being locally isomorphic* (for the metric $g = \mathrm{diag}\,(b_1^2, b_2^2, b_3^2, -c^2)$—see below for other cases). In fact, the structure constants of $\hat{O}^{\dagger}_{+3,1}$ coincide with those of $O^{\dagger}_{+3,1}$ for the case considered here (co-ordinates $(\boldsymbol{r}, t)$ and metric $\mathrm{diag}\,(+1, +1, +1, -c_0^2)$) The extension of the local isomorphism to the full groups $\hat{O}_{3,1}$ and $O_{3,1}$ is then trivial.

Despite that, the explicit form of the transformations of $\hat{O}^{\dagger}_{+3,1}$ and $O^{\dagger}_{+3,1}$ are significantly different. For instance, a Lorentz-isotopic transformation in the plane (3, 4) is given by

$$(14)\qquad x' = \begin{pmatrix} z' \\ t' \end{pmatrix} = \hat{A} * x = \begin{pmatrix} \cosh(uc) & -(c/b_3)\sinh(uc) \\ -(b_3/c)\sinh(uc) & \cosh(uc) \end{pmatrix}\begin{pmatrix} z \\ t \end{pmatrix},$$

$$b_3 = b_3(t, z, \ldots)\,,\qquad c = c(t, z, \ldots)$$

and can be written

$$(15)\qquad \begin{cases} z' = \hat{\gamma}(z - vt)\,, & \cosh(uc) = \hat{\gamma} = (1 - vb_3^2 v/c^2)^{-\frac{1}{2}}\,,\\ t' = \hat{\gamma}(-vb_3^2 z/c^2 + t)\,, & \sinh(uc) = \dfrac{vb_3}{c}\hat{\gamma}\,.\end{cases}$$

Numerous other examples of Lorentz-isotopic transformations can be explicitly computed with the methods presented here, *e.g.*, via expansions (11), where the only unknown is the assumed generalized metric. Explicit examples of isotopic rotations have been computed in ref. ([27]).

It is an instructive exercise for the interested reader to prove that the Lorentz-isotopic transformations verify all conditions *A*), *B*), *C*), by therefore constituting a *covering* of the conventional transformations. Their most salient difference is that the former are generally *nonlinear*, as evident from the dependence on the local co-ordinates of the metric g entering the expansions (11) and related explicit forms of type (15). As a matter of fact, this intrinsic nonlinearity, expressed in a formally linear theory (at the isotopic level), renders the covering transformations particularly intriguing for a number of problems, such as the characterization of hadrons and their interactions or decays.

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It should be indicated at this point that the $\hat{O}_{3,1}$ symmetry holds for all possible metrics g under the restrictions that they are nonsingular, Hermitean (and, thus, diagonalizable), and verify sufficient continuity properties. Thus, the $\hat{O}_{3,1}$ symmetry holds for a class of invariants substantially broader than (2). However, in relaxing condition C), we lose the covering nature of the generalized transformations. Also, in relaxing the positive definite character of the element g_{kk} and $-g_{44}$, the local isomorphism between $\hat{O}_{3,1}$ and $O_{3,1}$ is generally lost. The occurrence will be investigated in detail elsewhere.

Note that $\hat{O}_{3,1}$ contains as a particular case the generalized Lorentz transformations introduced in ref. (13) for the invariant

$$x^{\hat{2}} = x^\mu g_{\mu\nu} x^\nu = x^\mu [(v^\alpha \eta_{\alpha\beta} x^\beta / x^\alpha \eta_{\alpha\beta} x^\beta)^{r/2} \eta_{\mu\nu}] x^\nu \,, \tag{16}$$

where $\eta_{\mu\nu}$ is the conventional Minkowskian metric, v^α is a vector along the direction of anisotropy, and r is a scale parameter. The underlying transformations are then given by (11), *e.g.*, by (15) with $vb_3^2 z = vz$ and $\hat{\gamma} = [(1 - v/c)/(1 + v/c)]^{r/2}(1 - v^2/c^2)^{-\frac{1}{2}}$, and they exhibit an appreciable difference with the conventional ones only for speeds very close to that of light. However, the relationship with $\hat{O}_{3,1}$ demands specific investigations.

Similarly, isotopic transformations (11) can be enlarged to include the case $x'^{\hat{2}} = -x^{\hat{2}}$, by therefore permitting a generalization of the superluminous transformations of ref. (12) to the case of *variable* speeds of light. Other cases will be indicated elsewhere.

We now touch the problem of the *Lorentz-isotopic relativity*, that is, the relativity characterized by transformations (11). Our remarks will be as elementary as possible and restricted to the plane (3, 4) with $g_{33} = b^2$ and $g_{44} = -c^2$. The understanding is that at least two space dimensions are needed for an effective characterization of extended particles.

1) *Maximal speed of massive, ordinary particles.* The reader should keep in mind that the Lorentz-isotopic relativity is specifically conceived for the case when the speed of light, not only is different than that in vacuum, but possesses a dependence on local quantities of the type (2). Geometrically, this implies a deformation of the light-cone according to fig. 1. The following particular cases are then relevant.

Case 1*A*) $v_{\max} = c_0$, $c < c_0$. This is the case, for instance, of the Čerenkov light in water which travels at the speed $c = c_0/n < c_0$, while ordinary electrons can travel at $v_{\max} = c_0 > c$. The case is readily represented by the Lorentz-isotopic relativity with $b = 1/n$ and $c = c_0/n$.

Case 1*B*) $v_{\max} < c_0$, $c < c_0$. This case is predicted by the theory as a modification of case 1*A*) when particles cannot be considered as pointlike. Additional studies are, however, needed to reach quantitative predictions for each given medium and each given extended particle.

Case 1*C*) $v_{\max} < c_0$, $c > c_0$. This is the case submitted in ref. (7) for nuclear constituents, where the speed c is referred not necessarily to light itself, but to any causal signal propagating within hadronic matter.

Case 1*D*) $v_{\max} > c_0$, $c > c_0$. This is the case submitted in ref. (7) for the hadronic constituents, where the interpretation of c is the same as that of case 1*C*).

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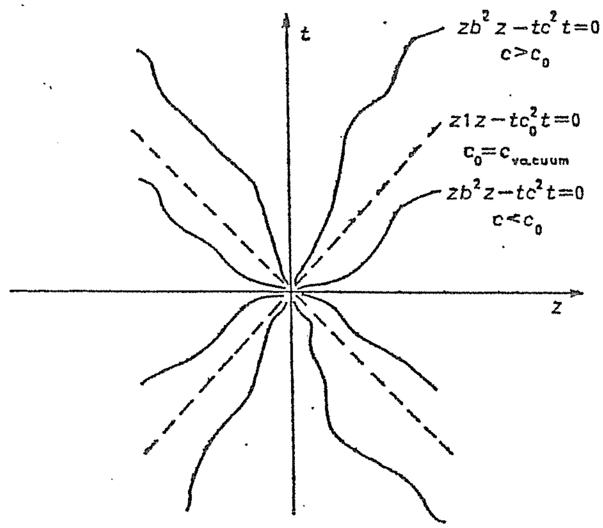

Fig. 1. – A schematic view of the deformation of the cone of light in vacuum predicted by the Lorentz-isotopic relativity submitted in this paper. The most dominant physical concept results to be the extended character of the particles considered (such as hadrons), with consequential possibility of the deformation of their spherical charge distribution into ellipsoids for sufficiently intense, short-range, external forces. In turn, these deformations imply deviations, first, from the rotational symmetry, and then from the Lorentz symmetry. Deformations of the light-cone are then unavoidable under the conditions considered. In the final analysis, they merely represent the dependence of the speed of light on the local characteristics of the material medium in which it propagates. Only two cases are considered in the figure. The first with $c < c_0$ depicts the Čerenkov light (which is fully represented by the Lorentz-isotopic relativity); while the second with $c > c_0$ depicts the hypothesis submitted in ref. (7), according to which causal signals can propagate within hadronic matter with speeds higher than that of light in vacuum owing to expected contact forces among extended particles which, besides not admitting a Hamiltonian, are instantaneous by conception. The deformations of the light-cone here submitted appear to be confirmed by a number of experimental data, although in a preliminary way, such as: the measures of rotational-asymmetry of ref. (22), the data of Lorentz asymmetry of ref. (19), and others.

2) *Isotopic composition of speeds*. The use of successive transformations (15) readily yields the composition of speed according to the isotopic rule

$$v_{tot} = (v_1 + v_2)/(1 + v_1 b^2 v_2/c^2) .$$

The maximal possible speed of particles is then compatible with (3). This is in full agreement with experimental evidence for the case of the Čerenkov light (case 1*A*)), and appears plausible for the remaining cases.

3) *Isotopic proper time, dilation, and contraction*. The remaining aspects of the Lorentz-isotopic relativity can be developed via suitable generalizations of the conventional setting. For instance, the proper time of the theory is the $\hat{O}_{3,1}$-scalar

$$d\tau^2 = dt^2 - dr b^2 dr/c^2 = dt^2 \hat{\gamma}^{-2} .$$

The time dilation is then given by $\Delta t = \Delta t_0 \hat{\gamma}$, while the Lorentz contraction is given by $\Delta l = \Delta l_0 \hat{\gamma}^{-1}$. Thus, the Lorentz-isotopic relativity implies deviations from the

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standard predictions for the case of extended particles moving within material media, whether a macroscopic charge moving within a liquid, or a hadron moving whitin hadronic matter. In the final analysis, this is precisely the case of the deviations from the mean life of unstable hadrons considered earlier [9,10].

As concluding remarks, we can say that, on classical grounds, the Lorentz-isotopic relativity represents in full the physical conditions of the Čerenkov light (for which no further test is needed) and extrapolates them to the case of extended particles (for which additional theoretical studies are needed to achieve quantitative predictions suitable for experiments).

In regard to particle physics, the Lorentz-isotopic relativity has been conceived to represent extended particles, that is particles that can be deformed under sufficiently intense external fields, resulting first in the rotational asymmetry $xb_1^2x + yb_2^2y + zb_3^2z = 1$, and then in Lorentz-asymmetric invariants of type (2). Deviations from the standard mean life and other predictions of the special relativity are then consequential.

The available direct experimental infomation reviewed earlier is encouragingly in favour of the need for a generalization of the special relativity, hopefully of the unifying type submitted here, although the information is far from a final form.

The needed fundamental tests are evidently those on the *continuous* part of the conventional Lorentz symmetry (besides those on the discrete part calling for a separate analysis), *e.g.*:

i) Finalization of the apparent Lorentz-boost asymmetry in the mean life of unstable hadrons (and *not* leptons) in flight, with particular reference to pions and kaons, according to the experiments reviewed, *e.g.*, in ref. [10]. In order to be effective for the selection of the suitable generalization of the law $\Delta t = \Delta t_0(1 - v^2/c^2)^{-\frac{1}{2}}$ and of the underlying metric, the experiments should finalize possible deviations per each individual particle (because expected to be different for different particles), and at different energies (because important for the selection of the generalized metric whether, *e.g.*, with a Minkowskian or a Finslerian topology);

ii) Finalization of the apparent 1% deformation/rotational-asymmetry of low-energy neutrons within the intense fields in the vicinity of nuclei, as reported in ref. [22] via interferometric measures on the periodicity of the neutron wave functions for two spin flips. The tests should then be repeated according to a number of suitable variations, *e.g.*, for $2n$ spin flips, $n = 1, 2, 3, \ldots$ (apparently, current technology in neutron interferometry can permit up to 50 spin flips); or via linear increases of the width of the material penetrated by the neutron beam (whose nuclear fields are responsible for the apparent deformation/rotational asymmetry); etc.

iii) Finalization of possible, sufficiently small deviations from Pauli's exclusion principle in open nuclear reactions, as theoretically predicted in ref. [4], elaborated by a number of authors in ref. [5] and not excluded in the tests of neutron-tritium scattering of ref. [22] and quoted recent experiments.

It is evident that the ultimate roots of tests i), ii), iii) (and several others that are conceivable along the same lines) are given by the possible deformation of the charge distribution of hadrons (and, possibly, of their constituents) under sufficiently intense, short-range fields. In fact, such deformation (tests ii)) implies a manifest, generally small, rotational-asymmetry. In turn, the transition from the space part of invariant (1) to that of (2) implies the necessary transition to the entire invariant (2). A deviation from the Lorentz boosts is then consequential (tests i)). On the other side, a rotational asymmetry may well imply a corresponding, sufficiently small deviation from the exact fermionic character of nucleons. A corresponding deviation from Pauli's exclusion principle is then also consequential (tests iii)). (Apparently, the rotational asymmetry seems also to imply deviations from the discrete symmetries because, while

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the generators $\hat{P}$, $\hat{T}$, etc. isotopically commute with $\hat{O}^{\dagger}_{+3,1}$ in the frame in which invariant (2) is diagonal, such commutativity demands specific studies in arbitrary frames for which the metric is not diagonal.)

But, above all, the most encouraging aspect is that all tests i), ii), iii) and others, are well within current technical capabilities (besides being of quite moderate cost when compared to high-energy experiments). The physics community has, therefore, reached in full the capability to resolve experimentally the apparent approximate character of the conventional Lorentz transformations in particle physics.

On theoretical grounds the basic issue is so simple to appear trivial. The special relativity was conceived for pointlike particles moving in empty space. When extended particles moving in material media are considered, deviations from the special relativity are expected to be consequential. The selection of the appropriate generalization will of course be the result of a long scientific process of trial and error. But the insufficiency for extended particles of the relativity of pointlike particles should be out of question.

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Nonlinear, nonlocal and noncanonical isotopies of the Poincarè symmetry

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Abstract. We first outline the nonlinear-nonlocal-noncanonical,axiom-preserving isotopies of: fields, metric and Hilbert spaces, transformation theory, Lie's theory and quantum mechanics. We then apply these novel techniques to the construction of the isotopies of the Poincarè symmetry $P(3.1){=}SO(3.1){\times}T(3.1)$ as well as of its spinorial covering $\mathcal{P}(3.1){=}SL(2.C){\times}T(3.1)$. We finally point out a number of preliminary, yet intriguing applications and experimental verifications in nuclear physics, particle physics, superconductivity and other fields.

1. Statement of the problem

As is well known, the fundamental symmetries of contemporary theoretical physics, the Lorentz symmetry [1] $O(3.1)$, the Poincarè symmetry [2] $P(3.1) = SO(3.1) \times T(3.1)$ and the spinorial covering [3] $\mathcal{P}(3.1) = SL(2.C) \times T(3.1)$, are linear, local and canonical.

According to impressive experimental evidence, these symmetries have resulted to be *exactly* verified under well known physical conditions which can be identified, classically and quantum mechanically, with those of the *exterior dynamical problem*, i.e., point-like particles moving in the homogeneous and isotropic vacuum under action-at-a-distance interactions. In fact, the point-like character of the particles ensures the exact validity of the underlying local-differential geometry, while their potential character ensures the exact applicability of Lie's theory in canonical realization.

The physical conditions studied in this paper are those of the more general *interior dynamical problem*, which consists of *extended*, and therefore *deformable* particles while moving within *inhomogeneous* and *anisotropic* physical media, thus resulting in the most general known systems which are: *nonlinear*, in the coordinates x *and* in their derivatives $\dot{x}, \ddot{x}, \ldots$ as well as in the wavefunctions ψ *and* in their derivatives $\partial\psi, \partial\partial\psi, \ldots$; *nonlocal*, in the sense of having a generally integral dependence on all of the preceding quantities; and *noncanonical*, i.e., violating the integrability conditions for the existence of a Lagrangian or a Hamiltonian, the *conditions of variational selfadjointness* [4].

The distinction between exterior and interior problems was identified by the

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founders of analytic mechanics, such as Lagrange, Hamilton and Jacobi (see, e.g., [4], and kept up to the early part of this century (one may inspect the care with which Schwartzschild [5] presented his metrics in two separate papers, one for the exterior and one for the interior problem), although the distinction was abandoned in more recent times.

In this paper we shall return to the teaching of the founders of analytic mechanics, because recent studies have proved the impossibility of reducing interior systems to the exterior form. This is due to the so-called *No-reduction theorems* [4], which essentially state that an interior system such as a satellite during re-entry with monotonically decaying angular momentum, simply cannot be decomposed into a finite collection of elementary constituents each of which has conserved angular momentum. Vice versa, the latter cannot possibly reproduce the former.

It is evident that the linear-local-canonical Poincarè symmetry is *inapplicable* (and not 'violated') for nonlinear-nonlocal-noncanonical interior systems on a number of independent counts of topologic, geometric, algebraic and analytic nature. The objective of this paper is therefore to identify the generalization of the Poincarè symmetry $P(3.1)$ and of its spinorial form $\mathcal{P}(3.1)$ verifying the following conditions:

(A) The generalized *transformations* are structurally nonlineal, nonlocal and noncanonical so as to be directly applicable to the invariance of the systems considered.

(B) The generalized *symmetry* is locally isomorphic to the conventional symmetry, so as to preserve the structural axioms of contemporary physics.

(C) The generalized symmetry admits the conventional Poincarè symmetry as a particular case, so that the former can qualify as a mathematical and physical covering of the latter.

We should therefore indicate from the outset that, by no means, we want to 'abandon' the structural axioms of the Poincarè symmetry, because our objective is merely that of realizing them in their most general possible form.

We should also indicate that this presentation is merely preliminary and still far from the needed mathematical and physical maturity, because the studies are just at the beginning and so much remains to be done, mathematically and physically.

We would like finally indicate that the line of inquiry of this paper is definitely not new, having been initiated by numerous physicists, most notably, by Blochintsev (see, e.g., [6]) and his group at the JINR in Dubna, Russia. More recently, another line of inquiry has been initiated via the so-called *q-deformations* and *quantum groups* by numerous authors (see, e.g., [7]). We apologize for our inability to review other generalizations for brevity.

A novelty of our studies rests in the presentation of the structural axioms of the Poincarè symmetry, thus permitting a number of developments, such as a *causal* description of *nonlocal* interactions. In fact, the Poincarè axiomatic structure is generally lost in the q-deformations and other approaches. However, as shown by Lopez [8], the q-deformations are particular cases of the techniques used in this paper. Thus, most (but not all) of the existing studies on the q-deformation of the Poincarè symmetry can be reformulated in our axiom-preserving form.

2. Isotopies and isodualities of contemporary mathematical structures

The methods which permit the achievement of the objectives identified in the preceding section were introduced by this author [9] back in 1978 (when at the Department of

Mathematics of Harvard University with support from the US Department of Energy), under the name of *isotopies*, from the Greek 'ισοσ τοποσ', meaning 'same configuration' and interpreted as 'axiom-preserving'.

The fundamental isotopy from which the entire content of this paper can be derived, is the lifting of the n-dimensional unit $I = \mathrm{diag.}(1, 1, \ldots, 1)$ of Lie's theory into an n-dimensional matrix $\hat{I}$ whose elements have the most general known dependence indicated in section 1,

$$\begin{aligned} &I = \mathrm{diag.}(1, 1, \ldots, 1) \rightarrow \\ &\hat{I} = \hat{I}(t, x, \dot{x}, \ddot{x}, \psi, \psi^\dagger, \partial\psi, \partial\psi^\dagger, \partial\partial\psi, \partial\partial\psi^\dagger, \ldots) \end{aligned} \tag{2.1}$$

under the condition (necessary for an isotopy) of preserving the original axioms of I, i.e., nonsingularity, Hermiticity and positive-definiteness.

The isotopies of the unit demand, for consistency, a corresponding, compatible lifting of all associative products AB among generic quantities A, B, into the *isoproduct*

$$\begin{aligned} &AB \Rightarrow A * B = ATB \qquad T = \text{fixed and inv.} \\ &IA = AI \equiv A \rightarrow I * A = A * I \equiv A \end{aligned} \tag{2.2}$$

whose isotopic character is ensured by the preservation of associativity, $A(BC) = (AB)C \rightarrow A * (B * C) = (A * B) * C$. Under the above conditions, $\hat{I}$ is called the *isounit* and T the *isotopic element*.

One should recall the *necessity*, e.g., in number theory, of changing the multiplication whenever the unit is changed and vice versa. Note also that in q-deformations of associative algebras, $AB \rightarrow qAB$, the multiplication is changed, but the conventional unit of Lie's theory is preserved. The reformulation of these q-deformations in terms of the isotopies, $qAB = A * B$, $\hat{I} = q^{-1}$, permits their generalization and axiomatization into the most general possible integro-differential operator T (which, for this reason is sometimes denoted Q) [8].

The isotopies of the unit $I \Rightarrow \hat{I}$ and of the product $AB \Rightarrow A * B$ are mathematically and physically nontrivial, inasmuch as they imply the necessary lifting of *all* mathematical structures of contemporary physics into an isotopic form admitting of $\hat{I}$ as the left and right unit (see, e.g., [10–15, 18–41]. For brevity, we can here only touch the most salient aspects.

To begin our outline, the conventional fields $F(a, +, \times)$ of real numbers R, complex number C, and quaternions Q with elements a, conventional sum $+$ and product $a \times b := ab$, must be lifted into the so-called *isofields*

$$\begin{aligned} &F(a, +, *) \rightarrow \hat{F}(\hat{a}, +, *) \qquad \hat{a} = a\hat{I} \\ &\hat{a} * \hat{b} = \hat{a}T\hat{b} = (ab)\hat{I} \qquad \hat{I} = T^{-1} \end{aligned} \tag{2.3}$$

with elements $\hat{a}$ called *isonumbers*, conventional sum $+$ and isoproduct (2.2), under the condition (again necessary for an isotopy) of preserving the original axioms of F. All operations in F must then be generalized for $\hat{F}$. We then have, e.g., *isosquares* $\hat{a}^{\hat{2}} = \hat{a} * \hat{a} = \hat{A}T\hat{a} = a^2\hat{I}$, *isoquotient* $\hat{a}\hat{/}\hat{b} \doteq (a/b)\hat{I}$, *isosquare roots* $\hat{a}^{1/2} = a^{1/2}\hat{I}$, etc. Note that $\hat{a} * A \equiv aA$ (see the recent studies [10] for details).

One can begin to understand the inapplicability of conventional mathematical thinking for isotopic formulations by noting that statements such as 'two multiplied by two equals four' are generally incorrect under isotopies. In fact, for $\hat{I} = 3$, 'two multiplied by two equals twelve', with the understanding that the very notion of integer number is lost in favour of an integro-differential generalization, e.g., DI9

$$\hat{2} = 2 \exp\left\{ N \int \mathrm{d}x \, \psi\dagger(x)\phi(x) \right\}.$$

Liftings $I \Rightarrow \hat{I}$, $AB \Rightarrow A * B$ and $F \Rightarrow \hat{F}$ then require the isotopies of carrier spaces, evidently because they centrally depend on the field in which they are defined. For example, a real metric/pseudo-metric space $S(x, g, R)$ must be subjected to the liftings into the so-called *isospaces* (first introduced in [11] as the foundations of the isolorentz symmetry)

$$\begin{aligned} &S(x,g,R) \ \Rightarrow \ \hat{S}(x,\hat{g},\hat{R}) \qquad \hat{g} = Tg \\ &\hat{I} = T^{-1} \qquad x^{\hat{2}} = (x^{t}\hat{g}x)\hat{I} \in \hat{R} \end{aligned} \tag{2.4}$$

under the condition, again, of preserving the original axioms of $S(x, g, R)$, with similar isotopies for complex spaces. In particular, *the basis of a metric (or, more generally, vector) space is preserved under isotopies*, thus including the preservation of the basis of a Lie algebra. This results in nonlinear (in $\dot{x}, \ddot{x}, \ldots$), nonlocal and noncanonical generalizations of the Euclidean, symplectic and Riemannian geometries called *isogeometries* [12, 13], with intriguing novel possibilities.

Another understanding of the inapplicability of conventional mathematical thinking for isotopic formulation can be reached by noting that all familiar notions (such as that of angles) are inapplicable in isospaces, trivially, because they are spaces with the most general known curvature, that depending also on the velocities and accelerations, thus implying the loss of straight intersecting lines. A novel aspect of the isogeometries is that they are isotopic, that is, they preserve the original geometric axioms, thus permitting the recovering of the original notions, although in a generalized form [12, 13].

These features have permitted the identification of a new branch of functional analysis called *functional isoanalysis* [14] which begins with a classification of the isounits into five, topologically different classes with corresponding classification of s, isospaces, etc herein adopted. In this paper we shall mainly use class I (for isounits which are smooth, bounded, nowhere singular, Hermitean and positive-definite), and class II (the same except that the isounits are negative-definite), with only marginal comments on the remaining classes for brevity.

The next necessary lifting is that of the conventional linear transformations in S, into the so-called *isotransformations* in $\hat{S}$ [9]

$$\begin{aligned} &x' = U(w)x \qquad w \in F \ \rightarrow \ x' = \hat{U}(\hat{w}) * x = \hat{U}(\hat{w})Tx \\ &T = \text{fixed} \qquad \hat{w} \in \hat{F} \end{aligned} \tag{2.5}$$

which are *isolinear* in $\hat{S}$, i.e., verify the conventional axioms of linearity merely expressed in the appropriate isotopic form

$$\hat{U} * (\hat{n} * r + \hat{n}' * r') = \hat{n} * (\hat{U} * r) + \hat{n}' * (\hat{U} * r') \qquad \hat{n}, \hat{n}' \in \hat{R} \tag{2.6a}$$

$$(\hat{n} * \hat{U} + \hat{n}' * \hat{U}') * r = \hat{n} * (\hat{U} * r) + \hat{n}' * (\hat{U}' * r)$$

$$\hat{U} * (\hat{U}' * r) = (\hat{U} * \hat{U}') * r. \tag{2.6b}$$

However, the same transforms are highly nonlinear when projected in the original space S, i.e., $x' = \hat{A}(w)Tx = \hat{A}(w)T(x, \dot{x}, \ddot{x}, \psi, \psi^{\dagger}, \ldots)x$. Note that nonlinear transformations can always be cast into an *identical* isolinear form. We learn in this way that *isotopic methods can turn notoriously difficult nonlinear problems into identical more manageable isolinear forms.*

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A similar occurrence holds for locality, because isotransforms $x' = \hat{U}(\hat{w}) * x$ are *isolocal*, i.e., verify the condition of locality in $\hat{S}$, but the same transforms are generally nonlocal-integral when projected in the original space S. Yet a similar occurrence holds for canonicity. In fact, the theories herein considered are called *isocanonical* in the sense that they are derivable from conventional variational principles formulated in $\hat{S}$, although the same theories are not derivable from a first-order variational principle in S. The objectives of this paper (section 1) can now be formulated by saying that *we shall seek isolinear, isolocal and isocanonical realizations of the Lorentz and Poincarè symmetries.*

The preceding liftings demand a corresponding compatible lifting of all branches of Lie's theory [16, 17]). In fact, the universal enveloping associative algebra $\xi(g)$ of a Lie algebra g [17] with generic product AB, must be lifted into the isotopes $\hat{\xi}(g)$ with isounit $\hat{I} = T^{-1}$ and isoproduct (2.2), first introduced in [9] jointly with the isotopy of the Poincarè–Birkhoff–Witt theorem. These studies permitted the identification of the infinite-dimensional *isobasis* of $\hat{\xi}$ in terms of the original (ordered) basis X of g and the *isoexponentiation* (see [18] for nonassociative envelopes)

$$\begin{aligned} \hat{\xi}: \quad & \hat{I} \quad X_i * X_j \quad (i \leqq j) \\ & X_i * X_j * X_k \quad (i \leqq j \leqq k), \ldots \; i, j, k = 1, 2, \ldots, n \end{aligned} \tag{2.7a}$$

$$\begin{aligned} e_{\hat{\xi}}^{\mathrm{i}\hat{w}*X} &= \hat{I} + (\mathrm{i}\,\hat{w} * X)/1! + (\mathrm{i}\,\hat{w} * X) * (\mathrm{i}\,\hat{w} * X)/2! + \cdots \\ &= \{e^{\mathrm{i}XTw}\}\hat{I} = \hat{I}\{e^{\mathrm{i}wTX}\}. \end{aligned} \tag{2.7b}$$

One can therefore see that all notions based on the conventional exponentiation need a suitable isotopic generalization. For instance, the Dirac δ-function must be lifted into the expression called *isoDirac function* [15, 19, 20]

$$\hat{\delta}(x) = (1/2\pi) \int_{-\infty}^{+\infty} \mathrm{d}y\, T e_{\hat{\xi}}^{\mathrm{i}xy} = (1/2\pi) \int_{-\infty}^{+\infty} \mathrm{d}y\, e^{\mathrm{i}xTy} \tag{2.8}$$

the conventional Fourier transform must be lifted into the *isoFourier transform* [15, 20]

$$\begin{aligned} f(x) &= (1/2\pi) \int_{-\infty}^{+\infty} \mathrm{d}k\, g(k) * e_{\hat{\xi}}^{\mathrm{i}kx} \\ g(k) &= (1/2\pi) \int_{-\infty}^{+\infty} \mathrm{d}x\, f(x) * e_{\hat{\xi}}^{\mathrm{i}kx} \end{aligned} \tag{2.9}$$

with consequential loss of the notion of Gaussian into the form (here re-expressed in terms of the conventional exponentiation for clarity) [15, 20]

$$\psi(x) = N e^{-x^2 T/2a^2} \qquad \phi(k) = N' e^{-k^2 T a^2/2}. \tag{2.10}$$

The nontriviality of functional isoanalysis can then be easily seen by noting that the above isoGaussians imply the following predictable generalization of Heisenberg's uncertainties: $\Delta x \Delta k \approx a^{-1}a = 1 \rightarrow a^{-1}T^{-1/2}aT^{-1/2} = \hat{I}$ evidently for particles in interior conditions (see also next section). The need for the isotopies of all remaining special functions transforms and distribution follows.

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The preceding liftings evidently require that of Lie algebra [16, 17] $g \approx [\xi(g)]^-$ with familiar Lie theorems, e.g., $[X_i, X_j]_\xi = X_i X_j - X_j X_i = C_{ij}{}^k X_k$, into the *Lie-isotopic algebras* $\hat{g} \approx [\hat{\xi}(g)]^- \not\approx g$ first submitted in [9] with the *Lie-isotopic theorems*, e.g.,

$$\begin{aligned} \hat{g}: \quad [X_i, X_j]_{\hat{\xi}} &= X_i * X_j - X_j * X_i = X_i T X_j - X_j T X_i \\ &= \hat{C}_{ij}{}^k(t, x, \dot{x}, \ddot{x}, \psi, \psi^\dagger, \ldots) * X_k \end{aligned} \tag{2.11}$$

where the $\hat{C}$s are called *structure functions*, and are restricted by the Lie-isotopic third theorem [9]. Note the presentation of the Lie algebra axioms by the isotopic product $[AB]_{\hat{\xi}}$.

The preceding isotopies then yield the (connected) *Lie-isotopic transformation groups* [9]

$$\begin{aligned} &\hat{U}(0) = \hat{I} \qquad \hat{U}(\hat{w}) * \hat{U}(\hat{w}') = \hat{U}(\hat{w}') * \hat{U}(\hat{w}) = \hat{U}(\hat{w} + \hat{w}') \\ &\hat{U}(\hat{w}) * \hat{U}(-\hat{w}) = \hat{I} \end{aligned} \tag{2.12a}$$

$$\begin{aligned} &\hat{G}: \quad x' = \hat{U} * x \\ &\hat{U}(w) = \prod_k e_{\hat{\xi}}^{\mathrm{i}\hat{w}_k * X_k} = \hat{I}\left\{\prod_k e^{\mathrm{i}w_k T X_k}\right\} = \left\{\prod_k e^{\mathrm{i}X_k T w_k}\right\}\hat{I} \end{aligned} \tag{2.12b}$$

$$\begin{aligned} &\{e_{\hat{\xi}}^{\mathrm{i}X_1}\} * \{e_{\hat{\xi}}^{\mathrm{i}X_2}\} = e_{\hat{\xi}}^{\mathrm{i}X_3} \\ &X_3 = X_1 + X_2 + [X_1, X_2]_{\hat{\xi}} + [(X_1 + X_2) \hat{;} [X_1, X_2]_{\hat{\xi}}]_{\hat{\xi}}/12 + \cdots \end{aligned} \tag{2.12c}$$

where one should note the appearance of the isotopic element T directly in the iso-exponent, thus ensuring the desired nonlinear, nonlocal and noncanonical character. The above isogroups are turned into *isosymmetries* via the following

Theorem [21]. Let G be an N-dimensional Lie group of isometries of an m-dimensional, metric or pseudo-metric, and real or complex space $S(x, g, F)$ over a field $F(= R \text{ or } C)$,

$$\begin{aligned} G: \quad & x' = A(w)x \\ & (x' - y')^\dagger A^\dagger g A (x' - y') \equiv (x - y)^\dagger g (x - y) \\ & A^\dagger g A = A g A^\dagger = g. \end{aligned} \tag{2.13}$$

Then, the infinitely possible isotopes $\hat{G}$ of G of class III characterized by the same generators and parameters of G and new isounits $\hat{I}$ (isotopic elements T), leave invariant the isocomposition on the isospaces $\hat{S}(x, \hat{g}, \hat{F})$, $\hat{g} = Tg$, $\hat{I} = T^{-1}$,

$$\begin{aligned} \hat{G}: \quad & x' = \hat{A}(w) * x \\ & (x' - y')^\dagger * \hat{A}^\dagger \hat{g} \hat{A} * (x' - y') = (x - y)^\dagger \hat{g} (x - y) \\ & \hat{A}^\dagger \hat{g} \hat{A} = \hat{A} \hat{g} \hat{A}^\dagger = \hat{I} \hat{g} \hat{I}. \end{aligned} \tag{2.14}$$

This yields the 'direct universality' of the Lie-isotopic symmetries, i.e., their capability of providing the invariance of all infinitely possible deformations $\hat{g} = Tg$

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of the original metric g (universality), directly in the frame of the experimenter (direct universality). Note also the simplicity of the explicit construction of the desired isosymmetries via rule (2.12b) where w and X are those of G and T is derived from the deformed metric $\hat{g} = Tg$.

It is easy to prove that $\hat{G} \approx G$ for all class isotopies ($\hat{I} > 0$). This property identifies one of the primary applications of isosymmetries, the reconstruction of exact symmetries when believed to be conventional broken. In fact, we have: the reconstruction of the exact rotational symmetry at the isotopic level $\hat{O}(3) \approx O(3)$ for all ellipsoidical deformations of the sphere [21]; the reconstruction of the exact Lorentz and Poincarè symmetries at the isotopic level $\hat{P}(3.1) \approx P(3.1)$ for all signature preserving ($T > 0$) deformations of the Minkowski metric $\hat{\eta} = T\eta$ [11]; the reconstruction of the *exact* isospin symmetry at the isotopic level $\hat{SU}(2) \approx SU(2)$ under *weak and* ELM *interactions*; while other cases are under study (e.g., the possible reconstruction of the *exact* parity for *weak* interactions at the isotopic level).

Despite the isomorphism $\hat{G} \approx G$, Lie and Lie-isotopic symmetries are inequivalent on numerous counts, such as:

(1) G is customarily linear-local-canonical, while $\hat{G}$ is nonlinear-nonlocal-noncanonical;

(2) the mathematical structures underlying $\hat{G}$ and G (fields, spaces, etc) are structurally different;

(3) $\hat{G}$ can be derived from G via *nonunitary* transformations under which

$$UU^\dagger = \hat{I} \neq I \qquad U(AB - BA)U^\dagger = A'TB' - B'TA'$$
$$T = (UU^\dagger)^{-1} = T^\dagger \qquad A' = UAU^\dagger \qquad B' = UBU^\dagger . \tag{2.15}$$

Visible differences also emerge in the *isorepresentation theory* [22, 23], e.g., because weights, Cartan tensors, etc acquire a nonlinear-nonlocal-noncanonical dependence on the base manifold. The irreducible isorepresentations of Lie-isotopic algebras $\hat{g}$ have been preliminarily classified into [22]: (1) *regular isorepresentations*, when the structure constants of g and $\hat{g}$ coincide, in which case the eigenvalues of g and $\hat{g}$ differ by suitable *multiplicative* functions on the base manifolds; (2) *irregular isorepresentations*, when the original structure constant of g are turned into *structure functions*, in which case at least one of the eigenvalues of $\hat{g}$ and g is not related by a multiplicative factor; and (3) *standard isorepresentations*, when both the structure constants and eigenvalues $\hat{g}$ coincide with those of g, even though T is a nontrivial isotopic element.

In closing this section we should also recall that isotopies introduce rather naturally the antihomomorphic conjugation called *isoduality* first identified in [21] $\hat{I} \to \hat{I}^d = -\hat{I}$, $A * B \to A *^d B = -A * B$, with consequential isoduality of all the preceding structures. In fact, isoreals $\hat{R}$ are mapped into the *isodual isoreals* [10] $\hat{R}^d(\hat{n}^d, +, *^d)$, $\hat{n}^d = n\hat{I}^d = -\hat{n}$, $*^d = \times T^d \times = -*$, with rather intriguing properties, such as negative-definite norm $\hat{|}\hat{n}^d\hat{|}^d = -\hat{|}\hat{n}\hat{|} < 0$, $\hat{n} \neq 0$. The isocomplex $\hat{C}(\hat{c}, +, *)$ are mapped into the *isodual isocomplex* fields $\hat{C}^d(\hat{c}^d, *, d)$ with conjugation $\hat{c} \to \hat{c}^d = -\hat{c}\dagger$. Similarly, isospaces $\hat{S}(x, \hat{g}, \hat{R})$ are mapped into the *isodual isospaces* [12, 13] $\hat{S}^d(x, \hat{g}^d, \hat{R}^d) : \hat{g}^d = -\hat{g}$, which evolve *backward in time*, have *negative-definite* physical quantities such as energy, etc. Yet the isodual separation $x^{\hat{2}d}$ coincides with the isoseparation $x^{\hat{2}}$, $x^{\hat{2}d} = (x^t\hat{g}^d x)\hat{I}^d \equiv x^{\hat{2}} = (x^t\hat{g}x)\hat{I}$, thus permitting an intriguing novel interpretation of antiparticles from their known origin in the negative-energy solutions of conventional relativistic equations [24].

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Similarly, Lie-isotopic algebras $\hat{g}$ and groups $\hat{G}$ admit the *isodual algebras* $\hat{g}^d$ and *groups* [12, 13] $\hat{G}^d$ on $\hat{S}^d(x, \hat{g}^d, \hat{R}^d)$ over $\hat{F}^d$ in which the generators, the parameters and the isotopic element change sign

$$\hat{g}^d: \quad [X^d{}_i, X^d{}_j]_{\hat{\xi}^d} = -X^d{}_i T^d X^d{}_j - X^d{}_j T^d X^d{}_i$$
$$= \hat{C}^d{}_{ij}{}^k(t, x, \dot{x}, \ddot{x}, \psi, \psi^\dagger, \ldots) T^d X^d{}_k \qquad (2.16a)$$
$$\hat{G}^d: \quad x' = \hat{U}^d(\hat{w}) T^d x$$
$$\hat{U}^d(\hat{w}) = \prod_k e_{\hat{\xi}^d}{}^{i^d \hat{w}^{d *d} X^d{}_k} = \left\{ \prod_k e^{iX_k T w_k} \right\} \hat{I}^d \qquad (2.16b)$$

thus leading to a new *universal invariance law under sodality* [13]. Similar isodualities occur for the isoDirac function, the isoFourier transform, etc. See monograph [25] for a detailed study.

3. Isotopies and isodualities of quantum mechanics

The isotopic methods were proposed by this author for the specific purpose of constructing the isotopies of quantum mechanics (QM), originally submitted under the name of *hadronic mechanics* (HM) [26] also called *isotopic completion of quantum mechanics* [27].

The original proposal was studied by numerous authors in the ensuing years. A detailed presentation of the state of the art in the construction of this new discipline is available in monographs [28], with the understanding that these too are at the beginning and so much remains to be done. Here, we can evidently touch only some of the most essential aspects.

The objective is to construct a covering discipline capable of quantitative studies suitable for experimental verifications of the old legacy that particle interactions have a nonlinear-nonlocal-noncanonical component due to mutual overlapping of their wavepackets–wavelengths–charge distributions. Along conditions (A), (B), (C) of section 1, the covering discipline is constructed in such a way as to permit a direct representation of interior conditions in a way preserving the abstract axioms of QM for exterior conditions, as well as admitting the latter as a particular case.

By recalling that Lie's theory in operator realization characterizes the structure of QM, one can easily see that the Lie-isotopic theory in operator realization characterizes the structure of HM. In fact, the essential structural elements of HM can already be seen in the preceding section, e.g., in the isoDirac delta (2.8) because the original singularity at $x = 0$ can be spread over the region of space occupied by the particle. In turn, we should expect the capability of HM to remove the divergencies of QM for suitable values of the isotopic element $|T| \ll 1$ [15, 28].

In order to achieve an operator realization of the Lie-isotopic theory, the fundamental isotopy of HM is that of the underlying space, the Hilbert space $\mathcal{H}$ with inner product $< \psi \mid \phi > \in C$, into the so-called *isoHilbert space* $\hat{\mathcal{H}}$ with *isoinner product* and *isonormalization* first introduced in [19]

$$\hat{\mathcal{H}}: \quad < \hat{\psi} \hat{|} \hat{\phi} > = < \hat{\psi} \mid T \mid \hat{\phi} > \hat{I} \in \hat{C}$$
$$< \hat{\psi} \hat{|} \hat{\psi} > = \hat{I} \qquad (\text{or } < \hat{\psi} \mid * \mid \hat{\psi} > = 1). \qquad (3.1)$$

Note that the isoinner product remains inner for isotopies of class I (i.e., $\hat{\mathcal{H}}$ is still Hilbert) because of the positive-definiteness of T. For future needs to understand the isotopic realization of 'hidden variables', note that $\mathcal{H}$ and $\hat{\mathcal{H}}$ coincide at the abstract level and that, for T independent of the integration variables (or a constant), $< \hat{\psi} \hat{|} \hat{\phi} >=< \hat{\psi} \mid \hat{\phi} > T\hat{I} \equiv < \hat{\psi} \mid \hat{\psi} >$.

An important implication of the isotopy $\mathcal{H} \rightarrow \hat{\mathcal{H}}$ is that operators X on the enveloping algebra ξ over $F(= R, C)$ which are Hermitean in $\mathcal{H}$, remain Hermitean in $\hat{\mathcal{H}}$ when reinterpreted on the isoenvelope $\hat{\xi}$ over $\hat{F}$ [29, 30]. This yields the important property that *relativistic* QM *observables remain observable for* HM, thus including the observability of all conventional quantities, such as energy, linear momentum, angular momentum, spin parity, etc.

The liftings of the Hilbert space require corresponding isotopies of all conventional operations [15, 29, 30]. We here mention the *isounitary transformations*

$$\hat{U} * \hat{U}^{\hat{\dagger}} = \hat{U}^{\hat{\dagger}} * \hat{U} = \hat{I} \tag{3.2}$$

which can *turn conventionally nonunitary transformations* (2.15) *into a form axiomatically equivalent to the unitary ones*; the *isoeigenvalue equations*

$$H* \mid \hat{\psi} >= HT \mid \hat{\psi} >= \hat{E}* \mid \hat{\psi} \qquad \hat{E} \in \hat{R}. \tag{3.3}$$

The *isodeterminant* of a matrix A (see [28–30] for additional properties)

$$\hat{\text{Det}} A = [\text{Det}(AT)]\hat{I} \in \hat{R} \text{ or } \hat{C}. \tag{3.4}$$

We are now equipped to outline the basic axiomatic structure of HM [15, 28] on isoEuclidean spaces $\hat{E}(r, \hat{\delta}, \hat{R})$, $\hat{\delta} = T\delta$, for isounits of class I without gravitational content (i.e., for $\partial \hat{I} / \partial r \equiv 0$):

Fundamental assumptions. (A)integro-differential generalization $\hat{\hbar} = \hat{I} = T^{-1}$ of Planck's unit $\hbar = 1$; (B)reconstruction of the entire QM formalism to admit $\hat{I}$ as the correct left and right unit; and (C) representation of all local-potential forces with the Hamiltonian $H = K + V$ and all nonlocal-nonpotential interactions with the isounit $\hat{I}$ (or isotopic element T), as per the preceding isotopic methods and following physical axioms:

Isoaxiom I. The states are elements of a isoHilbert space $\hat{\mathcal{H}}$ interpreted as (left or right) isomodule with isoeigenvalue equations and isonormalization

$$H* \mid \hat{\psi} >= HT \mid \hat{\psi} >= \hat{E}* \mid \hat{\psi} > \qquad < \hat{\psi} \hat{|} \hat{\psi} >= \hat{I} = T^{-1}. \tag{3.5}$$

Isoaxiom II. Measurable quantities are represented by isocommuting isoHermitean operators on $\hat{\mathcal{H}}$ whose eigenvalues are conventional real numbers,

$$H^{\hat{\dagger}} \equiv H^{\dagger} \qquad H* \mid \hat{\psi} >= \hat{E}* \mid \hat{\psi} >\equiv E \mid \hat{\psi} >$$
$$\hat{E} \in \hat{R}, \; E \in R. \tag{3.6}$$

Isoaxiom III. The fundamental dynamical operators, coordinates r^k and momenta p_k, are characterized by isoeigenvalue equations and isocommutation rules (in momentum representation)

$$p_k * \mid \hat{\psi} >= -\mathrm{i}\, \hat{I}_k{}^i \nabla_i \mid \hat{\psi} >$$
$$r^k{}_{op} * \mid \hat{\psi} >= \hat{r}^k * \mid \hat{\psi} >\equiv r^k \mid \hat{\psi} > \qquad \hat{r} \in \hat{R} \quad r \in R \tag{3.7a}$$

$$[a^\mu, a^\nu]_{\hat{\xi}} = a^\mu T a^\nu - a^\nu T a^\mu = \mathrm{i}\,\omega^{\mu\alpha}\,\hat{I}_\alpha{}^\nu$$
$$a = (p, r) \qquad (\hat{I}_\alpha{}^\nu) = \mathrm{diag.}\,(T^{-1}, T^{-1}). \tag{3.7b}$$

where $\omega^{\mu\nu}$ is the 6×6 canonical-Lie tensor.

Isoaxiom IV. The time evolution of states is characterized by isounitary transformations with the (isoHermitean) Hamiltonian as generator

$$|\,\hat{\psi}(t)> = \hat{U}(t, t_0) * |\,\hat{\psi}(t_0)> = \left\{ e_{\hat{\xi}}{}^{\mathrm{i}H(t_0-t)} \right\} * |\,\hat{\psi}(t_0)> \equiv e^{\mathrm{i}HT(t_0-t)}\,|\,\hat{\psi}(t_0)>. \tag{3.8}$$

while the time evolution of operators is characterized by an equivalent, one-dimensional, Lie-isotopic group of isounitary transformations with the same Hamiltonian as generators, expressible in the finite form

$$A(t) = \hat{U} * A(t_0) * \hat{U}^{\hat{\dagger}} = \left\{ e_{\hat{\xi}}{}^{\mathrm{i}H(t-t_0)} \right\} * A(t_0) * \left\{ e_{\hat{\xi}}{}^{-\mathrm{i}(t_0-t)H} \right\} \tag{3.9}$$

with infinitesimal version provided by the isoHeisenberg equations

$$\mathrm{i}\,\frac{\hat{\mathrm{d}}A}{\hat{\mathrm{d}}t} = [A, H]_{\hat{\xi}} = ATH - HTA \tag{3.10}$$

where $\hat{\mathrm{d}}/\hat{\mathrm{d}}t = \hat{I}_t \mathrm{d}/\mathrm{d}t$ is the isotopic derivative and $\hat{I}_t$ is the isounit of time [10, 30].

Isoaxiom V. The values expected in measurements of observables are given by the isoexpectation values

$$\hat{<}A\hat{>} = \frac{<\hat{\psi}\,|*A*|\,\hat{\psi}>}{<\psi\,|*|\,\hat{\psi}>} = \frac{<\hat{\psi}\,|\,TAT\,|\,\hat{\psi}>}{<\psi\,|\,T\,|\,\hat{\psi}>} \in R \tag{3.11}$$

which reduce under isonormalization $<\hat{\psi}\,|*|\,\hat{\psi}> = 1$ *to* $\hat{<}A\hat{>} = <\hat{\psi}\,|*A*\hat{\psi}> \in R$.

The *isodual* HM for antiparticles can be constructed via the techniques of section 2. In particular, *isoduality results to be a geometric reformulation of charge conjugation* [15, 24, 28].

The above isoaxioms imply the following properties of the isounits [10, 30]: (1) $\hat{I}$ is isoidempotent of arbitrary (finite) degree, $\hat{I}^{\hat{n}} = \hat{I} * \hat{I} * \cdots * \hat{I} \equiv \hat{I}$; (2) the isoquotient of $\hat{I}$ by itself is $\hat{I}$, $\hat{I}\hat{/}\hat{I} \equiv \hat{I}$; (3) the isosquare root of $\hat{I}$ is $\hat{I}$, $\hat{I}^{\hat{\frac{1}{2}}} \equiv \hat{I}$; (4) $\hat{I}$ isocommutes with all operators, $[A, \hat{I}]_{\hat{\xi}} = A - A \equiv 0$; (5) $\hat{I}$ is left invariant by isounitary transformations, $\hat{U} * \hat{I} * \hat{U}^{\hat{\dagger}} \equiv U * \hat{U}^{\dagger} = \hat{I}$; (6) $\hat{I}$ is conserved in time, $\mathrm{i}\hat{\mathrm{d}}\hat{I}/\hat{\mathrm{d}}t \equiv [\hat{I}, H]_{\hat{\xi}} \equiv 0$; and (7) all infinitely possible isounits $\hat{I}$ admit as isoeigenvalues the ordinary number 1, $\hat{<}\hat{I}\hat{>} = <\hat{\psi}\,|\,TT^{-1}T\,|\,\hat{\psi}> / <\hat{\psi}\,|\,T\,|\,\hat{\psi}> \equiv 1$. The following primary consequences then hold:

(A) *Quantum and hadronic mechanics coincide, by construction, at the abstract, realization-free level.* In fact, at the abstract level, all distinctions cease to exist between $\hat{F}$ and F, $\hat{E}(r, \hat{\delta}, R)$ and $E(r, \delta, R)$, $\hat{\xi}$ and ξ, $\hat{\mathcal{H}}$ and $\mathcal{H}$ etc. A subtle implication is that criticisms on the above axiomatization may eventually result to be criticisms on the axiomatic structure of quantum mechanics itself.

(B) *Hadronic mechanics is form-invariant under its own transformation theory, the isounitary transformations.* This can be seen from the fact that isocommutators are invariant under isounitary transformations, $\hat{U} * [A, B]_{\hat{\xi}} * \hat{U}^{\hat{\dagger}} = [A', B']_{\hat{\xi}}$, or the invariance of eigenvalues and isoexpectation values under isounitary transformations, etc. This form-invariance should be compared with the general *lack* of invariance of q-deformations under their time evolution [8].

(C) *Hadronic mechanics provides a fully* $<$ *causal* $>$ *treatment of* $<$ *nonlocal* $>$ *interactions.* This property originates from the embedding of *all* nonlocal interactions in the isounit of the theory. Causality then follows from the isoexpectation values of all admissible nonlocal isounits $\hat{<}\hat{I}\hat{>} = 1$. Causality can also be proved in a number of other ways, e.g., from the fact that HM implies an axiom-preserving isotopy of the conventional causal treatment [9]. The above causal description of nonlocal interactions in a way embedded in the basic axioms of the theory should be compared with the loss of causality for conventional treatments of nonlocal interactions.

(D) *The property* $\hat{<}\hat{I}\hat{>} = 1$ *implies the reconstruction of Planck's constant* $\hbar = 1$ *at the level of measurements.* In different terms, the integro-differential generalization of Planck's constant (1.1) which is at the foundation of HM holds only within its mathematical structure, but the conventional value $\hbar = 1$ is reconstructed in the measurement theory.

(E) *Currently available experimental measures cannot distinguish between quantum and hadronic mechanics, that is, they cannot identify whether the interactions are local or nonlocal.* In fact, the differentiation can be best tested experimentally via the verification of the novel predictions of HM, that is, predictions beyond the descriptive capacities of QM.

(F) *Hadronic mechanics permits an axiomatization of discrete-time theories via their embedding in the isounit* $\hat{I}$, *which therefore result to be 'hidden' in, and compatible with the conventional axioms of* QM. In fact, isounits of Kadeisvili's class V [14] have precisely a discrete structure. Yet their isoeigenvalues remains the same as those of class I, $\hat{<}\hat{I}\hat{>} = 1$. This implies in particular that the isogeometries admit discrete-time realizations based on the same axioms of conventional continuous geometries.

(G) *Total physical quantities of isolated systems are conserved under isotopies.* This is due, first, to the preservation of Hermiticity / observability under isotopies, and then to the invariance of the basis of a vector space under isotopies up to renormalization factors [7–9]. In particular, the generators of conventional and Lie-isotopic symmetries coincide. This implies that currently available centre-of-mass measures on *total* quantities of interacting and / or bound states, by no means, can ascertain whether the internal forces are of quantum or hadronic type, i.e., of local–canonical or nonlocal–noncanonical.

4. Isotopies and isodualities of the Lorentz and Poincarè symmetries

Consider the Minkowski space $M(x, \eta, R)$ with local coordinates $x = \{x, x^4\}$, $x^4 = c_0 t$, $c_0 =$ speed of light in vacuum, metric $\eta = \mathrm{diag.}(1, 1, 1, -1)$, separation $x^2 = x^\mu \eta_{\mu\nu} x$ and invariant measure $\mathrm{d}s^2 = -\mathrm{d}x^\mu \eta_{\mu\nu} \mathrm{d}x^\nu$. Its group of linear–local–canonical isometries is the ten-dimensional Poincarè group $P(3.1) = O(3.1) \times T(3.1)$ characterized by the (ordered sets of) parameters $w = \{\theta, v, a\}$ (Euler's angles θ_k, speed parameter v_k and translation parameters a), and generators, say, for a system of particles with with non-null masses m_a, $X = \{X_k\} = \{M_{\mu\nu}\} = \sum_a (x_{a\mu} p_{a\nu} - x_{a\nu} p_{a\mu})$, $P_\mu = \sum_a p_{a\mu}$, $\mu, \nu = 1, 2, 3, 4$, $a = 1, 2, \ldots, N$, in their known adjoin (fundamental) representation [3].

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Three realizations of the ten-dimensional isotopic covering $\hat{P}(3.1)$ of $P(3.1)$ have been constructed via the Lie-isotopic theory, the classical [13], operator [30] and abstract [11] ones. We now present the construction of the abstract realization of $\hat{P}(3.1)$ via the following five steps, and then the operator one, while that of the isospinorial covering will be presented in section 8.

Step 1 is the identification of the fundamental isotopic element T (which can be interpreted as 4×4 matrix generalization of q-number-deformations [7]) via its fundamental implication, the deformation of the Minkowski metric η into the most general known metric $\hat{\eta} = T\eta$ which is nonlinear, nonlocal-integral, and noncanonical in all variables, wavefunctions and their derivatives, as well as density μ of the interior medium considered, its local temperature τ, the local index of refraction n, and any other needed physical quantity

$$\hat{\eta} = T(s, x, \dot{x}, \ddot{x}, \psi, \partial\psi, \partial\partial\psi, \ldots)\eta \tag{4.1}$$

here assumed to be of Kadeisvili class III [14] (smooth, bounded, nowhere singular and Hermitean, but not necessarily positive or negative-definite). Under the assumed conditions, the T-matrix can always (but not necessarily) be diagonalized in the form

$$T = \text{diag.}(g_{11},\ g_{22},\ g_{33},\ g_{44}) = T^{\dagger} \qquad \text{Det}\,T \neq 0\,. \tag{4.2}$$

The isosymmetry $\hat{P}(3.1)$ is then constructed with respect to the isounit $\hat{I} = T^{-1}$.

Step 2 is the lifting of the conventional field $R(n, +, \times)$ of real numbers n into the isofield $\hat{R}(\hat{n}, +, *)$ of isoreal numbers $\hat{n} = n\hat{I}$, $\hat{I} = T^{-1}$.

Step 3 is the lifting of space $M(x, \eta, R)$ on the field R into the *isoMinkowski* space $\hat{M}(x, \hat{\eta}, \hat{R})$ on the isofield $\hat{R}$ with isoseparation [6]

$$(x-y)^{\hat{2}} = [(x^{\mu} - y^{\mu})\eta\hat{_{\mu\nu}}(s, x, \dot{x}, \ddot{x}, \psi, \partial\psi, \partial\partial\psi, \ldots)(x^{\nu} - y^{\nu})]\,\hat{I} \in \hat{R}. \tag{4.3}$$

Step 4 identifies the basic isotransformations leaving invariant (4.3)

$$\begin{aligned} &x' = \hat{\Lambda}(w) * x \qquad \hat{\Lambda}^{\dagger}\hat{\eta}\hat{\Lambda} = \hat{\Lambda}\hat{\eta}\hat{\Lambda}^{\dagger} = \hat{I}\hat{\eta}\hat{I} \\ &\hat{\text{Det}}\hat{\Lambda}\left[\text{Det}(\hat{\Lambda}T)\right] = \pm\hat{I} \qquad x' = x + A \end{aligned} \tag{4.4}$$

where the quantity A will be identified shortly. The connected component $\hat{P}^{\circ}(3.1) = S\hat{O}(3.1) \times \hat{T}(3.1)$ is characterized by $\hat{\text{Det}}\hat{\Lambda} = +\hat{I}$ with structure [11, 13, 30]

$$\begin{aligned} \hat{O}(3.1): \quad \hat{\Lambda}(w) * x &= \left\{\prod\nolimits^{*}_{k} e_{\hat{\xi}}^{\text{i}X_k * \hat{w}_k}\right\} Tx \\ &= \left\{\prod\nolimits_{k} e^{\text{i}X_k T w_k}\right\} x \end{aligned} \tag{4.5a}$$

$$\begin{aligned} \hat{T}(3.1): \quad &\left\{e_{\hat{\xi}}^{\text{i}P\eta a}\right\} * x = \left\{e^{\text{i}P\hat{\eta}a}\right\} x \\ &\left\{e_{\hat{\xi}}^{\text{i}P\eta a}\right\} * p \equiv 0. \end{aligned} \tag{4.5b}$$

where w_k and X_k are conventional [3] and T is given by (4.2). The isocommutation rules of $\hat{P}^{\circ}(3.1)$ are given by [loc cit]

$$[M_{\mu\nu} \hat{,} M_{\alpha\beta}] = \text{i}\,(\hat{\eta}_{\nu\alpha}M_{\beta\mu} - \hat{\eta}_{\mu\alpha}M_{\beta\nu} - \hat{\eta}_{\nu\beta}M_{\alpha\mu} + \hat{\eta}_{\mu\beta}M_{\alpha\nu}) \tag{4.6a}$$

$$[M_{\mu\nu} \hat{,} P_{\alpha}] = \text{i}\,(\hat{\eta}_{\mu\alpha}P_{\nu} - \hat{\eta}_{\nu\alpha}P_{\mu}) \qquad [P_{\mu} \hat{,} P_{\nu}] = 0 \tag{4.6b}$$

where the product is the isocommutator $[A \hat{,} B] = ATB - BTA$. The isoCasimirs are then given by

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$$\hat{C}^{(0)} = \hat{I} \qquad C^{(1)} = P^{\hat{2}} = P * P = P_\mu \hat{\eta}^{\mu\nu} P_\nu$$
$$C^{(2)} = \hat{W}^{\hat{2}} = \hat{W}_\mu \hat{\eta}^{\mu\nu} \hat{W}_\nu \qquad \hat{W}_\mu = \epsilon_{\mu\alpha\beta\rho} J^{\alpha\beta} * P^\rho. \tag{4.7}$$

The *general isoPoincarè transformations* are given by [loc cit]

$$x' = \hat{\Lambda} * x \qquad \text{isoLorentz transforms} \tag{4.8a}$$
$$x' = x + A(s, x, \dot{x}, \ddot{x}, \ldots) \qquad \text{isotranslations} \tag{4.8b}$$
$$x' = \hat{\pi}_r * x = (-x, x^4)$$
$$x' = \hat{\pi}_t * x = (x, -x^4) \qquad \text{isoinversions} \tag{4.8c}$$

$$A_\mu = a_\mu \Big\{ g_{\mu\mu} + a^\alpha \left[g_{\mu\mu} \hat{,} P_\alpha\right]/1! + a^\alpha a^\beta \left[\left[g_{\mu\mu} \hat{,} P_\alpha\right] \hat{,} P_\beta\right]/2! + \cdots \Big\} \tag{4.8d}$$

with the *general isoLorentz transformations* given by the isorotations (see [21] for brevity) and the *isoboosts* first constructed in [11]

$$x'^1 = x^1 \qquad x'^2 = x^2 \tag{4.9a}$$

$$x'^3 = x^3 \cosh\left[v(g_{33}g_{44})^{1/2}\right] - x^4 g_{44}(g_{33}g_{44})^{-1/2} \sinh\left[v(g_{33}g_{44})^{1/2}\right] = \hat{\gamma}(x^3 - \beta x^4) \tag{4.9b}$$

$$x'^4 = -x^3 g_{33}(g_{33}g_{44})^{-1/2} \sinh\left[v(g_{33}g_{44})^{1/2}\right] + x^4 \cosh\left[v(g_{33}g_{44})^{1/2}\right] = \hat{\gamma}(x^4 - \hat{\beta} x^3) \tag{4.9c}$$

$$\hat{\beta} = v^k g_{kk} v^k / c_0 g_{44} c_0 \qquad \hat{\gamma} = \mid 1 - \hat{\beta}^2 \mid^{-1/2}. \tag{4.9d}$$

The classification of all possible isosymmetries $\hat{O}(3.1)$ is then straightforward, as done in the original proposal [11]. In fact, in the above formulation without a define signature in the metric (class III), the *abstract isoLorentz symmetry* $\hat{O}(3.1)$ unifies all possible simple, six-dimensional Lie and Lie-isotopic algebras, i.e.: (1) all six-dimensional simple algebras of Cartan's classification $O(4)$, $O(3.1)$ and $O(2.2)$ (over a field of characteristic zero); (2) all their isoduals $O^d(4)$, $O^d(3.1)$ and $O^d(2.2)$; and (3) all infinitely possible isotopes for each of the preceding algebras. Similarly, the *abstract isoPoincarè algebra* $\mathcal{P}(3.1)$ unifies all possible ten-dimensional inhomogeneous algebras, isoalgebras and their isoduals.

The above structure, even though mathematically significant, is excessively broad for physical applications. From here on we shall restrict our analysis to the isosymmetries of class I with realization

$$\hat{\eta} = T\eta = \text{diag.}({b_1}^2, {b_2}^2, {b_3}^2, -{b_4}^2) \equiv \text{diag.}({n_1}^{-2}, {n_2}^{-2}, {n_3}^{-2}, -{n_4}^{-2}) \qquad b_\mu,\ n_\mu > 0 \tag{4.10}$$

where the bs are called *characteristic functions* of the medium considered. The use of the quantity $T^d = -T$ then characterizes the isodual symmetry. The general functional dependence is needed for the study of a particle of an electromagnetic wave at

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a given interior point of an inhomogeneous and anisotropic medium. When global-exterior conditions are studied (e.g., for the average speed of light throughout an inhomogeneous and anisotropic atmosphere), the characteristic functions can be effectively averaged into constants $b^{\circ}{}_{\alpha} = \text{const} = \text{Aver.}(b_{\alpha})$, as is the case for most applications considered in this paper. In this case isotransforms (4.8) and (4.9) are called *restricted isoPoincarè and isoLorentz transformations*, respectively. Their primary implication is the regaining of locality and linearity, thus preserving inertial systems as in the conventional case, although the transformations remain noncanonical in $M(x, \eta, R)$.

It is easy to prove the local isomorphism $\hat{P}(3.1) \approx P(3.1)$ for all $T > 0$. This confirms a fundamental objective of section 1, the inapplicability of the Lorentz *transformations*, but the exact character of the Poincarè *symmetry*. The 'direct universality' of the isoPoincarè symmetry should be noted, i.e., its applicability for all infinitely possible isoseparations (4.3) (universality), directly in the x-frame of the experimenter (direct universality).

Despite their apparent simplicity, isotransformations (4.9) are highly nonlinear–nonlocal–noncanonical owing to the unrestricted functional dependence of the $g_{\mu\mu}$-quantities. The simplicity of the final invariance should also be noted. In fact, the invariance of all infinitely possible isoseparations (3.3) is merely given by plotting the given $g_{\mu\mu}$ elements in equations (3.9).

The operator *relativistic isokinematics* on $\hat{M}(x, \hat{\eta}, \hat{R})$ [15, 30] is characterized by the linear momentum here presented for simplicity for the case $\partial b_{\mu}/\partial x^{\nu} = 0$ or for $b^{\circ}{}_{\mu}$-constants

$$\begin{aligned} p &= (p^{\mu}) = (\hat{m}u^{\mu}) = (m_0\hat{\gamma}\hat{c}v^k, m_0\hat{\gamma}\hat{c}) \\ \hat{m} &= m_0\hat{\gamma} \qquad c = c_0 b_4 \end{aligned} \tag{4.11}$$

with isoeigenvalue form (isoaxiom III of HM)

$$p_{\mu} * \hat{\psi} = -\mathrm{i}\,\hat{I}_{\mu}{}^{\nu}\frac{\partial}{\partial x^{\nu}}\hat{\psi} = -\mathrm{i}\,b_{\mu}{}^{-2}\frac{\partial}{\partial x^{\mu}}\hat{\psi} = -\mathrm{i}\frac{\partial}{\partial x_{\mu}}\hat{\psi} \tag{4.12}$$

where the last identity is evidently due to the expressions $x_{\mu} = \hat{\eta}_{\mu\nu}x^{\nu} = b_{\mu}{}^2 x^{\mu}$. The fundamental isoinvariant is then given by from (4.7)

$$\begin{aligned} p^{\hat{2}} * \mid \hat{\psi} > &= \hat{\eta}^{\mu\nu} p_{\mu} * p_{\nu} * \mid \hat{\psi} > \\ &= (b_k{}^2 p_k * p_k - c^2 p_4 * p_4) * \mid \hat{\psi} > = (-m_0{}^2 c^4) \mid \hat{\psi} > . \end{aligned} \tag{4.13}$$

The *fundamental relativistic isocommutation rules* are then given by

$$\begin{aligned} &[p_{a\mu} \hat{,} x_{a\nu}] * \mid \hat{\psi} > = -\mathrm{i}\,\eta_{\mu\nu} * \mid \hat{\psi} > \\ &[x_{a\mu} \hat{,} x_{b\nu}] * \mid \hat{\psi} > = [p_{a\mu} \hat{,} p_{b\nu}] * \mid \hat{\psi} > \equiv 0 \end{aligned} \tag{4.14}$$

namely, the isoeigenvalues do not exhibit b-terms, by coinciding with the corresponding conventional eigenvalues [15, 28, 30].

The *operator isoPoincarè algebra* $\hat{P}(3.1)$ can then be computed and it is given by [15, 30]

$$\begin{aligned} [J_{\mu\nu} \hat{,} J_{\alpha\beta}] * \mid \psi > = \mathrm{i}\,(&\eta_{\nu\alpha}J_{\beta\mu} - \eta_{\mu\alpha}J_{\beta\nu} \\ &- \eta_{\nu\beta}J_{\alpha\mu} + \eta_{\mu\beta}J_{\alpha\nu}) * \mid \psi > \end{aligned} \tag{4.15a}$$

$$\begin{aligned} &[J_{\mu\nu} \hat{,} P_{\alpha}] * \mid \psi > = \mathrm{i}\,(\eta_{\mu\alpha}P_{\nu} - \eta_{\nu\alpha}P_{\mu}) * \mid \psi > \\ &[J_{\mu} \hat{,} P_{\nu}] * \mid \psi > = 0 \end{aligned} \tag{4.15b}$$

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namely, the structure constants of $\hat{P}(3.1)$ formally coincide with those of the conventional algebra, thus confirming not only the local isomorphisms $\hat{P}(3.1) \approx P(3.1)$, but also the identity at the abstract level of the conventional and isotopic symmetries and related relativities. The rest of the isoalgebras and isogroups can then be constructed via the preceding analysis for the matrix case. The isospinorial realization of the isoPoincarè symmetry is presented in section 8.

The first application of the isoPoincarè symmetry can be found in conventional, classical, *exterior* gravitation. To begin, *the isoPoincarè symmetry* $\hat{P}(3.1)$ *provides the universal invariance of general relativity*. In fact, the invariance of any gravitational (e.g., Schwartzschild's) line element is merely given by plotting the $g_{\mu\mu}$ elements in (4.9).

Another application is *a geometric unification of the Minkowskian and Riemannian spaces.* This result is achieved via the decomposition of the Riemannian metric $g(x) = T(x)\eta$, and the chain

$$\Re(x, g, R) \approx \hat{\Re}(x, g, \hat{R}) \equiv \hat{M}(x, \hat{\eta}, \hat{R}) \approx M(x, \eta, R) \tag{4.16}$$

where all isospaces are characterized by the *gravitational isounit* $\hat{I} = [T(x)]^{-1}$. Note that all Riemannian metrics admit the decomposition $g = T\eta$ with $T > 0$ (trivially, from their locally Minkowskian character).

The above geometric unification of Minkowskian and Riemannian spaces has been used by Lopez [31] to identify three geometric arguments supporting Logunov's [33] relativistic formulation of gravitation with a nowhere null source.

Further applications in gravitation under study are [15]: a novel treatment of singularities as singularities of the isounits $\hat{I} = [T(x)]^{-1}$; a novel operator form of gravitation given by its embedding in the unit of relativistic quantum theories; a novel 'iso-grand-unification'; and others, Applications of nongravitational character will be indicated below.

But perhaps the most remarkable aspect is the capability of the isoPoincarè symmetry to unify in one single abstract isosymmetry $\mathcal{P}(3.1)$ of class I: linear and nonlinear, local and nonlocal, Hamiltonian and nonhamiltonian, relativistic and gravitational, as well as exterior and interior systems, at classical, operator and statistical levels [13, 28].

5. Isotopies and isodualities of the special relativity

We shall now ignore gravitational profiles, and consider isotopic theories specifically built for interior relativistic problems of particles with $\partial b_\mu / \partial x_\nu = 0$ or $b^\circ{}_\alpha = \text{Aver.}(v_\alpha) = \text{const.} > 0$, $\alpha = 1, 2, 3, 4$.

The isotopies of the Poincarè symmetry $P(3.1) \rightarrow \hat{P}(3.1)$ imply corresponding, necessary liftings of the special relativity into a form called *isospecial relativity*, originally submitted in [11] and then studied in detail in [13, 15, 28, 30]. The objective is a form-invariant description of extended-deformable particles and electromagnetic waves propagating within inhomogeneous and anisotropic physical media represented by isospaces $\hat{M}(x, \hat{\eta}, \hat{R})$. The special relativity is admitted as a particular case in vacuum for which $\hat{I} \equiv I$.

The isospecial relativity is based on the isoPoincarè invariance on isospaces $\hat{M}(x, \hat{\eta}, \hat{R})$ of class I, with consequential isotopies of all basic postulates of the spe-

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cial relativity. Those important for this paper are the following ones presented for $b_1 = b_2 = b_3 \neq b_4$, with $\hat{\beta}$ and $\hat{\gamma}$ given by (4.9d):

Isopostulate I. The maximal, causal, invariant speed is given by

$$V_{\max} = | dr/dt |_{\max} = c_0 b_4 / b_3 . \tag{5.1}$$

Isopostulate II. The addition of speeds u and v is given by the isotopic law

$$v' = (u+v)/(1 + u_k b_k{}^2 v_k / c_0{}^2 b_4{}^2) . \tag{5.2}$$

Isopostulate III. Time intervals and lengths follow the isodilation-isocontraction laws

$$\hat{\tau} = \hat{\gamma}\tau_0 \qquad \hat{\Delta}L_0 = \hat{\gamma}\Delta L . \tag{5.3}$$

Isopostulate IV. Frequencies follow the isodoppler law [for aberration $\mathring{a} = 90$]

$$\hat{\omega} = \omega\gamma . \tag{5.4}$$

Isopostulate V. The energy equivalence of mass follows the isoequivalence principle

$$\hat{E} = mc^2 = mc_0{}^2 b_4{}^2 = mc_0{}^2 / n_4{}^2 . \tag{5.5}$$

The above generalized postulates are implicit in the preceding formulations, e.g., in isoinvariant (4.3), or in isoLorentz transformations (4.9); they recover identically the conventional postulates in vacuum for which $b_\mu = 1$; and they coincide with the conventional postulate at the abstract, realization-free level, where we lose all distinctions between $\hat{I}$ and I; $x^{\hat{2}}$ and x^2, $\hat{\beta}^2$ and β^2, $\hat{\tau}$ and τ, $\hat{\omega}$ and ω, $\hat{E}$ and E, etc. Thus, criticism of the above isotopic postulates may result to be criticism on Einstein's postulates themselves.

A most visible departure from the conventional theories is the abandonment of the speed of light as the invariant speed in favour of quantity (5.1) which is intrinsic of the isoMinkowski geometry and represents the maximal causal speed as characterized by an effect following a cause due to particles, fields or other means. Note that in vacuum $V_{\max} \equiv c_0$ by therefore recovering as a particular case the speed of light as the maximal causal speed.

The best way to verify isopostulate I is in the simplest possible medium, the homogeneous and isotropic water, where the speed of light is no longer c_0, but rather the familiar value $c = c_0/n^\circ < c_0$, where n° is the index of refraction. The insistence in keeping the speed of light as the invariant speed in water leads to a number of inconsistencies, such as: the violation of both the conventional and isotopic laws of addition of speeds, none of which yields the speed of light as the sums of two light speeds $u = v = c = c_0/n^\circ$ for causal speed c_0; electrons can propagate in water at speeds bigger than the assumed invariant speed, as experimentally established by the Cherenkov light; and others. These inconsistencies are resolved by the isospecial relativity with isoinvariant given by the simple *scalar isotopy* $x^2 = b^{\circ 2} x^2$ [11, 13, 30].

Even greater inconsistencies emerge if one insists in keeping the speed of light as the invariant speed for all media more complex than water, e.g., inhomogeneous and anisotropic atmospheres. To our best knowledge, a resolution of these inconsistencies requires the separation of the invariant speed from the speed of light, and the use of their identity only for the particular case in vacuum.

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Since isopostulates I–V are quantitatively different than the conventional ones, they are suitable for experimental verifications. Intriguingly, all available experimental evidence appears to confirm the above isopostulates, not only for simple media such as water or atmospheres, but also for the more complex media, such as the hyperdense media inside hadrons (see section 9).

In summary, the isotopies identify four physically different but axiomatically equivalent formulations of the special relativity: (1) the *conventional special relativity* based on the $P(3.1)$ form-invariant description on $M(x, \eta, R)$ of point-like particles in vacuum; (2) the *isodual special relativity* based on the $P^d(3.1)$-invariance on $M^d(x, \eta^d, R^d)$ for the point-like description of antiparticles in vacuum; (3) the *isospecial relativity* with $\hat{P}(3.1)$ form-isoinvariant description on $\hat{M}(x, \hat{\eta}, \hat{R})$ of extended-deformable particles in interior conditions; and (4) the *isodual isospecial relativity* with isodual $\hat{P}^d(3.1)$-invariance on $\hat{M}^d(x, \hat{\eta}, \hat{R}^d)$ for the description of extended-deformable antiparticles in interior conditions.

6. IsoMinkowskian geometrization of physical media

As is well known, the Minkowski space $M(x, \eta, R)$ provides a geometrization of the homogeneous and isotropic vacuum. A fundamental aspect of the isospecial relativity is that the isoMinkowski space $\hat{M}(x, \hat{\eta}, \hat{R})$ provides a geometrization of interior, classical and operator, physical media, e.g., the geometrization of our inhomogeneous and anisotropic atmospheres, or of the medium in the interior of nuclei, hadrons and stars.

An intuitive understanding can be reached by noting that the characteristic functions $b_\mu = 1/n_\mu$ essentially extend the local index of refraction $1/n_4$ to all space-time components. Equivalently, by recalling that physical media are generally opaque to light, *the isotopy $M(x, \eta, R) \rightarrow \hat{M}(x, \hat{\eta}, \hat{R})$ essentially extends to all physical media the geometric structure of light in vacuum.*

This geometrization has permitted the classification of physical media into nine significant types [30], p 103, i.e., first, into the three primary classes $\hat{\gamma} = \gamma$, $\hat{\gamma} < \gamma$ and $\hat{\gamma} > \gamma$ from (4.9d) and then on the three subclasses for each of them $b^\circ = b^\circ{}_4$, $b^\circ > b^\circ{}_4$ and $b^\circ < b^\circ{}_4$, $b^\circ = \text{Aver.}(b^\circ{}_k)$.

This classification is of primary phenomenological relevance as researchers in the field know, because it implies automatic redefinition of the *intrinsic* characteristics of particles and electromagnetic waves, called *isorenormalizations.* They can be anticipated from the deviations of the isoCasimirs (4.7) from the conventional expressions, or from the differences between conventional and isorepresentations (see next section), and are finalized by isopostulates I–V, such as the isorenormalization of the rest energy (5.5) for a particle in interior conditions (only). The identification of the type of isoMinkowskian geometry characterized by a given medium is therefore a basic problem for practical applications.

In regard to electromagnetic waves, the isospecial relativity predicts no change in frequency (i.e., no loss of energy) for light propagating in media of type 1, 2, 3 with $\hat{\gamma} \equiv \gamma$, such as water (as experimentally established), plus two predictions from isopostulate IV suggested for tests [13, 28, 30]: an *isoDoppler redshift* for $\hat{\gamma} < \gamma$ (i.e., a loss of energy) for light propagating within media of type 4 such as inhomogeneous and anisotropic atmospheres of low density; and an *isoDoppler blueshift* for $\hat{\gamma} > \gamma$ for

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light propagating in hyperdense media of type 9, such as those in the Bose–Einstein correlation fireball, and others.

In regard to particles, the isorenormalization of the intrinsic characteristics permits quantitative representations otherwise impossible, such as attractive interactions for the Cooper pair (e^-, e^-) in superconductivity (section 9), and imply the *novel* prediction of the apparent origin of cold fusion at the level of elementary particles, as an extension of that of the Cooper pair.

Note the *necessity* of the isotopies for the above results. Note also that the isoMinkowskian geometry is *isoflat* since it is the isotopy of a flat geometry (not so for the isotopies of Riemann [12, 13]). This implies the capability to reconstruct conventional and hyperbolic angles, even though the space has the most general possible curvature $\hat{\eta} = \hat{\eta}(x, \dot{x}, \ddot{x}, \ldots)$. For instance, if θ_{1-2} is a conventional angle in 1–2 space, the corresponding *isoangle* is given by $\hat{\theta}_{1-2} = b_1 b_2 \theta_{1-2}$, and if v— is the 'hyperbolic angle' in 3–4 space, the corresponding *hyperbolic isoangle* is $\hat{v}_{1-2} = b_3 b_4 v_{1-2}$. Thus the isoMinkowskian geometry predicts the functional dependence of the isoLorentz transforms (4.9) in a way independent from, but in full agreement with the Lie-isotopic theory. For numerous other properties we refer to [13, 28]. A technical knowledge of the isoMinkowskian geometry and its isospecial functions is therefore essential for practical applications.

7. Isotopies and isodualities of SU(2) with applications to spin and isospin

The best way to begin an outline of the applications of the isoLorentz and isoPoincarè symmetries is via their most important component, the isospinorial $S\hat{U}(2)$ subalgebras studied in [15, 21, 22]. In fact, we have the following adjoint isorepresentation along the classification of section 2:

(1) regular isoPauli matrices

$$\hat{\sigma}_1 = \Delta^{-1/2}\begin{pmatrix} 0 & g_{11} \\ g_{22} & 0 \end{pmatrix} \qquad \hat{\sigma}_2 = \Delta^{-1/2}\begin{pmatrix} 0 & -\mathrm{i}g_{11} \\ +\mathrm{i}g_{22} & 0 \end{pmatrix}$$
$$\hat{\sigma}_3 = \Delta^{-1/2}\begin{pmatrix} g_{22} & 0 \\ 0 & -g_{11} \end{pmatrix} \tag{7.1a}$$

$$T = \mathrm{diag.}(g_{11}, g_{22}) \qquad \Delta = \mathrm{Det}\, Q = g_{11}g_{22} > 0$$
$$[\hat{\sigma}_i, \hat{\sigma}_j]_{\hat{\xi}} = i2\epsilon_{ijk}\hat{\sigma}_k \tag{7.1b}$$

$$\hat{\sigma}_3 * \mid \hat{b} >= \pm\Delta^{1/2} \mid \hat{b} \qquad \hat{\sigma}^{\hat{2}} * \mid \hat{b} >= 3\Delta \mid \hat{b} \tag{7.1c}$$

(2) irregular isoPauli matrices

$$\hat{\sigma}_1{}' = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} = \sigma_1 \qquad \hat{\sigma}_2{}' = \begin{pmatrix} 0 & -\mathrm{i} \\ +\mathrm{i} & 0 \end{pmatrix} = \sigma_2$$
$$\hat{\sigma}_3{}' = \begin{pmatrix} g_{22} & 0 \\ 0 & -g_{11} \end{pmatrix} = \Delta\hat{I}\sigma_3 \tag{7.2a}$$

$$[\hat{\sigma}_1{}', \hat{\sigma}_2{}']_{\hat{\xi}} = 2i\hat{\sigma}_3{}' \qquad [\hat{\sigma}_2{}', \hat{\sigma}_3{}']_{\hat{\xi}} = 2i\Delta\hat{\sigma}_1{}'$$
$$[\hat{\sigma}_3{}', \hat{\sigma}_1{}']_{\hat{\xi}} = 2i\Delta\hat{\sigma}_2{}' \tag{7.2b}$$

$$\hat{\sigma}_3{}' * \mid \hat{b} >= \pm\Delta \mid \hat{b} > \qquad \hat{\sigma}^{\hat{2}} * \mid \hat{b} >= \Delta(\Delta + 2) \mid \hat{b} > \tag{7.2c}$$

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(3) standard isoPauli matrices

$$\hat{\sigma}_1 = \begin{pmatrix} 0 & \lambda \\ \lambda^{-1} & 0 \end{pmatrix} \qquad \hat{\sigma}_2 = \begin{pmatrix} 0 & -i\lambda \\ i\lambda^{-1} & 0 \end{pmatrix}$$
$$\hat{\sigma}_3 = \begin{pmatrix} \lambda^{-1} & 0 \\ 0 & -\lambda \end{pmatrix} \tag{7.3a}$$

$$T = \text{diag.}(\lambda, \lambda^{-1}) \qquad \lambda \neq 0$$
$$\Delta = \text{Det}\, Q = 1 \qquad [\hat{\sigma}''_i, \hat{\sigma}''_j]_{\hat{\xi}} = i\epsilon_{ijk}\hat{\sigma}''_k \tag{7.3b}$$

$$\hat{\sigma}''_3 * \mid \hat{b} >= \pm \mid \hat{b} \qquad \hat{\sigma}''^{\hat{2}} * \mid \hat{b} >= 3 \mid \hat{b} > . \tag{7.3c}$$

As one can see isoPauli matrices (7.1) preserve the original structure constants, but exhibit new eigenvalues illustrating the isorenormalization of spin mentioned in section 6. Matrices (7.2) show different isorenormalizations because of the appearance of the structure functions in the isocommutation rules. Finally, matrices (7.3) preserve the original structure constants *and* eigenvalues of Pauli's matrices, yet they exhibit the presence of a 'hidden' parameter (actually a nonlinear–nonlocal function) λ in the very structure of the spin $\frac{1}{2}$.

Isorepresentations with mutated values of spin are used for particles in interior conditions under sufficiently intense nonlinear–nonlocal–noncanonical interactions (e.g., a neutron in the core of a neutron star). Particles under less extreme conditions do preserve their conventional spin, in which case isorepresentation (7.3) is applicable.

We now indicate some of the applications of the above isorepresentations. In regard to the spin, a clear application of the isotopes $S\hat{U}(2)$ is the proof that *Bell's inequality holds, specifically, for conventional quantum mechanics and it is inapplicable under isotopies.* The proof is transparent for the regular and irregular isoPauli matrices (because of the different eigenvalues). What is intriguing is that Bell's inequality is also inapplicable under the standard isoPauli matrices (7.3) (see [27] for details.)

Another QM property which is inapplicable under isotopies is von Neumann's theorem on the lack of existence of 'hidden variables' because based the uniqueness of the spectrum of eigenvalues of a Hermitean operator, which is lacking in HM owing to the infinite possibilities of the isotopic element T for each Hermitean operator. This has permitted the *isotopic realization* of the *'hidden variables'* expressed precisely by the isotopic element T, i.e., the isoeigenvalue expressions $H * \mid \hat{\psi} >= HT \mid \hat{\psi} >= E_T \mid \hat{\psi} >$, or its diagonal elements. In fact, standard isoPauli matrices (7.3) are an explicit realization of 'hidden variables' [15, 27].

These inapplicabilities are important because they permit the (otherwise prohibited) *isotopic completion of* QM, which has resulted to be considerably along the celebrated Einstein–Podolsky–Rosen argument. In fact, one can select a classical isospace such as to permit the identity between the classical and the operator, isotopic versions of Bell's inequality [27]. Similarly the isouncertainties of a particle in the interior of a star collapsing all the way into a gravitational singularity (with $\hat{I} \to \infty$) recover the classical determinism because, from the isoGaussian (2.10), we have

$$\lim_{\hat{I}\to\infty} \Delta x \Delta k = \lim_{\hat{I}\to\infty} \hat{<}\hat{I}\hat{>}$$
$$= \lim_{T\to 0} < \hat{\psi} \mid TT^{-1}T \mid \hat{\psi} > \equiv 0. \tag{7.4}$$

We now illustrate the use of the $S\hat{U}(2)$ symmetry for the reconstruction of the *exact isospin symmetry under weak and* ELM *interactions.* The mechanism of the

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reconstruction is so simple to appear trivial [22]. Consider the isonormalized isostates of (7.3)

$$| \hat{\psi}_p >= \begin{pmatrix} \lambda^{-1/2} \\ 0 \end{pmatrix} \qquad | \hat{\psi}_n >= \begin{pmatrix} 0 \\ \lambda^{1/2} \end{pmatrix}$$
$$< \hat{\psi}_k | T | \hat{\psi}_k >= 1 \qquad k = p,\ n \tag{7.5}$$

where $T = \mathrm{diag.}(\lambda, \lambda^{-1})$. We now select such isospace to admit the same masses for the proton and the neutron. This is readily permitted by the 'hidden variable' λ when selected in such a way that $m_p \lambda^{-1} = m_n \lambda$, i.e., $\lambda^2 = m_p / m_n = 0.99862$. The mass operator is then defined by

$$\hat{M} = \left\{ \frac{1}{2} \lambda (m_p + m_n) \hat{I} + \frac{1}{2} \lambda^{-1} (m_p - m_n) \hat{\sigma}_3 \right\} \hat{I}$$
$$= \begin{pmatrix} m_p \lambda^{-1} & 0 \\ 0 & m_n \lambda \end{pmatrix} \tag{7.7}$$

and manifestly represents equal masses $\hat{m} = m_p \lambda^{-1} = m_n \lambda$ in isospace.

The recovering of conventional masses in our physical space is readily achieved via the isoeigenvalue expression on an arbitrary isostate

$$\hat{M} * | \hat{\psi} >= M \hat{I} Q | \psi >= M | \hat{\psi} >= \begin{pmatrix} m_p & 0 \\ 0 & m_n \end{pmatrix} | \hat{\psi} > \tag{7.8}$$

or, equivalently, via the isoexpectation values $< \hat{\psi}_p \mid T\hat{M}T \mid \hat{\psi}_p >= m_p$, $< \hat{\psi}_n \mid T\hat{M}T \mid \hat{\psi}_n >= m_n$. Similarly, the charge operator can be defined by $Q = \frac{1}{2} e (\hat{I} + \hat{\sigma}_3)$ with charges on isospace $Q_p = e\lambda^{-1}$ and $Q_n = 0$. However, the charges in our physical space are the conventional ones, $< \hat{\psi}_p \mid TQT \mid \hat{\psi}_p >= e$, $< \hat{\psi}_n \mid TQT \mid \hat{\psi}_n >= 0$. See [22] for more details.

The *isodual isospin* then characterizes the antiparticle $\overline{p}$ and $\overline{n}$.

8. Isotopies and isodualities of Dirac's equation

We are now sufficiently equipped to review the application of the isoPoincarè symmetry to the isotopies of Dirac's equation, called the *isoDirac equation* [15, 28, 33, 34]. The objective is to generalize the structure of the interactions admitted by the conventional Dirac's equation into their most general possible nonlinear–nonlocal–nonHamiltonian form.

The isolinearization of 2nd order invariant (4.7) can be done by introducing the 12-dimensional isospace

$$\{ \hat{M}^{\mathrm{orb.}}(x, \hat{g}, \hat{R}) \times \hat{S}^{\mathrm{intr.}}(2) \} \times \{ \hat{M}^{d,\mathrm{orb.}}(x, \hat{g}^d, \hat{R}^d) \times \hat{S}^{d,\mathrm{intr.}}(2) \}$$

for the characterization of the orbital and intrinsic angular momentum for particles and antiparticles, respectively. The following expression in self-explanatory notation (see [33, 34] for details) then characterizes the *isogamma matrices* $\hat{\gamma}$

$$(\hat{\eta}^{\mu\nu} p_\mu *^{\mathrm{orb.}} p_\nu + \hat{m}^2) *^{\mathrm{orb.}} \hat{\psi}(x)$$
$$\equiv (\hat{\eta}^{\mu\nu} \hat{\gamma}_\mu *^{\mathrm{tot.}} p_\nu + i\hat{m}) *^{\mathrm{tot.}} (\hat{\eta}^{\alpha\beta} \hat{\gamma}_\alpha *^{\mathrm{tot.}} p_\beta - i\hat{m}) *^{\mathrm{tot.}} \hat{\psi}(x) \tag{8.1a}$$

$$\{ \hat{\gamma}_\mu \hat{,} \hat{\gamma}_\nu \}^{\mathrm{tot.}} = \hat{\gamma}_\mu T^{\mathrm{tot.}} \hat{\gamma}_\nu + \hat{\gamma}_\nu T^{\mathrm{tot.}} \hat{\gamma}_\mu = 2 \hat{\eta}_{\mu\nu} \hat{I}^{\mathrm{orb.}} \tag{8.1b}$$

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$$\hat{\gamma}_\mu = \tilde{\gamma}_\mu \hat{I}^{\text{orb.}}$$
$$\{\tilde{\gamma}_\mu \hat{,} \tilde{\gamma}_\nu\}^{\text{intr.}} = \tilde{\gamma}_\mu T^{\text{intr.}} \tilde{\gamma}_\nu + \tilde{\gamma}_\nu T^{\text{ntr.}} \tilde{\gamma}_\mu = 2\hat{\eta}_{\mu\nu}. \tag{8.1c}$$

The above formulation is verified by Dirac's [37] generalization of his equation [33], but is excessively general for our needs here. We shall therefore assume the simpler realization

$$\hat{I}^{\text{orb.}} \equiv \hat{I} = T^{-1} \qquad T^{\text{orb.}} \equiv T$$
$$I^{\text{spin.}} = I = \text{diag.}(1,1) \qquad \{\hat{\gamma}_\mu \hat{,} \hat{\gamma}_\nu\} = 2\hat{\eta}_{\mu\nu}\hat{I} \tag{8.2a}$$

$$\hat{\gamma}^k = b^k \hat{I} \begin{pmatrix} 0 & \sigma_k \\ -\sigma_k & 0 \end{pmatrix} \qquad \gamma^4 = i b^4 \hat{I} \begin{pmatrix} I_s & 0 \\ 0 & I^d{}_s \end{pmatrix}$$
$$I_s = \text{diag.}(1,1) \qquad I^d{}_s = -I_s \tag{8.2b}$$

where the γ- and σ-matrices are the conventional ones, and $\partial b_\mu / \partial x^\nu = 0$. One can see the emergence of the isodual isospaces $S^d(2)$ characterized by $I^d = -\text{diag.}(1,1)$ beginning with the *conventional* Dirac's equation, which then persist under isotopies to $\hat{S}^d(2)$. The isogeometries permit the identification of the origin of the negative-energy solutions precisely in this negative-definite unit. Isoduality then characterizes antiparticles as in ordinary charge conjugation [24]. The desired *isoDirac equation* on $\hat{M}(x, \hat{\eta}, \hat{R})$ can then be written

$$(\hat{\gamma}_\mu * p^\mu + i\hat{m}) * \hat{\psi}(x) = (\hat{\eta}^{\mu\nu} \hat{\gamma}_\mu T p_\nu + i\hat{m}) T \hat{\psi} = 0$$
$$\hat{m} = m\hat{I}. \tag{8.3}$$

The extension to include electromagnetic potentials is trivial and will be ignored. Experts in isotopies however know that such an addition is not necessary to represent ELM interactions, because they can be equivalently represented with the Lie-isotopic tensor (see vol II of [9]), that is, with the characteristic b-functions [13, 28]. Contrary to its seemingly 'free' appearance, equation (8.3) represents a spinor under the most general known combination of linear and nonlinear, local and nonlocal, as well as potential and nonpotential interactions. Constant b°-quantities then represent their average. Note finally the lack of unitary equivalence of the Dirac and isoDirac equations, e.g., because of the lack of existence of a unitary transformation under which $U\hat{\gamma}_\mu U\dagger = \gamma_\mu$, $\mu = 1, 2, 3, 4$.

The orbital and intrinsic angular momenta of particles with lowest admissible hadronic weight characterize the irregular isorepresentations

$$\hat{O}(3): \qquad \hat{L}_k = \epsilon_{kij} r_i p_j \qquad \left[\hat{L}_i \hat{,} \hat{L}_j\right] = \epsilon_{ijk} b_k{}^{-2} \hat{L}_k \tag{8.4a}$$

$$\hat{L}^{\hat{2}} * \hat{\psi} = (b_1{}^{-2} b_2{}^{-2} + b_2{}^{-2} b_3{}^{-2} + b_3{}^{-2} b_1{}^{-2})\hat{\psi}$$
$$\hat{L}_3 * \hat{\psi} = b_1{}^{-1} b_2{}^{-1} \hat{\psi} \tag{8.4b}$$

$$S\hat{U}(2): \qquad \hat{S}_k = \frac{1}{2}\epsilon_{kij} \hat{\gamma}_i * \hat{\gamma}_j \qquad \left[\hat{S}_i \hat{,} \hat{S}_j\right] = \epsilon_{ijk} b_k{}^2 \hat{S}_k \tag{8.4c}$$

$$\hat{S}^{\hat{2}} * \hat{\psi} = (1/4)(b_1{}^2 b_2{}^2 + b_2{}^2 b_3{}^2 + b_3{}^2 b_1{}^2)\hat{\psi}$$
$$\hat{S}_3 * \hat{\psi} = \frac{1}{2} b_1 b_2 \hat{\psi}. \tag{8.4d}$$

which confirm the existence of nontrivial isorenormalizations.

It is easy to see the existence of the standard isorepresentations which preserve conventional eigenvalues of spin. In fact, the isoDirac equation characterizes the following standard realization of the *isospinorial Poincarè symmetry* $\mathcal{P}(3.1) = S\hat{L}(2.\hat{C}) \times \hat{T}(3.1)$ over the isofield $\hat{C}$ with generators and isocommutators

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$$J_{\mu\nu} = \left\{\hat{S}'_{ij}, \hat{L}'_{k4}\right\}$$
$$\hat{L}_{k4} = \frac{1}{2}\hat{\gamma}_k * \hat{\gamma}_4 = \frac{1}{2}\{b_k b_4 \gamma_k \gamma_4\}\,\hat{I} \qquad \hat{L}' \equiv L \tag{8.5a}$$

$$\hat{S}'_{12} = b_2{}^{-1} b_3{}^{-1} \hat{S}_{12}$$
$$\hat{S}'_{23} = b_1{}^{-1} b_3{}^{-1} \hat{S}_{23} \qquad \hat{S}'_{31} = b_1{}^{-1} b_2{}^{-1} \hat{S}_{31} \tag{8.5b}$$

$$[J_{\mu\nu} \hat{,} J_{\alpha\beta}] * \mid \psi >= \mathrm{i}\,(\eta_{\nu\alpha} J_{\beta\mu} - \eta_{\mu\alpha} J_{\beta\nu} - \eta_{\nu\beta} J_{\alpha\mu} + \eta_{\mu\beta} J_{\alpha\nu}) * \mid \psi > \tag{8.5c}$$

$$[J_{\mu\nu} \hat{,} P_\alpha] * \mid \psi >= \mathrm{i}\,(\eta_{\mu\alpha} P_\nu - \eta_{\nu\alpha} P_\nu) * \mid \psi >$$
$$[J_\mu \hat{,} P_\nu] * \mid \psi >= 0 \tag{8.5d}$$

which have conventional structure constants, thus coinciding with rules (5.15). The *standard isospinorial and isodual isoPoincarè group* can then be constructed via the rules of section 2.

A simple isotopy of the corresponding conventional derivation, yields the *magnetic and electric isodipole moments* (assumed for simplicity along the third axis)

$$\hat{\mu} = \frac{b_3}{b_4}\mu \qquad \hat{m} = \frac{b_3}{b_4} m \tag{8.6}$$

first derived in [26], equations (4.20.16), p 803, and then isotopically reformulated in [15, 33, 34].

9. Experimental verifications

In the preceding sections we have outlined a number of applications of isotopic methods, such as the use of the isoPoincarè symmetry for the invariance of exterior gravitation, or the reconstruction of the exact isospin symmetry in isospace under weak and ELM interactions. In this final section we present a number of phenomenological applications and experimental verifications which, even though evidently preliminary, are nevertheless encouraging and sufficient to warrant additional studies.

1. A first verification is the use of the isoDirac equation for a quantitative representation of Rauch's interferometric measures on the 4π-spinorial symmetry of neutrons (see review [38] and references quoted therein), which do not yield the predicted angle of two spin flips, $720°$, but the values $\theta = 715.87° \pm 3.8°$. Even though the deviation is smaller than the error, thus requiring experimental finalization, the measures are significant because the neutron beam of the experiment passes near the intense electric, magnetic and nuclear fields of Mu-metal nuclei placed in the electromagnet gap to reduce stray fields.

The expected physical origin of the measures is therefore a deformation of the charge distribution of the neutrons with consequential necessary (for Maxwell's electrodynamics) alteration of their intrinsic magnetic moments, under the preservation of the conventional spin $\frac{1}{2}$. These conditions are ideal for the isoDirac equation with expressions

$$\hat{I} = \mathrm{diag.}\,(b^\circ{}_1{}^{-2}, b^\circ{}_2{}^{-2}, b^\circ{}_3{}^{-2})$$
$$\hat{\psi}' = \hat{R}(\theta) * \hat{\psi} = e^{i b^\circ{}_1 b^\circ{}_2 \gamma_1 \gamma_2 \theta_3 / 2}\,\hat{\psi} \tag{9.1}$$

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where the first characterizes the nonspherical charge distribution of the neutron, and the second expresses the covering isospinorial transformation. The use of: (a) the general rule for the isorotational symmetry $\hat{\theta}_3 = b^\circ{}_1 b^\circ{}_2 \theta_{3|\theta_3=716^\circ} = 720^\circ$ [13, 21]; (b) the value $b^\circ{}_4$ from the geometrization of the p–$\overline{p}$ fireball in the Bose–Einstein correlation [30, 35]; and (c) the proportionality in first approximation $\hat{\mu}/\mu \approx 716^\circ/720^\circ$, where $\mu(\hat{\mu})$ is mutated (conventional) magnetic moment of the neutron, yield the numerical values of the characteristic constants of the isoDirac equation, as an average of the characteristic functions for the neutron in Rauch's experiment

$$b^\circ{}_1 = b^\circ{}_2 \approx 1.0028 \qquad b^\circ{}_3 \approx 1.644 \qquad b^\circ_4 = 1.653\,. \tag{9.2}$$

The mutated magnetic moments (along the third axis) is given by

$$\hat{\mu} = \mu b^\circ{}_3/b^\circ{}_4 = -1902 < \mu \tag{9.3}$$

which is smaller than the conventional value thus confirming the 'angle-slow-down' occurred in all Rauch's measures (see [33] for more details). Note that data (9.2) characterize the neutron as an isoMinkowskian medium of type 9; a property verified by all phenomenological data known to date (see below).

2. Another application of the isoDirac equations for *a quantitative representation of the total magnetic moments for few-body nuclear structures*, a problem which has essentially remained unsolved for over half a century. It is essentially based on the isotopy of the conventional QM treatment, that is, on the direct representation of nucleons as extended nonspherical charge distributions which experience deformations under nuclear conditions, thus implying consequential alterations of their intrinsic magnetic moments. In turn, these deviations appear to be the reason for the inability of QM to reach a numerical representation of the total nuclear magnetic moments, despite relativistic and other corrections.

The isoDirac equation permits a direct representation of the actual nonspherical shape of nucleons, predicts their (generally small) deformation when members of a nuclear structure with consequential mutation of their intrinsic magnetic moments, and yields the following HM *model of total nuclear magnetic moments*

$$\begin{aligned} \mu_{\text{tot.}}{}^{\text{HM}} &= \sum_k \left(\hat{g}_k{}^{(L)} L_{k3} + \hat{g}_k{}^{(S)} S_{k3}\right) \\ \hat{g}_k{}^{(L)} &= 0.605\, b^\circ{}_{k3} \hat{g}_k{}^{(L)} \qquad \hat{g}_k{}^{(S)} = 0.605\, b^\circ{}_{k3} \hat{g}_k{}^{(S)}\,. \end{aligned} \tag{9.4}$$

where we have the conventional values $g_p{}^{(s)} = 5.585$, $g_n{}^{(s)} = -3.816$, $g_p{}^{(L)} = 1$, $g_n{}^{(L)} = 0$, $b^\circ{}_4 = 1.653$ as for the neutron and $b^\circ{}_k$ must be determined from the experimental data. By assuming $L = 0$ for the ground state, by ignoring the contributions from $L = 2$ because they are very small, by recalling that $L = 1$ is unallowed by parity, and assuming that protons and neutrons experience the same deformation, we have the following *numerical representation of the total magnetic moment of the deutron*

$$\mu_D{}^{\text{HM}} = 0.605\, b^\circ{}_3 (g_p + g_n) \equiv \mu_D{}^{\text{Exp}} = 0.857 \qquad b^\circ{}_3 = 1.611\,. \tag{9.5}$$

which simply shows that nucleons become oblate in the deutron with their semiaxis $b^\circ{}_3{}^{-2}$. The representations of the magnetic moment of tritium, helium and other nuclei are studied in [36].

3. The isoMinkowskian geometrization of the interior of hadrons is confirmed by the phenomenological calculations [39] of deviations from the Minkowskian geometry

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inside pions and kaons conducted via standard gauge models in the Higgs sector, with deformed metric $\hat{\eta} = \text{diag.}((1-\alpha/3), (1-\alpha/3), (1-\alpha/3), -(1-\alpha))$ precisely of the isoMinkowskian type and values

$$\text{PIONS } \pi^{\pm}: \quad {b^{\circ}_1}^2 = {b^{\circ}_2}^2 = {b^{\circ}_3}^2 \cong 1 + 1.2 \times 10^{-3} \quad {b^{\circ}_4}^2 \cong 1 - 3.79 \times 10^{-3} \tag{9.6a}$$

$$\text{KAONS } K^{\pm}: \; {b^{\circ}_1}^2 = {b^{\circ}_2}^2 = {b^{\circ}_3}^2 \cong 1 - 2 \times 10^{-4} \quad {b^{\circ}_4}^2 \cong 1 + 6.1 \times 10^{-4}. \tag{9.6b}$$

Pions $\pi^{\pm}$ are then isoMinkowskian media of type 4, while the heavier kaons $K^{\pm}$ are of type 9 [30]. All hadrons heavier than $K^{\pm}$ are expected to be isoMinkowskian media of type 9.

4. The isoMinkowskian geometrization of hadrons was confirmed by independent phenomenological plots [40] on the behaviour of the meanlife of the $K^{\circ}{}_S$ (which, according to current experiments, is anomalous from 30 to 100 GeV and conventional from 100 to 350 GeV) yielding the following characteristic b°-values of the $K^{\circ}{}_S$

$$\begin{aligned} {b^{\circ}_1}^2 = {b^{\circ}_2}^2 = {b^{\circ}_3}^2 \simeq 0.909080 \pm 0.0004 \\ {b^{\circ}_4}^2 \simeq 1.002 \pm 0.007 \end{aligned} \tag{9.7a}$$

$$\Delta {b^{\circ}_k}^2 \cong 0.007 \qquad \Delta {b^{\circ}_4}^2 \cong 0.001 \tag{9.7b}$$

which are of the same order of magnitude as values (9.6b). Measures (9.7a) therefore support the hypothesis that the interior of kaons is an isoMinkowskian medium of type 9. Measures (9.7b) confirm the prediction of the isospecial relativity in the range 30–400 GeV that the $b^{\circ}{}_4$ quantity, being an average of internal density and nonlocal affects, is constant for the particle considered (although varying from hadron to hadron with the density), while the dependence in the velocities rests with the b_k-quantities.

5. An important verification of the isoMinkowskian geometrization of hadrons and related isospecial relativity has been recently achieved via theoretical [30] and experimental [35] studies on the Bose–Einstein correlation. These results are important because they confirm, not only the fundamental isoMinkowskian *laws*, but also the *numerical* values of the b°s.

In essence, studies conducted via the full use of nonlinear–nonlocal–nonHamiltonian isoMinkowskian geometrization of the p–$\overline{p}$ fireball result in the two-point boson isocorrelation function on $\hat{M}(x, \hat{\eta}, \hat{R})$ [30], equation (10.8), p 122,

$$\begin{aligned} \hat{C}_{(2)} = 1 + \frac{K^2}{3} \sum_{\mu} \hat{\eta}_{\mu\mu} (e^{-{q_t}^2/{b^{\circ}_{\mu}}^2}) \\ \hat{\eta} = \text{diag.}({b^{\circ}_1}^2, {b^{\circ}_2}^2, {b^{\circ}_3}^2, -{b^{\circ}_4}^2) \end{aligned} \tag{9.9}$$

where q_t is the momentum transfer and $K = {b^{\circ}_1}^2 + {b^{\circ}_2}^2 + {b^{\circ}_3}^2$ is normalized to 3, under the sole approximation, also assumed in conventional treatments, that the longitudinal and fourth components of the momentum transfer are very small.

Phenomenological studies conducted in [35] via the UAI data at CERN confirm model (9.9) in its entirety, and identify the numerical values

$$\begin{aligned} b^{\circ}{}_1 = 0.267 \pm 0.054 \qquad b^{\circ}{}_2 = 0.437 \pm 0.035 \\ b^{\circ}{}_3 = 1.661 \qquad\qquad b^{\circ}{}_4 = 1.653 \pm 0.015. \end{aligned} \tag{9.10}$$

Theses measures have the following implications: (a) they confirm the nonlocal–nonHamiltonian origin of the correlation, which is at the foundation of these studies; (b) they confirm the isoMinkowskian geometrization of type 9 ($\hat{\beta} < \beta$, $\hat{\gamma} > \gamma$, Aver. $(b^{\circ}{}_k) < b^{\circ}{}_4$) for the $p-\overline{p}$ fireball which is directly applicable to the nuclear cases studied earlier; (c) they provide a numerical confirmation of rest energy isorenormalization (isoaxiom V); (d) they confirm the capability of the isotopies of directly representing nonspherical shapes and all their deformations; (e) they prove the reconstruction of the exact Poincarè symmetry under nonlocal–nonHamiltonian interactions.

6. The isoMinkowskian geometry has also been verified by recent studies in [41] on the quantitative, isotopic representation of an attractive interaction between the Cooper pair (e^-e^-) in superconductivity, with numerous phenomenological plots. This is achieved via the lifting of the conventional Coulomb Hamiltonian for the (e^-e^-) system and the simple isotopic element $T = \exp\left\{tN\int \mathrm{d}x'\hat{\psi}^\dagger(x')\hat{\phi}(x')\right\}$ representing the wave-overlapping of the two electrons. By comparison, one should recall the known difficulties in achieving *attractive* interactions for the pairing of two electrons of the same charge under the *exact* validity of QM axioms.

7. By far the most speculative, thus intriguing prediction of HM is the existence of the cold fusion of protons and electrons into neutrons (plus neutrinos). The first direct experimental verification of this prediction was done by don Borghi *et al* [42]. The experiments essentially consist in forming a gas of protons and electrons inside a metallic chamber (called klystron) via the electrolytic separation of the hydrogen. Since the protons and electrons are charged, they cannot escape the metallic chamber. Nevertheless, numerous transformations of nuclei occurred for matter put in the outside of said chamber. The measures can then be solely interpreted, in the absence of any other neutron source, by the cold fusion of the protons and electrons into neutrons which, being neutral, can escape the chamber and cause the measured transmutations.

Physics is a science with an absolute standard of value: the experiments. Experiments themselves have their own standard of value, the more fundamental the law to be tested, the more relevant the experiment. In particular, experiments such as don Borghi's tests of the cold fusion $n = (\hat{p}^+, \hat{e}^-)_{\mathrm{HM}}$, can only be dismissed via other experiments, and simply cannot be credibly dismissed via theoretical considerations or personal views.

We therefore suggest the repetition of experiments [41], the measure of the apparent isotopic component of the redshift of sunlight at sunset predicted by the isoMinkowskian geometry [13] and other tests [28] proposed for the verification or dismissal of what appears to be the fundamental profile: the isoMinkowskian geometrization of physical media.

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Dedicated to the memory of Hanno Rund

ISONUMBERS AND GENONUMBERS OF DIMENSION 1, 2, 4, 8, THEIR ISODUALS AND PSEUDODUALS, AND "HIDDEN NUMBERS" OF DIMENSION 3, 5, 6, 7

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Abstract

In this paper we study: new numbers called isonumbers and genonumbers of dimension 1, 2, 4, 8, characterized by certain axiom-preserving liftings of the multiplication for normed algebras with multiplicative identity; the isodual isonumbers and isodual genonumbers of the same dimension, characterized by a certain antiautomorphic conjugation; the pseudoisonumbers, pseudogenonumbers and their isoduals characterized by the further lifting of the addition with loss of the distributive law; and submit the conjecture of "hidden numbers" of dimension 3, 5, 6, 7 which appear to be permitted by the pseudoisotopic and pseudogenotopic techniques, and present an explicit example of dimension 3. We show that the theory of isonumbers is at the foundation of the Lie-isotopic theory, which is a nonlinear-nonlocal-noncanonical, axiom-preserving lifting of of the conventional Lie theory, while the theory of genonumbers is at the foundation of the yet more general Lie-admissible theory. As such, the theories of isonumbers and genonumbers submitted in this paper emerge at the foundation of the ongoing studies of nonlocal interactions in various branches of physics, including nuclear, particle and statistical physics, superconductivity and other fields.

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UNQUESTIONABLE PATERNITY OF "SANTILLI ISONUMBERS, GENONUMBERS AND THEIR ISODUALS" UNDER CONVENTIONAL FIELD ACTIONS

I: STATEMENT OF THE PROBLEM

As well known, the *theory of numbers* received momentous advances in the past century, thanks to the contributions of famed scholars such as Gauss [1], Abel [2], Hamilton [3], Cayley [4], Galois [5] and others (see review [6] in the early part of this century, and ref.s [7–9] for contemporary presentations).

Additional important advances in number theory were made during this century, including the axiomatic formulation, the theory of algebraic numbers, etc. (see, e.g., ref.s [10] and contributions quoted therein).

The "numbers" significant for this paper are the *real numbers, complex numbers, quaternions* and *octonions*. The topic is therefore the classification of all normed algebras with identity over the reals according to the studies, e.g., by Hurwitz [11], Albert [12] and (N.) Jacobson [13] (see also reviews [7,8]) which can be expressed via the following

THEOREM 1.1 (see, e.g, ref. [8], p. 122): All possible normed algebras with multiplicative unit over the field of real numbers are given by algebras of dimension 1 (real number), 2 (complex numbers), 4 (quaternions) and 8 (octonions).

During an talk at the conference *Differential Geometric Methods in Mathematical Physics* held in Clausthal, Germany, in 1980[1], this author submitted new numbers based on a certain axiom-preserving generalization of the multiplication, today known as *isotopic numbers* or *isonumbers* for short. The generalization is induced by the so-called *isotopies* of the conventional multiplication, with consequential generalization of the multiplicative unit, where the term "isotopy" was suggested from the Greek "ισοσ τοποσ", i.e., "same topology" [14,15]. The author subsequently submitted a new conjugation, under the name of *isoduality* [18–20] which yields an additional class of numbers, today known as *isodual isonumbers.*

These studies were motivated by specific physical needs outlined in this paper and were essentially restricted to the isotopies and isodualities of real and complex numbers. As such, the studies were conducted in the physical literature and do not appear to have propagated as yet to mathematical circles.

In this paper we present a systematic study of the isotopies and isodualities of normed algebras with multiplicative unit of dimensions 1, 2, 4 and 8, including a realization of *isoquaternions* and *isooctonions* and their isoduals in terms of the isotopies and isodualities of Pauli's matrices here presented apparently for the first time.

[1] Thanks to a kind invitation by Prof. H.-D. Doebner which is here gratefully acknowledged.

We then study a generalization of the isonumbers, here called *pseudoisonunmber*, and of their isoduals which are characterized by a certain lifting of the operation of addition, with loss this time of the distributive law.

We also submit a conjecture on the existence of "hidden numbers" of dimension 3, 5, 6, 7 as hidden in the operations of conventional numbers, and present an explicit illustration of dimension 3.

Finally, we introduce, apparently for the first time, an additional new class of numbers called *genonumbers* which are characterized by an axiom-preserving ordering of the isotopies. We then identify the pseudogenonumbers and their isoduals.

The mathematical nontriviality of these new numbers is indicated by the lack of unitary equivalence of isotopic and genotopic theories to conventional ones, the lack of applicability of conventional trigonometry and related Gauss plane in favor of covering notions, and other aspects.

The physical nontriviality stems from the fact that the novel *theory of isonumbers* introduced in this paper is at the foundations of the *Lie-isotopic theory*, which is a certain axiom-preserving isotopy of the conventional formulation of Lie theory for the study of nonlinear, nonlocal and nonhamiltonian systems. The more general *theory of genonumbers* results to be at the foundation of the still more general *Lie-admissible theory*, which is an axiom-inducing *genotopy* (from the Greek γενοσ τοποσ) of Lie's theory [14,15]. As such, the new theory of numbers studied in this paper is at the foundation of the current studies of nonlinear-nonlocal-nonhamiltonian systems in nuclear, particle and statistical physics, superconductivity and other fields.

In the main text of this paper we shall study isonumbers, pseudoisonumbers, "hidden numbers" and their isoduals. Genonumbers, pseudogenonumbers and their isoduals are studied in the appendix. A few introductory sections are presented to render the presentation self-sufficient.

The author would be grateful to any colleague who cares to bring to his attention contributions in the specialized mathematical literature in number theory which are directly or indirectly connected to topic of this paper.

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2: PHYSICAL ORIGIN OF ISONUMBERS

The submission of isonumbers was made by this author for the specific physical need of a quantitative representation of the transition from:

a) the *exterior dynamical problem*, i.e., particles moving in the homogeneous and isotropic vacuum (empty space), with consequential local-differential and potential-canonical equations of motion, to

b) the *interior dynamical problem*, i.e., extended and therefore deformable particles while moving within an inhomogeneous and anisotropic physical medium, with consequential equations of motion of the most general known nonlinear, nonlocal-integral and nonpotential-noncanonical type.

Theoretical studies [14-27] (see also the independent reviews [28,31]) have shown that the above transition can be effectively represented via the isotopy of the conventional multiplication of numbers a, b (or functions or operators), from its simplest possible associative form a×b of current use, into the *isotopic multiplication*, or *isomultiplication* for short, introduced in ref. [14]

$$a \hat{\times} b \ := a \times T \times b, \qquad (2.1)$$

hereon denoted $\hat{\times} = \times T \times$, where T is a fixed and invertible quantity for all possible elements a, b called *isotopic element*.

The conventional (right and left) multiplicative unit I of current mathematical and physical theories, I×a = a×I ≡ a , is then lifted into the form

$$\hat{1} \hat{\times} a = a \hat{\times} \hat{1} \equiv a, \qquad \hat{1} := T^{-1}, \qquad (2.2)$$

called the *multiplicative isounit*.

Under the condition that $\hat{1}$ preserves all the axioms of I (boundedness, smoothness, nowhere degeneracy, Hermiticity and positive-definiteness) the lifting $I \rightarrow \hat{1}$ is an *isotopy*, that is, the conventional unit I and the isounit $\hat{1}$ (as well as the conventional product a×b and its isotopic form $a\hat{\times}b$) coincide at the abstract level by conception.

The *isonumbers* can be first introduced as the generalization of conventional numbers when characterized by isoproduct (2.1) with respect to the generalized isounit $\hat{1}$.

The consequences shown in ref.s [14-28] are that, for evident mathematical consistency, the isotopies of ordinary numbers imply compatible liftings of all mathematical structures used in physics [29,30]

Isonumbers → isofields → → Isospaces → Isotransformations →
→ isoalgebras → isogroups → isosymmetries →
→ isorepresentations → isogeometries, etc.

The isotopic generalizations of classical [24,25] and quantum [26,27] Hamiltonian mechanics (with interconnecting isotopic quantization) are then consequential with the resulting capability to represent nonlinear, nonlocal and noncanonical systems.

In fact, the isounit $\hat{1}$ is generally assumed to be *outside* the original field, with the most general possible, axiom-preserving, integro-differential dependence on local coordinates x and their derivatives with respect to an

endent variable t of arbitrary order $\dot{x}, \ddot{x}$, ..., wavefunctions ψ(t,x), ψ†(t,x) and derivatives also of arbitrary order ∂ψ, ∂ψ†, ..., as well as any needed ional quantity to represent the physical media of the interior problem, such nsity μ, temperature τ, index of refraction n, etc.

$$\hat{1} = \hat{1}(t, x, \dot{x}, \ddot{x}, \psi, \psi^\dagger, \partial\psi, \partial\psi^\dagger, \mu, \tau, n, \ .....) . \qquad (2.3)$$

Conventional, local-potential systems are represented by only one quantity, lamiltonian H over the ordinary field R of real numbers, which implies the assumption of the trivial quantity I as basic unit. The more general ical-nonpotential systems are represented by the two independent quantities, ame Hamiltonian H and generalized unit (2.3).

Stated in a nutshell, the isounit $\hat{1}$ can be interpreted as providing a ietrization of the nonlinear, nonlocal and noncanonical, as well as nogeneous and anisotropic characters of physical media, in such a way to t the conventional geometrization of the homogeneous and isotropic vacuum particular case.

A mathematical presentation of the above ideas can be found in memoirs] (see also the independent review [31]).

This author briefly inspected the lifting of the addition in ref. [21]

$$+ \ \rightarrow \ \hat{+} = +\hat{K}+, \ \hat{K} = K\times\hat{1} \qquad (2.4)$$

consequential redefinition of the conventional additive unit

$$0 \rightarrow \hat{0} = -\hat{K} . \qquad (2.5)$$

However, unlike the isotopy of the multiplication $\times \rightarrow \hat{\times}$, the lifting of the ion $+ \rightarrow \hat{+}$ implies the general loss of the right and left distributive laws (see 4). Thus, only the lifting of the multiplication continues to be used for ical applications at this time. The understanding is that the lifting of the ion is indeed mathematically intriguing and it will be studied in this paper at light.

3: PHYSICAL ORIGIN OF ISODUAL NUMBERS AND ISODUAL ISONUMBERS

The isodual isonumbers were introduced in ref.s [18-20] via the following igation of multiplication (2.1)

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$$a \hat{\times} b \rightarrow a \hat{\times}^d b := a \times T^d \times b = - a \times T \times b = - a \hat{\times} b, \; T^d = - T, \qquad (3.1)$$

under the name of *isoduality*. The isounit $\hat{1}$ is then no longer the (left and right) unit of the theory and must be lifted into the form

$$\hat{1}^d \hat{\times}^d a = a \hat{\times}^d \hat{1}^d \equiv a, \quad \hat{1}^d := - \hat{1}, \qquad (3.2)$$

called *isodual isounit*.

The *isodual isonumbers* where first conceived as characterized by isodual multiplication (3.1) with respect to the the multiplicative isodual isounit $\hat{1}^d$.

Note that the notion of isoduality first applies to conventional numbers. In fact, the expressions

$$T^d = - 1, \quad \hat{1}^d = 1^d := - 1, \qquad (3.3)$$

characterize *isodual numbers* consisting of *isodual reals, isodual complex, isodual quaternions and isodual octonions*. The isodual isonumbers then occurs for the most general possible isodual isomultiplication (3.1) and isodual isounit $\hat{1}^d = - \hat{1}$.

One can now see the necessity of lifting the product $\times \rightarrow \hat{\times}$ for the very conception of isodual numbers and isodual isonumbers. The restriction of the studies in number theory to the conventional multiplication $\times$ may therefore be a reason why isodual numbers have escaped detection until recently.

The isodual numbers and isodual isonumbers also emerged from quite specific physical needs according to the following general overview [21,22,25,27]:

1) conventional numbers are and will remain fundamental for the characterization of ordinary particles in vacuum (*exterior dynamical problem of particles*);

2) isonumbers are useful for the characterization of ordinary particles when moving within physical media (*interior dynamical problem of particles*);

3) isodual numbers are useful for the characterization of ordinary antiparticles in vacuum (*exterior dynamical problem of antiparticles*); and

4) isodual isonumbers are useful for the characterization of antiparticles moving within physical media (*interior dynamical problem for antiparticles*).

The treatment of antiparticles with isodual numbers emerged from a reinterpretation of the customary characterization of antiparticles via negative-energy solutions of Dirac's equations. As well known, such solutions behave in an unphysical way when conventionally interpreted, that is, interpreted with respect to the same numbers and unit 1 of particles, thus forcing physicists into various hypothetical assumption, such as postulating infinite seas of undetectable

particles which have left the characterization of antiparticles still resolved to this day.

On the contrary, the same negative energy solutions behaved in a fully physical way when reinterpreted as belonging to the field of isodual numbers, i.e., when reinterpreted as being defined with respect to the isodual multiplication $\times^d = \times (-1) \times$ and isodual unit $1^d = -1$. In particular, this reinterpretation implies no need of hypothesizing seas of undetectable particles.

The treatment of antiparticles with isodual numbers has rather intriguing geometrical implications. In fact, it permits the mathematical prediction of a hitherto unknown universe, called *isodual universe*, which is interconnected to our universe via isoduality, and identified by the isotopies of the Riemannian geometry and their isoduals [25,30,31].

In this paper we shall conduct a systematic study of the theory of isonumbers and their isoduals because they have a mathematical significance per se, irrespective of any possible physical application.

In closing these introductory words, the reader not familiar with isotopies should be alerted against the use of conventional mathematical thinking under isotopies because leading to (often undetected) inconsistencies. As an example, traditional statements of the type "two multiplied by two equals four" are, at best, mathematically incomplete because lacking the joint identification of the related unit, and they are inapplicable under isotopies. In fact, if we assume for multiplicative unit $\hat{1} = 3^{-1}$, "two multiplied two equal twelve".

Additional, often undetected inconsistencies occur in the preservation under isotopies of conventional operations on vector spaces and their completion, e.g., into Hilbert spaces, which have motivated the recent identification of a new branch of functional analysis under the name of *functional isoanalysis* [32].

As an example, the notion of exponentiation has no mathematical meaning under isotopy, evidently because of the lack of conventional multiplication needed for its definition as a power series expansion [14,15]; the notion of unitarity is also inapplicable because, again, referred to conventional products and units [11,13]; etc.

For these isotopic operations we refer the interested reader to ref.s [26,27]. Here we limit ourselves to recalling for later use that the notion of determinant of a matrix A is also inapplicable under isotopies because it does not preserve the basic axioms. We have instead the *isodeterminant* [16,21,26,27]

$$\hat{\mathrm{Det}}\, A := [\, \mathrm{Det}_F (A \times T) \,] \times \hat{1}, \qquad (3.4)$$

where Det A represents the conventional determinant computed in the selected (ordinary) field F, which does preserve the axioms of Det A at the isotopic level because

$$\hat{\mathrm{D\hat{e}t}}\,(A \hat{\times} B) = (\mathrm{D\hat{e}t}\,A)\hat{\times}(\mathrm{D\hat{e}t}\,B),\quad \mathrm{D\hat{e}t}\,(A^{-1}) = (\mathrm{D\hat{e}t}\,A)^{-1}. \tag{3.5}$$

The corresponding *isodual isodeterminant* is given by

$$\mathrm{D\hat{e}t}^d\,A \ := \ [\,\mathrm{Det}_{F}\,(A \times T^d)\,] \times 1^d\ ; \tag{3.6}$$

Similar isotopic liftings occur for trace, Hermiticity, unitarity and all other operations [27].

4: ISOFIELDS, PSEUDOISOFIELDS AND THEIR ISODUALS

To render this paper minimally self-sufficient as well as for notational convenience, it appears recommendable to outline the essential background notions needed for the analysis.

Let us begin with the following definition of isofields [29].

DEFINITION 4.1: Let $F = F(a, +, \times)$ *be a "field", here defined as a ring with elements* a, b, c, ..., *which is commutative and associative under the operation of conventional addition* + *and (generally nonassociative but) alternative under the operation of conventional multiplication* × *with corresponding additive unit* 0 *and multiplicative unit* I. *Then, the "isofields"* $\hat{F} = \hat{F}(\hat{n}, +, \hat{\times})$ *are given by elements* $\hat{a}, \hat{b}, \hat{c}$, ... *characterized by one-to-one and invertible maps* $a \Rightarrow \hat{a}$ *of the original elements* $a \in F$ *equipped with two operations* $(+, \hat{\times})$, *the conventional addition* + *of* F *and a new multiplication* $\hat{\times}$ *called "isomultiplication", with corresponding conventional additive unit* 0 *and a generalized multiplicative unit* $\hat{1}$, *called "multiplicative isounit", which are such to verify all axioms of the original field* F, *i.e.:*

1) Axioms of addition:

1.A) The set $\hat{F}$ *is closed under addition,*

$$\hat{a} + \hat{b} \in \hat{F} \qquad \forall\ \hat{a}, \hat{b} \ \in\ \hat{F}, \tag{5.1}$$

1.B) The addition is commutative for all elements $\hat{a}, \hat{b} \in \hat{F}$

$$\hat{a} + \hat{b} = \hat{b} + \hat{a}\ ; \tag{4.2}$$

1.C) The addition is associative for all $\hat{a}, \hat{b}, \hat{c}, \in F$,

$$\hat{a} + (\hat{b} + \hat{c}) = (\hat{a} + \hat{b}) + \hat{c}\ ; \tag{4.3}$$

1.D) There is an element 0, *the"additive unit", such that for all elements* $\hat{a} \in \hat{F}$

$$\hat{a} + 0 = 0 + \hat{a} \equiv \hat{a}\ ; \tag{4.4}$$

1.E) For each element $\hat{a} \ \in \hat{F}$, *there is an element* $-\hat{a} \in \hat{F}$, *called the "opposite of* $\hat{a}$*", which is such that*

$$\hat{a} + (-\hat{a}) = 0 \tag{4.5}$$

2) Axioms of isomultiplication:

2.A) The set $\hat{F}$ *is closed under isomultiplication,*

$$\hat{a} \hat{\times} \hat{b} \ \in\ \hat{F}, \quad \forall\ \ \hat{a}, \hat{b} \in \hat{F}, \tag{4.6}$$

2.B) The multiplication is generally non-isocommutive, i.e., $\hat{a} \hat{\times} \hat{b} \neq \hat{b} \hat{\times} \hat{a}$, *but "isoalternative", i.e., it verifies the following left and right isoalternative laws for all elements* $\hat{a}, \hat{b}, \in \hat{F}$

$$\hat{a} \hat{\times} (\hat{b} \hat{\times} \hat{b}) = (\hat{a} \hat{\times} \hat{b}) \hat{\times} \hat{b}\ ;\ \ (\hat{a} \hat{\times} \hat{a}) \hat{\times} \hat{b} = \hat{a} \hat{\times} (\hat{a} \hat{\times} \hat{b}), \tag{4.7}$$

2.C) There exists a quantity $\hat{1}$, *the "multiplicative isounit", which is such that, for all elements* $\hat{a} \in \hat{F}$,

$$\hat{a} \hat{\times} \hat{1} = \hat{1} \hat{\times} \hat{a} \equiv \hat{a}, \tag{4.8}$$

2.D) For each element $\hat{a} \in \hat{F}$, *there is an element* $\hat{a}^{-1} \in \hat{F}$, *called the "isoinverse", which is such that*

$$\hat{a} \hat{\times} (\hat{a}^{-1}) = (\hat{a}^{-1}) \hat{\times} \hat{a} = \hat{1}. \tag{4.9}$$

3) Properties of joint addition and isomultiplication:

3.A) The set $\hat{F}$ *is closed under joint isomultiplication and addition,*

$$\hat{a} \hat{\times} (\hat{b} + \hat{c}) \ \in\ \hat{F}, \quad (\hat{a} + \hat{b}) \hat{\times} \hat{c} \ \in\ \hat{F}, \ \forall\ \hat{a}, \hat{b}, \hat{c} \in \hat{F}, \tag{4.10}$$

3.B) All elements $\hat{a}, \hat{b}, \hat{c} \in \hat{F}$ *verify the right and left "isodistributive laws"*

$$\hat{a} \hat{\times} (\hat{b} + \hat{c}) = \hat{a} \hat{\times} \hat{b} + \hat{a} \hat{\times} \hat{c}, \quad (\hat{a} + \hat{b}) \hat{\times} \hat{c} = \hat{a} \hat{\times} \hat{c} + \hat{b} \hat{\times} \hat{c}, \tag{4.11}$$

When there exists a least positive integer p *such that the equation*

$$p \hat{\times} \hat{a} = 0, \tag{4.12}$$

admits solution for all elements $\hat{a} \in \hat{F}$, *then* $\hat{F}$ *is said to have "isocharacteristic p". Otherwise,* $\hat{F}$ *is said to have "isocharacteristic zero".*

The elements $\hat{a}$ *of isofields* $\hat{F}(\hat{a}+, \hat{\times})$ *are called "isonumbers".*

The reader is aware that there are various definitions of "fields" in the mathematical literature [7–10], with stronger or weaker conditions depending on the case at hand. Often, "fields" $F(a, +, \times)$ are assumed to be *associative under the multiplication* (see, e.g., ref. [8], p. 101)

$$a \times (b \times c) = (a \times b) \times c \quad \forall a, b, c, \in F, \tag{4.13}$$

while in Definition 4.1 we have assumed "fields" to be alternative, i.e.,

$$a \times (b \times b) = (a \times b) b, \quad (a \times a) \times b = a \times (a \times b), \ \forall a, b \in F, \tag{4.14}$$

which is an evident generalization of associativity because every associative ring is also alternative, but an alternative ring is not necessarily associative (see ref. [8] for details).

Therefore, the "isofields" as per Definition 4.1 are not, in general isoassociative, i.e., they generally violate the *isoassociative law of the multiplication*

$$\hat{a} \hat{\times} (\hat{b} \hat{\times}) = (\hat{a} \hat{\times} \hat{b}) \hat{\times} \hat{c} \quad \forall \hat{a}, \hat{b}, \hat{c} \in \hat{F}, \tag{4.15}$$

and verify instead the weaker isoalternative laws (4.7).

The above assumptions are suggested by our need to reach a definition of "number" which is unified with the results of Theorem 1.1, and includes: the real numbers $R(n,+,\times)$, complex numbers $C(c,+,\times)$, quaternions $Q(q,+,\times)$ and octonions $O(o,+,\times)$. The corresponding "isofields" given by *isoreal numbers* $\hat{R}(\hat{n},+,\hat{\times})$, *isocomplex numbers* $\hat{C}(\hat{c},+,\hat{\times})$, *isoquaternions* $\hat{Q}(\hat{q},+,\hat{\times})$ and *isooctonions* $\hat{O}(\hat{o},+,\hat{\times})$, the latter being isoalternative but not isoassociative.

The realizations of the isonumbers, isomultiplication and related isounits used in this paper are those reviewed earlier, i.e.,

$$\hat{a} = a \times 1, \quad \hat{\times} = \times T \times, \quad 1 = T^{-1}. \tag{4.16}$$

where $\times$ is evidently the original multiplication in F, and 1 preserves all

properties of I (smoothness, boundedness, nondegeneracy, Hermiticity, and positive-definiteness).

Note that the lifting $\times \rightarrow \hat{\times} = \times T \times$ is an isotopy in the sense that it preserves the axioms verified by the original multiplication $\times$, i.e., if $\times$ is associative, $\hat{\times}$ is isoassociative, if $\times$ is alternative $\hat{\times}$ is isoalternative, etc. (see ref. [29], Sect. 5 for details).

Thus, "fields" and "isofields" as per Definition 4.1 coincide at the abstract level by conception, as a necessary condition to have an isotopy. In fact, all distinctions between the multiplications $\times$ and $\hat{\times}$ (as well as between the unit I and the isounit 1) cease to exist at the abstract level.

The liftings $a \rightarrow \hat{a}$, and $\times \rightarrow \hat{\times}$ can be used jointly or individually. The following properties are then important for our analysis.

PROPOSITION 4.1: Necessary and sufficient condition for the lifting (where the multiplication is lifted but the elements are not)

$$F(a, +, \times) \rightarrow \hat{F}(a, +, \hat{\times}), \quad \hat{\times} = \times T \times, \quad 1 = T^{-1} \tag{4.17}$$

to be an isotopy (that is, for $\hat{F}$ *to verify all axioms of the original field* F*) is that* T *is a non-null element of the original field* F.

In fact, the laws of addition are unchanged, while the multiplication and distributive laws can be readily verified to hold. The closure of the original set under the addition is evident because that operation is not changed. We then remain with the closure under the isomultiplication,

$$a \hat{\times} b = a \times T \times b \in \hat{F}, \quad \forall a, b \in \hat{F}, \tag{4.18}$$

which does indeed hold when $T \in \hat{F}$, by therefore establishing the sufficiency of the condition. Its necessity follows from simple contrary arguments.

PROPOSITION 4.2: The lifting (where both the multiplication and the elements are lifted)

$$F(a, +, \times) \rightarrow \hat{F}(\hat{a}, +, \hat{\times}), \ \hat{a} = a \times 1, \ \hat{\times} = \times T \times, \quad 1 = T^{-1}, \tag{4.19}$$

constitutes an isotopy even when the multiplicative isounit 1 *is not an element of the original field* F.

In fact, one can readily verify the validity of all axioms of a field, and closure under addition. Closure under multiplication readily holds because

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$$\hat{a} \hat{\times} \hat{b} \;=\; (a \times b) \times \hat{1} \;=\; c \times \hat{1} \;=\; \hat{c} \in \hat{F}, \quad \forall\, a, b, c = a \times b \in F, \tag{4.20}$$

The mathematically simple Proposition 4.2 expresses the physically fundamental capability of generalizing Planck's unit $\hbar = 1$ of quantum mechanics into an integro-differential operator $\hat{1}$ for a quantitative treatment of nonlocal interactions [26,27].

A first application of the isotopies of numbers is the following. As well known, the set of purely imaginary numbers $S = \{in\}$ *is not* a field, evidently because it is not closed under the multiplication, $in \times im = -nm \notin S$. However, the set of real numbers $\hat{S}(\hat{n},+,\hat{\times})$, $\hat{n} = ni$ with the purely imaginary isounit $\hat{1} = i$ is indeed an isofield, that is, it verifies all axioms of a field, including the closure under the isomultiplication, because $T = i^{-1}$, and we have $in \hat{\times} im = inm \in \hat{S}$.

This illustrates the possibility that, when a given set does not constitute a field, there may exist an isotopy under which it verifies all axioms for a field.

The following property illustrates the reasons for restricting the isotopies in Definition 5.1 to only those of the multiplication.

PROPOSITION 4.3: The lifting

$$F(a, +, \times) \quad \rightarrow \quad \hat{F}(\hat{a}, \hat{+}, \hat{\times}), \tag{4.21a}$$

$$\hat{a} = a \times 1, \quad \hat{+} = +\hat{K}+, \quad \hat{0} = -\hat{K} = -K \times \hat{1}, \quad \hat{\times} = \times T \times, \quad \hat{1} = T^{-1}, \tag{4.21b}$$

where K is an element of the original field F and T is arbitrary invertible quantity, is not an isotopy for all nontrivial values of the quantity $K \neq 0$, because it preserves all axioms of Definition 4.1, except the distributive law (4.11)

In fact, all axioms (4.1)–(4.10) can be readily verified to be preserved under liftings (5.21). On the contrary, for the right distributive law we have

$$\hat{a} \hat{\times} (\hat{b} \hat{+} \hat{c}) \;=\; a \times (b + K + c) \times \hat{1} \;=\; (a \times b \;+\; a \times K \;+\; a \times c) \times \hat{1} \;\neq$$

$$\neq\; \hat{a} \hat{\times} \hat{b} \;\hat{+}\; \hat{a} \hat{\times} \hat{c} \;=\; (a \times b \;+\; K \;+\; a \times c) \times \hat{1}, \tag{4.22}$$

with similar lack of identities for the left isodistributive law. Note that the set $\hat{F}$ in lifting (4.21) is closed under isoaddition for $K \in F$ (but not for $K \notin F$), and, separately, under isomultiplication for an arbitrary isounit $\hat{1}$ outside the original set F. The same results hold for the lifting $F(a, +, \times) \rightarrow \hat{F}(a, \hat{+}, \hat{\times})$, $\hat{+} = +K+$, $K \in F$, $K \neq 0$.

A central property expressed by Proposition 4.3 is that lifting (5.21) is not an isotopy because one of the original axioms is not preserved. We shall then use the term *"pseudoisotopy"* to denote the preservation of only part of the original axioms.

DEFINITION 4.2: Let $\hat{F}(\hat{a},+,\hat{\times})$ be an isofield as per Definition 4.1. Then, the "pseudoisofields" are given by the images of $\hat{F}(\hat{a},+,\hat{\times})$ under all possible further liftings of the addition $+ \rightarrow \hat{+} = +\hat{K}+$, with additive isounit $\hat{0} = -\hat{K} = -K \times \hat{1}$, $K \neq 0$, in which case the elements $\hat{a}$ are called "pseudoisonumbers".

After having identified the notions of fields, isofields and pseudoisofields, we now study their *isotopic conjugation*, that is, their images under change of sign of the isounit

$$\hat{1} \;\rightarrow\; \hat{1}^d \;=\; -1, \tag{4.23}$$

called *isoduality* [20–22].

DEFINITION 4.3: Let $F(a,+,\times)$ be a field as per Definition 4.1. Then the "isodual field" $F^d(a^d,+,\times^d)$ is constituted by elements called "isodual numbers"

$$a^d \;:=\; a \times 1^d \;=\; -a, \tag{4.24}$$

defined with respect to the "isodual multiplication" and related "isodual unit"

$$\times^d \;:=\; \times 1^d \times \;=\; -\times, \quad 1^d \;=\; -1. \tag{4.25}$$

Let $\hat{F}(\hat{a},+,\hat{\times})$ be an isofield as per Definition 4.1. Then, the "isodual isofield" $\hat{F}^d(\hat{a}^d,+,\hat{\times}^d)$ is given by "isodual isonumbers"

$$\hat{a}^d \;:=\; a^c \times \hat{1}^d \;=\; -a^c \times \hat{1}, \tag{4.26}$$

where a^c is the conventional conjugation of F (e.g., complex conjugation), defined in terms of the "isodual isomultiplication"

$$\hat{\times}^d \;:=\; \times T^d \times \;=\; -\hat{\times}, \quad T^d \;=\; -T. \tag{4.27}$$

Finally, let $\hat{F}(\hat{a},\hat{+},\hat{\times})$ be a pseudoisofield as per Definition 4.2. Then the "isodual pseudoisofield" $\hat{F}^d(\hat{a}^d,\hat{+}^d,\hat{\times}^d)$ is given by the image of the original isofield under isodualities (4.25) and (4.26), plus the additional isoduality

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$$\hat{0} \rightarrow \hat{0}^d = -\hat{0}. \qquad (4.28)$$

and its elements $\hat{a}^d$ *are called "isodual pseudoisonumbers".*

A few comments are now in order. All conventional operations with numbers depending on the multiplication are evidently altered under lifting to isofields. Let us consider first the isofields $\hat{F}(\hat{a}, +, \hat{\times})$ of Proposition 4.1. Then, the "square" $a^2 = a \times a$ is lifted into the *isosquare* $a^{\hat{2}} = a \times T \times a$, with *n-th isopower*

$$a^{\hat{n}} = a \times T \times a \times T \times a \times \ldots\ldots \times T\, a \quad (n \text{ times}) \qquad (4.29)$$

Recall that the conventional square root can be defined as the quantity $a^{\frac{1}{2}}$ such that $(a^{\frac{1}{2}}) \times (a^{\frac{1}{2}}) = a$. Then, for the simple case in which T commutes with all elements $a \in \hat{F}$, the *isosquare root* is given by

$$a^{\hat{\frac{1}{2}}} = a^{\frac{1}{2}} \times \hat{1}^{\frac{1}{2}}, \quad a^{\hat{\frac{1}{2}}} \hat{\times} a^{\hat{\frac{1}{2}}} = a^{\hat{\frac{1}{2}}} \times T \times a^{\hat{\frac{1}{2}}} = a. \qquad (4.30)$$

The *isoinverse*, from Eq. (4.9), is given by

$$a^{\hat{-1}} = \hat{1}\, a^{-1}\, \hat{1}. \qquad (4.31)$$

The *isoquotient* can then be defined by

$$a \,\hat{/}\, b = c', \qquad c' \times T \times b = a. \qquad (4.32)$$

The reader can then compute all other isooperations.

Note that the isounit $\hat{1}$ is idempotent of arbitrary (finite) order n as the original one

$$\hat{1}^{\hat{n}} = \hat{1} \times T \times \hat{1} \times T \times \ldots\ldots \times T \times \hat{1} \quad (n \text{ times}) \equiv \hat{1} \qquad (4.33)$$

the isosquare root of the isounit is the isounit itself,

$$\hat{1}^{\hat{\frac{1}{2}}} = \hat{1}, \qquad (4.34)$$

and the isoquotient of the isounit by itself is the isounit,

$$\hat{1} \,\hat{/}\, \hat{1} \equiv \hat{1}, \qquad (4.35)$$

thus confirming the isotopic nature of the lifting $1 \rightarrow \hat{1}$.

Fully equivalent expressions hold for the isofields $\hat{F}(\hat{a}, +, \hat{\times})$ of Proposition 5.2, for which we have

$$\hat{a}^{\hat{2}} = \hat{a} \hat{\times} \hat{a} \hat{\times} \ldots \hat{\times} \hat{a} = a^2 \times \hat{1}, \qquad (4.36a)$$

$$\hat{a}^{\hat{\frac{1}{2}}} = a^{\frac{1}{2}} \times \hat{1}^{\frac{1}{2}}, \qquad (4.36b)$$

$$\hat{a} \,\hat{/}\, \hat{b} = \hat{c} = c \times \hat{1}, \quad \hat{c} \hat{\times} \hat{b} = (c \times b) \times 1 = \hat{a}. \qquad (4.34c)$$

Note also that the number 1 may be an element of the isofield $\hat{F}(a,+,\hat{\times})$, although it is no longer the unit. Similarly, the number 0 may be an element of the pseudoisofield $\hat{F}(a,\hat{+},\times)$, but it is no longer the additive identity.

Kadeisvili [32] provided an important classification of isounits into five primary classes which is hereon tacitly assumed.. In this paper we shall only study two out of five classes, namely, Class I with $\hat{1} > 0$ for isofields and Class II with $\hat{1} < 0$ for isodual isofields, for the sole case of isocharacteristic zero. Among the remaining classes not studied in this paper for brevity, Class IV is particularly intriguing inasmuch as it deals with degenerate isotopic elements $T \rightarrow 0$ and corresponding singular isounits $\hat{1} \rightarrow \infty$ which can represent gravitational collapse into a singularity.

5: ISOSPACES, PSEUDOISOSPACES AND THEIR ISODUALS

Consider a metric or pseudo metric n–dimensional space $S(x,g,R(n,+,\times))$ with local coordinates x and (Hermitean) metric $g = g^\dagger$ over the reals $R(n,+,\times)$. Another notion needed for our analysis is given by the *isospaces* $\hat{S}(x,\hat{g},\hat{R}(n,+,\hat{\times}))$ over the isoreals $\hat{R}(n,+,\hat{\times})$ (see Proposition 4.1), first introduced in ref. [18] (see also ref.s [19,23,28]),

$$\hat{S}(x,\hat{g},\hat{R}(n,+,\hat{\times})), \quad \hat{g} = T \times g, \quad \hat{\times} = \times T, \quad \hat{1} = T^{-1}; \qquad (5.1)$$

The *isoduals isospaces*, first introduced in ref. [20] (see also ref.s [21,23,28]) are then given by

$$\hat{S}^d(x,\hat{g}^d,\hat{R}^d(n^d,+,\hat{\times}^d)): \hat{g}^d = T^d \times g = -T \times g, \quad \hat{\times}^d = \times T^d \times = -\times T \times, \quad \hat{1}^d = -\hat{1}. \qquad (5.2)$$

Again, as it is the case for isotopies of fields, isospaces $\hat{S}(x,\hat{g},\hat{R})$ coincide, by construction with the conventional spaces $S(r,g,R)$ at the abstract, realization-free level, thus verifying the isomorphism $\hat{S}(x,\hat{g},\hat{R}) \approx S(x,g,\Re)$. Nevertheless, the former have the most general known curvature and integral character owing to the arbitrariness in the isotopic element T. In fact, the isometrics $\hat{g} = T \times x$ have the most general possible, nonlinear, nonlocal and noncanonical dependence in all variables,

$$g = g(x) \rightarrow \hat{g} = T(t, x, \dot{x}, \ddot{x}, \ldots) \times g(x) \quad \hat{g}(t, x, \dot{x}, \ddot{x}, \ldots) . \tag{5.3}$$

Similarly, isodual isospaces $\hat{S}^d(x,\hat{g},\hat{R}^d(\hat{n}^d,+,\hat{\times}^d))$ are locally isomorphic to the *isodual spaces* $S^d(x,g^d,R^d(n^d,+,\times^d))$, which are conventional spaces although defined on the isodual real fields R^d.

The isospaces most important for physical and mathematical applications are the *isoeuclidean spaces* $\hat{E}(x,\hat{\delta},\hat{R})$, *isominkowski spaces* $\hat{M}(x,\hat{\eta},\hat{R})$ and *isoriemannian spaces* $\hat{R}(x,\hat{g},\hat{R})$, which are at the foundations of the representation of nonlinear, nonlocal and noncanonical interior systems in nonrelativistic, relativistic and gravitational interior problems, respectively (see ref.s [25,29] for details).

Note that in the above definition the local coordinates x and numbers n of an isospace $\hat{S}(x,\hat{g},\hat{R}(n,+,\hat{\times}))$ are not lifted into the forms $\hat{x} = x \times 1$, $\hat{n} = n \times 1$, which renders them the vector space equivalent of Proposition 4.1. Needless to say, the liftings $x \rightarrow \hat{x} = x \times 1$ and $n \rightarrow \hat{n} = n \times 1$ are indeed possible, implying the additional forms $\hat{S}(x,\hat{g},\hat{R}(\hat{n},+,\hat{\times}))$, primarily used in this paper, and $\hat{S}(\hat{x},\hat{g},\hat{R}(\hat{n},+,\hat{\times}))$.

Given an isospace $\hat{S}(x,\hat{g},\hat{R}(n, +, \hat{\times})$, then a *pseudoisospace* is given by the image $\hat{S}(x,\hat{g},\hat{R}(n,\hat{+},\hat{\times})$ of the original space characterized by the further lifting $+ \rightarrow \hat{+} = + K +, 0 \rightarrow \hat{0} = - K$. The *isodual pseudoisospace* is then defined accordingly.

6: ISOTRANSFORMATIONS

Another notion needed for this paper is the applicable transformation theory. Consider an isospace $\hat{S}(x,\hat{\delta},\hat{R}(n,+,\hat{\times}))$. Conventional linear, local and canonical transformations $x' = A \times x$ are now afflicted by a host of mathematical inconsistencies (such as the violation of linearity, transitivity and others) whenever applied to $\hat{S}(x,\hat{g},\hat{R}(n,+,\hat{\times}))$. For this reason this author introduced in ref. [14] the *isotransformations* as the right isomodular actions on $\hat{S}(x,\hat{\delta},\hat{R}(n,+,\hat{\times}))$

$$x' = A \hat{\times} x = A \times T \times x , \tag{6.1}$$

where the isotopic element T is fixed for all $x \in \hat{S}$, which now do verify all needed conditions, although expressed in their isotopic form. The left isotransformations are defined by

$$x^{t\,\prime} = x^t \hat{\times} A^t = x^t \times T \times A^t , \tag{6.2}$$

because $T = T^t$ for the considered Class I of isonumbers and isospaces.

The *isodual isotransformations* are given by

$$x'^{\,d} = A^d \hat{\times}^d x^d . \tag{6.3}$$

Transformations (6.1) are called *isolinear* because they coincide with the conventional linear transformations at the abstract level. Note that all nonlinear transformations $x' = B(x)$ can be always cast into an identical isolinear form [29]

$$x' = B(x) \equiv A \hat{\times} x, \qquad T = A^{-1} \times B \times x^{-1} . \tag{6.4}$$

We can then say that linearity is a true axiomatic structure, but nonlinearity is not because it can be made to disappear under isotopies.

Transformation (6.1) are also *isolocal* , in the sense that they coincide with the conventional local transformations $x' = A \times x$ at the abstract level. Again, all nonlocal integral transformations $x' = I(x)$ verifying the needed continuity conditions can always be identically written in an isotopic form [29]

$$x' = I(x) \equiv A \hat{\times} x, \qquad T = A^{-1} \times I \times x^{-1} . \tag{6.5}$$

In this way one can see that locality is a true axiomatic structure, but nonlocality is not because it can be made to disappear at the abstract level under isotopies.

Transformations (6.1) are finally called *isocanonical* , in the sense that they generally violate the conditions to constitute canonical transformations, but they nevertheless coincide with conventional canonical transformations at the abstract level. Thus, the canonical structure is a true axiomatic structure, but its absence (violation of the integrability conditions for the existence of a Hamiltonian, the *conditions of variational selfadjointness* [15]) is also not a true axiomatic structure because it can be made to disappear at the abstract level under isotopies. In fact, in ref. [15] one can see the construction of the *Birkhoffian generalization of Hamiltonian mechanics* for the representation of all possible, sufficiently smooth and regular, local but nonlinear and nonhamiltonian systems, under the condition that Birkhoffian and Hamiltonian mechanics coincide at the abstract level.

The *pseudoisotransformations* are then isotransformations (4.1) on a pseudoisospace $\hat{S}(x,\hat{g},\hat{R}(n,\hat{+},\hat{\times})$. However, while the original transformations (4.1) are distributive, the latter ones are not,

$$A \hat{\times} (x \,\hat{+}\, x') \neq A \hat{\times} x \,\hat{+}\, A \hat{\times} x' , \tag{6.6}$$

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in view of Proposition 4.3. The *isodual pseudoisotransformations* are then defined accordingly.

7: ISOALGEBRAS, PSEUDOISOALGEBRAS AND THEIR ISODUALS

A further notion needed for our analysis is the applicable definition of algebra and of the representation theory. An isovector space $\hat{U}$ with elements A, B, C, ... and isomultiplication $\hat{\circ}$ over an isofield $\hat{F}(a,+,\hat{\times})$ of elements a, b, c, and isomultiplication $a \hat{\times} b$ with multiplicative isounit $\hat{1} = T^{-1}$ is called an (associative or nonassociative) *isoalgebra* [14,29], when it satisfies the left and right scalar and distributive laws

$$(a \hat{\times} A) \hat{\circ} B = A \hat{\circ} (a \hat{\times} B) = a \hat{\times} (A \hat{\times} B),$$

$$(A \hat{\times} a) \hat{\circ} B = A \hat{\circ} (B \hat{\times} a) = (A \hat{\circ} B) \hat{\times} a,$$

$$A \hat{\circ} (B + C) = A \hat{\circ} B + A \hat{\circ} C, \quad (B + C) \hat{\circ} A = B \hat{\circ} A + C \hat{\circ} A. \quad (7.1)$$

for all elements $A, B, C \in \hat{A}$ and $a, b, c \in \hat{F}$.

Note the differentiation between the isomultiplication $A\hat{\circ}B$ of the elements of the algebras, which are, say, matrices, from the isomultiplication of the elements of the isofields $a\hat{\times}b$, which can be ordinary numbers.

The isoalgebra $\hat{U}$ is called an *isodivision algebra* when the equation $A \hat{\times} x = B$ always admit a solution for $A \neq 0$.

Recall that a basis e_k, k = 1, 2, ..., m of a conventional algebra U (i.e., one verifying the conventional form of the scalar and distributive laws) remains unchanged under isotopies, except for possible renormalization $e_k \to \hat{e}_k$ (ref. [29], Proposition 3.1, p. 181). Thus a generic element $A \in \hat{U}$ can be written

$$A = \sum_{k=1,...,m} \hat{n}_k \hat{\times} \hat{e}_k, \qquad \hat{n}_k \in \hat{F}(\hat{a},+,\hat{\times}). \quad (7.2)$$

The *isonorm* of $\hat{U}$ in the basis considered is then given by

$$\uparrow A \uparrow = (\sum_{k=1,...,m} n_k \times n_k)^{\frac{1}{2}} \times \hat{1} \in \hat{F}. \quad (7.3)$$

An isoalgebra $\hat{U}$ is called *isonormed*, when the isonorm verifies the axiom

$$\uparrow A \hat{\circ} B \uparrow = \uparrow A \uparrow \hat{\times} \uparrow B \uparrow \in \hat{F}, \uparrow \hat{n} \hat{\times} A \uparrow = \uparrow \hat{n} \uparrow \hat{\times} \uparrow A \uparrow, \quad (7.4)$$

/here we have differentiated the product $A\hat{\circ}B$ of the elements A and B of the lgebras from the product $\uparrow A \uparrow \hat{\times} \uparrow B \uparrow$ of the elements of the isofield $\uparrow A \uparrow$ and $B \uparrow$.

The isoalgebra $\hat{U}$ is said to be *isoassociative* when it verifies the soassociative law

$$A \hat{\circ} (B \hat{\circ} C) = (A \hat{\circ} B) \hat{\circ} C, \quad \forall A, B, C \in \hat{U}; \quad (7.5)$$

t is said to be *isoalternative* when it verifies the isoalternative laws

$$A^{\hat{2}} \hat{\circ} B = A \hat{\circ} (A \hat{\circ} B), \quad A \hat{\circ} B^{\hat{2}} = (A \hat{\circ} B) \hat{\circ} B, \quad (7.6)$$

t is said to be *Lie-isotopic* when the product $A\hat{\circ}B$ verifies the Lie algebra axioms n isotopic form (anticommutativity and Jacobi law) as in the realization [14,29]

$$A \hat{\circ} B = A T B - B T A, \quad A T, B T, \text{etc.} = \text{assoc.} \quad (7.7)$$

ınd it is said to be *Lie-admissible* when the antisymmetric product attached to $A\hat{\circ}B$

$$[A \hat{,} B] := A \hat{\circ} B - B \hat{\circ} A, \quad (7.8)$$

s Lie-isotopic as in the realization

$$A \hat{\circ} B = A R B - B S A. \quad (7.9)$$

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The *isodual isoalgebras* $\hat{U}^d$ are then those characterized over an isodual isofield $\hat{F}^d(\hat{n}^d,+,\hat{\times}^d)$.

Suppose that $\hat{U}$ is isoassociative and let $\hat{R}_A$ and $\hat{L}_A$ represent the right and left isomultiplication of the element $A \in \hat{U}$. It is possible to prove that the map $A \to \hat{R}_A$ ($A \to \hat{L}_A$) constitutes a homomorphism (antihomomorphism) of $\hat{U}$ into the algebra of all isolinear transformations of $\hat{U}$ as a vector isospace called *right (left) isorepresentations* (see the forthcoming paper [35] for details).

A dominant aspect of the transition from conventional representations to the covering isorepresentations, for which the isonumbers were conceived, is the transition from the conventional linear, local and canonical representations currently used in physics to their most general possible nonlinear, nonlocal and noncanonical form.

As well known, the distributive laws are basic axioms for any structure to characterize an "algebra" as commonly understood [7–10]. The image of an isoalgebra $\hat{U}$ under the transition an isofield $\hat{F}(a,+,\hat{\times})$ to a pseudoisofield $\hat{F}(a,\hat{+},\hat{\times})$ then implies the loss of the basic distributive laws and, for this reason it will be called *pseudoisoalgebra*.

8: REALIZATION OF ISOREAL NUMBERS AND THEIR ISODUALS

8.A: Realization of ordinary real numbers. Recall (see, e.g., ref. [7]) that conventional real numbers $n \in R(n,+,\times)$ are realized on the one-dimensional real Euclidean space $E_1(x,\delta,R(n,+,\times))$, which essentially represents a straight line with origin at 0, local coordinates x, metric $\delta = 1$, additive unit 0 and multiplicative unit 1. In fact, the *dilations*

$$x' = n \times x, \qquad n \in R(n,+,\times), \qquad x, x' \in E_1(x,\delta,R) , \tag{8.1}$$

characterize an isomorphism of the reals $R(n,+,\times)$ into the commutative one-dimensional group of dilations G(1).

The trivial basis is

$$e = 1, \tag{8.2}$$

with the familiar norm

$$|n| = (n \times n)^{\frac{1}{2}} > 0, \tag{8.3}$$

verifying axioms (7.4),

$$|n \times n'| = |n| \times |n'|. \tag{8.4}$$

This show that *real numbers constitute a one-dimensional normed associative and commutative algebra* U(1).

8.B: Realization of isodual real numbers. Isodual real numbers $n^d \in R^d(n^d,+,\times^d)$ are conventional numbers n, although defined with respect to the isodual unit $1^d = -1$. The isodual conjugation for real numbers can then be written

$$n = n \times 1 \quad \rightarrow \quad n^d = n \times 1^d = -n. \tag{8.5}$$

All numerical values therefore change sign under isoduality. One should however keep in mind that such a sign inversion occurs only when the isodual real numbers are projected in the field of conventional real numbers.

As an example, the negative integer number −3 referred to the negative unit − 1 is fully equivalent to the positive integer number +3 referred to the positive unit +1, and this illustrates that the change of sign under isoduality occurs only in the projection of the isodual numbers in the original conventional field.

The representation of $R^d(n^d,+,\times^d)$ requires the use of the one-dimensional, real isodual Euclidean space $E^d(x,\delta^d,R^d(n^d,+,\times^d))$, which is also a straight line, this time with conventional additive unit 0, and isodual multiplicative unit $1^d = -1$. The *isodual dilations* are then given by

$$x' = n^d \times^d x = n \times x. \tag{8.6}$$

They establish an isomorphism between $R^d(n^d,+,\times^d)$ and the isodual group of dilations $G^d(1)$, i.e., the conventional group G(1) reformulated with respect to the multiplicative unit 1^d.

Note that $E_1(x,\delta,R)$ and $E_1{}^d(x,\delta^d,R^d)$ are anti-isomorphic and the same property holds for G(1) and $G^d(1)$. Note that isodual dilations (8.2) coincide with the conventional ones (8.1), and this could be a reason for the lack of detection of isodual numbers until ref.s [18–20].

The *isodual basis* is now

$$e^d = 1^d \tag{8.7}$$

with *isodual norm*

$$|n|^d := (n \times n)^{\frac{1}{2}} \times 1^d = |n| \times 1^d = -|n| < 0 \tag{8.8}$$

verifying axioms (7.4).

$$|n^d \times n'^d|^d = |n^d|^d \times^d |n'^d|^d. \tag{8.9}$$

This shows that *isodual real numbers constitute a one-dimensional isodual, associative and commutative normed algebra* $U^d(1)$ *which is anti-isomorphic to* U(1).

8.C: Realization of isoreal numbers. We consider now the isoreal numbers $\hat{n} = n \times \hat{1}$ as elements of an isofield of Class I [32], $\hat{R}_I(\hat{n},\hat{+},\hat{\times})$ with isomultiplication $\hat{\times} = \times T \times$, and multiplicative isounit $\hat{1} = T^{-1} > 0$ generally outside the original set $R(n,+,\times)$. Their representation requires the isoeuclidean spaces of

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Class I, $\hat{E}_{I,1}(x,\hat{\delta},\hat{R}(\hat{n},+,\hat{\times}))$, $\hat{\delta} = T\delta$, over $\hat{R}(\hat{n},+,\hat{\times})$, which are the isotopes of the conventional one-dimensional Euclidean spaces $E_1(x,\delta,R)$.

One should keep in mind that:

A) $\hat{E}_{I,1}(x,\hat{\delta},\hat{R})$ is a simple, yet bona-fide *isoriemannian space* [30], because $\hat{\delta} = T \times \delta = \hat{\delta}(t, x, \dot{x}, \ddot{x}, \ldots)$, where the local dependence is generally nonlinear, nonlocal and noncanonical in all variables;

B) $\hat{E}_{I,1}(x,\hat{\delta},\hat{R})$ is not a Riemannian space because of the intrinsic dependence of the isometric $\hat{\delta}$ on the derivatives $\dot{x}$, $\ddot{x}$, ... as well as the fact that the basic unit is not the conventional quantity I; and

C) Despite their differences, the conventional Euclidean space $E_1(x,\delta,R)$ and its isotopic covering $\hat{E}_{I,1}(x,\hat{\delta},\hat{R})$ are locally isomorphic due to the joint liftings $\delta \to \hat{\delta} = T\times\delta$ *and* $I \to \hat{1} = T^{-1}$.

Thus, the one-dimensional isospace $\hat{E}_{I,1}(x,\hat{\delta},\hat{R})$ represents a generalization of the conventional straight line, here called an *isoline*, because of its intrinsically nonlinear, nonlocal and noncanonical metric $\hat{\delta}(t, x, \dot{x}, \ddot{x}, \ldots)$ with multiplicative isounit $\hat{1} = \hat{1}(t, x, \dot{x}, \ddot{x}, \ldots)$.

$\hat{R}_I(\hat{n},\hat{+},\hat{\times})$ can then be realized via the *isodilations* on $\hat{E}_{I,1}(x,\hat{\delta},\hat{R})$

$$x' = \hat{n} \hat{\times} x = n \times x, \tag{8.10}$$

which formally coincide the original dilations (8.1), as it is the case for the isodual dilations, thus providing a reason for the lack of detection of the isoreal numbers until recently.

Isodilations (8.10) characterize an isomorphism of the isoreal numbers with the one-dimensional isogroup of isodilations $\hat{G}(1)$, i.e., the group G(1) realized with respect to the isounit $\hat{1}$. The isomorphism $E(x,\delta,R(n,+,\times)) \approx \hat{E}_{I,1}(x,\hat{\delta},\hat{R}(\hat{n},+,\hat{\times}))$ then readily implies $\hat{G}(1) \approx G(1)$.

The *isobasis* is given by

$$\hat{e} = \hat{1}, \tag{8.11}$$

while the *isonorm* can be defined by

$$\hat{|}\hat{n}\hat{|} := (n \times n)^{\frac{1}{2}} \times \hat{1} = |n| \times \hat{1}, \tag{8.12}$$

namely, by the conventional norm, only rescaled to the new unit $\hat{1}$, which is the essence of the transition from real number n to their isotopes $\hat{n} = n\times\hat{1}$.

In particular, axioms (7.4) trivially hold,

$$\hat{|}\hat{n} \hat{\times} \hat{n}'\hat{|} = \hat{|}\hat{n}\hat{|} \hat{\times} \hat{|}\hat{n}'\hat{|}. \tag{8.13}$$

with the same product inside and out because referred to the same elements. One can see that the *isoreal numbers constitute a one-dimensional, isonormed, isoassociative and isocommutative isoalgebra* $\hat{U}(1) \approx U(1)$.

8.D: Realization of isodual isoreal numbers. We consider now the isodual numbers $\hat{n}^d = n\times\hat{1}^d$, $\hat{1}^d = -\hat{1}$ belonging to an isodual isofield $\hat{R}_{II}{}^d(\hat{n}^d,+,\hat{\times}^d)$. In this case we need the one-dimensional, isodual isoeuclidean space of Class II, $\hat{E}_{II}{}^d(x,\hat{\delta}^d,\hat{R}^d)$, and the *isodual isodilations*

$$x' = \hat{n}^d \hat{\times}^d x, \tag{8.14}$$

which also coincide with the conventional dilations (8.1), by characterizing an isomorphism of the isodual isoreal numbers with the one-dimensional isodual isogroup $\hat{G}^d(1)$, i.e., the image of G(1) under the isodual isounit $\hat{1}^d = -\hat{1}$. the underlying isomorphism $E_I{}^d(x,\delta^d,R^d(n^d,+,\times^d)) \approx \hat{E}_{II,1}{}^d(x,\hat{\delta}^d,\hat{R}^d(\hat{n}^d,+,\hat{\times}^d))$ then implies $\hat{G}^d(1) \approx G^d(1)$.

The *isodual isobasis* is given by

$$\hat{e}^d = \hat{1}^d, \tag{8.15}$$

with *isodual isonorm*

$$\hat{|}\hat{n}^d\hat{|}^d := (n \times n)^{\frac{1}{2}} \times \hat{1}^d = -\hat{|}\hat{n}\hat{|}, \tag{8.16}$$

verifying axioms (7.4),

$$\hat{|}\hat{n}^d \hat{\times}^d \hat{n}'\hat{|}^d = \hat{|}\hat{n}^d\hat{|}^d \hat{\times}^d \hat{|}\hat{n}'{}^d\hat{|}^d. \tag{8.17}$$

Thus, *the isodual isoreal numbers are a realization of the one-dimensional isodual, isonormed, isoassociative and isocommutative isoalgebra* $\hat{U}^d(1) \approx U^d(1)$.

The pseudoisoreal numbers $\hat{n} \in \hat{R}(\hat{n},\hat{+},\hat{\times})$ and their isoduals $\hat{n}^d \in \hat{R}^d(\hat{n}^d,\hat{+}^d,\hat{\times}^d)$ can be readily constructed from the above lines although, as now familiar, they are no longer distributive.

9: REALIZATION OF ISOCOMPLEX NUMBERS AND THEIR ISODUALS

9.A: Realization of ordinary complex numbers. Recall (see, e.g., ref. [7]) that conventional complex numbers $c = n_0 + n_1 \times i \in C(c,+,\times)$, where n_0, $n_1 \in$

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$R(n,+,\times)$, and i is the imaginary unit, are represented in a *Gauss plane* [1] which is essentially a realization of the two-dimensional Euclidean space $E_2(x,\delta,R(n,+,\times))$ with basic separation

$$x^2 = x^t \delta x = x_i \delta_{ij} x_j = x_1^2 + x_2^2 \in R(n,+,\times) \qquad (9.1)$$

whose group of isometries, the one-dimensional Lie group O(2), is the invariance of the circle, as well known. We then expect complex number to be representable via the fundamental representation of O(2) (see below).

The correspondence between complex numbers $c = n_0 + n_1 \times i$ and the Gauss plane with points $P = (x_1, x_2)$ is then made one-to-one by the *dilative rotations*

$$z' = (x_1 + x_2 \times i)' = c \odot z = (n_0 + n_1 \times i) \odot (x_1 + x_2 \times i), \qquad (9.2)$$

with multiplication rule

$$c \odot z = (n_0, n_1) \odot (x_1, x_2) =$$

$$= (n_0 \times x_1 - n_1 \times x_2, n_0 \times x_2 + n_1 \times x_1). \qquad (9.3)$$

which is known to preserve all properties to characterize a field, thus establishing a one-to-one correspondence between complex numbers and points in the Gauss plane. Transformations (9.3) also forms a two-dimensional group G(2) in one to one correspondence with $C(c,+,\times)$.

Complex numbers also admit the matrix representation

$$c := n_0 \times I_0 + n_1 \times i_1 = \begin{pmatrix} n_0 & n_1 \times i \\ n_1 \times i & n_0 \end{pmatrix}, \qquad (9.4a)$$

$$I_0 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}, \qquad i_1 = \begin{pmatrix} 0 & i \\ i & 0 \end{pmatrix}, \qquad (9.4b)$$

which are the identity and fundamental representation of O(2), respectively, as expected.

The *norm* is then given by the familiar expression

$$|c| = |n_0 + n_1 \times i| := (\text{Det } c)^{\frac{1}{2}} = (\bar{c} \times c)^{\frac{1}{2}} = (n_0^2 + n_1^2)^{\frac{1}{2}}. \qquad (9.5)$$

and readily verifies axiom (7.4)

$$|c \odot c'| = |c| \times |c'| \in R, \quad c, c' \in C. \qquad (9.6)$$

where now we have different products because referred to different elements.

Finally, the identification of the basis in terms of matrices (9.4b)

$$e_1 = I_0, \quad e_2 = i_1, \qquad (9.7)$$

implies the equally well known result that *complex numbers constitute a two-dimensional, normed, associative and commutative algebra* U(2).

9.B: Realization of isodual complex numbers. We now consider the isodual complex numbers

$$C^d = \{ (c^d,+,\times^d) \mid \times^d = -\times;\ I^d = -I;\ c^d = \bar{c} \times I^d = -\bar{c},\ \bar{c} \in \bar{C} \}, \qquad (9.8)$$

where $\bar{c}$ is the usual complex conjugation. Thus, given a complex number $c = n_0 + n_1 \times i$, its isodual is given by

$$c^d = -\bar{c} = n_0^d + n_1^d \times \bar{i} = -n_0 - n_1 \times \bar{i} = -n_0 + n_1 \times i \in C^d. \qquad (9.9)$$

In this case we need the two-dimensional isodual Euclidean space $E_2^d(x,\delta^d,R^d(n^d,+,\times^d))$ with basic invariant

$$x^{2d} = x^t \delta^d x = x_i \delta^d_{ij} x_j = x_1^{2d} + x_2^{2d} =$$

$$= x_1 \times^d x_1 + x_2 \times^d x_2 = -x_1^2 - x_2^2 \in R^d(n^d,+,\times^d) \qquad (9.10)$$

whose group of isometries is the one-dimensional isodual Lie group $O^d(2)$, i.e., the image of O(2) under the lifting $I = \text{diag.}(1,1) \rightarrow I^d = \text{diag.}(-1,-1)$ [20]. We then expect isodual complex numbers to be characterized by the isorepresentation of O(2).

We can then introduce the *isodual Gauss plane* as the image of the conventional plane under isoduality. The correspondence between isodual complex numbers and the isodual Gauss plane with points $P = (x_1, x_2)$ is then made one-to-one by the *isodual dilative rotations*

$$z' = (x_1 + x_2 \times i)' = c^d \odot^d z = (-n_0 + n_1 \times i) \odot^d (x_1 + x_2 \times i), \qquad (9.11)$$

with multiplication rules

$$c^d \odot^d z = (-n_0, n_1) \odot^d (x_1, x_2) =$$

$$= (-n_0 \times x_1 \times n_1 \times x_2, -n_0 \times x_2 + n_1 \times x_1), \qquad (9.12)$$

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which can be easily shown to preserve all properties to characterize a field. Also isodual transformations (9.12) form an isodual group $G^d(2)$ antiisomorphic to G(2). We therefore see that, as expected, the one-to-one correspondence between complex numbers and the Gauss plane persists under isoduality.

Isodual complex numbers also admit the matrix representation

$$c^d := n_0^d \times 1_0^d + n_1^d \times i_1^d = \begin{pmatrix} -n_0 & n_1 \times i \\ n_1 \times i & -n_0 \end{pmatrix}, \qquad (9.13a)$$

$$1_0^d = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix}, \qquad i_1 = \begin{pmatrix} 0 & -i \\ -i & 0 \end{pmatrix}, \qquad (9.13b)$$

which are the isodual unit and isodual representations of $O^d(2)$, respectively.

The *isodual norm*, from rule (3.6), is now given by

$$|c^d|^d = |-n_0 + n_1 \times i|^d := [\det_R (c^d \times T^d)]^{\frac{1}{2}} \times 1_0^d = (\bar{c}^d \times^d c^d)^{\frac{1}{2}} \times 1_0^d, \qquad (9.14)$$

can be written

$$|c^d|^d = (c \times \bar{c}) \times 1_0^d = (n_0^2 + n_1^2) \times 1_0^d. \qquad (9.15).$$

and also verifies axioms (7.4),

$$|c^d \odot^d c'^d|^d = |c^d|^d \times^d |c'^d|^d \in R^d, \quad c^d, c'^d \in C^d. \qquad (9.16)$$

Finally, the identification of the *isodual basis* in terms of matrices (9.13b)

$$e_1^d = 1_0^d, \quad e_2^d = i_1^d, \qquad (9.17)$$

implies that *isodual complex numbers constitute a two-dimensional, isodual, normed, associative and commutative algebra* $U^d(2)$ *which is anti-isomorphic to* U(2).

9.C: Realization of isocomplex numbers. We consider now the isofield of isocomplex numbers

$$\hat{C} = \{ (\hat{c}, \hat{+}, \hat{\times}) \mid \hat{\times} = \times T \times, \hat{1} = T^{-1}, \hat{c} = c \times \hat{1}, c \in C(c,+,\times) \}, \qquad (9.18)$$

with generic element $\hat{c} = \hat{n}_0 + \hat{n}_1 \times i$. In this case we need the two-dimensional isoeuclidean space of Class I, $\hat{E}_{1,2}(x,\hat{\delta},\hat{R}(\hat{n},+,\hat{\times}))$. Their realization most used in the

physical literature is that with a diagonalized and positive-definite isotopic element and isounit

$$T = \mathrm{diag.}(b_1^2, b_2^2), \quad \hat{1} = \mathrm{diag.}(b_1^{-2}, b_2^{-2}), \quad b_k > 0, \ k = 1, 2, \qquad (9.19)$$

with basic isoseparation

$$x^2 = (x^t \hat{\delta} x) \times \hat{1} = (x_i \hat{\delta}_{ij} x_j) = (x_1 b_1^2 x_1 + x_2 b_2^2 b_2) \times \hat{1} \in \hat{R}(\hat{n},+,\hat{\times}), \qquad (9.20)$$

whose group of isometries is the Lie-isotopic group $\hat{O}(2) \approx O(2)$ [20], i.e., the group O(2) constructed with respect to the multiplicative isounit $\hat{1} = \mathrm{diag.}(b_1^{-2}, b_2^{-2})$, which provides the invariance of all possible ellipses with semiaxes $a = b_1^{-2}$, $b = b_2^{-2}$ as the infinitely possible deformation of the circle (9.1). We then expect that isocomplex numbers are characterizable via the fundamental isorepresentation of $\hat{O}(2)$.

We now introduce the *isogauss plane* which is the set of points $P = (\hat{x}_1, x_2)$ on $\hat{E}_{1,2}(x,\hat{\delta},\hat{R}(\hat{n},+,\hat{x}))$ for the characterization of isocomplex numbers $\hat{c} = (\hat{n}_0, \hat{n}_1)$.

The correspondence between the isocomplex numbers $\hat{C}(\hat{c},+,\hat{\times})$ and the isogauss plane can be made one-to-one by the *isodilative isorotations*

$$z' = (x_1 + x_2 \times i)' = \hat{c} \hat{\odot} z \qquad (9.21)$$

with isomultiplication rule

$$\hat{c} \hat{\odot} z = (\hat{n}_0, \hat{n}_1) \hat{\odot} (x_1, x_2) =$$

$$= \{ [(n_0 \times x_0) \times \hat{1} - \Delta^{\frac{1}{2}} \times (n_1 \times x_2) \times \hat{1}], [(n_0 \times x_2) \times \hat{1} + (n_1 \times x_1) \times \hat{1}] \},$$

$$\Delta = \mathrm{Det}\, T = b_1^2 \times b_2^2, \qquad (9.22)$$

where the appearance of the $\Delta^{\frac{1}{2}}$ factor will be justified shortly, and confirmed later on in this section for the case of isoquaternions and isooctonions.

Isocomplex numbers also admit the following two-by-two matrix representation

$$\hat{c} = \hat{n}_0 \times \hat{1}_0 \hat{+} n_1 \hat{1}_1 = \begin{pmatrix} n_0 \times b_1^{-2} & i \times n_1 \times b_1^2 \times \Delta^{-\frac{1}{2}} \\ i \times n_1 \times b_2^2 \times \Delta^{-\frac{1}{2}} & n_0 \times b_1^{-2} \end{pmatrix}, \qquad (9.23a)$$

$$\hat{1} = \hat{1}_0 = \begin{pmatrix} b_1^{-2} & 0 \\ 0 & b_2^{-2} \end{pmatrix}, \qquad \hat{1}_1 = \Delta^{-\frac{1}{2}} \begin{pmatrix} 0 & i \times b_1^2 \\ i \times b_2^2 & 0 \end{pmatrix}, \qquad (9.23b)$$

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$$\Delta = \text{Det}\, T = b_1^2\, b_2^2 , \qquad (9.23c)$$

which verify rule (9.22) and characterize the isounit and the fundamental (adjoint) representation of $\hat{O}(2)$ respectively (see ref. [23,38] and the following article [40] in this Journal on the fundamental isorepresentation of the isotopic $\hat{su}(2)$ algebras, as well as the application to isoquaternions provided below).

Then, the set $\hat{S}(\hat{c},\hat{+},\hat{\times})$ of matrices (9.23a) is closed under addition and isomultiplication, each element possesses the isoinverse

$$\hat{c}^{-\hat{1}} = \hat{c}^{-1} \times \hat{1} \qquad (9.24)$$

where $\hat{c}^{-1}$ is the ordinary inverse. Thus, $\hat{S}(\hat{c},+,\hat{\times})$ is an isofield and the local isomorphism $\hat{S}(\hat{c},+,\hat{\times}) \approx \hat{C}(\hat{c},+,\hat{\times})$ follows.

It is easy to see that the isogauss plane possesses all axioms to characterize an isofield. In particular, isotransformations (9.22) form a two-dimensional isodilation isogroup $\hat{G}(2) \approx G(2)$. As expected, the one-to-one correspondence between complex numbers and Gauss plane is preserved under isotopy.

The implications are however nontrivial, as illustrated by a number of properties, such as the lack of existence of a unitary transformations $c' = U \odot c \odot \hat{U}$, $U \odot U^\dagger = U^\dagger \odot U = I = \text{diag.}(1, 1)$, mapping representations (9.4) into their isotopic form (9.23). The understanding that a transformation does indeed exist, but it is isounitary $\hat{c} = \hat{U}\hat{o}\hat{c}\hat{o}\hat{U}^\dagger$, $\hat{U}\,\hat{o}\,\hat{U}^\dagger = \hat{U}^\dagger\,\hat{o}\,\hat{U} = \hat{1}$.

Another way to see the nontriviality of the isotopy is by noting that the conventional trigonometry is inapplicable to the isogauss plane. In fact, conventional functions such as cos α, sin α, etc. which are well defined in the Gauss plane, have no mathematical meaning in our isogauss plane because it is isocurved. A study of the generalization of trigonometric functions needed for the isogauss plane shall be presented elsewhere [27].

The reader should be aware that, by no means, realization (9.23) is unique, owing to the intriguing "degrees of freedom" of the isotopic formulations which are not studied here for brevity (see, ref.s [15,20,21])..

The *isonorm* is defined, from Eq.s (3.4) by

$$\hat{|}\,\hat{c}\,\hat{|} = [\,\text{Det}_R(\,\hat{c} \times T)\,]^{\frac{1}{2}} \times \hat{1}_0 = (\,n_0^2 + \Delta\, n_1^2\,)^{\frac{1}{2}} \times \hat{1}_0 , \qquad (9.25)$$

and readily verifies axiom (7.4),

$$\hat{|}\,\hat{c}\,\hat{o}\,\hat{c}'\,\hat{|} = \hat{|}\,\hat{c}\,\hat{|}\,\hat{\times}\,\hat{|}\,\hat{c}'\,\hat{|} \in \hat{R}, \quad \hat{c}, \hat{c}' \in \hat{C} \qquad (9.26)$$

Finally, the *isobasis*

$$\hat{e}_1 = \hat{1}_0 , \quad \hat{e}_2 = \hat{i} , \qquad (9.27)$$

show that *isocomplex numbers constitute a two-dimensional, isonormed, isoassociative and isocommutative isoalgebras over the isoreals* $\hat{U}(2) \approx U(2)$.

9.D: Representation of isodual isocomplex numbers. We consider now the isodual isocomplex numbers

$$\hat{C}^d = \{\, (\hat{c}^d,+,\hat{\times}^d) \mid \hat{c}^d = -\,\bar{c}\,\hat{1}^d,\ \hat{\times}^d = \times\, T^d \times,\ T^d = -\,T,\ \hat{1}^d = T^{d-1} ,\ c \in C(c,+,\times)\,\} , \qquad (9.28)$$

with generic element $\hat{c}^d = \hat{n}^d + \hat{n}_1{}^d \times \hat{i}^d = -\,\hat{n}_0 + \hat{n}_1 \times \hat{i}$. In this case we need the two-dimensional isodual isoeuclidean space of Class II, $\hat{E}_{II,2}{}^d(x,\delta^d,\hat{R}^d(\hat{n}^d,+,\hat{\times}^d))$ with realization

$$T^d = \text{diag.}\,(\,-b_1^2 , -b_2^2\,) , \quad \hat{1}^d = \text{diag.}\,(\,-b_1^{-2} , -b_2^{-2}\,) , \quad b_k > 0, \ \ k = 1, 2, \qquad (9.29)$$

and basic isodual isoseparation

$$x^{2d} = (\,x^t\,\delta^d\,x\,) \times \hat{1}^d = (x_i\,\delta^d{}_{ij}\,x_j\,) \times \hat{1}^d =$$
$$= (-\,x_1\,b_1^2\,x_1 - x_2\,b_2^2\,b_2\,) \times \hat{1}^d \in \hat{R}^d\,(\hat{n}^d,+,\hat{\times}^d\,), \qquad (9.30)$$

whose group of isometries is the isodual isoorthogonal group $\hat{O}^d(2) \approx O^d(2)$ [20].

The *isodual isogauss plane* is then the set of points $P = (\hat{x}_1, x_2)$ on $\hat{E}_{I,2}{}^d(x,\delta^d,\hat{R}^d(\hat{n}^d,+,\hat{\times}^d))$ for the characterization of isocomplex numbers $\hat{c} = (-\hat{n}_0 , \hat{n}_1\,)$.

The correspondence between the isodual isocomplex numbers $\hat{C}^d(\hat{c}^d,+,\times^d)$ and the isodual isogauss plane can be made one-to-one by the *isodual isodilative isorotations*

$$z' = (\,x_1 + x_2 \times i\,)' = \hat{c}^d\,\hat{o}^d\,z \qquad (9.31)$$

with multiplication rule

$$\hat{c}\,\hat{o}^d\,z = (\,\hat{n}_0 , \hat{n}_1\,)\,\hat{o}^d\,(\,x_1 , x_2\,) = \qquad (9.32)$$
$$= (\,[\,(-\,n_0 \times x_0\,) \times \hat{1} + \Delta^{\frac{1}{2}} \times (\,n_1 \times x_2\,) \times \hat{1}\,] , [\,(-\,n_0 \times x_2\,) \times \hat{1} + (\,n_1 \times x_1\,) \times \hat{1}\,]\,)$$

It is easy to see that the isodual isogauss plane preserves all axioms to characterize an isodual isofield. Also, isodual isotransformations (9.32) forms an isodual isogroup $\hat{G}^d(2) \approx G^d(2)$. As expected, the one-to-one correspondence between complex numbers and Gauss plane is also preserved under isodual isotopy.

Isodual isocomplex numbers also admit the following two-by-two matrix representation

$$\hat{c}^d = \hat{n}_0{}^d \times \hat{1}_0{}^d + n_1{}^d \times \hat{1}^d = \begin{pmatrix} -n_0 \times b_1{}^{-2} & i \times n_1 \times b_1{}^2 \times \Delta^{-\frac{1}{2}} \\ i \times n_1 \times b_2{}^2 \times \Delta^{-\frac{1}{2}} & -n_0 \times b_2{}^{-2} \end{pmatrix}, \quad (9.33a)$$

$$1^d = 1_0{}^d = \begin{pmatrix} -b_1{}^{-2} & 0 \\ 0 & -b_2{}^{-2} \end{pmatrix}, \quad \hat{1}^d = \begin{pmatrix} 0 & -i \times b_1{}^2 \times \Delta^{-\frac{1}{2}} \\ -i \times b_2{}^2 \times \Delta^{-\frac{1}{2}} & 0 \end{pmatrix}, \quad (9.33b)$$

which satisfies isomultiplication rule (9.32), which characterize the isodual isounit and fundamental representation of $\hat{O}^d(2)$, respectively.

Then, the set $\hat{S}^d(\hat{c}^d, +, \times^d)$ of matrices (9.33a) is closed under addition and isomultiplication, each element possesses the isodual isoinverse

$$\hat{c}^{-1d} = (\hat{c}^d)^{-1} \times 1^d \quad (9.34)$$

Thus $\hat{S}^d(\hat{c}^d, +, \times^d)$ is an isofield. The local isomorphism $\hat{S}^d(\hat{c}^d, +, \hat{\times}^d) \approx \hat{C}^d(\hat{c}^d, +, \times^d)$ is then consequential.

The *isodual isonorm* is defined, from Eq.s (3.6), by

$$|\hat{c}^d|^d = [\, \mathrm{Det}_R\, (\hat{c}^d \times T^d)\,]^{\frac{1}{2}} \times 1_0{}^d = (n_0{}^2 + \Delta \times n_1{}^2)^{\frac{1}{2}} \times 1^d , \quad (9.35)$$

and readily verifies axioms (7.4),

$$|\hat{c}^d\, \hat{o}^d\, \hat{c}'^d|^d = |\hat{c}^d|^d \times^d |\hat{c}'^d|^d \in \hat{R}^d, \quad \hat{c}^d, \hat{c}'^d \in \hat{C}^d . \quad (9.36)$$

Finally, the *isodual isobasis*

$$\hat{e}_1{}^d = 1_0{}^d, \quad \hat{e}_2{}^d = \hat{1}_1{}^d, \quad (9.37)$$

shows that *isodual isocomplex numbers constitute a two-dimensional, isodual, isonormed, isoassociative and isocommutative isoalgebras over the isodual isoreals isoreals* $\hat{O}^d(2) \sim \hat{U}^d(2)$.

The extension of the above results to the pseudoisocomplex numbers $\hat{C}(\hat{c}, \hat{+}, \hat{\times})$, $\hat{+} = +K \times 1$, $\hat{0} = -K \times 1$ and their isoduals $\hat{C}^d(\hat{c}^d, \hat{+}^d, \hat{\times}^d)$ is straighforward. Note that in this case a generic pseudoisocomplex number is given by

$$\hat{c} = n_0 \hat{+} n_1 \times \hat{1} = n'_0 + n'_1 \times \hat{1}, \quad n'_0 = n_0 + K, \quad n'_1 = n_1 + K, \quad (9.38)$$

thus showing an intrinsic rescaling of both the real and imaginary parts.

10: REALIZATION OF ISOQUATERNIONS AND THEIR ISODUALS

10.A: Realization of quaternions. Among their various realizations (see ref. [39]), we consider now the conventional form of quaternions $q \in Q(q,+,\times)$ [see also ref.,s [7,8]) with realization in the complex Hermitean Euclidean plane $E_2(z,\delta,C)$ with separation

$$E_2(z,\delta,C): \quad z^\dagger z = \bar{z}_i\, \delta_{ij}\, z_j = \bar{z}_1 z_1 + \bar{z}_2 z_2 \quad \delta^\dagger \equiv \delta . \quad (10.1)$$

whose basic (unimodular) invariant is SU(2). We therefore expect quaternions to be characterizable via the fundamental (adjoint) representation of SU(2), i.e., by Pauli's matrices, as reviewed below.

Quaternions can be realized via pairs of complex numbers, $q = (c_1, c_2)$. A *Hermitean dilative rotation* on $E_2(z,\delta,C)$, i.e., one leaving invariant $z^\dagger z$, is given by

$$z'_1 = c_1 \odot z_1 + c_2 \odot z_2 , \quad z'_2 = -\bar{c}_2 \odot z_1 + \bar{c}_1 \odot z_2 , \quad (10.2)$$

where the dilation is represented by the value $\bar{c}_1 \odot c_1 + \bar{c}_2 \odot c_2 \neq 1$. Again, transformations (10.2) form a group G(4), this time associative but non-commutative, which is in one-to-one correspondence with quaternions.

Rule (10.2) characterizes the following matrix representation of quaternions $Q(q,+,\times)$ over the field of complex numbers $C(c,+,\times)$

$$q = \begin{pmatrix} c_1 & c_2 \\ -\bar{c}_2 & \bar{c}_1 \end{pmatrix}, \quad (10.3)$$

which is also one-to-one. By assuming

$$c_1 = n_0 + n_3 \times i, \quad c_2 = n_1 + n_2 \times i, \quad (10.4)$$

matrix (10.3) admits the representation

$$q = n_0 \times I_0 + n_1 \times I_1 + n_2 \times I_2 + n_3 \times I_3 , \quad (10.5)$$

where the I's are the celebrated two-dimensional *Pauli's matrices* plus the two-dimensional identity,

$$I_o = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}, \; i_1 = \begin{pmatrix} 0 & i \\ i & 0 \end{pmatrix}, \; i_2 = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}, \; i_3 = \begin{pmatrix} i & 0 \\ 0 & -i \end{pmatrix}, \quad (10.6)$$

with fundamental properties

$$i_n \times i_m \;=\; -\epsilon_{nmk}\, i_k\,, \quad n \neq m\,, \quad n, m = 1, 2, 3\,, \quad (10.7)$$

where ϵ_{nmk} is the conventional totally antisymmetric tensor of rank three. The algebra A of Pauli's matrices is closed under commutators, and characterize the fundamental representation of the Lie algebra su(2)

$$[\, i_n , i_m \,] \;=\; i_n \times i_m \;-\; i_m \times i_n \;=\; -\,2\,\epsilon_{nmk}\, i_k\,, \quad (10.8)$$

with Casimir invariants I_o and $i^2 = \sum_{k=1,2,3} i_k{}^2$,

$$[\, I_o , i_k \,] \;=\; [\, i^2 , i_k \,] = 0\,, \quad k = 1, 2, 3\,, \quad (10.9)$$

and eigenvalues on a two-dimensional basis ψ with normalization $\psi\dagger \times \psi = 1$

$$\textstyle\sum_{k=1,2,3} i_k{}^2 \times \psi \;=\; \sum_{k=1,2,3} i_k \times i_k \times \psi \;=\; -\,3 \times \psi, \quad (10.10)$$

By noting that

$$q\dagger \;=\; n_o\, I_o \;-\; n_1\, i_1 \;-\; n_2\, i_2 \;-\; n_3\, i_3\,, \quad (10.11)$$

the *norm* of q can be written

$$|\, q \,| \;=\; (\, q\dagger q\,)^{\frac{1}{2}} \;=\; (\, \textstyle\sum_{k=0,1,2,3} n_k{}^2\,)^{\frac{1}{2}}, \quad (10.12)$$

and also satisfies axioms (7.4),

$$|\, q \odot q' \,| \;=\; |\, q \,| \times |\, q \,| \;\in R, \quad q, q' \in Q\,. \quad (10.13)$$

The *basis*

$$e_1 = I_o\,, \quad e_{k+1} \;=\; i_k\,, \quad k = 1, 2, 3\,, \quad (10.14)$$

then establishes that *quaternions constitute a normed, associative, noncommutative algebra of dimensions 4 over the reals* U(4) [7,8].

10.B: Realization of the isodual quaternions. We consider now the isodual quaternions $q^d \in Q^d(q^d,+,\times^d)$ which can be represented via the isodual complex Hermitean Euclidean space $E_2{}^d\,(z,\delta^d,C^d(c^d,+,\times^d))$ with separation

$$(\, \bar{z}_i\, \delta^d{}_{ij}\, z_j\,) \times I^d \;=\; (\, -\,\bar{z}_1\, z_1 \;-\; \bar{z}_2\, z_2\,) \times I^d \;\;\in\;\; R^d\,. \quad (10.15)$$

Isodual quaternions can be realized via pairs of isodual complex numbers, $q^d = (c_1{}^d, c_2{}^d)$. An *Isodual Hermitean dilative rotation* on $E_2{}^d(z,\delta^d,C^d(c^d,+,\times^d))$, i.e., one leaving invariant $z\dagger\delta^d z$, is given by

$$z'_1 \;=\; c_1{}^d \odot^d z_1 \;-\; \bar{c}_2{}^d \odot^d z_2\,, \qquad z'_2 \;=\; c_2{}^d \odot^d z_1 \;+\; \bar{c}_1{}^d \odot^d z_2\,, \quad (10.16)$$

where the dilation is represented by the value $\bar{c}_1{}^d \odot^d c_1{}^d + \bar{c}_2{}^d \odot^d c_2{}^d \neq -1$. Again, transformations (10.16) form an associative but noncommutative isodual group $G^d(4)$, which is in one-to-one correspondence with isodual quaternions $Q^d(q^d,+,\times^d)$.

Rule (10.16) characterizes the following matrix representation of isodual quaternions over the field of isodual complex numbers $C^d(c^d,+,\times^d)$

$$q^d \;=\; \begin{pmatrix} c_1{}^d & -\bar{c}_2{}^d \\ c_2{}^d & \bar{c}^d \end{pmatrix}, \quad (10.17)$$

By assuming

$$c_1{}^d = -\,n_0 + n_3 \times i\,, \qquad c_2{}^d \;=\; -\,n_1 + n_2 \times i, \quad (10.18)$$

and by recalling that $-\,\bar{c}^d = c$, we have the representation

$$q^d \;=\; n_o{}^d \;+\; n_1{}^d \times i_1{}^d \;+\; n_2{}^d \times i_2{}^d \;+\; n_3 \times i_3{}^d \;=$$

$$=\; -\,n_o \;+\; n_1 \times i_1 \;+\; n_2 \times i_2 \;+\; n_3 \times i_3\,, \quad (10.19)$$

where the i's are the Pauli's matrices reviewed above.

The *isodual norm* is then defined by

$$|\, q^d \,|^d \;=\; [\, (q^d)^\dagger \times^d q\,]^{\frac{1}{2}} \times I^d \;=\; [\, \mathrm{Det}_C\, (q^d \times T^d\,)\,]^{\frac{1}{2}} \times I^d \;=$$

$$=\; (\, \textstyle\sum_{k=0,1,2,3} n_k{}^2\,)^{\frac{1}{2}} \times I^d, \quad (10.20)$$

with property

$$|\, q^d \odot^d q'^d \,|^d \;=\; |\, q^d \,|^d \;\times^d\; |\, q'^d \,|^d \in R^d\,, \quad q^d, q'^d \;\in\; Q^d. \quad (10.21)$$

The use of the isodual basis

$$e^d{}_1 \;=\; I^d{}_0\,, \quad e^d{}_{k+1} \;=\; i_k\,, \; k = 1, 2, 3, \quad (10.22)$$

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then shows that *isodual quaternions constitute an isodual four-dimensional, normed, assocoiative and noncommutative algebra over the isodual reals* $U^d(4)$, *which is antiisomorphic to* U(4).

10.C: Realization of isoquaternions. To study the isoquaternions $\hat{q} \in \hat{Q}(\hat{q},+,\hat{\times})$, we need the *two-dimensional, complex Hermitean isoeuclidean space* of Class I, $\hat{E}_{1,2}(z,\hat{\delta},\hat{C})$ on the isofield $\hat{C}(\hat{c},+,\hat{\times})$ with separation

$$z^\dagger \hat{\delta} z = \bar{z}_i \hat{\delta}_{ij} z_j = \bar{z}_1 b_1^2 z_1 \hat{+} \bar{z}_2 b_2^2 z_2 \quad \hat{\delta}^\dagger \equiv \hat{\delta} > 0, \qquad (10.23)$$

basic isotopic element and isounit

$$T = \text{Diag.}(b_1^2, b_2^2), \quad \hat{1} = \text{Diag.}(b_1^{-2}, b_2^{-2}), \qquad (10.24)$$

whose (unimodular) invariance group is the Lie-isotopic group $\hat{SU}(2)$ [21,23,27].

A *Hermitean isodilative isorotation* on $\hat{E}_{1,2}(z,\hat{\delta},\hat{C}(\hat{c},+,\hat{\times}))$, i.e., one leaving invariant $z^\dagger\hat{\delta}z$, is given by

$$z'_1 = \hat{c}_1 \hat{\circ} z_1 + \hat{c}_2 \hat{\circ} z_2, \qquad z'_2 = -\hat{c}_2 \hat{\circ} z_1 + \bar{c}_1 \hat{\circ} z_2, \qquad (10.25)$$

where the dilation is represented by the value $\bar{c}_1 \hat{\circ} \hat{c}_1 + \bar{c}_2 \hat{\circ} \hat{c}_2 \neq \hat{1}$.

The map of isoquaternions into two-by-two matrices on $\hat{C}(\hat{c},\hat{+},\hat{\times})$ must now be characterized by the fundamental (adjoint) isorepresentations of the Lie-isotopic algebra $\hat{su}(2)$ studied in ref.s [21,23,38] (see several alternatives in [38] and the review in the subsequent article [40] in this Journal) which can be written

$$\hat{1}_o = \begin{pmatrix} b_1^{-2} & 0 \\ 0 & b_2^{-2} \end{pmatrix}, \qquad (10.26)$$

$$\hat{1}_1 = \Delta^{-\frac{1}{2}} \begin{pmatrix} 0 & i \times b_1^2 \\ i \times b_2^2 & 0 \end{pmatrix}, \hat{1}_2 = \Delta^{-\frac{1}{2}} \begin{pmatrix} 0 & b_1^2 \\ -b_2^2 & 0 \end{pmatrix}, \hat{1}_3 = \Delta^{-\frac{1}{2}} \begin{pmatrix} i \times b_2^2 & 0 \\ 0 & -i \times b_1^2 \end{pmatrix},$$

$$\Delta = \text{Det}\, T = b_1^2 b_2^2, \qquad (10.26c)$$

and are called *isopauli matrices* [loc. cit.]. As expected, the $\hat{1}$-matrices verify the isotopic image of properties (10.7), i.e.,

$$\hat{1}_n \hat{\times} \hat{1}_m = -\Delta^{\frac{1}{2}} \epsilon_{nmk} \hat{1}_k, \quad n \neq m, \quad n, m = 1, 2, 3. \qquad (10.28)$$

and are therefore closed under isocommutators (as a necessary condition to have an isotopy), resulting the Lie-isotopic algebra

$$[\hat{1}_n \hat{,} \hat{1}_m] := \hat{1}_n \hat{\times} \hat{1}_m - \hat{1}_m \hat{\times} \hat{1}_n = -2\Delta^{\frac{1}{2}} \epsilon_{nmk} \hat{1}_k, \qquad (10.29)$$

with *isocasimir invariants* $\hat{1}_o$ and $\hat{1}^2 = \sum_{k=1,2,3} \hat{1}_k^{\hat{2}} = \sum_{k=1,2,3} \hat{1}_k \times \hat{1}_k$,

$$[\hat{1}_o \hat{,} \hat{1}_k] = [\hat{1}^{\hat{2}} \hat{,} \hat{1}_k] = 0, \quad k = 1, 2, 3, \qquad (10.30)$$

and generalized eigenvalues on a two-dimensional basis $\hat{\psi}$ with isonormalization $\hat{\psi}^\dagger \hat{\times} \hat{\psi} = \hat{1}$

$$\hat{1}_3 * \psi = \pm \Delta^{\frac{1}{2}} \times \psi, \ \sum_{k=1,2,3} \hat{1}_k^{\hat{2}} \hat{\times} \hat{\psi} = \sum_{k=1,2,3} \hat{1}_k \hat{\times} \hat{1}_k \hat{\times} \hat{\psi} = -3 \times \Delta \times \hat{\psi}, \qquad (10.31)$$

Note the complete abstract identity of the isotopic $\hat{su}(2)$ with the conventional su(2) algebra [38]. Nevertheless, it is easy to prove that Pauli's matrices and their isotopic covering are not unitarily equivalent, and this establishes the nontriviality of the isotopies here considered.

Note that the isoinvariance $\hat{O}(2)$ of the isocomplex numbers is a subgroup of $\hat{SU}(2)$ characterizable by $\hat{1}_1$. Note also that there exist isopauli matrices with $\Delta = 1$ (see [38] and the following review [40]).

Isoquaternions can therefore be written in the form (apparently presented here for the first time)

$$\hat{q} = n_0 \hat{1}_o + n_1 \hat{1}_1 + n_2 \hat{1}_2 + n_3 \hat{1}_3 =$$

$$= \begin{pmatrix} (n_0 \times b_1^{-2} + i \times n_3 \times b_2^2 \times \Delta^{-\frac{1}{2}}) & (i \times n_1 - n_2) \times b_1^2 \times \Delta^{-\frac{1}{2}} \\ (i \times n_1 + n_2) \times b_2^2 \times \Delta^{-\frac{1}{2}} & (n_0 \times b_2^{-2} + i \times n_3 \times b_1^2 \times \Delta^{-\frac{1}{2}}) \end{pmatrix}. \qquad (10.32)$$

It is straightforward to show that the set $\hat{S}(\hat{q},+,\hat{\times})$ of all possible expression (10.32) preserves the axioms of the original set $S(q,+,\times)$. In fact, the set $\hat{S}(\hat{q},\hat{+},\hat{\times})$ is a four-dimensional vector space over the isoreals $\hat{R}(\hat{n},+,\hat{\times})$ which is closed under the operation of conventional addition and isomultiplication, thus being an isofield. The isomorphism $\hat{S}(\hat{q},+,\hat{\times}) \approx \hat{Q}(\hat{q},+,\hat{\times})$ then follows.

The *isonorm* of the isoquaternions is given by

$$\hat{|}\hat{q}\hat{|} = [\text{Det}_R(\hat{q} \times T)]^{\frac{1}{2}} \times \hat{1}_0 = (\hat{q}^\dagger \hat{\times} \hat{q}) \times \hat{1}_0 =$$

$$= [n_0^2 + \Delta(n_1^2 + n_2^2 + n_3^2)]^{\frac{1}{2}} \times \hat{1}_0, \qquad (10.33)$$

which should be compared with expression (10.12) for the ordinary quaternions, with basic rule

$$\hat{|}\hat{q} \hat{\circ} \hat{q}'\hat{|} = \hat{|}\hat{q}\hat{|} \hat{\times} \hat{|}\hat{q}'\hat{|} \in \hat{R}, \quad \hat{q}, \hat{q}' \in \hat{Q}. \qquad (10.34)$$

The *isobasis*

$$\hat{e}_1 = \hat{1}_0, \quad \hat{e}_{k+1} = \hat{1}_k, \quad k = 1, 2, 3, \tag{10.35}$$

then establishes that *isoquaternions constitute a four-dimensional, isonormed, isoassociative, non-isocommutative isoalgebras over the isoreals* $\hat{O}(4) \approx U(4)$.

10.D: Realization of isodual isoquaternions. The *isodual isoquaternions* can be characterized via the two-dimensional isodual complex Hermitean isoeuclidean space of Class II over the isodual isocomplex field, $\hat{E}^d_{II,2}(z, \delta^d, \hat{C}^d(c^d, +, \hat{\times}^d))$, with separation

$$z^\dagger \delta^d z = \bar{z}_1 \hat{\times}^d z_1 + \bar{z}_2 \hat{\times}^d z_2 = -\bar{z}_1 b_1^2 z_1 - \bar{z}_2 b_2^2 z_2, \tag{10.36}$$

with basic isodual isotopic element and isodual isounit

$$T^d = \text{Diag.}(-b_1^2, -b_2^2), \quad \hat{1}^d = \text{Diag.}(-b_1^{-2}, -b_2^{-2}), \tag{10.37}$$

whose (unimodular) invariance is now that of the isodual Lie-isotopic group $S\hat{O}^d(2)$ [21,23,27]. An *isodual Hermitean isodilative isorotation* on $\hat{E}^d_{II,2}(z, \delta^d, \hat{C}^d(c^d, +, \hat{\times}^d))$, i.e., one leaving invariant $z^\dagger \delta z$, is given by

$$z'_1 = \hat{c}^d_1 \hat{\circ}^d z_1 - \bar{c}^d_2 \hat{\circ}^d z_2, \quad z'_2 = \hat{c}^d_2 \hat{\circ}^d z_1 + \bar{c}^d_1 \hat{\circ}^d z_2, \tag{10.38}$$

where the dilation is represented by the value $\bar{c}^d_1 \hat{\circ}^d \hat{c}^d_1 + \bar{c}^d \hat{\circ}^d \hat{c}^d_2 \neq \hat{1}^d$.

Isoquaternions then admit a realization in terms of the isodual isorepresentation of $S\hat{O}^d(2)$ which can be written

$$\hat{q}^d = \hat{n}_0^d \hat{+} \hat{n}_1^d \times \hat{1}_1^d \hat{+} \hat{n}_2^d \times \hat{1}_2^d + \hat{n}_3^d \times \hat{1}_3^d =$$

$$= -\hat{n}_0 + \hat{n}_1 \times \hat{1}_1 + \hat{n}_2 \times \hat{1}_2 + \hat{n}_3 \times \hat{1}_3 =$$

$$= \begin{pmatrix} (-n_0 \times b_1^{-2} + i \times n_3 \times b_2^2 \times \Delta^{-\frac{1}{2}}) & (i \times n_1 - n_2) \times b_1^2 \times \Delta^{-\frac{1}{2}} \\ (i \times n_1 + n_2) \times b_2^2 \times \Delta^{-\frac{1}{2}} & (-n_0 \times b_2^{-2} + i \times n_3 \times b_1^2 \times \Delta^{-\frac{1}{2}}) \end{pmatrix}. \tag{10.39}$$

It is again easy to show that the set $\hat{S}^d(\hat{q}^d, +, \times^d)$ of all possible matrices (10.39) is an isofield. The isomorphism $\hat{S}^d(\hat{q}^d, +, \times^d) \approx \hat{Q}^d(\hat{q}^d, +, \hat{\times}^d)$ then follows.

The *isodual isonorm* is now given by

$$\uparrow \hat{q}^d \uparrow^d = [\text{Det}_R (\hat{q}^d \times T^d)]^{\frac{1}{2}} \times \hat{1}_0^d = (\hat{q}^{\dagger d} \times^d \hat{q}^d)^{\frac{1}{2}} \times \hat{1}_0^d =$$

$$= [n_0^2 + \Delta(n_1^2 + n_2^2 + n_3^2)]^{\frac{1}{2}} \times \hat{1}_0^d, \tag{10.40}$$

and also verified the basic rule

$$\uparrow \hat{q}^d \hat{\circ}^d \hat{q}'^d \uparrow^d = \uparrow \hat{q}^d \uparrow^d \hat{\times}^d \uparrow \hat{q}'^d \uparrow^d \in \hat{R}^d, \quad \hat{q}^d, \hat{q}^d \in \hat{Q}^d. \tag{10.41}$$

The *isodual isobasis*

$$\hat{e}^d_1 = \hat{1}^d_0, \quad \hat{e}^d_{k+1} = \hat{1}^d_k, \quad k = 1, 2, 3, \tag{10.42}$$

then shows that *isodual isoquaternions constitute a four-dimensional, isodual, isonormed, isoassociative, non-isocommutative isoalgebra over the isodual isoreals* $\hat{O}^d(4) \approx U^d(4)$.

We shall leave to the interested reader the study of the isotopies of other forms of quaternions, the *split quaternions, antiquaternions and semiquaternions* [39], as well as the study of *pseudoisoquaternions* and their isoduals.

11: REALIZATION OF ISOOCTONIONS AND THEIR ISODUALS

The realizations of octonion, isodual octonions, isooctonions and isodual isooctonions follow very closely the corresponding realizations at the quaternionic level. In particular, the realizations of the isooctonions and their isoduals follows very closely the construction of isoquaternions and their isoduals from isocomplex numbers and their isoduals.

11.A: Realization of octonions. Recall (see, e.g., ref.s [7,9,39] and contributions quoted therein), that the octonions $o \in O(o, +, \times)$ can be realized via two quaternions, $o = (q_1, q_2)$, with composition rules

$$o \odot o' = (q_1, q_2) \odot (q'_1, q'_2) = (q_1 \odot q'_1 + q_1 \odot q'_2, -\bar{q}_1 \odot q'_2 + \bar{q}_1 \odot q_2), \tag{11.1}$$

The antiautomorphic conjugation of an octonion is given by

$$\bar{o} = (\bar{q}_1, -q_2). \tag{11.2}$$

It is then possible to introduce the *norm*

$$|o|^2 := (\bar{o} \odot o) = |q_1| + |q_2|, \tag{11.3}$$

which also verified the basic axiom

$$|o \odot o'| = |o| \times |o'| \in R, \quad o, o' \in O. \tag{11.4}$$

We finally recall that *the octonions form an eight dimensional normed, nonassociative and noncommutative, alternative algebra* U(8) *over the field of reals* R(n,+,×) [loc. cit.].

11.A: Realization of isodual octonions. The *isodual octonions* are defined via the isoconjugation

$$o^d = (q_1{}^d, q_2{}^d) \tag{11.5}$$

this time, over the isodual reals $R^d(n^d,+,\times^d)$, and are therefore different than the conventional conjugate octonions $\bar{o}$, Eq.(11.2). Their isodual multiplication is

$$o^d \odot^d o'^d = (q_1{}^d, q_2{}^d) \odot^d (q'_1{}^d, q'_2{}^d) =$$

$$= (q_1{}^d \odot^d q'_1{}^d - \bar{q}_1{}^d \odot q'_2{}^d,\ q_1{}^d \odot^d q'_2{}^d + \bar{q}_1{}^d \odot^d q_2{}^d), \tag{11.6}$$

the isodual antiautomorphism is the given by

$$\bar{o}^d = (\bar{q}_1{}^d, -q_2{}^d). \tag{11.7}$$

It is then possible to introduce the *isodual norm*

$$|o^d|^{d\,2} := (\bar{o}^d \odot^d o^d) \times 1^d = |q_1{}^d|^d + |q_2{}^d|^d \tag{11.8}$$

which also verifies the basic axiom

$$|o^d \odot^d o'^d|^d = |o^d|^d \times^d |o'^d|^d \in R^d, \quad o^d, o'^d \in O^d. \tag{11.9}$$

Thus, *the isodual octonions form an eight dimensional isodual, normed, nonassociative, alternative and noncommutative algebra* $U^d(8)$ *over the isodual real numbers* $R^d(n^d,+,\times^d)$.

11.C: Realization of the isooctonions. Isooctonions $\hat{o} \in \hat{O}(\hat{o},+,\hat{\times})$ can be defined as the pair of isoquaternions, $\hat{o} = (\hat{q}_1, \hat{q}_2)$ over the isoreals $\hat{R}(\hat{n},+,\hat{\times})$ with multiplication rules

$$\hat{o} \hat{\odot} \hat{o}' = (\hat{q}_1, \hat{q}_2) \hat{\odot} (\hat{q}'_1, \hat{q}'_2) = (\hat{q}_1 \hat{\odot} \hat{q}'_1 + \hat{q}_1 \hat{\odot} \hat{q}'_2, -\bar{q}_1 \hat{\odot} \hat{q}'_2 + \bar{q}_1 \hat{\odot} \hat{q}_2), \tag{11.10}$$

It is then easy to see that the lifting $o \rightarrow \hat{o}$ is an isotopy, thus preserving all original axioms of o. In fact, we have the antiautomorphic conjugation

$$\bar{o} = (\bar{q}_1, -\hat{q}_2), \tag{11.11}$$

and the *isonorm*

$$|\hat{o}|^2 := (\bar{o} \hat{\odot} \hat{o}) \times 1 = |\hat{q}_1| + |\hat{q}_2| \tag{11.12}$$

with property

$$|\hat{o} \hat{\odot} \hat{o}'| = |\hat{o}| \hat{\times} |\hat{o}'| \in \hat{R}, \quad \hat{o}, \hat{o}' \in \hat{O}. \tag{11.13}$$

It is then easy to see that *isooctonions form an eight dimensional isonormed, non-isoassociative, non-isocommutative, isoalternative isoalgebra* $\hat{U}(8) \approx U(8)$ *over the isoreals* $\hat{R}(\hat{n},+,\hat{\times})$.

11.D: Realization of the isodual isooctonions. The notion of isoduality applies also to the isooctonions yielding the isodual isooctonions $\hat{o}^d = (\hat{q}_1{}^d, \hat{q}_2{}^d)$ with composition rule

$$\hat{o}^d \hat{\odot}^d \hat{o}'^d = (\hat{q}_1{}^d, \hat{q}_2{}^d) \hat{\odot}^d (\hat{q}'_1{}^d, \hat{q}'_2{}^d) =$$

$$= (\hat{q}_1{}^d \hat{\odot}^d \hat{q}'_1{}^d - \bar{q}_1{}^d \hat{\odot}^d \hat{q}'_2{}^d,\ q_1{}^d \hat{\odot}^d q'_2{}^d + \bar{q}_1{}^d \hat{\odot}^d q_2{}^d), \tag{11.14}$$

Then we have the isodual isoantiautomorphism

$$\bar{o}^d = (\bar{q}_1{}^d, -\hat{q}_2{}^d). \tag{11.15}$$

the *isodual isonorm*

$$|\hat{o}^d|^{d\,2} := (\bar{o}^d \hat{\odot}^d \hat{o}^d) \times 1^d = |\hat{q}_1{}^d|^d + |\hat{q}_2{}^d|^d \tag{11.16}$$

which also verifies the basic axiom

$$|\hat{o}^d \hat{\odot}^d \hat{o}'^d|^d = |\hat{o}^d|^d \hat{\times}^d |\hat{o}'^d|^d \in \hat{R}^d, \quad \hat{o}^d, \hat{o}'^d \in \hat{O}^d. \tag{11.17}$$

It is then possible to prove that *isodual isooctonions form an eight dimensional isodual, isonormed, non-isoassociative, non-isocommutative, but isoalternative isoalgebra* $\hat{U}^d(8) \approx U^d(8)$ *over the isodual isofield* $\hat{R}^d(\hat{n}^d,+,\times^d)$.

The extension of the results to the pseudoisooctonions and their isoduals is

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left to interested readers.

12: CLASSIFICATION OF ISCNORMED ISOALGEBRAS WITH IDENTITY AND THE CONJECTURE OF NEW "HIDDEN NUMBERS"

Historically, the "numbers" studied in this paper are those permitting a solution of the following problem (see, e.g., ref. [8])

$$(a_1^2 + a_2^2 + ... + a_n^2) \times (b_1^2 + b_2^2 + ... + b_n^2) = A_1^2 + A_2^2 + ... + A_n^2, \quad (12.1a)$$

$$A_k = \sum_{r,s} c_{krs} \times a_r \times b_s . \quad (12.1b)$$

where all the a's, b's and c's are elements of a field $F(a,+,\times)$ with conventional operations + and ×. As well known, the only possible solutions of problem (12.1) are of dimension 1, 2, 4, 8 (Theorem 1.1).

The isotopies and pseudoisotopies of the theory of numbers evidently creates the problem of the possible existence of *"hidden numbers"*, that is, new solutions of dimension different than 1, 2, 4, 8 which are hidden in the operations × and/or +. This problem essentially asks whether the classification of Theorem 1.1 persists under isotopies, pseudoisotopies and their isodualities, or it is incomplete.

It is easy to see that the reformulation of problem (12.1) under the isotopies of the multiplication

$$\times \rightarrow \hat{\times} = \times T \times, \quad 1 \rightarrow \hat{1} = T^{-1}, \quad (12.2)$$

does not lead to new solutions. In fact, Problem (12.1) under lifting (12.2) is given by

$$(a_1^2 + a_2^2 + ... + a_n^2) \hat{\times} (b_1^2 + b_2^2 + ... + b_n^2) = A_1^2 + A_2^2 + ... + A_n^2, \quad (12.3a)$$

$$A_k = \sum_{r,s} c_{krs} \hat{\times} a_r \hat{\times} b_s , \quad (12.3b)$$

where now all the a's, b's and c's belong to an isofield of the type $\hat{F}(a,+,\hat{\times})$, in which case $\hat{1}$ is an element of the original field F (Proposition 4.1). Problem (12.3) can be written in conventional operations

$$(a_1^2 + a_2^2 + ... + a_n^2) \times (b_1^2 + b_2^2 + ... + b_n^2) = T^{-2} \times (A_1^2 + A_2^2 + ... + A_n^2), \quad (12.4a)$$

$$A_k = T^2 \times \sum_{r,s} c_{krs} \times a_r \times b_s , \quad (12.4)$$

The substitution of of the latter expression into the former, then recovers Problem (12.1) identically. The reformulation in the isofield $\hat{F}(\hat{a},+,\hat{\times})$ is also equivalent to the original one. We can therefore summarize the studies of this paper with the following isotopies and isodualities of Theorem 1.1:

THEOREM 12.1: All possible isonormed isoalgebras with multiplicative isounit over the isoreals are the isoalgebras of dimension 1 (isoreals), 2 (isocomplex), 4 (isoquaternions) and 8 (isooctonions), and the classification persists under isoduality.

Nevertheless, there exists a third formulation of pseudoisotopic type (Proposition 4.3 and Definition 4.2) characterized by the further lifting of the addition

$$+ \rightarrow \hat{+} = + \hat{K}, \quad 0 \rightarrow \hat{0} = -\hat{K}, \quad \hat{K} = K \times \hat{1}, \quad (12.5)$$

A more general formulation of Problem (12.1) can be written over the pseudoisofield $\hat{F}(\hat{a},\hat{+},\hat{\times})$, where the elements $\hat{a}$, the addition $\hat{+}$ and the multiplication $\hat{\times}$ are lifted

$$(\hat{a}_1^{\hat{2}} \hat{+} \hat{a}_2^{\hat{2}} \hat{+} .... \hat{+} \hat{a}_n^{\hat{2}}) * (\hat{b}_1^{\hat{2}} \hat{+} \hat{b}_2^{\hat{2}} \hat{+} .... \hat{+} \hat{b}_n^{\hat{2}}) = \hat{A}_1^{\hat{2}} \hat{+} \hat{A}_2^{\hat{2}} \hat{+} .... \hat{+} \hat{A}_n^{\hat{2}}, \quad (12.6a)$$

$$\hat{A}_k = \sum_{r,s} \hat{c}_{krs} * \hat{a}_r * \hat{b}_s = (\sum_{r,s} c_{krs}\, a_r\, b_s)\, \hat{1} = A_k \hat{1}, \quad (12.6b)$$

and can be rewritten in conventional operations

$$[(a_1^2 + a_2^2 + ... + a_n^2)\hat{1} + (n-1) K \hat{1}]\, T\, [(b_1^2 + b_2^2 + ... + b_n^2)\hat{1} + (n-1) K \hat{1}] =$$

$$= (A_1^2 + A_2^2 + ... + A_n^2)\hat{1} + (n-1) K \hat{1}, \quad (12.7a)$$

$$A_k = (\sum_{r,s} c_{krs}\, a_r\, b_s)\hat{1}, \quad (12.7)$$

where we have the cancellation of the isounit as in preceding cases, but the appearance of the "hidden" degree of freedom K.

The existence of the "hidden numbers", that is, of solutions of problem (12.7) of dimension other than 1, 2, 4, 8, is here submitted, apparently for the first time, *as a conjecture under the pseudoisofield* $\hat{F}(\hat{a},\hat{+},\hat{\times})$, *i.e., under the loss of the needed axioms of a field, such as the distributive laws* (Proposition 2.3.3), although without technical study at this time.

We merely limit ourselves to indicate the existence of the following example of "hidden numbers" of dimension 3

$$(1^2 \hat{+} 2^2 \hat{+} 3^2) \hat{*} (5^2 + 6^2 + 7^2) = 12^2 \hat{+} 24^2 \hat{+} 30^2. \qquad (12.8)$$

Note the original combinations for the numbers on the r.h.s 12 = 2×6, 24 = 2×5 + 2×7, 30 = 3×3 + 3×7, although a solution in three dimension does not exist, i.e.,

$$(1^2 + 2^2 + 3^2)(5^2 + 6^2 + 7^2) \neq 12^2 + 24^2 + 30^2. \qquad (12.9)$$

However, the more general problem (12.8) can be written

$$[\,(1^2 + 2^2 + 3^2)\,1 + 2\,K\,1\,]\,T\,[\,(5^2 + 6^2 + 7^2)\,1 + 2\,K\,1\,] =$$

$$= (12^2 + 24^2 + 30^2)\,1 + 2K\,1, \qquad (12.10)$$

and reduces to the equation in K

$$4\,K^2 + 246\,K - 80 = 0, \qquad (2.A.11)$$

with solution

$$K = 0.325.......... \qquad (2.A.11)$$

Thus, a solution exists under the relaxations of a sufficient number of axioms of the original fields, in addition to the loss of distributivity. In fact, in the case considered we start from the set of integers which is a field. However, the emerging solution for K is not an integer. This implies the loss of closure under the isoaddition (see the comments after Proposition 4.3) for the case of integers. However, closure is regained if the field is enlarged to include all real numbers. The issue whether such solutions of problem (12.9) do indeed form a pseudoisofield is left to the interested mathematician.

Note that Problems (12.3) and (12.6) are restricted to dimensions $n \leq 8$. This is due to the fact that algebras of dimensions higher than 8 are no longer alternative [8], and such a property is expected to persist under isotopies and pseudoisotopies.

Among endless novel (and intriguing) problems identified by the isofields which are still open at this writing, we indicate:

> The novel notion of "number with a singular unit", i.e., the isofields of Class IV which are at the foundations of the isotopic studies of gravitational collapse and are vastly unknown at this writing;

> The study of isofields of isocharacteristic $p \neq 0$, to see whether new

fields, and therefore new Lie algebras, are permitted by the isotopies;

> The study of the integro-differential topology characterized by isofields with local-differential structure and integral isounits; and others.

APPENDIX A: GENONUMBERS AND THEIR ISODUALS

In the main text of this paper we have studied the degrees of freedom in the characterization of numbers originating from the *addition* and *multiplication*. The emerging generalized field are at the foundations of the Lie-isotopic theory [14,15,37]. In this appendix we shall indicate the existence of a third degree of freedom originating in the *ordering* of the above operations, which results in a further generalization of fields, this time, at the foundation of the Lie-admissible algebras [14,15,27]

Let $F(a,+,\times)$ be a field of ordinary numbers with generic elements a, b, c, ..., addition $a + b = b + a$ and multiplication $a \times b$. Each of these operations can be defined with respect to the following:

Ordering of the multiplication: multiplication of a time b from the left, $a \times^> b$, and multiplication of b time a from the right, $a \,{}^<\!\times b$, here called *genomultiplications*.

Ordering of the addition: addition of a to b from the left, $a +^> b$, and addition of b to a from the right, $a \,{}^<\!+ b$, here called *genoaddition*;

Let us study genomultiplications. The first property to note is that the ordering of the multiplication is fully compatible with its basic axioms, such as alternativity (for octonions), associativity (for quaternions) and commutativity (for complex and real numbers). In fact in the latter case we have

$$a \times^> b \equiv b \times^> a, \qquad a \,{}^<\!\times b \equiv b \,{}^<\!\times a. \qquad (A.1)$$

However, the identity of the two ordered multiplications is an un-necessary condition of the current theory of numbers, because the two genomultiplications can be assumed to be different

$$a \times^> b \neq a \,{}^<\!\times b, \qquad (A.2)$$

with realization

$$a \times^> b := a\,R\,b, \qquad a \,{}^<\!\times b := a\,S\,b, \quad R \neq S, \qquad (A.3)$$

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where R and S are fixed, sufficiently smooth, bounded and nowhere singular (but not necessarily Hermitean) elements outside the original field, here called *genotopic elements*.

In the multiplication of two integers, say, two and three, we then have the following cases:

1) The conventional multiplications "two multiplied by three and three multiplied by two equal six", which hold under the (generally tacit) assumption of the number one as the unit with consequential conventional multiplication;

2) The isotopic multiplications "two multiplied by three and three multiplied by two equal twelve" which hold for the isotopic element T = 2 and isounit $\hat{1} = 1/4$; and

3) The genotopic multiplications "two multiplied by three from the right and three multiplied by two from the right equal twelve", and "two multiplied by three and three multiplied by two from the left equal eighteen" which hold for the isotopic element for the right ordering R = 2 and that for the left ordering S = 3.

We can then introduce the following two generalized (left and right) units, here called *genounits*

$$\hat{1}^{>} = R^{-1}: \qquad \hat{1}^{>} \times^{>} a = a \times^{>} \hat{1}^{>} \equiv a, \tag{A.4a}$$

$$^{<}\hat{1} = S^{-1}: \qquad ^{<}\hat{1} \, ^{<}\!\times a = a \, ^{<}\!\times \, ^{<}\hat{1} \equiv a, \tag{A.4b}$$

It is then easy to see that all axioms and properties of Definition 4.1 are preserved under the restriction of the multiplication to one of the above two orderings for all dimensions 1, 2, 4, 8. This yields a new type of fields here called *genofield* and denoted with the symbols $\hat{F}^{>}(\hat{a}^{>}, +, \hat{\times}^{>})$, $^{<}\hat{F}(^{<}\hat{a}, +, ^{<}\hat{\times})$, or with the unified symbol $^{<}\hat{F}^{>}(^{<}\hat{a}^{>}, +, ^{<}\hat{\times}^{>})$ where the need to select one ordering at the time is understood.

All properties of isofields also extend to genofields, as the reader is encouraged to verify. In particular, we have the *isodual genofields* characterized by the antiautomorphic conjugations

$$R \rightarrow R^{d} = -R, \qquad S \rightarrow S^{d} = -S, \tag{A.5}$$

denoted $^{<}\hat{F}^{>d}(^{<}\hat{a}^{>d}, +, ^{<}\hat{\times}^{>d})$.

It is evident that isofields are a particular case of genofield when the genotopic elements coincide

$$^{<}\hat{F}^{>}(^{<}\hat{a}^{>}, +, ^{<}\hat{\times}^{>})_{|R = S = T} = \hat{F}(\hat{a}, +, \hat{\times}). \tag{A.6}$$

We now show that genofields are the correct fields underlying the Lie-admissible algebras. Let [A,B] = AB – BA be the conventional Lie product among generic quantities A, B (such as vector fields on a cotangent bundle or operators on a Hilbert space), where AB is the conventional associative product.

The general realization of the Lie-admissible algebras [14] can be constructed via the following R-S-mutation of the above Lie product

$$(A, B) := A R B - B S A, \tag{A.7}$$

and results to be Lie-admissible because the attached antisymmetric product

$$[A\hat{,} B] := (A, B) - (B, A) = A T B - B T A, \quad T = R - S, \tag{A.8}$$

is Lie-isotopic.

The lifting $[A, B] \rightarrow [A\hat{,}B]$ was called an *isotopy* in ref. [14], while the lifting $[A, B] \rightarrow (A, B)$ was called a *genotopy* (Sect. 1), and this motivates the corresponding names of "isofields" and "genofields".

Now, the Lie-isotopic algebras are characterized by one single isotopy of the enveloping associative algebra and related unit

$$AB = A \times B \rightarrow A \hat{\times} B = A T B, \qquad I \rightarrow \hat{1} = T^{-1}. \tag{A.9}$$

As such, to be consistently formulated, Lie-isotopic algebras must be defined over an isofield $\hat{F}(\hat{a}, +, \hat{\times})$ with isounit $\hat{1} = T^{-1}$.

Note that, strictly speaking, the conventional multiplication × admits no ordering because $I^{>} \equiv {}^{<}I = I$. The above orderings exist for the isomultiplication $\hat{\times} = \times T \times$ because in this case we can have different isounits $\hat{1}^{>} \neq {}^{<}\hat{1}$.

It is then evident that the Lie-admissible algebras are generated by two different isotopies of the original associative enveloping algebras with corresponding isotopies of the units

$$AB \rightarrow ARB := A \times^{>} B, \qquad I \rightarrow \hat{1}^{>} = R^{-1}, \tag{A.10a}$$

$$BA \rightarrow BSA := B \, ^{<}\!\times A, \qquad I \rightarrow {}^{<}\hat{1} = S^{-1}. \tag{A.10b}$$

and, as such, they must be defined over the genofields $^{<}\hat{F}^{>}(^{<}\hat{a}^{>}, +, ^{<}\hat{\times}^{>})$ with isounits $^{<}\hat{1}^{>}$.

In Eq.s (A.10) we have presented the right and left isomultiplications and related isounits as disjoint, in which case the isounits can indeed be Hermitean and real–valued, thus admitting of Kadeisvili classification into Classes I, II, III, IV, V.

Nevertheless, the realizations used in physics are those when the forward and back genounits are inter–related by a conjugation, such as the Hermitean conjugation

$$\hat{1}^{>} = ({}^{<}\hat{1})^{\dagger}. \qquad (A.11)$$

In this case the genofields assume particular physical significance because they provide an axiomatization of irreversibility (see [27] for details).

The preceding results on the ordering of the multiplication extend to the ordering of the addition. The understanding is that, as it was the case for the conventional multiplication, the conventional addition admits no meaningful ordering because $\hat{0}^{>} = {}^{<}\hat{0} \equiv 0$. The ordering exists for the isoaddition $\hat{+} = + K +$, because in this case $\hat{+}^{>} \neq {}^{<}\hat{+}$, $K^{>} \neq {}^{<}K$. The understanding is that genofield are closed under distributive law, while this is no longer the case under the genoadditions ${}^{<}\hat{+}^{>}$.

We reach in this way the broadest possible generalization of the conventional theory of numbers permitted by the isotopies and genotopies, that characterized by:

1) *pseudogenofields* ${}^{<}\hat{F}^{>}({}^{<}\hat{a}^{>}, {}^{<}\hat{+}^{>}, {}^{<}\hat{\times}^{>})$, here defined via the genotopies of all aspects of conventional fields $F(a,+,\times)$, including elements $a \rightarrow {}^{<}\hat{a}^{>}$, addition $+ \rightarrow {}^{<}\hat{+}^{>}$ and related unit $0 \rightarrow {}^{<}\hat{0}^{>}$, and multiplication $\times \rightarrow {}^{<}\hat{\times}^{>}$ and related unit $1 \rightarrow {}^{<}\hat{1}^{>}$.

2) *isodual pseudogenofields* ${}^{<}\hat{F}^{>d}({}^{<}\hat{a}^{>d}, {}^{<}\hat{+}^{>d}, {}^{<}\hat{\times}^{>d})$ here defined via the isoduality of pseudogenofields.

The emerging broadening of the theory of numbers is then considerable because we now have:

A) Conventional numbers of dimension 1, 2, 4, 8 and their isoduals;

B) Isonumbers of the same dimension and their isoduals;

C) Genonumbers of the same dimensions and their isodual;

D) Pseudoisonumbers of the same dimension and their isoduals;

E) Pseudogenonumbers of the same dimension and their isoduals;

F) "Hidden pseudoisonumbers" of dimension 3, 4, 5, 7 and their isoduals;

G) "Hidden pseudogenonumbers" of dimension 3, 4, 5, 7, and their isoduals;

each of which can be defined over a field of characteristic 0 of $p \neq 0$, as well as in Kadeisvili topologically different classes whenever applicable.

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E1

Quasar Redshifts in Iso-Minkowski Spaces

R. Mignani

Abstract

We suggest a possible interpretation of the large redshifts of quasars in terms of a deformation of their interior metric, based on Santilli's Lie-isotopic lifting of special relativity. The Lie-isotopic Doppler effect is due to the inhomogeneity and anisotropy of the hyperdense quasar's atmosphere. Numerical estimates are derived from available astrophysical data, which indicate a possible revision of the speed of quasars with respect to the associated galaxy, while leaving current views on the expansion of the universe completely unaffected.

Key words: quasars, redshifts, deformed space-time

Soon after the discovery in 1963 of quasistellar sources (quasars),[1] a debate arose about their cosmological nature. Indeed, it is well known that they exhibit very large redshifts $(0.1 < z < 5)$. If, as usual, one assumes that the redshift has a cosmological origin, then, according to Hubble's law, quasars must be at tremendous distances from us. This poses serious problems in explaining their consequent enormous emissions of energy.[1,2] Moreover, in some cases the nucleus of a quasar consists of two components which (if quasars are very distant) appear to recede from each other with relative speed much greater than the velocity of light.[3]

Because most of the difficulties encountered in the explanation of quasar properties arise from the cosmological interpretation of their large redshifts, attempts have been made to circumvent them by a "nearby" localization of quasars. Such a "local" hypothesis has appeared as early as 1966 by Hoyle and Burbidge[4] and, subsequently, was strongly supported by Arp.[5] However, standard noncosmological interpretations of the quasar redshifts are all imperfect (for instance, their gravitational explanation clashes with stability problems, due to the strong gravitational fields needed to create them).[2] Therefore, in order to uphold a noncosmological hypothesis of origin of the quasar redshifts, one is forced to invoke a breakdown in quasars of conventional physical laws.

In this paper we shall apply to the quasar's redshift, apparently for the first time, Santilli[6,7] a hypothesis, according to which, in the transition from motion in the homogeneous and isotropic vacuum (Einsteinian conditions) to motion within inhomogeneous and anisotropic atmospheres (non-Einsteinian conditions), light experiences a redshift described by a certain geometrical modification (called "mutation") of the Minkowski space-time (see below). The main aspect we shall investigate in this paper is therefore the possibility that the currently measured quasar redshifts may be partially due to the propagation of light within the quasar's hyperdense, inhomogeneous, and anisotropic atmosphere.

In essence Santilli first showed[6] that the quasar's atmosphere can be quantitatively described by a mutation $\hat{g} = Tg$ of the Minkowski metric $g = \mathrm{diag}(-1, 1, 1, 1)$ induced by a positive-definite element $T > 0$ (called an "isotopic element") which describes precisely the inhomogeneous and anisotropic character of the hyperdense quasar atmosphere. In turn, this implies a Lie-isotopic generalization of the Lorentz symmetry constructed with respect to the generalized unit $I = T^{-1}$. This implies a step-by-step generalization of special relativity. Santilli included these studies in a detailed treatment in Ref. 7, where it was shown that, besides representing the global effect of the propagation of light within inhomogeneous and anisotropic media via a suitable selection of T (see below), the Lie-isotopic theory can also represent the physically different case of extended-deformable particles under the contact, nonlinear, nonlocal, and nonpotential interactions caused by motion within physical media, and a number of other non-Einsteinian conditions. Santilli then completed his studies in the recent monographs.[8] Independent reviews have appeared in Ref. 9.

To avoid possible misrepresentations, it should be noted that Santilli's Lie-isotopic theory describes physical conditions (inhomogeneous and anisotropic

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geometries, nonlocal and non-Hamiltonian interactions, etc.) under which special relativity is clearly *inapplicable* (and not "violated"). Also, the emerging generalizations encompass special relativity because (1) they are based on structurally more general mathematics (the Lie-isotopic generalization of Lie's theory); (2) they represent physical conditions fundamentally more general than those of special relativity (motion of extended-deformable particles or of electromagnetic waves within physical media); and (3) they include special relativity as a particular case for $T = 1$.

Santilli[6] originally proposed the names "Lorentz-isotopic transformations" for the new symmetries and "Lorentz-isotopic relativity" for the emerging new relativity. However, these new structures are now called "Lorentz-Santilli transformations" and "Santilli's special relativity."

Let us briefly summarize the main foundation of Santilli's generalization of special relativity to the readers not acquainted with it. The basic idea is that in transition from empty space (exterior, Hamiltonian dynamics) to a physical medium (interior, non-Hamiltonian dynamics), the Minkowski space-time $\mathcal{M}(x, g, \mathcal{R})$ is changed ("mutated") to an isotopic Minkowski space $\hat{\mathcal{M}}(x, \hat{g}, \hat{\mathcal{R}})$ (Santilli space of class I):

$$\hat{\mathcal{M}}(x, \hat{g}, \hat{\mathcal{R}}) : \hat{g} = Tg; \quad g = \mathrm{diag}(-1, 1, 1, 1),$$

$$T = \mathrm{diag}(b_0^2, b_1^2, b_2^2, b_3^2), \; b_\mu^2 > 0 \tag{1}$$

where the local coordinates x are conventional, and $\hat{\mathcal{R}}$ is the isofield of isonumbers[1]:

$$\hat{\mathcal{R}} = \{\hat{a} | \hat{a} = a\hat{1}, \; a \in \mathcal{R}, \; \hat{1} = T^{-1}\}. \tag{2}$$

In general, the interior metric (and therefore the b_μ's) depend (in a generally nonlinear, nonlocal, or other functional way) on the coordinates x, the velocities $\dot{x}$, the index of refraction n, the density μ, the temperature τ, and any needed additional quantity (such as accelerations $\ddot{x}$, etc.):

$$\hat{g}_{\mu\nu} = \hat{g}_{\mu\nu}(x, \dot{x}, \ddot{x}, n, \mu, \tau, \ldots). \tag{3}$$

A few comments are in order. First, let us stress that the deformation of the metric has nothing to do with gravitation.[2] It merely represents a geometrization of the physical medium that describes, on average, the effect of nonpotential, non-Hamiltonian forces on a test particle, and, for the different case of propagation of electromagnetic waves, the geometrical implications of the inhomogeneity and the anisotropy of the medium in which propagation occurs. The meaning of the coefficients b_μ is then easily seen by considering the generalized interval

$$\hat{x}^2 = x^\mu \hat{g}_{\mu\nu} x^\nu = x_1^2 b_1^2 + x_2^2 b_2^2 + x_3^2 b_3^2 - c_0^2 b_0^2 t^2. \tag{4}$$

It is therefore easily realized that the generalized quantity $c = b_0 c_0$ (with c_0 being the usual light speed in a vacuum) represents the speed of light in the physical medium considered (assumed to be transparent).[3] In this case we have the simple geometric interpretation $b_0 = 1/n$, where n is the index of refraction. The space elements $\hat{g}_{ii} = b_i^2$ have similar interpretations: they represent the inhomogeneous and anisotropic character of the physical medium in which motion occurs. It is therefore clear that there exist infinitely many isotopes of the Minikowski space (corresponding to the infinitely many different interior physical media).

Let us now discuss the problem of the quasar redshifts. We assume that (because of the presence inside quasars of non-Hamiltonian forces; we shall come back to their possible origin later) the quasar atmosphere can be considered as an anisotropic and inhomogeneous medium and therefore described by an isotopic Minkowski space-time of the kind (1), with metric tensor[4]:

$$\hat{g}_{\mu\nu} = \mathrm{diag}(-b_0^2, b_1^2, b_2^2, b_3^2). \tag{5}$$

The corresponding Lorentz-Santilli transformations (for a boost, say, along the third axis) read[6-8]

$$\begin{aligned} x_1' &= x_1, \\ x_2' &= x_2, \\ x_3' &= \hat{\gamma}(x_3 - \hat{\beta}x_0), \\ x_0' &= \hat{\gamma}(x_0 - \hat{\beta}x_3), \end{aligned} \tag{6}$$

where

$$\hat{\gamma} = (1 - \hat{\beta}^2)^{-1/2}; \quad \hat{\beta} = Vb_3/c_0 b_0 = \beta b, \tag{7}$$

and $\beta = V/c_0$ is the usual velocity parameter, and we put

$$b = b_3/b_0. \tag{8}$$

Then Santilli's iso-Doppler formula[7] holds:

$$\omega' = \omega\hat{\gamma}(1 - \hat{\beta}), \tag{9}$$

whence one immediately gets the *Lie-isotopic expression for the redshift*:

$$\hat{z} = \frac{\hat{\lambda} - \lambda_0}{\lambda_0} = \left(\frac{1 + \hat{\beta}}{1 - \hat{\beta}}\right)^{1/2} - 1, \tag{10}$$

which is proposed in this paper apparently for the first time.

It is now easily seen that due to the presence of the geometrical parameter b, the *apparent* behavior of the quasar corresponds to that of an object with speed $\hat{\beta}$ in the *geometric* Minkowski-isotopic space, whereas its real cosmological distance is still determined by the standard velocity parameter β in the *physical* Minkowski space. Obviously, the actual value of b is expected to depend, in general, on the quasar considered and represents a measure of the degree of anisotropy and inhomogeneity of the quasar medium. Let us refer to this alternative mechanism of explanation of the large quasar redshift as "Lie-isotopic" (because it is obtained in the context of the Lie-isotopic relativity) or "quasicosmological," since it is able to simulate large redshifts for nearby objects.

Needless to say, our interpretation of large redshifts completely overcomes the problem of the relative superluminal speeds between two components in some quasar nuclei, which clearly do not occur if quasars are nearby objects. Moreover, it does not conflict by any means with the standard expansion of the universe (due to the big bang), because its origin is not of gravitational nature (as stressed before). In other words, in this framework the *local* deformation of the Minkoswki metric in the interior of the quasar atmosphere does not affect the *global* behavior of quasars considered as pointlike objects moving in the curved space-time of Einstein's general relativity. The first problem concerns the (interior) motion of light *inside* the quasar medium;

geometries, nonlocal and non-Hamiltonian interactions, etc.) under which special relativity is clearly *inapplicable* (and not "violated"). Also, the emerging generalizations encompass special relativity because (1) they are based on structurally more general mathematics (the Lie-isotopic generalization of Lie's theory); (2) they represent physical conditions fundamentally more general than those of special relativity (motion of extended-deformable particles or of electromagnetic waves within physical media); and (3) they include special relativity as a particular case for $T = 1$.

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$$\hat{z} = \frac{\hat{\lambda} - \lambda_0}{\lambda_0} = \left(\frac{1 + \hat{\beta}}{1 - \hat{\beta}}\right)^{1/2} - 1. \tag{10}$$

which is proposed in this paper apparently for the first time.

It is now easily seen that due to the presence of the geometrical parameter b, the *apparent* behavior of the quasar corresponds to that of an object with speed $\hat{\beta}$ in the *geometric* Minkowski-isotopic space, whereas its real cosmological distance is still determined by the standard velocity parameter β in the *physical* Minkowski space. Obviously, the actual value of b is expected to depend, in general, on the quasar considered and represents a measure of the degree of anisotropy and inhomogeneity of the quasar medium. Let us refer to this alternative mechanism of explanation of the large quasar redshift as "Lie-isotopic" (because it is obtained in the context of the Lie-isotopic relativity) or "quasicosmological," since it is able to simulate large redshifts for nearby objects.

Needless to say, our interpretation of large redshifts completely overcomes the problem of the relative superluminal speeds between two components in some quasar nuclei, which clearly do not occur if quasars are nearby objects. Moreover, it does not conflict by any means with the standard expansion of the universe (due to the big bang), because its origin is not of gravitational nature (as stressed before). In other words, in this framework the *local* deformation of the Minkowski metric in the interior of the quasar atmosphere does not affect the *global* behavior of quasars considered as pointlike objects moving in the curved space-time of Einstein's general relativity. The first problem concerns the (interior) motion of light *inside* the quasar medium;

Table I

Galaxy Name	z	*Quasar Name*	$\hat{z}$	b
NGC 622	0.018	UBI	0.91	31.91
		BSOI	1.46	20.25
NGC 470	0.009	68	1.88	87.98
		68D	1.53	67.21
NGC 1073	0.004	BSO1	1.94	198.94
		BSO2	0.60	109.98
		RSO	1.40	176.73
NGC 3842	0.020	QSO1	0.34	14.51
		QSO2	0.95	29.75
		QSO3	2.20	41.85
NGC 4319	0.0056	MARK 205	0.07	12.14
NGC 3067	0.0049	3C32	0.5303	82.17

the second one concerns the exterior motion in a vacuum of quasars as pointlike objects subjected to standard gravitation. In different terms our application of Santilli's special relativity to the problem of quasar redshifts can provide a possible revision of the relative speed between the quasar considered and its associated galaxy, while leaving the current theories of the expansion of the galaxy-quasar system totally unaffected.

In order to get some quantitative information on the possible values of b, we consider some cases in which (as stressed by Arp[5]) there are reasonable arguments to think that quasars (sometimes in numbers of two or three together) are associated with a galaxy (the probability of causal association being about is about one in a thousand). A little algebra provides us with the following formula for b as a function of the galaxy and quasar redshifts, z and $\hat{z}$:

$$b = \left[\frac{(z+1)^2+1}{(z+1)^2-1}\right]\left[\frac{(\hat{z}+1)^2-1}{(\hat{z}+1)^2+1}\right]. \tag{11}$$

The numerical results obtained from Eq. (11) for some of the most probable associations of galaxies and quasars are given in Table I.

Some remarks are in order. First of all, in deriving the values of Table I, we have considered b as a constant for a given quasar, thus neglecting its explicit functional dependence on local quantities and, therefore, its possible variations inside the quasar atmosphere. In this approximation it is clear that the b values represent only an average (and rough) estimate of the deformation of the interior metric. However, also in this approximation, our results are in good qualitative agreement with the main features of the Lie-isotopic Santilli relativity in the following respects. First, the calculated values of b are *different* for *different* quasars (as expected on theoretical grounds). Second, the values of b obtained for the quasars associated with the same galaxy are about of the same order of magnitude. This, too, is a foreseen effect, since on physical grounds the quantity measuring the degree of affinity among quasars is not redshift $\hat{z}$, but the deformation parameter b. Due to the very nature of b, it is expected that, irrespective of $\hat{z}$, quasars associated with the same galaxy have the same physical origin and, therefore, a comparable amount of deformation of the metric. Indeed, if one is of the view that quasars are expelled from the core of the associated galaxy,[5,11] then it is plausible to think that all the quasars expelled from the same galaxy do possess-intrinsic and peculiar non-potential forces acting inside them at about the same rate. Needless to say, the very nature and mechanism giving rise to such nonpotential effects are only a matter of speculation and critically depend on the kind of model adopted for quasars.[1,2]

For instance, in a model that depicts quasars as supermassive stars, magnetoturbulence plays a basic role, and the corresponding magnetic force is just a nonpotential force.[2] On the other hand, in quasars considered as stellar systems their mass is primarily due to stars (including neutron stars) embedded in a hot gas.[12] Although the system as a whole is transparent to light, it is expected that the internal components of such an object are subjected to strong forces of the nonlocal, non-Hamiltonian type.

As a final consideration, let us stress that a generalized Doppler effect of the type (8) [and therefore leading to a different redshift, according to (9)] applies as well to the intergalactic space between quasars and Earth, which is far from empty, and filled instead with dark matter, radiation and particles. This would imply a further (probably second-order) correction to the above redshifts calculations. Moreover, the latter consideration also holds for galaxies (especially for the very distant galaxies), thus leading to a predictable revision of the currently assumed galaxy distances, as already suggested by Santilli.[8] Clearly, in this case one expects values of b for galaxies much lower than for quasars, thus providing only very small corrections to the standard galactic redshifts.

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Résumé

Nous proposons une possible explication des grands déplacements vers le rouge des quasars en termes d'une déformation de leur métrique interne, basée sur la "déformation Lie-isotopique" de la relativité restreinte proposée par Santilli. Cet effet Doppler Lie-isotopique ensuit par la inhomogénéité et anisotropie de l'atmosphère hyperdense des quasars. Nous dérivons, des données astrophysiques disponibles, quelques évaluations numeriques qui montrent une possible révision de la vitesse des quasars relative à la galaxie associée, toutefois en laissant inalterées les opinions actuelles sur l'expansion de l'univers.

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Endnotes

[1] The reason for introducing the isofield $\hat{\mathcal{R}}$ is to preserve (at an abstract level) linearity in $\hat{\mathcal{M}}$. In fact, transformations in $\hat{\mathcal{M}}$ are now given by

$$x' = A * x = ATx,$$

which are isolinear, that is, linear at the abstract, realization-free level; nevertheless, they are intrinsically nonlinear because of the dependence of T on x [cf. Eq. (3)]. See Refs. 6 to 9.

[2] However, we recall that Einstein's general relativity is a special case of Lie-isotopic relativity in the so-called Santili spaces of class III. See Refs. 7 and 8.

[3] If the medium is not transparent, the meaning of c is that of the maximal causal speed of propagation inside the medium considered. See Refs. 6 and 8.

[4] Metrics of the type (1) have been already used in the literature within different frameworks, all, however, dealing with the problem of a possible breakdown of Lorentz invariance.[10] Clearly, metric (1) is Lorentz noninvariant according to standard views. However, Lorentz symmetry can be proved to be still exact, provided one understands that is is realized at the covering isotopic level. This only apparently paradoxical fact can be seen by noticing that the inhomogeneity and anisotropy of Santilli's metric (1) originate from the physical medium in which motion occurs, whereas the space (empty space) remains perfectly homogeneous and isotropic. The unconvinced reader is strongly referred to Refs 7, 8 for a thorough discussion of this important and delicate point.

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LETTER TO THE EDITOR

On a possible non-Lorentzian energy-dependence of the K_S^0 lifetime

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Abstract. A fit to the experimental data reported by Aronson *et al* on the K_S^0 lifetime shows a good agreement with a generalized expression for time dilation, obtained by a Lie isotopic lifting of the Poincaré symmetry.

In 1982 Aronson *et al* [1] discussed the behaviour of the K^0–$\bar{K}^0$ system at the energies available at Fermilab at the time (30–110 GeV). They found that the basic K^0–$\bar{K}^0$ parameters (i.e. the K_L^0–K_S^0 mass difference, the K_S^0 lifetime, and the CP-violation parameter $|\eta_{+-}\rangle$) exhibit an anomalous dependence on energy of the type

$$x = x_0(1 + b_x^{(N)}\gamma^N) \tag{1}$$

where x is any of the above parameters, $\gamma = E_k/m_0 = (1-\beta^2)^{-1/2}$ is the usual relativistic factor, the b_x are suitable slope parameters and N is an integer equal to 1 or 2.

In particular, as far as the K lifetime is concerned, equation (1) is clearly at variance with the standard Einstein relation

$$\tau = \tau_0\gamma \tag{2}$$

and is compatible instead with a Blokhintsev–Redei [2] behaviour of τ, obtained via the introduction of a fundamental length.

A possible role of non-local forces in an anomalous behaviour of hadron lifetimes has been stressed by Kim [3], in agreement with the original proposal by one of us [4]. More recently, Nielsen and Picek [5], studying mechanisms of breakdown of Lorentz invariance within unified gauge theories, showed that spontaneous symmetry breaking in the Higgs sector implies deformations of the spacetime metric in the interior of mesons. This leads to a non-Einsteinian behaviour of meson meanlife with speed that depends on the Lorentz-non-invariance parameter (different for pions and kaons).

A geometrization of the above theoretical results has been achieved by one of us [6, 7] in the context of the so-called Lie-isotopic generalization of Lie's theory [8–10]. In particular, the Lie-isotopic lifting of the Poincaré symmetry is obtained essentially by the following generalization of the conventional Minkowski metric $g_{\mu\nu} = \mathrm{diag}(1, 1, 1, -1)(\mu, \nu = 1, 2, 3, 4)$:

$$g_{\mu\nu} \to \eta_{\mu\nu} = \mathrm{diag}(b_1^2, b_2^2, b_3^2, -b_4^2) \tag{3}$$

where the b_μ have an arbitrary, generally non-local, dependence on all local variables (like coordinates, velocities, density, temperature, etc). The space characterized by metric (3) is called an isotopic Minkowski space. We refer the reader to the quoted literature for further details. Let us only stress that, in the Lie-isotopic approach, the Lorentz (or Poincaré) symmetry is not broken, but is realized in a generalized form, while Einstein's special relativity is no longer valid (see [6–10]). Then, for instance, one gets *the isotopic law of time dilation*

$$\tau = \tau_0 \hat{\gamma} \qquad \hat{\gamma} = (1-\hat{\beta}^2)^{-1/2} \qquad \hat{\beta} = \frac{b_3}{b_4}\frac{v}{c_0} = \frac{b_3}{b_4}\beta \tag{4}$$

(where c_0 is the usual light speed in vacuum), that is clearly a covering of the Einstein relation (2).

As recently shown by Aringazin [11], a simple dependence of only b_3 on speed is enough to get a Blokhintsev–Redei behaviour of the K^0–$\bar{K}^0$ parameters, in agreement with equation (1).

The aim of the present letter is a re-analysis of the data reported in [1] on the K^0_S lifetime, in the light of the above theoretical results, with special attention to the isotopic law (4). The difference with respect to the investigations of Aronson *et al* lies in the fact that we are not trying to fit the experimental data by *any* law, but to testing the validity of a *specific* law, derived from theoretical considerations.

Our main results are graphically summarized by figures 1–3. Figure 1 pictures a linear fit to the data of [1] by the standard formula (2). The fit parameter is $a = \tau_0/m_0$; the reduced chi-square is $\chi^2_n = 0.9$. The value found for τ_0 is $\tau_0 = (0.9375 \pm 0.0021) \times 10^{-10}$ s, to be compared with the *Particle Data Book* [12] value $\tau_0 = (0.8922 \pm 0.0020) \times 10^{-10}$ s. Moreover, the confidence level (CL) is 0.39, giving a probability of 61% that τ_0 is greater than the obtained value. It is therefore easily seen that, although a linear formula could fit the data, a linear fit is not able to reproduce the correct value of the K^0_S lifetime at rest as provided by low-energy (less

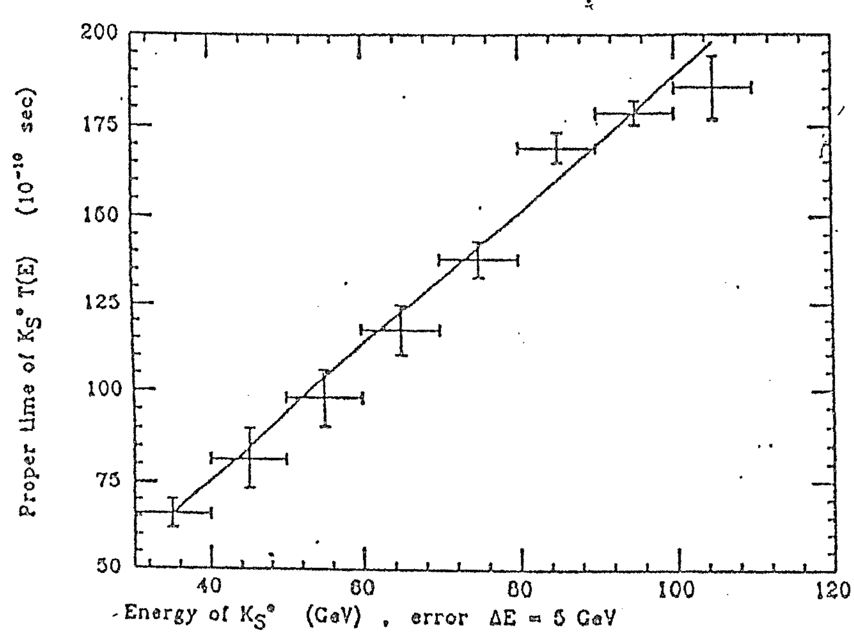

Figure 1. Linear fit of experimental data on K^0_S lifetime using Einstein's relation (2): see text for details.

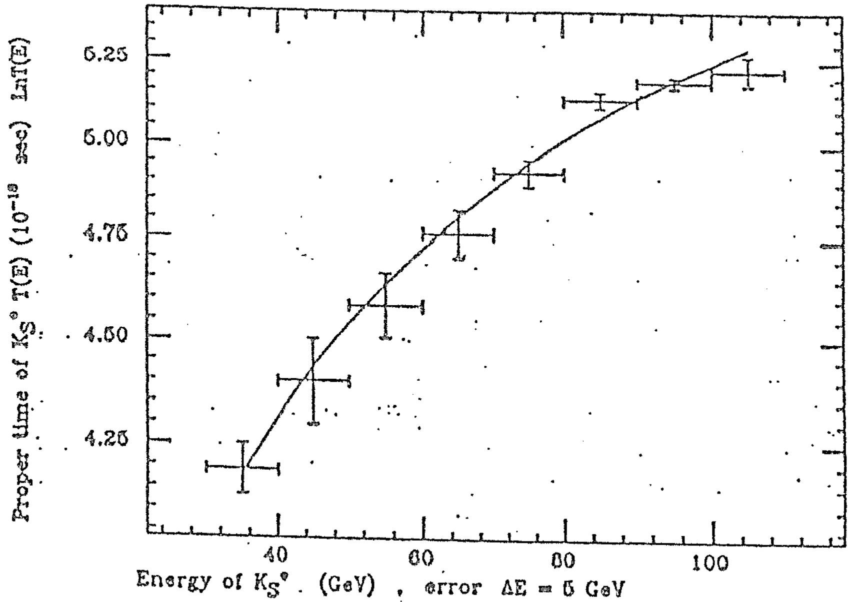

Figure 2. Logarithmic fit of experimental data on K_S^0 lifetime using the power law (5): see text for details.

than 3–5 GeV) measurements. This first fit shows clearly that the Lorentzian law of time dilation is unable to account for the available data in a satisfactory way, and that a *non-linear* dependence of τ on E is needed.

In order to further test the non-linearity of the τ-dependence on energy, we performed a second (logarithmic) fit by the formula

$$\tau = (\tau_0/m_0)E^n \qquad (5)$$

by taking $a = \tau_0/m_0$ and n as parameters. The results of this second fit are shown in

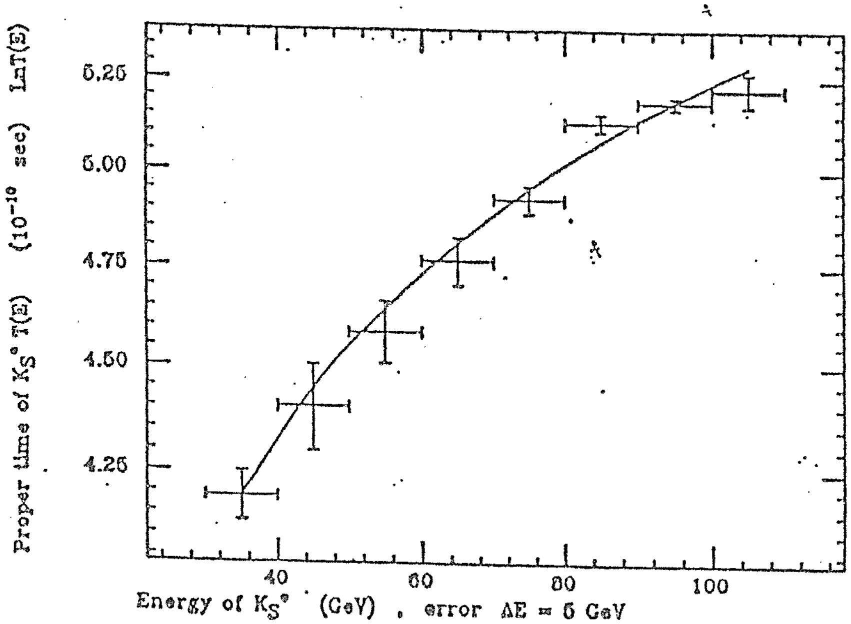

Figure 3. Logarithmic fit of experimental data on K_S^0 lifetime using the isotopic formula (4): see text for details.

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figure 2. We have now $\chi_n^2 = 0.85$, and the value obtained for the exponent of E is $n = 1.013 \pm 0.003$. Moreover, the upper limit on n is 1.023 ± 0.003 (95% CL). The deviation from linearity is 1.3% at 100 GeV, and therefore an effect of 13% at 1 TeV is expected.

The last (logarithmic) fit (figure 3) was finally aimed at directly testing the isotopic law (4). We considered the ratio b_3^2/b_4^2 as a single parameter a. We found for a the value 0.898 ± 0.021, with $\chi_n^2 = 0.86$. The deviation of a from unity is 10.2% at 100 GeV.

Let us also state that another fit, carried out by taking b_3^2 and b_4^2 as distinct parameters, allowed us to get the values $b_3^2 = 0.9023 \pm 0.0004$ and $b_4^2 = 1.003 \pm 0.0021$, whence the ratio $(b_3/b_4)^2 = 0.8996 \pm 0.0023$, in good agreement with the value obtained in the third fit. Moreover—as expected on theoretical grounds—there is evidence that both these parameters are not constants, but depend on the energy. Further details will be given in a forthcoming paper.

In conclusion, our re-analysis of the experimental data of [1] on the K_S^0 lifetime supports the validity (in the energy range considered) of the generalized time dilation provided by the Lie-isotopic theory. However, some points are to be stressed. First of all, our results are far from conclusive on a number of counts, the most important of which is obviously the lack of available data on hadron lifetimes. What is needed is a systematic investigation of the energy behaviour of lifetimes not only for kaons, but for all the unstable hadrons. We hope that our preliminary study will be a valid suggestion for experimentalists.

Let us recall, in this connection, that another set of data on the K_S^0 lifetime exists in the energy range 100–350 GeV, due to Grossmann *et al* [13]. They are in disagreement with the data of [1], showing no evidence for an energy dependence of τ. However, we think that the results of [13] are not at all conclusive, and that a further measurement is needed for the *whole* energy range covered by both experiments.

In any case, we think that our analysis is reliable enough at the intermediate energies of the experiment by Aronson *et al.* Indeed, on a theoretical basis [3, 4, 6–10], we expect a standard (Lorentzian) behaviour of lifetime at low energies (less than 10 GeV), whereas, at very high energies, the parameter $a(=b_3^2/b_4^2)$ exhibits a (presently not well known) dependence on energy. Only at intermediate energies we can safely approximate a as a constant (as we have just done in our present work). A global analysis of the whole data on K_S^0 lifetime (mainly aimed to just find the explicit functional dependence of a on energy) will be carried out in a forthcoming paper.

Let us also stress that this letter only aims to provide a different interpretation of the non-linearity of the K_S^0-lifetime behaviour in the range 35–110 GeV. Let us explicitly stress that our interpretation is based on a theoretical framework completely independent from the considerations which led some years ago to the renewed hypothesis of a fifth force [14].

Finally, although there is, in our opinion, a good chance that the lifetime law for hadrons has indeed the form (4) (with, in general, *different* parameters b_3, b_4 for *different* particles: cf the result of Nielsen and Picek [5] and [6–10]), we *do not* expect, *a priori*, that a similar formula must also hold for mass (at least on the same energy scale). In other words, it is easily possible (as apparently confirmed by the existing data on hadron masses) that the γ-factor for mass is still the usual, Einsteinian one. This seemingly contradictory statement can be motivated as

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follows. As is well known, the appearance of the same factor γ in the dilation laws of both time and mass in special relativity is strictly related to the point-like nature of particles (a *necessary* condition to ensure the validity of special relativity) and is simply a consequence of the Lorentz transformations (i.e. of the spacetime properties), without any connection at all with a possible particle structure. On the other hand, the Lie-isotopic theory is just aimed to account—at least in first approximation—for the internal structure of hadrons (namely, for the non-local forces among their constituents) [4, 9]. From this respect, lifetime is expected to be more sensible than mass to the composite nature of particles. This point can be easily understood by a standard thermodynamical reasoning (i.e. our ignorance of the internal coordinates of the constituents), and is also implicit in the very formulation of Lie-isotopic theories, according to which the usual dynamical behaviour is recovered for centre-of-mass quantities in the standard Minkowski space [10]†.

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† Indeed, the γ-factor connected with lifetime takes account of the internal energy of the physical system considered, whereas that entering the mass formula is related to the total energy of the system.

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LETTER TO THE EDITOR

Lie-isotopic energy-dependence of the K_S^0 lifetime

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Abstract. Fits to the experimental data on the K_S^0 lifetime in the energy range 30–350 GeV show a good agreement with a generalized expression for time dilation, obtained by a Lie-isotopic lifting of the Poincaré symmetry. We also get preliminary results on the energy dependence of the parameters that, in the Lie-isotopic theory, determine the deformed Minkowski metric inside hadrons.

In this paper we shall study the currently available phenomenological data on the behaviour of the meanlife of unstable hadrons with energy. According to a number of theoretical studies [1–6], this behaviour is expected to be at variance with the predictions of Einstein's special relativity, the celebrated law of time dilation

$$\tau = \tau_0 \gamma \qquad \gamma = (1-\beta^2)^{-1/2} \qquad \beta^2 = v^2/c_0^2 \tag{1}$$

(c_0 being the light speed in vacuum).

The initiation of quantitative studies in the subject is usually associated with Blokhintsev [1] and Redei [2] who, by an examination of the phenomenological data available at that time, suggested a modification of law (1) of the type

$$\tau = \tau_0 \gamma (1 + 10^{25} \gamma^2 a_0^2) \tag{2}$$

where a_0 is a fundamental length.

Later Kim [3]—resuming the historical legacy opened up by the founding fathers of strong interactions, according to which the ultimate structure of hadrons is expected to be non-local—predicted a violation of law (1) of 2.6% at 150 GeV and of 14.3% at 400 GeV.

Nielsen and Picek [4] studied the problem within the context of unified gauge theories and showed that the spontaneous symmetry breaking in the Higgs sector implies deformations of the Minkowski metric of the type

$$g = \mathrm{diag}\,\left[(1-\tfrac{1}{3}\alpha), (1-\tfrac{1}{3}\alpha), (1-\tfrac{1}{3}\alpha), -(1+\alpha)\right] \tag{3}$$

where the 'Lorentz asymmetry parameter' α has different values (and sign) for pions and kaons.

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This deformation effect results in a non-Einsteinian behaviour of the meanlife with speed of the type [4]

$$\tau = \tau_0 \gamma \left(1 + \tfrac{4}{3}\alpha\gamma^2\right)^{-1}. \tag{4}$$

A geometrization of the above results was achieved by one of us [5,6] via a generalization of the conventional Minkowski space $\mathcal{M}(x, g, R)$ (g being the usual metric tensor, and R the real field) of the type

$$\begin{aligned} &\hat{\mathcal{M}}(x, \eta, \hat{R}) : x^\mu \eta_{\mu\nu} x^\nu = x_1^2 b_1^2 + x_2^2 b_2^2 + x_3^2 b_3^2 - x_4^2 b_4^2 \\ &\eta = Tg \qquad T = \mathrm{diag}(b_1^2, b_2^2, b_3^2, b_4^2) \\ &\hat{R} = \{\hat{c} | \hat{c} = c\hat{I};\, c \in R, \hat{I} = T^{-1}\} \end{aligned} \tag{5}$$

called a *Minkowski-isotopic space.* Here, the positive-definite isotopic element T has an arbitrary, generally non-local (i.e. integro-differential) dependence on all local variables and quantities, such as coordinates, velocities, accelerations, density, temperature, etc:

$$b_\mu = b_\mu(x, \dot{x}, \ddot{x}, \ldots \rho, \ldots) \tag{6}$$

and $\hat{R}$ is an isofield, i.e. an ordinary field with conventional sum and product given by $\hat{c}_1 \times \hat{c}_2 \equiv c_1 c_2 \hat{I}$.

The lifting $\mathcal{M} \to \hat{\mathcal{M}}$ requires, for consistency, the generalization of the conventional Poincaré group of transformations (and its Lie structure) into a *Poincaré isotopic group* (with a Lie-isotopic structure). The resulting theory is then a Lie-isotopic theory (as originally proposed in [7]). The physical motivation of Lie-isotopic theories lies in their capability of representing non-local, non-Hamiltonian forces. In particular, the metric deformation (5) is representative—at least in first approximation—of the contact, non-local interactions that are expected in the interior of hadrons from the total mutual penetration of the wavepackets of the constituents. For further details, we refer the reader to the review [8].

The Lie-isotopic lifting of the Poincaré group leads to the following *isotopic law of time-dilation* (for a boost along x_3)

$$\tau = \tau_0 \hat{\gamma} \qquad \hat{\gamma} = (1 - \hat{\beta}^2)^{-1/2} \qquad \hat{\beta}^2 = b_3^2 / b_4^2 \beta^2. \tag{7}$$

As shown by Aringazin [9], the isotopic formula (7) admits as particular cases (depending on the assumed expansion) all available non-Einsteinian laws (like (2) and (4)).

Some features of (7) must be stressed. Firstly, we expect significant deviations from (1) only at high energies (cf the estimates by Kim [3] reported above). In other words, the energy dependence of the isotopic time dilation at low energies is in good approximation Lorentzian (in agreement with the low-energy measurements in the range 3–5 GeV [11]). Secondly, the parameters b_μ, on account of their physical meanings, are a priori *different* for different hadrons [5, 6] (cf the analysis by Nielsen and Picek [4]). Finally, still on physical grounds, one expects that there is a *different* dependence on energy for the spatial parameters b_i ($i = 1, 2, 3$) and for the temporal one, b_4. This can easily be seen by considering that the parameters b_μ take

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account, on average, of the non-local effects inside hadrons [5–7, 10]. These effects are obviously more effective as far as the spatial part of the metric is concerned, while for the time part they only give rise, essentially, to a change of the light speed [5–7, 10]. In other words, we expect that the time parameter b_4 is a very slow function of the energy (at limit constant) in comparison with the b_i's (as it can easily be inferred from the discussion of [5–7, 10]).

Another basic point to be stressed is the *different* predictive power of the time-dilation laws (1) and (7). Indeed, the Einsteinian law (1), being linear in energy, is expected to provide the value of the hadron meanlife in the rest system, τ_0. On the contrary, the isotopic law (7), after assuming the τ_0 value as given by the low-energy measurements (in the range 3–5 GeV, i.e. $\tau_0 = (0.8922 \pm 0.0020) \times 10^{-10}$ s) [11], is expected to yield information on the functional dependence of b_3 and b_4 on energy.

In this paper, we shall consider the only available data on the meanlife of an unstable hadron at high energies, i.e. those on K^0_S in the energy range 30–375 GeV. They have been obtained by two different experiments; the first by Aronson *et al* [12] in the range 30–100 GeV and the second by Grossman *et al* [13] in the range 100–375 GeV. Indeed the two experiments do not disprove each other, because they were conducted on *different* (and *non-overlapping*) ranges of energy. As we shall show in the following, the disagreement between the results of these two different measurements is only apparent: when considered as a *single* set of data (after a suitable weighting by proper statistical weights) they provide us with a self-consistent and coherent conclusion within the framework of the Lie-isotopic predictions. For brevity we shall refer to the two sets of data as 'A' and 'G', respectively. Let us stress that we are not interested at all in problems connected with the possible existence of a fifth fundamental force [14]. Our only aim is to test the predictive power of the time-dilation laws (1) and (7).

In the following, we shall consider first the data, A, separately and then the two sets of data, A + G, together, in order to investigate the behaviour of the parameters b_3 and b_4 with energy. In the latter case, of course, we have properly accounted for a suitable weighting of the two sets of data by considering the proper statistical weights for the two experiments (analogously to what was already done in [13]; cf figure 3). In particular, we have taken into account: (i) the different statistical uncertainties; (ii) the acceptances of the two apparatuses; and (iii) the different binning.

A preliminary analysis of the data A has already been given by us [15]. In particular, we have already checked that, as far as those data are concerned, a linear law of the type (1) fails to fit the experimental points, and must be replaced by a power law. This had already been realized by Aronson *et al* [12], who indeed proposed a generalized time-dilation law we shall not consider here, because it is a special case of the isotopic formula (7) [9].

However, for the sake of completeness and for comparison, we report here the results of the linear fit to data A (figure 1(*a*)). The fitted law is $\tau = \tau_0 E/m_0$, and τ_0 is taken as a parameter. The reduced χ-square is $\chi^2_n = 0.9$. The value found for τ_0 is $\tau_0 = (0.9375 \pm 0.0021) \times 10^{-10}$ s. The confidence level (CL) is 0.39, giving a probability of 61% that τ_0 is greater than the obtained value.

The set of data G was analysed separately in [13]. The result of the fit by Grossman *et al*, only confined to their data set, gives of course a good agreement with the low-energy value of τ. Indeed, we are just going to prove that it is the *whole* set of data A+G (when considered together) which seems to support the validity of the Lie-isotopic time-dilation law (7).

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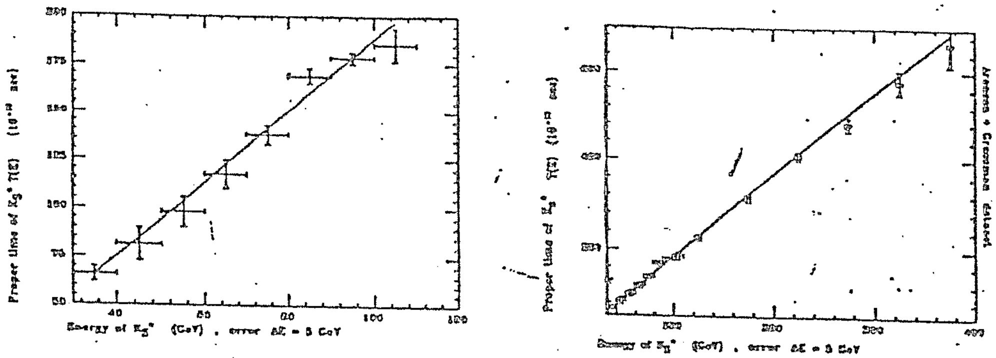

Figure 1. Linear fit of experimental data on K_S^0 lifetime using Einstein's relation (1) for: (*a*) the set of data A; (*b*) the set of data A+G. See the text.

The result of the linear fit to the two sets of data A+G is shown in figure 1(*b*). The value obtained for the meanlife of K_S^0 is $\tau_0 = (0.91444 \pm 0.00193) \times 10^{-10}$ s. The reduced χ-square is 1.23. The CL is 19%, with therefore a probability of 81% that the value of τ_0 is greater than that given by the fit. Let us further check the compatibility of the fitted value with that measured at low energies (see [11]) by considering the absolute values of the related errors, $\sigma_{\tau_0}^{(f)} = 0.00193$ and $\sigma_{\tau_0} = 0.0020$. We have

$$\Delta\tau_0 = \tau_0^{(f)} - \tau_0 = 0.022 = 11.1\sigma_{\tau_0} = 11.5\sigma_{\tau_0}^{(f)}. \tag{8}$$

We can therefore conclude that the Einsteinian law (1) *fails to predict* the right experimental value of the meanlife of K_S^0 at rest.

Let us now consider the Lie-isotopic law (7). In this case, we *assume* the value of τ_0 is known at low energies, and want to find the functions $b_3(E)$ and $b_4(E)$. We consider three parameters, i.e. b_3, b_4, and their difference, $\Delta = b_4^2 - b_3^2$. This last parameter is introduced because, as stressed above, we expect a different dependence of the two parameters on energy. The results of the fits are shown in figures 2(*a*) and (*b*) (data A and A+G, respectively). Let us summarize the fit results:

(i) data A (figure 2(*a*)):

$$\begin{aligned} &\chi^2/n = 0.86 \qquad \Delta(b_3^2, b_4^2) = (1.4 \pm 0.003) \times 10^{-7} \\ &b_3^2 = 0.9023 \pm 0.0004 \qquad b_4^2 = 1.0003 \pm 0.002 \end{aligned} \tag{9}$$

(ii) data A+G (figure 2(*b*)):

$$\begin{aligned} &\chi^2/n = 0.71 \qquad \Delta(b_3^2, b_4^2) = (3.926 \pm 0.002) \times 10^{-7} \\ &b_3^2 = 0.909080 \pm 0.00004 \qquad b_4^2 = 1.002 \pm 0.007. \end{aligned} \tag{10}$$

Denoting by $\sigma_{A,Bb_{3,4}}$ the absolute values of the errors on b_3^2, b_4^2 for the two sets of data (the lower index B referring to the set of data A+G), we have

$$\Delta b_3^2 = 0.007 = 17\sigma_{Ab_3} = 170\sigma_{Bb_3} \tag{11}$$

$$\Delta b_4^2 = 0.001 = 0.50\sigma_{Ab_4} = 0.14\sigma_{Bb_4}. \tag{12}$$

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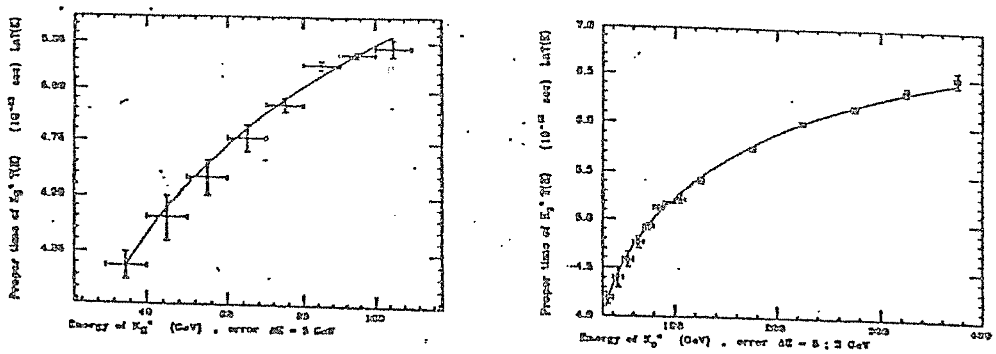

Figure 2. Logarithmic fit of experimental data on K_S^0 lifetime using the isotopic formula (7) for: (*a*) the set of data A; (*b*) the set of data A+G. See the text.

Therefore, our analysis supports a prediction of the Lie-isotopic theory, namely, b_3 changes significantly with energy, whereas b_4 is almost constant in the energy range considered (30–375 GeV).

A detailed investigation of the explicit functional form of $b_3(E)$ and $b_4(E)$ will be given, by a completely new method, in a forthcoming paper.

In conclusion, we want to stress the main results of the present study: the apparent failure of the standard time-dilation law in giving the right value of τ_0 for K_S^0 (when *the whole energy range 30–375 GeV is considered*), and the first experimental check of the energy dependence of the parameters b_3, b_4 predicted by the Lie-isotopic theory.

Of course, our analysis is far from conclusive for at least two reasons. Firstly, the experimental data on the K_S^0 lifetime in the energy range considered have been obtained by two different measurements carried out in two disjointed energy intervals. In this respect, a unique measurement in the same energy range would be in order. Secondly, as stressed above, the parameters entering into the Lie-isotopic law are expected to be different for different hadrons. Therefore, it would be worth performing further high-energy measurements of the meanlife of other unstable hadrons (charged, if possible) to further check the validity of the law (7) and find the parameters b_3, b_4 for each hadron separately. This last result would enable us to get useful information on the inner structure of hadrons.

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LETTER TO THE EDITOR

E13

On a possible non-Lorentzian energy-dependence of the K^0_S lifetime

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Abstract. A fit to the experimental data reported by Aronson *et al* on the K^0_S lifetime shows a good agreement with a generalized expression for time dilation, obtained by a Lie isotopic lifting of the Poincaré symmetry.

PROPER PATERNITY

In 1982 Aronson *et al* [1] discussed the behaviour of the K^0–$\bar{K}^0$ system at the energies available at Fermilab at the time (30–110 GeV). They found that the basic K^0–$\bar{K}^0$ parameters (i.e. the K^0_L–K^0_S mass difference, the K^0_S lifetime, and the CP-violation parameter $|\eta_{+-}\rangle$) exhibit an anomalous dependence on energy of the type

$$x = x_0(1 + b_x^{(N)}\gamma^N) \tag{1}$$

where x is any of the above parameters, $\gamma = E_k/m_0 = (1-\beta^2)^{-1/2}$ is the usual relativistic factor, the b_x are suitable slope parameters and N is an integer equal to 1 or 2.

In particular, as far as the K lifetime is concerned, equation (1) is clearly at variance with the standard Einstein relation

$$\tau = \tau_0\gamma \tag{2}$$

and is compatible instead with a Blokhintsev–Redei [2] behaviour of τ, obtained via the introduction of a fundamental length.

A possible role of non-local forces in an anomalous behaviour of hadron lifetimes has been stressed by Kim [3], in agreement with the original proposal by one of us [4]. More recently, Nielsen and Picek [5], studying mechanisms of breakdown of Lorentz invariance within unified gauge theories, showed that spontaneous symmetry breaking in the Higgs sector implies deformations of the spacetime metric in the interior of mesons. This leads to a non-Einsteinian behaviour of meson meanlife with speed that depends on the Lorentz-non-invariance parameter (different for pions and kaons).

A geometrization of the above theoretical results has been achieved by one of us [6, 7] in the context of the so-called Lie-isotopic generalization of Lie's theory [8–10]. In particular, the Lie-isotopic lifting of the Poincaré symmetry is obtained essentially by the following generalization of the conventional Minkowski metric $g_{\mu\nu} = \mathrm{diag}(1, 1, 1, -1)(\mu, \nu = 1, 2, 3, 4)$:

$$g_{\mu\nu} \to \eta_{\mu\nu} = \mathrm{diag}(b_1^2, b_2^2, b_3^2, -b_4^2) \tag{3}$$

where the b_μ have an arbitrary, generally non-local, dependence on all local variables (like coordinates, velocities, density, temperature, etc). The space characterized by metric (3) is called an isotopic Minkowski space. We refer the reader to the quoted literature for further details. Let us only stress that, in the Lie-isotopic approach, the Lorentz (or Poincaré) symmetry is not broken, but is realized in a generalized form, while Einstein's special relativity is no longer valid (see [6–10]). Then, for instance, one gets *the isotopic law of time dilation*

$$\tau = \tau_0 \hat{\gamma} \qquad \hat{\gamma} = (1 - \hat{\beta}^2)^{-1/2} \qquad \hat{\beta} = \frac{b_3}{b_4}\frac{v}{c_0} = \frac{b_3}{b_4}\beta \tag{4}$$

(where c_0 is the usual light speed in vacuum), that is clearly a covering of the Einstein relation (2).

As recently shown by Aringazin [11], a simple dependence of only b_3 on speed is enough to get a Blokhintsev–Redei behaviour of the K^0–$\bar{K}^0$ parameters, in agreement with equation (1).

The aim of the present letter is a re-analysis of the data reported in [1] on the K_S^0 lifetime, in the light of the above theoretical results, with special attention to the isotopic law (4). The difference with respect to the investigations of Aronson *et al* lies in the fact that we are not trying to fit the experimental data by *any* law, but to testing the validity of a *specific* law, derived from theoretical considerations.

Our main results are graphically summarized by figures 1–3. Figure 1 pictures a linear fit to the data of [1] by the standard formula (2). The fit parameter is $a = \tau_0/m_0$; the reduced chi-square is $\chi_n^2 = 0.9$. The value found for τ_0 is $\tau_0 = (0.9375 \pm 0.0021) \times 10^{-10}$ s, to be compared with the *Particle Data Book* [12] value $\tau_0 = (0.8922 \pm 0.0020) \times 10^{-10}$ s. Moreover, the confidence level (CL) is 0.39, giving a probability of 61% that τ_0 is greater than the obtained value. It is therefore easily seen that, although a linear formula could fit the data, a linear fit is not able to reproduce the correct value of the K_S^0 lifetime at rest as provided by low-energy (less

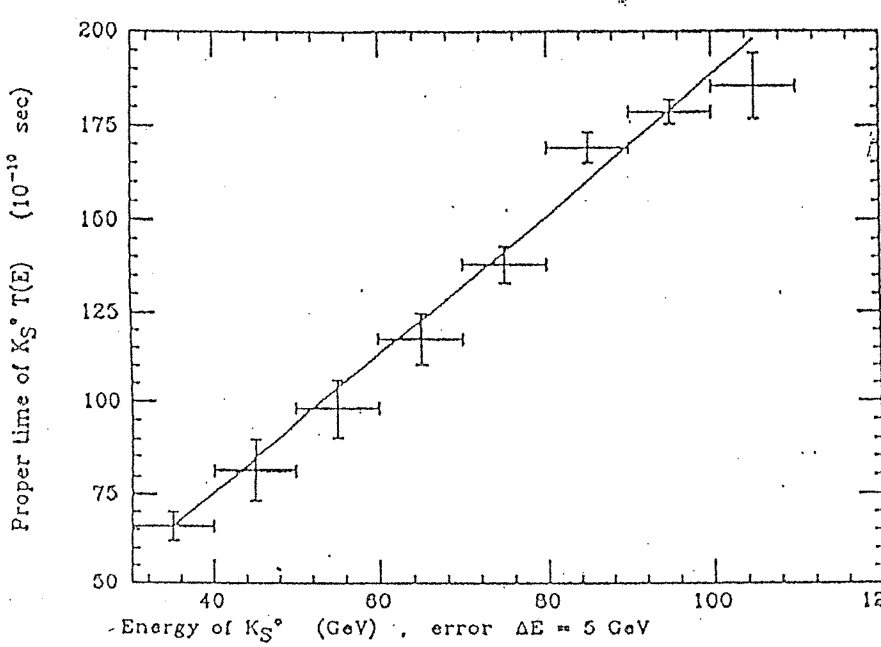

Figure 1. Linear fit of experimental data on K_S^0 lifetime using Einstein's relation (2): see text for details.

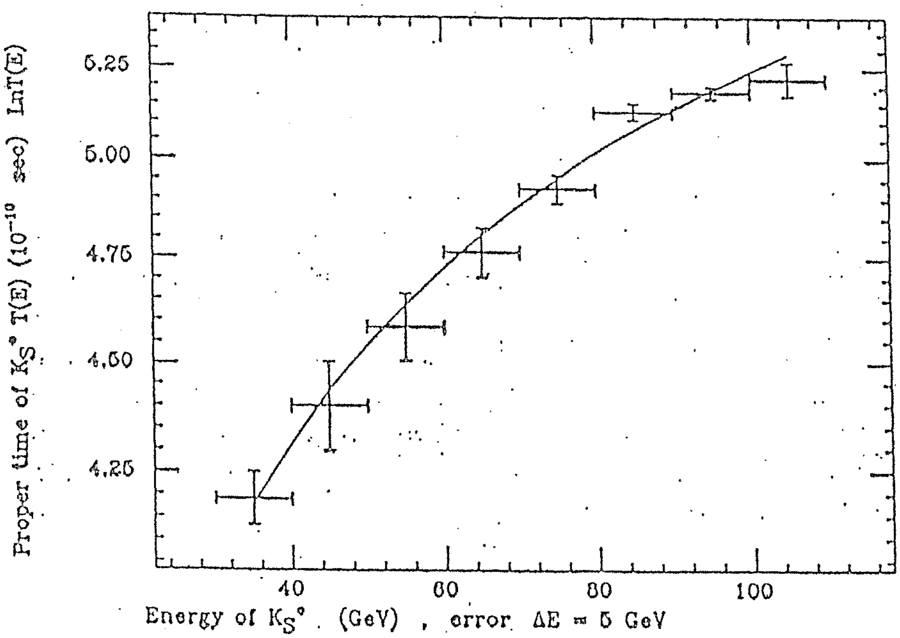

Figure 2. Logarithmic fit of experimental data on K^0_S lifetime using the power law (5): see text for details.

than 3–5 GeV) measurements. This first fit shows clearly that the Lorentzian law of time dilation is unable to account for the available data in a satisfactory way, and that a *non-linear* dependence of τ on E is needed.

In order to further test the non-linearity of the τ-dependence on energy, we performed a second (logarithmic) fit by the formula

$$\tau = (\tau_0/m_0)E^n \tag{5}$$

by taking $a = \tau_0/m_0$ and n as parameters. The results of this second fit are shown in

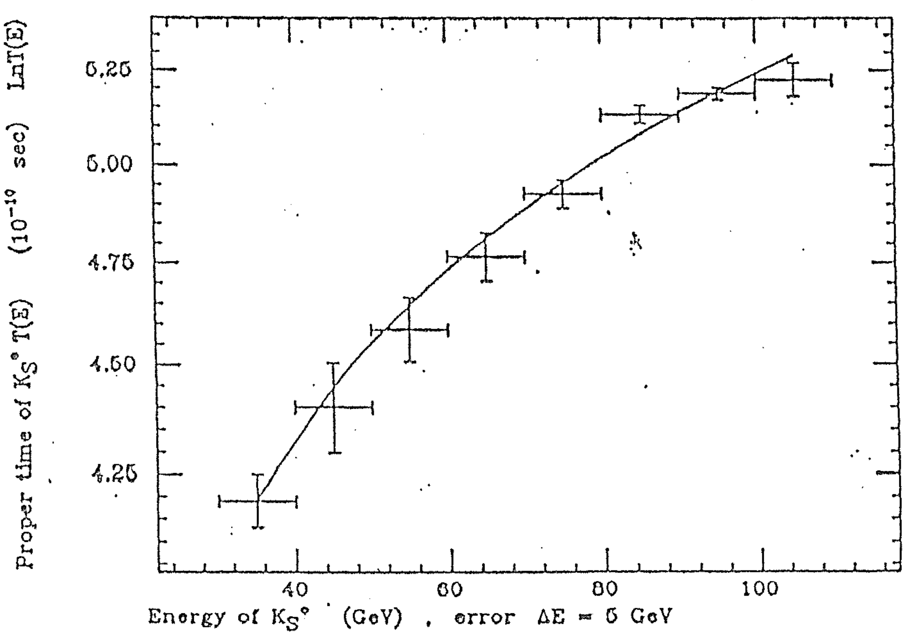

Figure 3. Logarithmic fit of experimental data on K^0_S lifetime using the isotopic formula (4): see text for details.

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figure 2. We have now $\chi_n^2 = 0.85$, and the value obtained for the exponent of E is $n = 1.013 \pm 0.003$. Moreover, the upper limit on n is 1.023 ± 0.003 (95% CL). The deviation from linearity is 1.3% at 100 GeV, and therefore an effect of 13% at 1 TeV is expected.

The last (logarithmic) fit (figure 3) was finally aimed at directly testing the isotopic law (4). We considered the ratio b_3^2/b_4^2 as a single parameter a. We found for a the value 0.898 ± 0.021, with $\chi_n^2 = 0.86$. The deviation of a from unity is 10.2% at 100 GeV.

Let us also state that another fit, carried out by taking b_3^2 and b_4^2 as distinct parameters, allowed us to get the values $b_3^2 = 0.9023 \pm 0.0004$ and $b_4^2 = 1.003 \pm 0.0021$, whence the ratio $(b_3/b_4)^2 = 0.8996 \pm 0.0023$, in good agreement with the value obtained in the third fit. Moreover—as expected on theoretical grounds—there is evidence that both these parameters are not constants, but depend on the energy. Further details will be given in a forthcoming paper.

In conclusion, our re-analysis of the experimental data of [1] on the K_S^0 lifetime supports the validity (in the energy range considered) of the generalized time dilation provided by the Lie-isotopic theory. However, some points are to be stressed. First of all, our results are far from conclusive on a number of counts, the most important of which is obviously the lack of available data on hadron lifetimes. What is needed is a systematic investigation of the energy behaviour of lifetimes not only for kaons, but for all the unstable hadrons. We hope that our preliminary study will be a valid suggestion for experimentalists.

Let us recall, in this connection, that another set of data on the K_S^0 lifetime exists in the energy range 100–350 GeV, due to Grossmann *et al* [13]. They are in disagreement with the data of [1], showing no evidence for an energy dependence of τ. However, we think that the results of [13] are not at all conclusive, and that a further measurement is needed for the *whole* energy range covered by both experiments.

In any case, we think that our analysis is reliable enough at the intermediate energies of the experiment by Aronson *et al.* Indeed, on a theoretical basis [3, 4, 6–10], we expect a standard (Lorentzian) behaviour of lifetime at low energies (less than 10 GeV), whereas, at very high energies, the parameter $a(=b_3^2/b_4^2)$ exhibits a (presently not well known) dependence on energy. Only at intermediate energies we can safely approximate a as a constant (as we have just done in our present work). A global analysis of the whole data on K_S^0 lifetime (mainly aimed to just find the explicit functional dependence of a on energy) will be carried out in a forthcoming paper.

Let us also stress that this letter only aims to provide a different interpretation of the non-linearity of the K_S^0-lifetime behaviour in the range 35–110 GeV. Let us explicitly stress that our interpretation is based on a theoretical framework completely independent from the considerations which led some years ago to the renewed hypothesis of a fifth force [14].

Finally, although there is, in our opinion, a good chance that the lifetime law for hadrons has indeed the form (4) (with, in general, *different* parameters b_3, b_4 for *different* particles: cf the result of Nielsen and Picek [5] and [6–10]), we *do not* expect, *a priori*, that a similar formula must also hold for mass (at least on the same energy scale). In other words, it is easily possible (as apparently confirmed by the existing data on hadron masses) that the γ-factor for mass is still the usual, Einsteinian one. This seemingly contradictory statement can be motivated as follows. As is well known, the appearance of the same factor γ in the dilation laws of both time and mass in special relativity is strictly related to the point-like nature of particles (a *necessary* condition to ensure the validity of special relativity) and is simply a consequence of the Lorentz transformations (i.e. of the spacetime properties), without any connection at all with a possible particle structure. On the other hand, the Lie-isotopic theory is just aimed to account—at least in first approximation—for the internal structure of hadrons (namely, for the non-local forces among their constituents) [4, 9]. From this respect, lifetime is expected to be more sensible than mass to the composite nature of particles. This point can be easily understood by a standard thermodynamical reasoning (i.e. our ignorance of the internal coordinates of the constituents), and is also implicit in the very formulation of Lie-isotopic theories, according to which the usual dynamical behaviour is recovered for centre-of-mass quantities in the standard Minkowski space [10]†.

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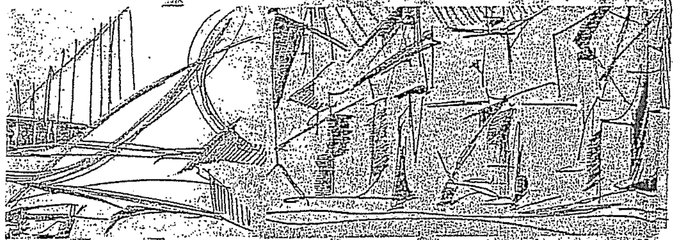
† Indeed, the γ-factor connected with lifetime takes account of the internal energy of the physical system considered, whereas that entering the mass formula is related to the total energy of the system.



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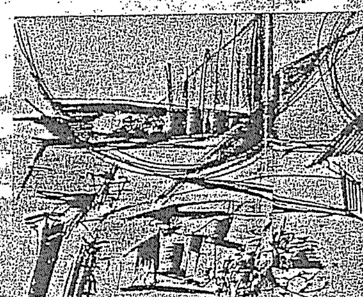

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To our parents

Maria Pia, Mario   Nietta[a], Pietro

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[a]After the completion of the book, the mother of R.M. passed in May 2003. R.M. dedicates this book to her memory.

PART I

GENERALIZING SPECIAL RELATIVITY

F4

1.3.2. *Potential and Nonpotential Interactions*

Let us stress, however, that "local" interaction (in the sense specified above) and "potential" interaction are *not* synonymous, in general. Once one fixes a space-time point, a local interaction is uniquely determined by an infinitesimal neighborhood of the point, whereas a potential interaction is just determined by the value the potential function takes at the point considered. Notice that the derivability from a potential requires the uniqueness of the potential function on the whole space-time region where the force field is defined.

An example of a nonlocal but potential interaction is provided by an interaction described by the potential

$$V(x_i) = \int \prod_{x_j \in \{x\}, j \neq i} dx_j V(\{x\}) \qquad (1.1)$$

where $\{x\}$ is the set of metric coordinates, the integration can be definite or indefinite (in the latter case, the potential will depend also on the geometry of the integration regions) and $V(\{x\})$ is regular enough to ensure its integrability (for instance, in the Riemann sense).

On the other side, the electromagnetic (e.m.) interaction associated to a magnetic monopole is an example of a local but nonpotential interaction. In this case, due to the presence of the singular Dirac string, the force field of the monopole is irrotational locally but not globally.[b] This implies that the monopole field is described by *many* (in general different) *local potentials*. By the non-uniqueness of the potential, the e.m. interaction of the magnetic monopole is nonpotential, but it is local indeed.

[b]In the language of differential geometry, the field of a Dirac magnetic monopole is associated to a differential form which is closed but not globally exact.

POTERNITY FRAUD

CHAPTER 2

DEFORMED MINKOWSKI SPACE-TIME

As is well known, the Minkowski metric[a]

$$g = \mathrm{diag}(1, -1, -1, -1) \qquad (2.1)$$

is a generalization of the Euclidean metric $\epsilon = \mathrm{diag}(1, 1, 1)$. On the basis of the discussion of Chap. 1, we assume that the metric describes, in an effective way, the interaction, and that there exist interactions more general than the electromagnetic ones (which, as well known, are long-range and derivable from a potential).

The simplest generalization of the space-time metric which accounts for such more general properties of interactions is provided by a *deformation*, η, of the Minkowski metric (2.1), defined as[3–5]

$$\eta = \mathrm{diag}(b_0^2, -b_1^2, -b_2^2, -b_3^2). \qquad (2.2)$$

Of course, from a formal point of view metric (2.2) is not new at all. Deformed Minkowski metrics of the same type have already been proposed in the past[6–9] in various physical frameworks, starting from Finsler's generalization of Riemannian geometry[6] to Bogoslowsky's anisotropic space-time[7] to Santilli's isotopic Minkowski space.[8] A phenomenological deformation of the type (2.2) was also obtained by Nielsen and Picek[9] in the context of the electroweak theory. Moreover, although for quite different purposes, "quantum" deformed Minkowski spaces have been also considered in the context of quantum groups.[10] Leaving to later considerations the true specification of the exact meaning of the deformed metric (2.2) in our framework, let us right now stress two basic points.

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[a]Throughout this book, lower Latin indices take the values $\{1, 2, 3\}$ and label spatial dimensions, whereas lower Greek indices vary in the range $\{0, 1, 2, 3\}$, with 0 referring to the time dimension. Ordinary 3-vectors are denoted in boldface. Moreover, we adopt the signature $(+, -, -, -)$, and employ the notation "*ESCon*" ("*ESCoff*") to mean that the Einstein sum convention on repeated indices is (is not) used.

1. Firstly, metric (2.2) is supposed to hold at a *local* (and not global) scale, *i.e.* to be valid not everywhere, but only in a suitable (local) space-time region (characteristic of both the system and the interaction considered). We shall therefore refer often to it as a "*topical*" deformed metric.

 In the present case, the term "local" must be understood in the sense that a deformed metric of the kind (2.2) describes the geometry of a 4-dimensional variety attached at a point x of the standard Minkowski space-time, in the same way as a local Lorentz frame is associated (as a tangent space) to each point of the (globally Riemannian) space of Einstein's GR. Another example, on some respects more similar to the present formalism, is provided by a space-time endowed with a vector fibre-bundle structure, where a (maximally symmetric) Riemann space with constant curvature is attached at each point x.[11]

2. Secondly, metric (2.2) is regarded to play a *dynamical role*. So, in order to comply with the solidarity principle, we assume that the parameters b_μ ($\mu = 0, 1, 2, 3$) are, in general, real and positive functions of a given set of observables $\{\mathcal{O}\}$ characterizing the system (in particular, of its total energy, as specified later):

$$\{b_\mu\} = \{b_\mu(\{\mathcal{O}\})\} \in R_0^+, \quad \forall \{\mathcal{O}\}. \tag{2.3}$$

The set $\{\mathcal{O}\}$ represents therefore, in general, a set of non-metric variables ($\{x_{n.m.}\}$).

Equation (2.2) therefore becomes:

$$\begin{aligned}\eta_{\mu\nu} &= \eta_{\mu\nu}(\{\mathcal{O}\}) \\ &= \mathrm{diag}(b_0^2(\{\mathcal{O}\}), -b_1^2(\{\mathcal{O}\}), -b_2^2(\{\mathcal{O}\}), -b_3^2(\{\mathcal{O}\})) \stackrel{\text{ESC off}}{=} \\ &= \delta_{\mu\nu}(\delta_{\mu 0} b_0^2(\{\mathcal{O}\}) - \delta_{\mu 1} b_1^2(\{\mathcal{O}\}) - \delta_{\mu 2} b_2^2(\{\mathcal{O}\}) - \delta_{\mu 3} b_3^2(\{\mathcal{O}\})).\end{aligned} \tag{2.4}$$

However, for the moment the deformation of the Minkowski space will be discussed only from a formal point of view, by disregarding the problem of the observables on which the coefficients b_μ actually depend (it will be faced in Chap. 3).

Notice that the first point, *i.e.* the assumed local validity of (2.2), differentiates this approach from those based on Finsler's geometry or from the Bogoslowski's one (which, at least in their standard meaning, do consider deformed metrics at a *global* scale), and makes it similar, on some aspects, to the philosophy and methods of the isotopic generalizations of Minkowski spaces. However, it is well known that Lie-isotopic theories rely in an essential way, from the mathematical standpoint, on (and are strictly characterized by) the very existence of the so-called isotopic unit.[8] In the

following, such a formal device will not be exploited (because unessential on all respects), so that the present formalism is not an isotopic one. Moreover, from a physical point of view, the isotopic formalism is expected to apply only to strong interactions.[8] On the contrary, it will be assumed that the (effective) representation of interactions through the deformed metric (2.2) does hold for *all* kinds of interactions (at least for their nonlocal component). In spite of such basic differences this formalism shares some common formal results — as we shall see in the following — with isotopic relativity (like the mathematical expression of the generalized Lorentz transformations).

It is now possible to define a generalized ("*deformed*") Minkowski space $\tilde{M}(x, \eta(\{\mathcal{O}\}))$ with the same local coordinates x of M (the four-vectors of the usual Minkowski space), but with metric given by the metric tensor η (2.4). The generalized interval in $\tilde{M}$ is therefore given by ($x^\mu = (x^0, x^1, x^2, x^3) = (ct, x, y, z)$, with c being the usual light speed in vacuum) (ESC on)[3–5]:

$$\begin{aligned} ds^{\tilde{2}}(\{\mathcal{O}\}) &\\ \equiv b_0^2(\{\mathcal{O}\})c^2dt^2 &- b_1^2(\{\mathcal{O}\})(dx^1)^2 - b_2^2(\{\mathcal{O}\})(dx^2)^2 - b_3^2(\{\mathcal{O}\})(dx^3)^2 \\ = \eta_{\mu\nu}(\{\mathcal{O}\})dx^\mu dx^\nu &= dx * dx. \end{aligned} \tag{2.5}$$

The last step in (2.5) defines the scalar product $*$ in the deformed Minkowski space $\tilde{M}$. Moreover, according to (2.5), we shall use the following notation for the deformed square norm of a four-vector:

$$|x|_*^2 \equiv x * x = \eta_{\mu\nu}(\{\mathcal{O}\})x^\mu x^\nu = x^{\tilde{2}}. \tag{2.5'}$$

In order to evidence some preliminary implications of metric (2.4), let us consider (for simplicity sake and without loss of generality) an isotropic 3-dimensional space, *i.e.*

$$b_1^2(\{\mathcal{O}\}) = b_2^2(\{\mathcal{O}\}) = b_3^2(\{\mathcal{O}\}) \equiv b^2(\{\mathcal{O}\}) \tag{2.6}$$

so that the corresponding deformed metric reads

$$\begin{aligned}\eta_{\mu\nu\mathrm{ISO}}(\{\mathcal{O}\}) &= \mathrm{diag}(b_0^2(\{\mathcal{O}\}), -b^2(\{\mathcal{O}\}), -b^2(\{\mathcal{O}\}), -b^2(\{\mathcal{O}\})) \stackrel{\text{ESC off}}{=} \\ &= \delta_{\mu\nu}[\delta_{\mu 0} b^2(\{\mathcal{O}\}) - (\delta_{\mu 1} + \delta_{\mu 1} + \delta_{\mu 1}) b^2(\{\mathcal{O}\})].\end{aligned} \tag{2.7}$$

One gets, for null separation $ds^{\tilde{2}} = 0$:

$$\begin{aligned} ds^{\tilde{2}}(\{\mathcal{O}\}) = 0 &\Leftrightarrow b_0^2(\{\mathcal{O}\})c^2dt^2 - b^2(\{\mathcal{O}\})[(dx^1)^2 + (dx^2)^2 + (dx^3)^2] = 0 \\ &\Leftrightarrow \frac{(dx^2 + dy^2 + dz^2)}{dt^2} = c^2 \frac{b_0^2(\{\mathcal{O}\})}{b^2(\{\mathcal{O}\})}. \end{aligned} \tag{2.8}$$

From Eq. (2.8) it is easily seen that the *maximal causal speed* in the generalized Minkowski space is given by:

$$u = \frac{b_0(\{\mathcal{O}\})}{b(\{\mathcal{O}\})}c. \tag{2.9}$$

It is worth noticing that a similar result (namely, a "maximum attain-able speed", *a priori* different for different physical processes) was also obtained by Coleman and Glashow,[12] in the framework of a discussion of possible effects breaking Lorentz invariance (essentially on a local scale).

Let us remark that u depends explicitly on the metric parameters b_μ, which are *a priori* different for every physical system. However, since the deformation of the metric represents, on average, the effects of the nonlocal interactions involved, it is expected that physical systems with the same kind of interactions (besides the electromagnetic ones) are described by metric parameters of the same order of magnitude (or, at least, this holds true for the ratio b_0/b). In this sense it is possible to refer to u as a "speed of interaction", rather than "speed of the physical system" considered (of course, at the same energy scale).

In Eq. (2.9), the value of u is parametrized in terms of c, and depends on the physical system (and its interactions). Moreover, it is

$$u \gtreqless c \Leftrightarrow \frac{b_0(\{\mathcal{O}\})}{b(\{\mathcal{O}\})} \gtreqless 1. \tag{2.10}$$

In other words, there may be maximal causal speeds either *subluminal* or *superluminal*, depending on the interaction considered.

It is worth to recall that the deformation of the metric, resulting in the interval (2.5), represents a geometrization of a suitable space-time region (corresponding to the physical system considered) that describes, in the average, the effect of nonlocal interactions on a test particle. It is clear that there exist infinitely many deformations of the Minkowski space (precisely, ∞^4), corresponding to the different possible choices of the parameters b_μ, *a priori* different for each physical system.

Moreover, since the usual, "flat" Minkowski metric g (2.1) is related in an essential way to the electromagnetic interaction, we shall always mean in the following — unless otherwise specified — that electromagnetic inter-actions imply the presence of a fully Minkowskian metric. Actually, as it will be seen, a deformed metric of the type (2.7) is required if one wants to account for possible nonlocal electromagnetic effects (like those occurring in the superluminal wave propagation in waveguides: see Chap. 7).

CHAPTER 3

DESCRIPTION OF INTERACTIONS BY ENERGY-DEPENDENT METRICS

3.1. Energy and the Finzi Principle

Now one has to go into the question of the dependence of the metric param-eters $b_\mu(\{\mathcal{O}\})$ on the set of observables $\{\mathcal{O}\}$ of the system considered, and to examine closely the physical meaning of such a functional dependence.

To this aim, the basic question to be put is how to implement Finzi's Principle of Solidarity for all interactions on a mere special-relativistic basis. At present, General Relativity (GR) is the only successful theoretical real-ization of geometrizing an interaction (the gravitational one). As is well known, energy plays a fundamental role in GR, since the energy-momentum tensor of a given system is the very source of the gravitational field.

A moment's thought shows that this occurs actually also for other inter-actions. Let us consider, for instance, the case of Euclidean geometry in its intrinsic meaning of a theory of the physical reality at its basic clas-sical (macroscopic) level. Actually, it describes in a quantitative way, in mathematical language, the relations among measured physical entities — distances, in this case —, and therefore of the physical space in which phe-nomena occur.

However, the measurement of distances depends on the motion of the body which actually performs the measurement. Such a dependence is indeed not on the *kind* of motion, but rather on the *energy* needed to let the body move, and on the *interaction* providing such energy. The mea-surement of time needs as well a periodic motion with constant frequency, and therefore it too depends on the energy and on the interaction.

This simple example shows how *energy does play a fundamental role in determining the very geometrical structure of space-time.*

Generalizing such an argument, we can state that exchanging energy between particles amounts to measure operationally their space-time separation.[a] Of course such a process depends on the interaction involved in the energy exchange; moreover, each exchange occurs at the maximal causal speed characteristic of the given interaction. It is therefore natural to assume that the measurement of distances, performed by the energy exchange according to a given interaction, realizes the "solidarity principle" between space-time and interactions at the microscopic scale. This allows one to identify the total energy E of the physical process considered as the observable on which the coefficients $b_\mu(\{\mathcal{O}\})$ depend:

$$\{\mathcal{O}\} \equiv E \Leftrightarrow \{b_\mu(\{\mathcal{O}\})\} \equiv \{b_\mu(E)\}, \quad \forall \mu = 0,1,2,3. \tag{3.1}$$

Actually, since all the functions $\{b_\mu\}$ are dimensionless, they must depend on a dimensionless variable. Then, one has to divide the energy E by a constant E_0 (in general characteristic of each fundamental interaction), with dimensions of energy, so that:

$$\{b_\mu(\{\mathcal{O}\})\} \equiv \left\{ b_\mu\left(\frac{E}{E_0}\right)\right\}, \quad \forall \mu = 0,1,2,3. \tag{3.2}$$

As it will be seen, E_0 has the meaning of a "threshold energy".

Thus, the distance measurement is accomplished by means of the deformed metric tensor, given explicitly by

$$\begin{aligned}\eta_{\mu\nu}(E) &= \mathrm{diag}(b_0^2(E), -b_1^2(E), -b_2^2(E), -b_3^2(E)) \overset{\mathrm{ESC\ off}}{=} \\ &= \delta_{\mu\nu}(\delta_{\mu 0}b_0^2(E) - \delta_{\mu 1}b_1^2(E) - \delta_{\mu 2}b_2^2(E) - \delta_{\mu 3}b_3^2(E)).\end{aligned} \tag{3.3}$$

Any interaction can be therefore phenomenologically described by metric (3.3) in an *effective* way. This is true in general, but necessary in the case of nonlocal and nonpotential interactions. For force fields which admit a potential, such a description is complementary to the actual one.[b]

One is therefore led to put forward a revision of the concept of "geometrization of an interaction": each interaction produces its own metric, formally expressed by the metric tensor (3.3), but realized via different choices of the set of parameters $b_\mu(E)$. Otherwise said, the $b_\mu(E)$'s are peculiar to every given interaction. The statement that (3.3) provides us with a metric description of an interaction must be just understood in such a sense.

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[a] Notice that, in this framework, a space-time point has only a mathematical (geometrical) meaning, since it physically corresponds to an energy insufficient to the motion (for the interaction considered). See also Sec. 11.2.

[b] As we shall see in Chap. 8, an example is just provided by the gravitational interaction in the Newtonian limit.

Therefore, the energy-dependent deformation of the Minkowski metric implements a generalization of the concept of geometrization of an interaction (in accordance with Finzi's principle). The GR theory implements a geometrization (at a *global* scale) of the gravitational interaction, based on its derivability from a potential and on the equivalence between the inertial mass of a body and its "gravitational charge". The formalism of energy-dependent metrics allows one instead to implement a geometrization (at a *local* scale) of any kind of interaction characterized by a phenomenology experimentally measurable. As already stressed before, such a formalism applies, in principle, to both fundamental and phenomenological interactions, either potential (gravitational, electromagnetic) or nonpotential (strong, weak), *local* and *nonlocal* (in the sense already specified), for which either an Equivalence Principle holds (as it is the case of gravitation) or (in the more general case) the inertial mass of the body *is not* in general proportional to its charge in the force field considered (e.m., strong, and weak interaction). The basic point of the present way of geometrizing an interaction (thus realizing the Finzi legacy) consists in a "upsetting" of the space-time-energy parametrization. Whereas for potential interactions there exists a potential energy depending on the space-time metric coordinates, one has here to do with a deformed metric tensor η, whose coefficients depend on the energy, that thus assumes a *dynamical* role.

3.2. Energy as Dynamical Variable

From the physical point of view, the energy E is to be understood as the measured energy of the system, and must be therefore regarded as a merely phenomenological variable. As is well known, all the physically realizable detectors work via their electromagnetic interaction in the usual Minkowski space. This is why, in this formalism, the Minkowski space and the e.m. interaction do play a fundamental role. The former is, as already stressed, the cornerstone on which to build up the generalization of Special Relativity based on the deformed metric (3.3). The latter is the comparison term for all fundamental interactions. Let us recall that they are strictly interrelated, since it is just electromagnetism which determines the Minkowski geometry.

From the mathematical standpoint, E is to be considered as a dynamical variable, because it specifies the dynamical behavior of the process under consideration, and, via the metric coefficients, it provides us with a dynamical map — in the energy range of interest — of the interaction ruling the given process.

Let us notice that metric (3.3) plays, for nonpotential interactions, a role analogous to that of the Hamiltonian H for a potential interaction. In particular, the metric tensor η as well is not an input of the theory, but must be built up from the experimental knowledge of the physical data of the system concerned (in analogy with the specification of the Hamiltonian of a potential system). However, there are some differences between η and H worth to be stressed. Indeed, as is well known, H represents the total energy E_{tot} of the system irrespective of the value of E_{tot} and the choice of the variables. On the contrary, $\eta(E)$ describes the variation in the measurements of space and time, in the physical system considered, as E_{tot} changes; therefore, η does depend on the numerical value of H, but not on its functional form. The explicit expression of η depends only on the interaction involved.

It is moreover worth recalling that the use of an energy-dependent space-time metric can be traced back to Einstein himself, who generalized the Minkowski interval as follows

$$ds^2 = \left(1 + \frac{2\phi}{c^2}\right) c^2 dt^2 - (dx^2 + dy^2 + dz^2) \qquad (3.4)$$

(where ϕ is the Newtonian gravitational potential), in order to account for the modified rate of a clock in presence of a (weak) gravitational field.

One may be puzzled about the dependence of the metric on the energy, which is not an invariant under usual Lorentz transformations, but transforms like the time-component of a four vector.

Actually, energy is to be regarded, in this formalism, from two different points of view. One has, on one side, the energy as measured in full Minkowskian conditions, which, as such, behaves as a genuine four-vector under usual Lorentz transformations (in the sense that it changes in the usual way if we go, say, from the laboratory frame to another frame in uniform motion with respect to it). Once fixed the frame, one gets a measured value of the energy for a given process (for instance, the energy of the Bose–Einstein correlation phenomenon in pion production, as measured at CERN by the UA1 collaboration). This is the value which enters, as a parameter, in the expression (3.3) of the deformed metric. Such an energy, therefore, is no longer to be considered as a four vector in the deformed Minkowski space, but it is just a quantity whose value determines the deformed geometry of the process considered (or, otherwise speaking, which selects the deformed space-time we have to use to describe the phenomenon).

Let us briefly discuss the phenomenological aspects of the metric dependence on energy. Notice that, in particle collisions, the energy of the incident

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particle in the laboratory frame, $E = E_L$, can be related to the Mandelstam invariant s (corresponding to the total energy of the colliding particles in the center-of-mass reference frame) by means of the relation, valid at sufficiently high energies:

$$s \approx 2E_L M, \qquad (3.5)$$

(where M is the mass of the target),[c] and analogous to the formula relating the laboratory momentum p_L and the invariant flux ϕ: $\phi = p_L M$.

Therefore, in particle collisions, the metric parameters can be indeed considered as dependent on the invariant s:

$$\{b_\mu(E_L)\} \approx \left\{b_\mu\left(\frac{s}{2M}\right)\right\} \equiv \{\tilde{b}_\mu(s)\}. \qquad (3.6)$$

Actually, s is a scalar under usual Lorentz transformations, and, in general, an usual relativistic invariant is no longer unchanged for transformations preserving the deformed interval (2.5). However, let us recall that the energy chosen as phenomenological parameter is that measured electromagnetically, and therefore in presence of a Minkowski metric. This interpretation is supported by the case of colliding beam reactions with different energies: indeed, it would be impossible, otherwise, to define what energy must be used as parameter. Such a point of view can be adopted e.g. in the analysis of the so called "ramping run" of UA1 in order to extract the parameters of the hadronic metric (as functions of the energy) from the experimental data (see Part III).

[c]Indeed, the Mandelstam invariant s for two colliding particles is defined as $s \equiv (p_1+p_2)^2$, where p_i is the 4-momentum of the ith particle. In their C.M. frame, $\underline{p_1} + \underline{p_2} = 0$, and $s = (E_1 + E_2)^2$. In the laboratory frame, where the target particle 2 of mass M is at rest, the 4-momenta of the two particles are:

$$p_1^\mu = \left(\frac{E_1}{c} = \sqrt{|\mathbf{p}_1|^2 + m^2c^2}, \mathbf{p}_1\right), \quad p_2^\mu = (Mc, 0).$$

Therefore

$$s = \frac{E_1^2}{c^2} + M^2c^2 + 2E_1 M - |\mathbf{p}_1|^2 = |\mathbf{p}_1|^2 + m^2c^2 + M^2c^2 + 2E_1M - |\underline{p_1}|^2$$
$$= m^2c^2 + M^2c^2 + 2E_1 M.$$

In the (ultra) relativistic limit $E_1 \gg mc^2$, $E_1 \gg Mc^2$, we get therefore

$$s \approx 2E_1 M$$

which coincides with Eq. (3.5) on account of the fact that $E_1 \equiv E_L$.

In other cases, the phenomenological energy parameter may not be so easy to identify, neither it can be directly related to an invariant quantity. This is the case, for instance, of the lifetime of unstable particles.

Let us explicitly stress that the theory of SR based on metric (2.4) has nothing to do with General Relativity. Indeed, in spite of the formal similarity between the interval (2.5), with the b_μ functions of the coordinates, and the metric structure of a Riemann space, in this framework no mention at all is made of the equivalence principle between mass and inertia, and among non-inertial, accelerated frames. Moreover, General Relativity describes geometrization on a large-scale basis, whereas the special relativity with topical deformed metric describes local (small-scale) deformations of the metric structure (although the term "small scale" must be referred to the real dimensions of the physical system considered).

But the basic difference is provided by the fact that actually the deformed Minkowski space $\tilde{M}$ has zero curvature, as it is easily seen by remembering that, in a Riemann space, the scalar curvature is constructed from the derivatives, with respect to space-time coordinates, of the metric tensor. In others words, the space $\tilde{M}$ is *intrinsically flat* — at least in a mathematical sense. Namely, it would be possible, in principle, to find a change of coordinates, or a rescaling of the lengths, so as to recover the usual Minkowski space. However, such a possibility is only a mathematical, and not a physical one. This is related to the fact that the energy of the process is fixed, and cannot be changed at will. For that value of the energy, the metric coefficients do possess values different from unity, so that the corresponding space $\tilde{M}$, for the given energy value, is actually different from the Minkowski one. The usual space-time M is recovered for a special value E_0 of the energy (characteristic of any interaction), such that indeed

$$\eta(E_0) = g = \text{diag}(1, -1, -1, -1). \tag{3.7}$$

Such a value E_0 (which must be derived from the phenomenology) will be referred to as *the threshold energy of the interaction considered.* As we shall see, it is just the constant introduced in Eq. (3.2) by dimensional arguments.

It is worth stressing that, due to the dependence on energy of the metric parameters b_μ, the maximal causal speed of any interaction, too, is a function of the energy, according to the relation

$$u(E) = \frac{b_0(E)}{b(E)} c. \tag{3.8}$$

However, it remains invariant — for fixed energy values — under generalized Lorentz transformations from a given reference frame to another. Clearly, in Eq. (3.8), the light speed in vacuum, c, does merely play the role of a phenomenological parameter on which the value of u depends.

The maximal causal speed u can be interpreted, from a physical standpoint, as the speed of the quanta of the interaction which requires a representation in terms of a generalized Minkowski space. Since these quanta are associated to lightlike world-lines in $\tilde{M}$ (see Eq. (2.8)), they must be zero-mass particles (with respect to the interaction considered), in analogy with photons (with respect to the e.m. interaction) in the usual SR.[d]

Let us clarify the latter statement. The carriers of a given interaction propagating with the speed u typical of that interaction *are expected to be strictly massless only inside the space whose metric is determined by the interaction considered. A priori*, nothing forbids that such "deformed photons" may acquire a nonvanishing mass in a deformed Minkowski space related to a different interaction.

This might be the case of the massive bosons W^+, W^- and Z^0, carriers of the weak interaction, which would therefore be massless in the space $\tilde{M}(\eta_{\text{weak}}(E))$ related to the weak interaction, but would acquire a mass when considered in the standard Minkowski space M of SR (that, as already stressed, is strictly connected to the electromagnetic interaction,[e] ruling the operation of the measuring devices). In this framework, therefore, it is not necessary to postulate a "symmetry breaking" mechanism (like the Goldstone one in gauge theories) to let particles acquire mass.[f] Mass itself would assume a *relative nature*, related not only to the interaction concerned, but also to the metric background where one measures the energy of the physical system considered. This can be seen if one takes into account the fact in general, for relativistic particles, mass is the invariant norm of 4-momentum, and what is usually measured is not the value of such an invariant, but of the related energy. As it will be seen in Chap. 14, it is possible indeed, in this framework, to give a geometrical meaning to the electron mass, and relate it to the breakdown of local Lorentz invariance.

[d] However, the problem of mass requires to be considered in more detail (see Chap. 14).
[e] Actually, as we shall see in Part III, this is strictly true only for $E > E_{0,\text{e.m.}}$, where $E_{0,\text{e.m.}} \simeq 4.5\,\mu\text{eV}$ is the threshold energy for the e.m. interaction, i.e.

$$\tilde{M}(g_{\text{e.m.}}(E))|_{E \gtrsim 4.5\,\mu\text{eV}} = M.$$

[f] On the contrary, if one could build up measuring devices based on interactions different from the e.m. one, the photon might acquire a mass with respect to such a non-e.m. background.

To end this chapter, let us notice that the deformation (3.3) of the Minkowski metric is expected to apply to the description not only of extended particles, but also of quantum pointlike particles, as far as their energy is such that one cannot neglect their associated cloud of virtual quanta.

The problem of a metric description of a given interaction is thus formally reduced to the determination of the coefficients $b_\mu(E)$ from the data on some physical system, whose dynamical behaviour is ruled by the interaction considered.

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PART II

RELATIVITY IN A DEFORMED SPACE-TIME

CHAPTER 4

GENERALIZED PRINCIPLE OF RELATIVITY AND LORENTZ TRANSFORMATIONS

4.1. Deformed Special Relativity

In order to develop the relativity theory in a deformed Minkowski space-time, one has to suitably generalize and clarify the basic concepts which are at the very foundation of SR.

Let us first of all define a "topical inertial frame":

(i) a *topical "inertial" frame* (TIF) is a reference frame in which space-time is homogeneous, but space is not necessarily isotropic.

Then, a "*generalized principle of relativity*" (or "*principle of metric invariance*") can be stated as follows:

(ii) all physical measurements within every topical "inertial" frame must be carried out via the *same* metric.

We shall call "*Deformed Special Relativity*" (DSR) the generalization of SR based on the above two postulates, and whose space-time structure is given by the deformed Minkowski space $\tilde{M}$ introduced in Chap. 2.

4.2. Deriving the Deformed Lorentz Transformations

It follows from the above points (i), (ii) that the transformation equations connecting topical "inertial" frames, *i.e.* the generalized Lorentz transformations, are those which leave invariant the deformed metric when passing from a topical "inertial" frame K, to another frame K', moving with constant velocity with respect to K. Then, physical laws are to be covariant with respect to such generalized transformations.

In other words, the generalized Lorentz transformations are the isometries of the deformed Minkowski space $\tilde{M}$. We shall refer to them in the following as *deformed Lorentz transformations* (DLT). Their explicit form can be derived by the same procedure followed in order to find the Lorentz transformations in the usual Minkowski space.

Consider two TIF, K and K'; by definition, the DLT's leave invariant the deformed interval (2.5), *i.e.*

$$b_0^2c^2t^2 - b_1^2x^2 - b_2^2y^2 - b_3^2z^2 = b_0^2c^2t'^2 - b_1^2x'^2 - b_2^2y'^2 - b_3^2z'^2. \qquad (4.1)$$

Moreover, it can be assumed, without loss of generality, that the frames K and K' are in standard configuration (*i.e.* their spatial frames coincide at $t = t' = 0$). By choosing the boost direction along $\hat{x}^1 = \hat{x}$, we have therefore $y' = y$, $z' = z$ and Eq. (4.1) reduces to

$$b_0^2c^2t^2 - b_1^2x^2 = b_0^2c^2t'^2 - b_1^2x'^2. \qquad (4.2)$$

From space-time homogeneity it follows that the functional relations between the two sets of coordinates $\{x, y, z, t\}$ and $\{x', y', z', t'\}$ must be linear. Then, in general, the deformed coordinate transformations are to be searched in the form

$$\begin{cases} x' = A_{11}x + A_{14}t \\ y' = y \\ z' = z \\ t' = A_{41}x + A_{44}t \end{cases} \qquad (4.3)$$

where the coefficients $A_{11}, A_{14}, A_{41}, A_{44}$ depend *a priori* in general on v and $\hat{x}$ (and, parametrically, on the energy).

Notice that the origin O' of TIF K' must move in K with velocity $\mathrm{v} = v^1\hat{x}$, and therefore:

$$x' = 0, \quad x = vt \Leftrightarrow A_{14} = -vA_{11} \Leftrightarrow x' = A_{11}(x - vt). \qquad (4.4)$$

Replacing (4.3), (4.4) in (4.2) yields

$$b_0^2c^2t^2 - b_1^2x^2 = b_0^2c^2(A_{41}x + A_{44}t)^2 - A_{11}^2b_1^2x^2(x - vt)^2 \qquad (4.5)$$

which implies the following 3×3 quadratic system:

$$\begin{cases} c^2 = c^2A_{44}^2 - \left(\dfrac{b_1}{b_0}\right)^2 A_{11}^2v^2 \\ -1 = c^2\left(\dfrac{b_0}{b_1}\right)^2 A_{41}^2 - A_{11}^2 \\ 0 = c^2\left(\dfrac{b_0}{b_1}\right)^2 A_{41}A_{44} + A_{11}^2v \end{cases} \qquad (4.6)$$

with general solution

$$A_{11} = A_{44} = \pm\left(1 - \left(\frac{vb_1}{cb_0}\right)^2\right)^{-1/2} \qquad (4.7)$$

$$A_{41} = \mp\left(\frac{vb_1^2}{c^2b_0^2}\right)\left(1 - \left(\frac{vb_1}{cb_0}\right)^2\right)^{-1/2} = -\left(\frac{vb_1^2}{c^2b_0^2}\right)A_{11}. \qquad (4.8)$$

The final result is

$$\begin{cases} x' = \tilde{\gamma}(x - vt) = \tilde{\gamma}\left(x - \tilde{\beta}\dfrac{b_0}{b_1}ct\right) \\ y' = y \\ z' = z \\ t' = \tilde{\gamma}\left(t - \dfrac{vb_1^2}{c^2b_0^2}x\right) = \tilde{\gamma}\left(t - \dfrac{\tilde{\beta}^2}{v}x\right) \end{cases} \qquad (4.9)$$

where v is the relative speed of the reference frames, and

$$\tilde{\beta} = \frac{v}{u}; \qquad (4.10)$$

$$\tilde{\gamma} = (1 - \tilde{\beta}^2)^{-1/2}. \qquad (4.11)$$

Transformations (4.9) do formally coincide with the isotopic Lorentz transformations. However, in the present context their physical meaning is different, as it is easily seen e.g. by the identification of the maximal causal speed u with the speed characteristic of the quanta of a given interaction (see Sec. 3). In particular, the parametrization (4.10) of the deformed velocity parameter $\tilde{\beta}$ in terms of u immediately shows that is always $\tilde{\beta} < 1$, so that $\tilde{\gamma}$ never takes imaginary values (contrarily to the isotopic case). Moreover, no reference at all is made, in this framework, to the existence of an underlying "medium".

It must be carefully noted that, like the metric, also the generalized Lorentz transformations depend on the energy. This means that one gets different transformation laws for different values of E, but still with the same functional dependence on the energy, so that the invariance of the deformed interval (2.5) is always ensured (provided that the process considered does always occur via the same interaction).

Indeed, the energy E can be considered fixed also because, from a quantum point of view, energy can be transferred only by finite amounts.

Differentiating Eqs. (4.9), we get therefore

$$\begin{cases} udt' + t'du = \tilde{\gamma}(udt - \tilde{\beta}dx) + [d\tilde{\gamma}(ut - \tilde{\beta}x) + \tilde{\gamma}(tdu - xd\tilde{\beta}]; \\ dx' = \tilde{\gamma}(dx - \tilde{\beta}udt) + [d\tilde{\gamma}(x - \tilde{\beta}ut) - \tilde{\gamma}(t\tilde{\beta}du + td\tilde{\beta})], \end{cases} \quad (4.12)$$

where, by the above argument, $dE = 0$ and therefore $d\tilde{\gamma} = d\tilde{\beta} = du = 0$. Squaring (4.12) and subtracting, we find

$$dx'^2 - u^2dt'^2 = \tilde{\gamma}^2[(dx - \tilde{\beta}dt)^2 - (udt - \tilde{\beta}dx)^2] = dx^2 - u^2dt^2 \quad (4.13)$$

where in the last step use has been made of Eq. (4.2). Exploiting the explicit expression of u, Eq. (2.9), one has finally

$$ds'^2 = ds^2, \quad (4.14)$$

i.e. the deformed Lorentz transformations (4.9) are actually the isometries of the deformed Minkowski space $\tilde{M}$, in spite of their dependence on the energy.

As already stressed in Chap. 2 (see Eq. (2.10)), it is possible to have $u \geq c$ and therefore $c \leq v \leq u$, *i.e.* superluminal motions are allowed. Let us remark that the possibility of tachyonic speeds is accomplished, within this framework, without any recourse neither to imaginary quantities nor to singularities in the transformation laws (unlike the standard case), because it is always $v \leq u$ (even if $v \geq c$), so that the relativistic factor $\tilde{\gamma}$ (Eq. (4.11)) takes only real values, as already noted above.

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4.3. Maximal Causal Speed Revisited

In $\tilde{M}$, it is possible *a priori* to consider two scalar products between 3-vectors $\mathrm{v}_1, \mathrm{v}_2$: the standard, Euclidean one $\cdot$, defined by means of the metric tensor $g_{ik} = \delta_{ik}$, and the deformed one, induced by the deformed scalar product $*$ in $\tilde{M}$, and defined by means of the metric tensor $-\eta_{ik}(E) \overset{\text{ESCoff}}{=} b_i^2(E)\delta_{ik}$ (where the sign $-$ is obviously introduced in order to get a positive 3-vector norm) as follows (cf. Eq. (2.5)):

$$\begin{aligned} \mathrm{v}_1 * \mathrm{v}_2 &\equiv -\sum_{i=1}^{3} \eta_{ij}(E)(v_1)^i(v_2)^j \\ &= \sum_{i=1}^{3} b_i^2(E)\delta_{ij}(v_1)^i(v_2)^j \\ &= b_1^2(E)(v_1)^1(v_2)^1 + b_2^2(E)(v_1)^2(v_2)^2 + b_3^2(E)(v_1)^3(v_2)^3. \end{aligned} \quad (4.15)$$

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In the following, $|\mathrm{v}|_*$ will denote the absolute value of a 3-vector with respect to the deformed scalar product $*$ (cf. Eq. (2.5′)), whereas the notation $|\mathrm{v}| = v$ will be used for the norm of v with respect to the standard product $\cdot$.

As is well known, the maximal causal speed in M is obtained by putting $ds^2 = 0$, whence

$$ds^2 = 0 \Leftrightarrow c^2dt^2 - dx^2 - dy^2 - dz^2 = 0 \Leftrightarrow \frac{dx^2 + dy^2 + dz^2}{dt^2} = c^2. \quad (4.16)$$

Then one interprets c as the maximal causal speed along any direction of the (Euclidean) space R^3 (embedded in the pseudo-euclidean Minkowski space-time M). Such an interpretation is obviously based on the physical fact that c coincides with the light speed in vacuum, and on the isotropy of R^3. Therefore c represents the value of any of the three components of the maximal causal velocity vector (m.c.v.) of SR, $\mathbf{u}_{SR}$, namely:

$$\mathbf{u}_{SR} = (c, c, c). \quad (4.17)$$

Then, c^2 is not, in general, a square modulus, but the square of any component of $\mathbf{u}_{SR}$, whose square modulus (with respect to the Euclidean scalar product $\cdot$), is instead:

$$|\mathbf{u}_{SR}|^2 \equiv \sum_{i=1}^{3}(u_{SR}^i)^2 = 3c^2 \quad (4.18)$$

so that

$$u_{SR}^i = \frac{1}{\sqrt{3}}|\mathbf{u}_{SR}| \quad \forall i = 1, 2, 3. \quad (4.19)$$

The above procedure must be suitably modified in the DSR case, due to the space anisotropy of $\tilde{M}$.

Actually, in order to sort out a single component of the 3-vector m.c.v., in a general 4-d special-relativistic theory (characterized by a diagonal metric tensor $g_{\mu\nu}(\{O\})$, where $\{O\}$ is a set of observables corresponding to non-metric variables), one has to exploit a "*directional separation*" (or "*dimensional separation*") method, which consists of the following three-step recipe (ESCoff throughout):

1. Set ds^2 equal to zero:

$$ds^2 = 0 \Leftrightarrow g_{00}(\{O\})c^2dt^2 + \sum_{i=1}^{3} g_{ii}(\{O\})(dx^i)^2 = 0. \quad (4.20)$$

2. In order to find the ith component $u^i(\{\mathcal{O}\})$ of the m.c.v., put $dx^j = 0$ $(j \neq i)$, thus getting

$$g_{00}(\{\mathcal{O}\})c^2dt^2 + g_{ii}(\{\mathcal{O}\})(dx^i)^2 = 0. \tag{4.21}$$

3. Evidence on the l.h.s. of (4.21) a quantity with physical dimensions $\frac{[\text{space}]}{[\text{time}]} = [\text{velocity}]$; at this point, we have two different subcases:

(I) One carries to the l.h.s. of (4.21) $\frac{dx^i}{dt}$ (which amounts to consider the 3-d Euclidean product $\cdot$), thus getting an *anisotropic* m.c.v.:

$$u^i(\{\mathcal{O}\}) \equiv \frac{dx^i}{dt} = \frac{(g_{00}(\{\mathcal{O}\}))^{1/2}}{(-g_{ii}(\{\mathcal{O}\}))^{1/2}}c \quad \forall i = 1,2,3. \tag{4.22}$$

(II) One carries to the l.h.s. of (4.21) $(-g_{ii}(\{\mathcal{O}\}))^{1/2}\frac{dx^i}{dt}$ (which amounts to consider the 3-d deformed product $*$ defined by $-g_{ij}(\{\mathcal{O}\}) = \delta_{ij}|g_{ii}(\{\mathcal{O}\})|$, thus getting an *isotropic* m.c.v.:

$$u^i(\{\mathcal{O}\}) \equiv (-g_{ii}(\{\mathcal{O}\}))^{1/2}\frac{dx^i}{dt} = (g_{00}(\{\mathcal{O}\}))^{1/2}c \quad \forall i = 1,2,3. \tag{4.23}$$

The two subcases I and II differ essentially by the different way of implementing the space anisotropy. In the former case, the anisotropy is embedded in the definition of m.c.v.; in the latter one, in the scalar product.[a]

Specializing the above equations to the DSR framework, we get therefore, in the two subcases:

(I)
$$u^i_{DSR,I}(E) \equiv u^i(E) = c\frac{b_0(E)}{b_i(E)} \tag{4.24}$$

[a]Let us notice that the directionally separating procedure can be consistently applied only to (special- or general relativistic) metrics which are fully diagonal. This is obviously due to the mixings between different space directions which arise in the case of non-diagonal metrics.

Of course, such a procedure gives (in either subcase) the same standard result when applied to SR. In fact:

$$u^i_{SR} = (-g_{ii})^{1/2}\frac{dx^i}{dt} = (g_{00})^{1/2}c = \frac{dx^i}{dt}$$
$$= \frac{(g_{00})^{1/2}}{(-g_{ii})^{1/2}}c = c \quad \forall i = 1,2,3.$$

$$|\mathbf{u}_{DSR,I}(E)| = \left(\sum_{i=1}^{3}(u^i_{DSR,I}(E))^2\right)^{1/2}$$
$$= cb_0(E)\left(\frac{1}{b_1^2(E)} + \frac{1}{b_2^2(E)} + \frac{1}{b_3^2(E)}\right)^{1/2} \tag{4.25}$$

The vector $\mathbf{u}$ is the (spatially) anisotropic generalization of the maximal causal speed derived in the (spatially) isotropic case, Eq. (3.8);

(II)
$$u^i_{DSR,II}(E) \equiv w^i(E) = cb_0(E) \tag{4.26}$$

$$|\mathbf{u}_{DSR,II}(E)|_* = \left(\sum_{i=1}^{3}b_i^2(E)(u^i_{DSR,II}(E))^2\right)^{1/2}$$
$$= cb_0(E)(b_1^2(E) + b_2^2(E) + b_3^2(E))^{1/2} \tag{4.27}$$

whence

$$u^i_{DSR,II}(E) = (b_1^2(E) + b_2^2(E) + b_3^2(E))^{-1/2}|\mathbf{u}_{DSR,II}(E)|_* \tag{4.28}$$

i.e. in this subcase (unlike the previous one, see Eqs. (4.24) and (4.25)) one can state a proportionality relation by an overall factor (even if dependent on the metric coefficients) between $u^i_{DSR,II}(E)$ and $|\mathbf{u}_{DSR,II}(E)|_*$.

We have therefore shown that the two different procedures of directional separation lead to two different mathematical definitions of maximal causal velocity, an isotropic ($\mathbf{w}$, Eq. (4.26)) and an anisotropic ($\mathbf{u}$, Eq. (4.24)) one. The choice between them must be done on a physical basis (see Subsec. 4.4.3).

4.4. Boosts in DSR

4.4.1. *Boost in a Generic Direction*

In this case, the relative velocity is $\mathbf{v} = v^1\hat{x} + v^2\hat{y} + v^3\hat{z}$, and we have to suitably generalize definitions (4.10), (4.11) as follows:

$$\tilde{\beta} \equiv \frac{\mathbf{v}}{\mathbf{u}} \equiv \left(\frac{v^1b_1(E)}{cb_0(E)}, \frac{v^2b_2(E)}{cb_0(E)}, \frac{v^3b_3(E)}{cb_0(E)}\right) \tag{4.29}$$

$$\tilde{\gamma} \equiv \left(1 - |\tilde{\beta}|^2\right)^{-1/2} \tag{4.30}$$

where (cf. Eq. (4.17))

$$\mathbf{u} = \left(c\frac{b_0(E)}{b_1(E)}, c\frac{b_0(E)}{b_2(E)}, c\frac{b_0(E)}{b_3(E)}\right). \tag{4.31}$$

Notice that $\tilde{\beta} \equiv \frac{\mathrm{v}}{\mathrm{u}} \neq \frac{\mathrm{v}}{u}$. This follows from the anisotropy of the 3-vector $\mathbf{u}$, and it is to be compared with the SR case, where $\beta \equiv \frac{\mathrm{v}}{\mathrm{u}} = \frac{\mathrm{v}}{c}$. In general, it is possible to state that

$$\frac{\mathrm{m}}{\mathrm{n}} = \frac{1}{n}\mathrm{m} \Leftrightarrow \mathrm{n} = (n, n, n)$$

i.e. iff n is a spatially isotropic 3-vector.

In order to derive the expression of the deformed boost in a generic direction, it is possible to use the same method of the previous case (see Appendix). However, it is simpler to consider the notion of parallelism between 3-vectors in $\tilde{M}(E)$[b] and decompose the space vector x in two components, $\mathrm{x}_\parallel$ and $\mathrm{x}_\perp$, parallel and orthogonal, respectively, to the boost direction $\hat{v}$

$$\mathrm{x} = \mathrm{x}_\parallel + \mathrm{x}_\perp \tag{4.32}$$

$$\begin{aligned} \mathrm{x}_\parallel &\equiv \hat{v}(\hat{v} * \mathrm{x}) = \frac{\mathrm{v}}{|\mathrm{v}|_*^2}(\mathrm{v} * \mathrm{x}) = \frac{\mathrm{v}}{\mathrm{v} * \mathrm{v}}(\mathrm{v} * \mathrm{x}) \\ &= \frac{\sum_{i=1}^3 b_i^2(E) v^i x^i}{\sum_{i=1}^3 b_i^2(E)(v^i)^2}\mathrm{v} \neq \hat{\tilde{\beta}}(\hat{\tilde{\beta}} * \mathrm{x}) \\ &= \frac{\tilde{\beta}}{|\tilde{\beta}|_*^2}(\tilde{\beta} * \mathrm{x}) = \frac{\tilde{\beta}}{\tilde{\beta} * \tilde{\beta}}(\tilde{\beta} * \mathrm{x}) = \frac{\sum_{i=1}^3 b_i^2(E)\tilde{\beta}^i x^i}{\sum_{i=1}^3 b_i^2(E)(\tilde{\beta}^i)^2}\tilde{\beta} \end{aligned} \tag{4.33}$$

(with $||_*$ denoting the absolute value of a 3-vector with respect to the deformed scalar product $*$, whereas the notation $||$ will be used for the 3-vector norm with respect to the standard product $\cdot$)

$$x_\parallel^i \equiv \frac{\sum_{k=1}^3 b_k^2(E) v^k x^k}{\sum_{k=1}^3 b_k^2(E)(v^k)^2} v^i \neq \frac{\sum_{k=1}^3 b_k^2(E)\tilde{\beta}^k x^k}{\sum_{k=1}^3 b_k^2(E)(\tilde{\beta}^k)^2}\tilde{\beta}^i \tag{4.34}$$

$$\begin{aligned} \mathrm{x}_\perp &\equiv \mathrm{x} - \mathrm{x}_\parallel = \mathrm{x} - \frac{\sum_{i=1}^3 b_i^2(E) v^i x^i}{\sum_{i=1}^3 b_i^2(E)(v^i)^2}\mathrm{v} \\ &\neq \mathrm{x} - \frac{\sum_{i=1}^3 b_i^2(E)\tilde{\beta}^i x^i}{\sum_{i=1}^3 b_i^2(E)(\tilde{\beta}^i)^2}\tilde{\beta} \end{aligned} \tag{4.35}$$

[b]The definitions of parallelism and orthogonality are to be meant in the sense of the deformed 3D scalar product $*$ (see Eq. (2.5)).

$$\begin{aligned} x_\perp^i &\equiv x^i - \frac{\sum_{k=1}^3 b_k^2(E) v^k x^k}{\sum_{k=1}^3 b_k^2(E)(v^k)^2} v^i \\ &\neq x^i - \frac{\sum_{k=1}^3 b_k^2(E)\tilde{\beta}^k x^k}{\sum_{k=1}^3 b_k^2(E)(\tilde{\beta}^k)^2}\tilde{\beta}^i. \end{aligned} \tag{4.36}$$

It is easily checked that indeed

$$\begin{aligned} \mathrm{x} * \mathrm{v} &= \sum_{i=1}^3 b_i^2(E) x^i v^i = \frac{\sum_{i=1}^3 b_i^2(E) x^i v^i}{\sum_{i=1}^3 b_i^2(E)(v^i)^2}\sum_{k=1}^3 b_k^2(E)(v^k)^2 \\ &= \frac{\sum_{i=1}^3 b_i^2(E) x^i v^i}{\sum_{i=1}^3 b_i^2(E)(v^i)^2}\mathrm{v} * \mathrm{v} = \mathrm{x}_\parallel * \mathrm{v} = |\mathrm{x}_\parallel|_* |\mathrm{v}|_* \end{aligned} \tag{4.37}$$

$$\mathrm{x}_\perp * \mathrm{v} = \mathrm{x} * \mathrm{v} - \mathrm{x}_\parallel * \mathrm{v} = 0. \tag{4.38}$$

Then, applying the boost (4.9) to $\mathrm{x}_\parallel$ and $\mathrm{x}_\perp$ yields

$$\begin{cases} \mathrm{x}'_\parallel = \tilde{\gamma}(\mathrm{x}_\parallel - \mathrm{v}t) \\ \mathrm{x}'_\perp = \mathrm{x}_\perp \\ t' = \tilde{\gamma}\left(t - \sum_{i=1}^3 \frac{v^i b_i^2(E)}{c^2 b_0^2(E)} x^i\right) = \tilde{\gamma}(t - \tilde{\mathrm{B}} \cdot \mathrm{x}) = \tilde{\gamma}(t - \tilde{\mathrm{B}}^{(*)} * \mathrm{x}) \end{cases} \tag{4.39}$$

where we put

$$\begin{aligned} \tilde{\gamma} &\equiv (1 - \tilde{\beta} \cdot \tilde{\beta})^{-1/2} = (1 - \tilde{\beta}^{(*)} * \tilde{\beta}^{(*)})^{-1/2} \\ &= \left[1 - \left(\frac{v^1 b_1(E)}{cb_0(E)}\right)^2 - \left(\frac{v^2 b_2(E)}{cb_0(E)}\right)^2 - \left(\frac{v^3 b_3(E)}{cb_0(E)}\right)^2\right]^{-1/2} \end{aligned} \tag{4.40}$$

$$\tilde{\beta}^{(*)} \equiv \frac{\mathrm{v}}{\mathrm{w}} = \left(\frac{v^1}{cb_0(E)}, \frac{v^2}{cb_0(E)}, \frac{v^3}{cb_0(E)}\right) = \frac{1}{cb_0(E)}\mathrm{v} \tag{4.41}$$

$$\mathrm{w} \equiv (cb_0(E), cb_0(E), cb_0(E)) \tag{4.42}$$

$$\tilde{\mathrm{B}} \equiv \frac{\mathrm{v}}{\mathrm{u}^2} = \left(\frac{v^1 b_1^2(E)}{c^2 b_0^2(E)}, \frac{v^2 b_2^2(E)}{c^2 b_0^2(E)}, \frac{v^3 b_3^2(E)}{c^2 b_0^2(E)}\right) \tag{4.43}$$

$$\tilde{\mathrm{B}}^{(*)} \equiv \frac{\mathrm{v}}{\mathrm{w}^2} = \frac{1}{c^2 b_0^2(E)}\mathrm{v}. \tag{4.44}$$

It follows therefore that the deformed boosts admit a double treatment, either:

(I) In terms of the Euclidean scalar product $\cdot$, of the (anisotropic) m.c.v. u and of the related velocity parameters $\tilde{\beta}$ and $\tilde{B}$, or

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(II) in terms of the deformed product $*$, of the (isotropic) m.c.v. $\mathbf{w}$ and of the related velocity parameters $\tilde{\beta}^{(*)}$ and $\tilde{\mathrm{B}}^{(*)}$.[c]

Then, the space vector transforms as:

$$\mathbf{x}' = \mathbf{x}'_{\parallel} + \mathbf{x}'_{\perp} = \tilde{\gamma}(\mathbf{x}_{\parallel} - \mathbf{v}t) + \mathbf{x}_{\perp}$$
$$= \mathbf{x} + (\tilde{\gamma} - 1)\hat{v}(\hat{v} * \mathbf{x}) - \tilde{\gamma}\mathbf{v}t = \mathbf{x} + (\tilde{\gamma} - 1)\frac{\mathbf{v}}{|\mathbf{v}|^2_*}(\mathbf{v} * \mathbf{x}) - \tilde{\gamma}\mathbf{v}t \quad (4.45)$$

and we eventually find the expression of the deformed boost in a generic direction:

$$\begin{cases} \mathbf{x}' = \mathbf{x} + (\tilde{\gamma} - 1)\dfrac{\mathbf{v}}{|\mathbf{v}|^2_*}(\mathbf{v} * \mathbf{x}) - \tilde{\gamma}\mathbf{v}t \\ t' = \tilde{\gamma}(t - \tilde{\mathrm{B}} \cdot \mathbf{x}) = \tilde{\gamma}(t - \tilde{\mathrm{B}}^{(*)} * \mathbf{x}). \end{cases} \quad (4.46)$$

4.4.2. *Symmetrization of Deformed Boosts*

As in the case of standard SR, it is possible to symmetrize the expression of boosts in DSR by introducing suitable time coordinates.

Let us first consider a deformed boost along $\hat{x}^i$ ($i = 1, 2, 3$); the symmetrization transformation (a "dimensionally homogenizing dilato-contraction") of t is given by

$$x^0 \equiv u^i t = c\frac{b_0(E)}{b_i(E)}t; \quad x^{i\prime} \equiv x^i. \quad (4.47)$$

The deformed metric tensor in the new "primed" coordinates, $\{x^{\mu\prime}\} = \{x^0, x, y, z\}$, reads:

$$\eta'_{\mu\nu}(E) \overset{\text{ESC on}}{=} \eta_{\alpha\beta}(E)\frac{\partial x^\alpha}{\partial x^{\mu\prime}}\frac{\partial x^\beta}{\partial x^{\nu\prime}} = \mathrm{diag}(b_i^2(E), -b_1^2(E), -b_2^2(E), -b_3^2(E))$$
$$\overset{\text{ESC off}}{=} \delta_{\mu\nu}[b_i^2(E)\delta_{\mu 0} - b_1^2(E)\delta_{\mu 1} - b_2^2(E)\delta_{\mu 2} - b_3^2(E)\delta_{\mu 3}]. \quad (4.48)$$

Equation (4.9) takes therefore the symmetric form in x^i e x^0 (ESC off):

$$\begin{cases} x^{i\prime} = \tilde{\gamma}(x^i - \tilde{\beta}^i x^0); \\ x^{k\neq i\prime} = x^{k\neq i}; \\ x^{0\prime} = \tilde{\gamma}(x^0 - \tilde{\beta}^i x^i). \end{cases} \quad (4.49)$$

Transformation (4.49) does not symmetrize the deformed boost in a generic direction (unlike the case of SR, where the same transformation

[c]It is possible to show that, in this case, more equivalent forms of the deformed boost (4.39) exist. As is easily seen, this is due to the fact that, in general, $\hat{\tilde{\beta}} \neq \hat{v}$ and $\hat{\tilde{B}} \neq \hat{v}$, whereas $\widehat{\tilde{\beta}^{(*)}} = \hat{v} = \widehat{\tilde{B}^{(*)}}$.

$x^0 = ct$ symmetrizes both boosts). In this case, the symmetrization is possible only if the treatment II (based on the deformed scalar product $*$) is used.

In fact, by using the proportionality (see Eqs. (4.41) and (4.44) and the footnote at p. 36) among $\tilde{\beta}^{(*)}$, $\tilde{\mathrm{B}}^{(*)}$ and $\mathbf{v}$, the following transformation on t (see Eq. (4.42))

$$x^0 \equiv cb_0(E)t = w^k t \ \ (\forall k = 1, 2, 3); \quad x^{i\prime} \equiv x^i \ \ (\forall i = 1, 2, 3) \quad (4.50)$$

does symmetrize Eq. (4.39) in $\mathbf{x}_{\parallel}$ e x^0:

$$\begin{cases} \mathbf{x}'_{\parallel} = (1 - \tilde{\beta}^{(*)} * \tilde{\beta}^{(*)})^{-1/2}(\mathbf{x}_{\parallel} - \tilde{\beta}^{(*)}x^0) \\ \mathbf{x}'_{\perp} = \mathbf{x}_{\perp} \\ x^{0\prime} = \begin{cases} (1 - \tilde{\beta}^{(*)} * \tilde{\beta}^{(*)})^{-1/2}(x^0 - \tilde{\beta}^{(*)} * \mathbf{x}) \\ = (1 - \tilde{\beta}^{(*)} * \tilde{\beta}^{(*)})^{-1/2}(x^0 - \tilde{\beta}^{(*)} * \mathbf{x}_{\parallel}). \end{cases} \end{cases} \quad (4.51)$$

Under transformation (4.51), the metric tensor becomes:

$$\eta'_{\mu\nu}(E) \overset{\text{ESC on}}{=} \eta_{\alpha\beta}(E)\frac{\partial x^\alpha}{\partial x^{\mu\prime}}\frac{\partial x^\beta}{\partial x^{\nu\prime}} = \mathrm{diag}(1, -b_1^2(E), -b_2^2(E), -b_3^2(E))$$
$$\overset{\text{ESC off}}{=} \delta_{\mu\nu}[\delta_{\mu 0} - b_1^2(E)\delta_{\mu 1} - b_2^2(E)\delta_{\mu 2} - b_3^2(E)\delta_{\mu 3}]. \quad (4.52)$$

Therefore the symmetrization of the deformed boost in a generic direction makes the 4-d metric isochronous, since $\eta'_{00} = 1$ so that $\tau = t$ (namely proper time coincides with coordinate time).

Let us finally notice that, like in the SR case, the boost in generic direction expressed in terms of $\mathbf{x}$ e t (Eq. (4.39)) cannot in general be symmetrized.

Apparently Eqs. (4.9) are asymmetrical in the behaviour of x' and t', unlike the usual Lorentz transformations, which are fully symmetric when putting $x^0 = ct$. However, such asymmetry is only formal. It can be removed by introducing, in analogy with the electromagnetic case, a time coordinate defined in terms of the maximal causal speed u in the generalized Minkowski space considered:

$$x^0 = ut = \left(\frac{b_0}{b}c\right)t \quad (4.53)$$

and changing the metric tensor η into

$$\eta' = \mathrm{diag}(b^2, -b^2, -b^2, -b^2) = b^2 g. \quad (4.54)$$

Then, the generalized Lorentz transformations in $\tilde{M}'$ take the symmetrical form

$$\begin{cases} x^{0\prime} = \tilde{\gamma}(x^0 - \tilde{\beta}x^1); \\ x^{1\prime} = \tilde{\gamma}(x^1 - \tilde{\beta}x^0); \\ x^{2\prime} = x^2; \\ x^{3\prime} = x^3. \end{cases} \tag{4.55}$$

It is easily seen that the deformed Minkowski spaces $\tilde{M}$ and $\tilde{M}'$, with metrics (2.2) and (4.54) respectively, are isometric, because they have the same interval (2.5). They are therefore fully equivalent in every respect, and it is therefore possible to use indifferently either transformation (4.9) or (4.55). The main advantage of the latter ones is that, due to relation (4.53), the formulae holding for $\tilde{M}'$ are immediately got from those of the standard special relativity by simply replacing everywhere c by u.

4.4.3. *Velocity Composition Law in $\tilde{M}$ and the Invariant Maximal Speed*

We have seen in Sec. 4.3 that the directionally separating approach (mandatory in the deformed case) yields two different *mathematical* definitions **u** (Eq. (4.24)) and **w** (Eq. (4.26)) of maximal causal velocity in DSR. The choice between them must be done on a physical basis, by checking their actual invariance under deformed boosts.

To this aim, one has to derive the generalized velocity composition law valid in $\tilde{M}$. For a deformed boost in the direction $\hat{x}^i$, differentiating the inverse of Eq. (4.9) yields (on account of the fact that $dE = 0$ in DSR) (ESC off):

$$\begin{cases} dx^i = \tilde{\gamma}(dx^{i\prime} + v^i dt') \\ dx^{k\neq i} = dx^{k\neq i\prime} \\ dt = \tilde{\gamma}\left(dt' + \dfrac{v^i b_i^2(E)}{c^2 b_0^2(E)} dx^{i\prime}\right) \end{cases} \tag{4.56}$$

with $\tilde{\gamma}$ given by (4.11). Since

$$\frac{dx^i}{dt} = v^i, \quad \frac{dx^{i\prime}}{dt'} = v^{i\prime}, \quad \frac{dx^{k\neq i}}{dt} = v^{k\neq i}, \quad \frac{dx^{k\neq i\prime}}{dt'} = v^{k\neq i\prime} \tag{4.57}$$

one gets the *deformed velocity composition law* (in compact notation, ESC off)

$$v^k = \frac{v^{k\prime} + \delta_{ik}v^i}{\left[1 + \left(\dfrac{b_i(E)}{b_0(E)}\right)^2 \dfrac{v^i v^{i\prime}}{c^2}\right]\{\tilde{\gamma}(E) + \delta_{ik}[1 - \tilde{\gamma}(E)]\}}. \tag{4.58}$$

This relation can be expressed in terms of the standard 3-d scalar product $\cdot$ (and therefore of the anisotropic maximal velocity **u**) (approach I) as

$$v^k = \frac{v^{k\prime} + \delta_{ik}v^i}{\left[1 + \dfrac{\mathbf{v}\cdot\mathbf{v}'}{(u^i(E))^2}\right]\{\tilde{\gamma}(E) + \delta_{ik}[1 - \tilde{\gamma}(E)]\}} = \frac{v^{k\prime} + \delta_{ik}v^i}{\left[1 + \dfrac{\tilde{\beta}\cdot\mathbf{v}'}{u^i(E)}\right]\{\tilde{\gamma}(E) + \delta_{ik}[1 - \tilde{\gamma}(E)]\}} \tag{4.59}$$

where

$$\tilde{\beta}^i(E) = \frac{v^i}{u^i(E)}; \quad \tilde{\gamma}(E) = (1 - \tilde{\beta}(E)\cdot\tilde{\beta}(E))^{-1/2}. \tag{4.60}$$

Alternatively, we can use approach II, based on the deformed scalar product $*$ (and therefore the isotropic maximal velocity **w**) and write Eq. (4.59) as

$$v^k = \frac{v^{k\prime} + \delta_{ik}v^i}{\left[1 + \dfrac{\mathbf{v} * \mathbf{v}'}{(w^i(E))^2}\right]\{\tilde{\gamma}(E) + \delta_{ik}[1 - \tilde{\gamma}(E)]\}} = \frac{v^{k\prime} + \delta_{ik}v^i}{\left[1 + \dfrac{\tilde{\beta}^{(*)} * \mathbf{v}'}{w^i(E)}\right]\{\tilde{\gamma}(E) + \delta_{ik}[1 - \tilde{\gamma}(E)]\}} \tag{4.61}$$

with

$$\tilde{\beta}^{(*)i}(E) = \frac{v^i}{w^i(E)}; \quad \tilde{\gamma}(E) = (1 - \tilde{\beta}^{(*)}(E) * \tilde{\beta}^{(*)}(E))^{-1/2}. \tag{4.62}$$

It is now an easy task to check the truly maximal character of the two velocities. Indeed, if $v^{i\prime} = u^i(E)$, one gets, from Eq. (4.59)

$$v^i = \frac{u^i(E) + v^i}{1 + \dfrac{v^i}{u^i(E)}} = u^i(E) \tag{4.63}$$

whereas, for $v^{i\prime} = w^i(E)$, Eq. (4.61) yields

$$v^i = \frac{w^i(E) + v^i}{1 + \frac{(b_i(E))^2 v^i}{w^i(E)}} \neq w^i(E). \qquad (4.64)$$

We can therefore conclude, on a physical basis, that $\mathbf{u}$ is the maximal, invariant causal velocity in DSR, and it plays in the deformed Minkowski space $\tilde{M}$ the role of the light speed in standard SR.[d]

It is also easy to see why — although approach (II) looks at first sight more rigorous mathematically, because it permits to connect the peculiar features of spatial anisotropy of DSR to the deformed product $*$, "naturally induced" from the metric of $\tilde{M}(E)$ — actually it's approach (I) which yields the physically relevant result. Indeed, the velocity $\mathbf{u}$ is just defined as $\frac{d\mathbf{x}}{dt}$, and it therefore represents the physically measured velocity, for a particle moving in the usual, physical Euclidean 3-d space. On the other hand, this result clearly shows that the space anisotropy introduced by the deformed metric is not a mere mathematical artifact, but it reflects itself in the physical properties (imposed by the interaction involved) of the phenomenon described by the deformed space-time.

The comparison of the deformed boost expression (Eq. (4.9)) with the corresponding ones of the standard Lorentz boosts shows clearly that the transition from SR (based on M) to DSR (based on $\tilde{M}$) is simply carried out by letting

$$\mathbf{u}_{SR} = (c, c, c) \to \mathbf{u}_{DSR}(E) = \left(\frac{cb_0(E)}{b_1(E)}, \frac{cb_0(E)}{b_2(E)}, \frac{cb_0(E)}{b_3(E)} \right). \qquad (4.65)$$

In other words, the difference between M and $\tilde{M}(E)$ (at least as far as the finite coordinate transformations are concerned) is completely embodied in the 3-vector m.c.v. $\mathbf{u}$.

[d] Of course, in the case of space isotropy, we get an isotropic maximal causal velocity given by (cf. Eq. (2.9))

$$u^i_{\mathrm{iso}}(E) = u^i_{DSR,II}(E)|_{b_i(E)=b(E)} = c\frac{b_0(E)}{b(E)} \quad \forall i = 1,2,3$$

$$|\mathbf{u}_{\mathrm{iso}}(E)| = \left(\sum_{i=1}^{3} (u^i_{\mathrm{iso}}(E))^2 \right)^{1/2} = \sqrt{3}c\frac{b_0(E)}{b(E)}$$

4.4.4. *Choosing the Boost Direction in DSR*

We want now to remark a difficulty arising in the context of DSR, due to the space anisotropy.

Indeed, the space anisotropy (reflected in the physical anisotropic m.c.v. $\mathbf{u}$) produces a triple indetermination in the process of identifying the motion axis with any of the space coordinate axes, since now — unlike the SR case — the space dimensions are no longer equivalent.

However, this indeterminacy can be removed (at least in principle) by means of the following *Gedankenexperiment*. Consider three particles (ruled by one and the same interaction) in general different but able to move at the maximal causal velocity $u^i(E)$. Suppose they are moving in the 3-d Euclidean space along mutually independent (orthogonal) spatial directions. Assigning an arbitrary labelling to the particle motion directions, we can fix an orthogonal, left-handed frame of axes. Since by assumption we know the interaction which the particles are subjected to, we know the deformed metric and therefore the metric coefficients as functions of the energy, $b^2_\mu(E)$. Then, a measurement of the particle velocities allows us to determine the right labelling of the spatial frame.

This implies that in the context of DSR, too, it is always possible, at physical level, to let one of the three space axes to coincide with the direction of motion of a physical object, and therefore apply the suitable deformed boost.

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4.4.5. *Appendix — Another Derivation of a Generic Boost*

The procedure followed in Sec. 4.2 in order to derive the expression of a boost along a coordinate axis can in principle be exploited too in deriving the deformed boost in a generic direction. In this case, the coordinate transformations are

$$\begin{cases} x' = A_{11}x + A_{12}y + A_{13}z + A_{14}t \\ y' = A_{21}x + A_{22}y + A_{23}z + A_{24}t \\ z' = A_{31}x + A_{32}y + A_{33}z + A_{34}t \\ t' = A_{41}x + A_{42}y + A_{43}z + A_{44}t. \end{cases} \qquad (A.1)$$

From the physical requirement that the origin O' of TIF K' must move in K with velocity components v^1 along $\hat{x}$, v^2 along $\hat{y}$, v^3 along $\hat{z}$, one gets:

$$\left.\begin{array}{l} x' = 0,\ x = v^1 t \\ y' = 0,\ y = v^2 t \\ z' = 0,\ z = v^3 t \end{array}\right\} \Leftrightarrow \left\{\begin{array}{l} A_{11}v^1 + A_{12}v^2 + A_{13}v^3 + A_{14} = 0 \\ A_{21}v^1 + A_{21}v^2 + A_{31}v^3 + A_{24} = 0 \\ A_{31}v^1 + A_{32}v^2 + A_{33}v^3 + A_{34} = 0 \end{array}\right. . \qquad (A.2)$$

Equation (A.1) becomes therefore

$$\begin{cases} x' = A_{11}(x - v^1t) + A_{12}(y - v^2t) + A_{13}(z - v^3t) \\ y' = A_{21}(x - v^1t) + A_{22}(y - v^2t) + A_{23}(z - v^3t) \\ z' = A_{31}(x - v^1t) + A_{32}(y - v^2t) + A_{33}(z - v^3t) \\ t' = A_{41}x + A_{42}y + A_{43}z + A_{44}t. \end{cases} \quad \text{(A.3)}$$

Replacing (A.3) in (A.1) yields

$$\begin{aligned} & b_0^2(E)c^2t^2 - b_1^2(E)x^2 - b_2^2(E)y^2 - b_3^2(E)z^2 \\ & = c^2 b_0^2(E)(A_{41}x + A_{42}y + A_{43}z + A_{44}t)^2 \\ & \quad - b_1^2(E)(A_{11}(x - v^1t) + A_{12}(y - v^2t) + A_{13}(z - v^3t))^2 \\ & \quad - b_2^2(E)(A_{21}(x - v^1t) + A_{22}(y - v^2t) + A_{23}(z - v^3t))^2 \\ & \quad - b_3^2(E)(A_{31}(x - v^1t) + A_{32}(y - v^2t) + A_{33}(z - v^3t))^2. \end{aligned} \quad \text{(A.4)}$$

Equating the coefficients on both sides of (A.4) one gets a system of 10 quadratic equations in the 13 unknown coefficients $\{A_{ij}, A_{4i}\}$ $(i, j = 1, 2, 3)$, namely:

I. From the coefficient of t^2:

$$c^2(A_{44}^2 - 1) - \frac{1}{b_0^2(E)} \sum_{i,j,l=1}^{3} b_j^2(E) v^j v^l A_{ij} A_{il} = 0. \quad \text{(A.5)}$$

II. From the coefficients of $x^i x^j$ $(i, j = 1, 2, 3)$, 6 independent equations:

$$c^2 A_{4i} A_{4j} - \frac{1}{b_0^2(E)} \sum_{l=1}^{3} b_l^2(E)(A_{li} A_{lj} - \delta_{ij}\delta_{il}) = 0. \quad \text{(A.6)}$$

III. From the coefficients of $x^i t$ $(i = 1, 2, 3)$, 3 independent equations:

$$c^2 A_{4i} A_{44} + \frac{1}{b_0^2(E)} \sum_{j,l=1}^{3} b_j^2(E) v^l A_{ji} A_{jl} = 0. \quad \text{(A.7)}$$

Although the above system in the set $\{A_{ij}, A_{4i}\}$ $(i, j = 1, 2, 3)$ can in principle be solved, the general solution for the boost expressed in the form (A.3) is quite cumbersome. This motivates the choice (adopted in Subsec. 4.4.1) of deriving the form of the deformed boost in a generic direction by exploiting the notion of "deformed" parallelism between 3-vectors.

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CHAPTER 5

RELATIVISTIC KINEMATICS IN A DEFORMED MINKOWSKI SPACE

From the knowledge of the generalized Lorentz transformations it is easy to derive the main kinematical and dynamical laws valid in DSR.[3,4] In this Chapter, we shall merely list those which are useful to phenomenological purposes.

- **Velocity composition law** (cf. Eq. (4.58)):

$$V_{\text{tot}} = \frac{v_1 + v_2}{1 + \dfrac{v_1 v_2}{u^2}} \quad \text{(5.1)}$$

which obviously for, say, $v_1 = u$ yields $V_{\text{tot}} = u$.

If the condition of spatial isotropy is given up, the composition law for motion, say, along the x_k-axis, becomes

$$V = \frac{v_1 + v_2}{1 + \dfrac{v_1 v_2}{u_k^2}}; \quad u_k = \frac{c b_0}{b_k} \quad \text{(5.2)}$$

and, therefore, the speed that has an invariant character is

$$u_k = \frac{c b_0}{b_k}. \quad \text{(5.3)}$$

It follows that, in a given Minkowski space with deformed metric, there exist infinitely many different, maximal causal speeds, corresponding to the different possible directions of motion (although, of course, only three of them are independent). Clearly, this result is a strict consequence of the spatial anisotropy of the space-time region considered. Let us notice that there is indeed a phenomenon — the Bose–Einstein correlation — which can be fully described in the framework of such a Minkowski space, but with the consequence of a local loss of space isotropy (see Part III).

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- **Time dilation:**

$$\Delta t = \tilde{\gamma}(E)\Delta t_0; \quad \text{(5.4)}$$

- Length contraction:

$$\Delta L = \tilde{\gamma}^{-1}(E)\Delta L_0; \tag{5.5}$$

- Four-velocity:

$$V^\mu = \frac{d}{dt_0}x^\mu, \tag{5.6}$$

whose explicit form (with dt_0 derived from Eq. (5.4)) reads

$$V^0(E) = \tilde{\gamma}(E)u(E); \tag{5.7}$$
$$V^k(E) = \tilde{\gamma}(E)u^k(E). \tag{5.8}$$

Therefore, the generalized expression of the momentum fourvector (in the case of spatial isotropy) is

$$p^\mu = m_0 V^\mu(E) = (m_0\tilde{\gamma}(E)u(E), m_0\tilde{\gamma}(E)v^k). \tag{5.9}$$

In the general case, the deformed relativistic energy, for a particle subjected to a given interaction and moving along $\hat{x}^i$, has the form:

$$E = mu_i^2(E)\tilde{\gamma}(E) = mc^2\frac{b_0^2(E)}{b_i^2(E)}\tilde{\gamma}(E) \tag{5.10}$$

where $\mathbf{u}(E)$ is the maximal causal velocity (4.31) for the interaction considered. In the non-relativistic (NR) limit of DSR, *i.e.* at energies such that

$$v_i \ll u_i(E). \tag{5.11}$$

Equation (5.10) yields the following NR expression of the energy corresponding to the given interaction:

$$E_{NR} = mu_i^2(E) = mc^2\frac{b_0^2(E)}{b_i^2(E)}. \tag{5.12}$$

Lastly, let us consider a plane wave propagating with speed u (e.g. in the xy plane, at angles θ, θ' in frames K, K') with dispersion relation $u = \lambda\nu = \lambda'\nu'$, where ν, ν' are the wave frequencies in K, K'. Applying the generalized Lorentz transformations, it is easy to get the following laws:

- Doppler effect:

$$\nu = \tilde{\gamma}(E)\nu'(1 + \tilde{\beta}(E)\cos\theta'); \tag{5.13}$$

- Aberration law:

$$tg\theta = \frac{\sin\theta'}{\tilde{\gamma}(E)(\tilde{\beta}(E) + \cos\theta')}. \tag{5.14}$$

We want now to provide a comparison between the main kinematical laws in the usual Minkowski space M and in the deformed one $\tilde{M}$ (in the hypothesis of spatial isotropy), because their different behaviors may help one to understand the peculiar features of leptonic, hadronic (and gravitational) interactions with respect to the electromagnetic one. Such laws are summed up in Table 5.1, where the maximal speed u has been expressed in terms of c, in order to emphasize the dependence of the deformed laws on the parameter ratio b/b_0 and exhibit their scale invariance.

In the limiting case $v = c$, one gets explicitly

$$v_1 = c \Rightarrow V_{\text{tot}} = \frac{c + v_2}{1 + \left(\frac{b}{b_0}\right)^2 \frac{v_2}{c}}; \tag{5.15}$$

$$v = c \Rightarrow \Delta t = \frac{\Delta t_0}{\left[1 - \left(\frac{b}{b_0}\right)^2\right]^{1/2}}; \tag{5.16}$$

$$v = c \Rightarrow \Delta L = \Delta L_0\left[1 - \left(\frac{b}{b_0}\right)^2\right]^{1/2}. \tag{5.17}$$

Remember that, in this framework, c has lost its meaning of maximal causal speed, by preserving the mere role of maximal causal speed for electromagnetic phenomena in $\tilde{M}$.

Table 5.1

Minkowski space	Deformed Minkowski space
$V_{\text{tot}} = \frac{v_1 + v_2}{1 + \frac{v_1 v_2}{c^2}}$	$V_{\text{tot}} = \frac{v_1 + v_2}{1 + \left(\frac{b}{b_0}\right)^2 \frac{v_1 v_2}{c^2}}$
$\Delta t = \frac{\Delta t_0}{\left(1 - \frac{v^2}{c^2}\right)^{1/2}}$	$\Delta t = \frac{\Delta t_0}{\left[1 - \left(\frac{b}{b_0}\right)^2 \frac{v^2}{c^2}\right]^{1/2}}$
$\Delta L = \Delta L_0\left(1 - \frac{v^2}{c^2}\right)^{1/2}$	$\Delta L = \Delta L_0\left[1 - \left(\frac{b}{b_0}\right)^2 \frac{v^2}{c^2}\right]^{1/2}$

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Table 5.2

Minkowski space	Deformed Minkowski space
$\Delta t = \Delta t_0 \dfrac{E}{m_0}$	$\Delta t = \Delta t_0 \left[1 - \left(\dfrac{b}{b_o}\right)^2 + \left(\dfrac{b}{b_o}\right)^2 \left(\dfrac{m_0}{E}\right)^2\right]^{-1/2}$
$\Delta L = \Delta L_0 \dfrac{m_0}{E}$	$\Delta L = \Delta L_0 \left[1 - \left(\dfrac{b}{b_o}\right)^2 + \left(\dfrac{b}{b_o}\right)^2 \left(\dfrac{m_0}{E}\right)^2\right]^{1/2}$

To the purpose of an experimental verification, it is worth to express the deformed kinematical laws of time dilation and length contraction for a particle of rest mass m_0 in terms of the *usual* energy E. Clearly, for $E \gg m_0 c^2$, E can be considered the total energy of the particle, measured (as already stressed in Sec. 3.2) by electromagnetic methods in the usual Minkowski space. We report such laws in Table 5.2 (in comparison with the standard, Einsteinian ones).

It is easily seen that, in the case of the time-dilation law, the main difference is the loss of linearity in the dependence on the energy of the deformed law, as compared to the Lorentzian one. Such a different behaviour is therefore a clear signature of the presence of nonlocal effects in the interaction considered. A first evidence is provided by the lifetime of the meson K_s^0 in the range $3 \div 400$ GeV, as it will be seen in Part III.

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CHAPTER 6

WAVE PROPAGATION IN A DEFORMED SPACE-TIME

6.1. Deformed Helmholtz Equation

We want now to approach the problem of wave propagation in a deformed Minkowski space-time.[13,14] To this end, let us introduce the generalized D'Alembert operator $\tilde{\Box}$, defined by means of the scalar product $*$ in $\tilde{M}$ (see Eq. (2.5)):

$$\tilde{\Box} \equiv \partial * \partial = \eta_{\mu\nu}\partial^\mu \partial^\nu = \frac{b_0^2}{c^2}\partial_t^2 - (b_1^2\partial_x^2 + b_2^2\partial_y^2 + b_3^2\partial_z^2). \qquad (6.1)$$

Therefore, the deformed Helmholtz–D'Alembert wave equation is given by

$$\tilde{\Box} f = 0 \qquad (6.2)$$

with f being any component of the field associated to the wave considered. For instance, the field of such a wave propagating in the Minkowski space $\tilde{M}$ can be written as

$$\mathrm{f}(x) = \mathrm{A}(\mathrm{x})e^{ik*x} \qquad (6.3)$$

where k is the wavevector and e^{ik*x} is the generalized phase.

By assuming a spatially isotropic deformed metric (see Eq. (2.7)), in the corresponding deformed space-time the generalized phase takes the "Minkowskian-like" form $e^{i\tilde{k}\cdot x}$ (where the dot denotes the usual scalar product in the Minkowski space), with

$$\tilde{k}^\mu = \left(\frac{2\pi\nu}{c}, \tilde{k}_x, \tilde{k}_y, \tilde{k}_z\right) \qquad (6.4)$$

and ν is the frequency measured in the ordinary space-time. Then, Eq. (6.3) becomes

$$\mathrm{f}(x) = \mathrm{A}(\mathrm{x})e^{i\tilde{k}\cdot x}. \qquad (6.5)$$

A wave propagating in a deformed Minkowski space-time will be referred to in the following as a *non-Lorentzian wave*.

the metric (15.8) can be obtained as the only metric which lives in the intersection of three of the relevant classes, namely it is obtained by setting:

$$q = 2, \quad m = n = p = r = 0, \tag{15.13}$$

which obviously reduces to (8.27) by a rescaling and a translation of the energy parameter E_0.

Needless to say, the fact that it is possible — by the mere consideration of the Einstein equations in vacuum — to recover all the phenomenological metrics for the four fundamental interactions, is a further confirmation of the fact that DSR is indeed naturally embedded in the five-dimensional scheme of DSR5.

ALL PAPERS MARKED WIT "—" TO BE ADDED TO THE LAWSUIT

FRAUD IN REFERENCES

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FRAUD IN TITLE

Killing symmetries of generalized Minkowski spaces. 2- Finite structure of space-time rotation groups in four dimensions

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Abstract

In this paper, we continue the study of the Killing symmetries of a N-dimensional generalized Minkowski space, i.e. a space endowed with a (in general non-diagonal) metric tensor, whose coefficients do depend on a set of non-metrical coordinates. We discuss here the finite structure of the space-time rotations in such spaces, by confining ourselves (without loss of generality) to the four-dimensional

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FRAUD IN FILE

The electron mass from Deformed Special Relativity

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Abstract

Deformed Special Relativity (DSR) is a generalization of Special Relativity based on a deformed Minkowski space, i.e. a four-dimensional space-time with metric coefficients depending on the energy. We show that, in the DSR framework, it is possible to derive the value of the electron mass from the space-time geometry via the experimental knowledge of the parameter of local Lorentz invariance breakdown, and of the Minkowskian threshold energy $E_{0,em}$ for the electromagnetic interaction.

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FRAUD IN TYTLE

Killing symmetries of generalized Minkowski spaces. 3- Space-time translations in four dimensions

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Abstract

In this paper, we continue the study of the Killing symmetries of a N-dimensional generalized Minkowski space, i.e. a space endowed with a (in general non-diagonal) metric tensor, whose coefficients do depend on a set of non-metrical coodinates. We discuss here the translations in such spaces, by confining ourselves (without loss of generality) to the four-dimensional case. In particular, the results obtained

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Killing symmetries of generalized Minkowski spaces.
1- Algebraic-infinitesimal structure of space-time rotation groups

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Abstract

In this paper, we introduce the concept of N-dimensional generalized Minkowski space, i.e. a space endowed with a (in general non-diagonal) metric tensor, whose coefficients do depend on a set of non-metrical coodinates. This is the first of a series of papers devoted to the investigation of the Killing symmetries of generalized Minkowski spaces. In particular, we discuss here the infinitesimal-algebraic structure of the space-time rotations in such spaces. It is shown that the

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A geometrical meaning to the electron mass from breakdown of Lorentz invariance

Abstract

We discuss the problem of the electron mass in the framework of Deformed Special Relativity (DSR), a generalization of Special Relativity based on a deformed Minkowski space (*i.e.* a four-dimensional space-time with metric coefficients depending on the energy). We show that, by such a formalism, it is possible to derive the value of the electron mass from the space-time geometry via the experimental knowledge of the parameter of local Lorentz invariance breakdown, and of the Minkowskian threshold energy $E_{0,e.m.}$ for the electromagnetic interaction. We put forward the suggestion that mass generation can be related, in DSR, to the possible dependence of mass on the metric background (*relativity of mass*).

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H

July 26, 2006

Mr. K. K. Phua,
President
World Scientific Publishing
1060 Main Street, Suite 202
River Edghe, NJ 07661

Dear Mr. Phua,

I have been informed that you have published in 2004 the book authored by F. Cardone and R. Mignani entitled "Energy and Geometry, an Introduction to Deformed Special Relativity."

Regrettably, this book is a gross plagiarism and paternity fraud of my "isotopies of special relativity" first appeared in print in 1983 and then developed in numerous papers and books you can see in my CV http://www.i-b-r.org/Ruggero-Maria-Santilli.htm, including papers appeared in some of your Journals, all works I have copyrighted.

Please contact me as soon as possible to halt all sales, advertisement and promotion of this paternity fraud on a world wide basis, as well as to halt any and all additional publications by said authors without serious reviews. In the absence of any answer from you, I assume you intend to continue the sale, promotion and advertisement of this book and have to act accordingly.

Yours Truly

Dr. Ruggero Maria Santilli
acting pro se
35246 US 19 No. # 215
Palm harbor, FL 34684
tel. 727-934 9593

I1

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I2

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- Nonlinear Sciences (**nlin** new, recent, find)
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- some background blurb, including invited talk at UNESCO HQ (Paris, 21 Feb '96), update Sep '96
- some info on hypertex

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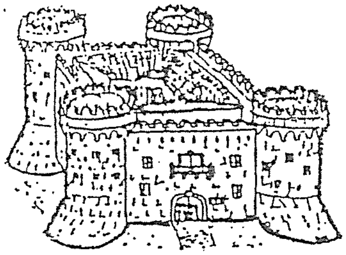
Contact

J1



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022-222-07

Professor David J. Skorton
President
Cornell University
Ithaca, NY 14853-6902

Dear Professor Skorton,

It is my duty to inform, you that on February 20, 2007, I have filed at the United Stated Federal Court lawsuit number 8:07-CV-00308-T-23MSS partially on grounds of papers hep-th/0505032, hep-th/0505088, hep-th/0505105, hep-th/0505116, hep-th/0505134, hep-th/0505137, hep-th/050529, accepted by your University for uploading in your arxiv. The complete lawsuit is available in the web sitehttp://www.scientificethics.org./Lawsuit-Cardone-Mignani.htm. A courtesy copy of the lawsuit is herewith enclosed.

Please note that Cornell University is quoted in paragraphs 118 and 129, but I have abstained from listing your University as a defendant. I have done this as a gesture of respect to you and to your difficult post, as well as in respect of the history and role of Cornell University in our Country and around the world.

HOWEVER, in response to this consideration, I need your personal and solicit intervention on the following requests:

1) Please terminate the internationally known and denounced, blatant discrimination by your University in uploading my papers in your archiv.

As documented in the messages herewith attached, I have been formally endorsed for listing my papers in the section hep-th as per your own rules by Professor V. Dvoeglazov, from Mexico, a fully qualified endorser with outstanding ethical and scientific statute, but your University continued to discriminate me against your own formally announced rules and continue to restrict the listing of my papers in the section of "general physics" internationally known to be reserved to outcasts and the like.

Additionally, the last paper endorsed by Professor Dvoeglazov has had been formally approved for publication by a refereed journal (in which I am not an editor) following the review by Professor Larry Horwitz, from Israel, another scientist of outstanding ethical

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and scientific stature. Yet, your University has confirmed the discrimination and restricted the uploading of my papers to a marginal listing to such an extreme to be quite offensive toward distinguished scientists such as Professors Dvoeglazov, Horwitz and others.

This case is rendered more serious, as your attorneys can clarify for you, by the fact that, while my papers are so blatantly discriminated, your University has accepted with an incredible easiness the uploading in hep-th of papers (in essentially the same topics as mine) hep-th/0505032, hep-th/0505088, hep-th/0505105, hep-th/0505116, hep-th/0505134, hep-th/0505137, hep-th/050529 that are so catastrophically inconsistent to have motivated the above quoted lawsuit for fraud, deception, abuse of public funds and other charges. The attached lawsuit is fully self-sufficient for an understanding of the fraud, as I hope you can see for yourself particularly in view of the fact that the lawsuit has been ultimately filed also in protection of the increasingly cataclysmic climactic events whose orderly study is severely disrupted by so manifest misconducts by your University.

In any case, not to be vane, but I am a senior, 72 years old, American physicist, formerly from the Department of Mathematics of Harvard University under five grants from the DOE, with considerable scientific achievements and a large international reputation (see my attached CV). In particular, I have received several honors, including various gold medals for scientific merits, the nomination by the Estonia Academy of Sciences among the most illustrious applied mathematicians of all times, and various nominations for a Nobel Prize in physics (for the discovery of the covering of quantum mechanics known as *Hadronic Mechanics* needed to predict and treat quantitatively new clean energies) and chemistry (for the discovery of the new chemical species of "Santilli magnecules" as predicted by *Hadronic Chemistry* and now under large industrial development).

Hence, your University as no arguments in discriminating against the proper uploading of my papers in conformity with your own publicly released rules. The only credible explanation is the occurrence of some open or covert conspiracy at your University so manifestly damaging the image of Cornell University around the world. I hope these documented facts illustrate the need for your personal and rapid intervention.

2. Remove immediately from your arxiv all the above quoted papers by defendants Fabio Cardone and Roberto Mignani.

This is necessary in the interest of your University, NOT because of my lawsuit, but because it is known internationally that these papers are catastrophically inconsistent, since they verify the well known *Theorems of Catastrophic Mathematical and Physical Inconsistencies of Noncanonical and Nonunitary Theories.* published by refereed journals in various countries, some of the papers being written by the same defendants. The knowledge by international observers that Cornell University lists in your arxiv papers that are known to be catastrophically inconsistent while discriminating on other that address and solve said catastrophic inconsistencies, such as my rejected paper, illustrates again - I hope - the need for your personal and rapid intervention.

J3 E-15

Allow me to suggest that you acquire a personal knowledge of these theorems of catastrophic inconsistencies and make sure that no paper under public support is released by your University following this notification without quoting and resolving said inconsistencies theorems because that may mandate responsible scientists to file lawsuits.

3. List as soon as possible the names of the managers of your arxiv in the very top of the web site http://www.arxiv.org/.

To begin, the current anonymous conduct of the arxiv by your University gives the idea of some scientific version of old outlaw conspiracies such as that of "La Mano Nera" and; it is manifestly undemocratic; and it invites abuses by your hidden manipulators , while causing so blatant a damage to the image of Cornell University throughout the world.

Additionally, my attorneys recommend that you consult your personal counsel, as well as the formal counsel of Cornell University on this latter issue. As a result of the current entirely anonymous conduct of your arxiv, and in view of extreme manipulations of very qualified scientific knowledge for personal gains, as President you acquire a *personal responsibility,* in addition to the responsibility and liability acquired by Cornell University as an institution. When you add various threats of lawsuits I have heard of from scientists the world over for mistreatment by your University in your arxiv, I hope you understand the urgency of your action.

In summary, Cornell University can indeed continue the arxiv in a form that is valuable for international science at large as well as for Cornell University, BUT under the uncompromisable conditions of: carefully eliminating current incontrovertible misconducts for personal gains by your anonymous managers; implementing the existing excellent rules without discrimination or scientific corruption; and merely implement what the arxiv is expected to be, just an ARCHIVE of qualified papers for individual scientists to exchange ideas and comments and not a manipulated alternative to refereed journals.

Please understand that there are legal proceedings going on partially based on improper listing of papers at your arxiv. Consequently, it is essential that you act on the above requests 1), 2),) prior to the initiation of the Discovery Process expected by the middle of next month.

Since I know you are unaware of the above, please accept my sincere sentiments of sincere respect. If I can be of any assistant to help you in the above delicate tasks, please do not hesitate to call me,

Yours, ~~Truly~~

Ruggero Maria Santilli
U. S. Citizen acting pro se.

K1

CRIMINAL PROCEEDINGS
FILED ON SEPT. 10, 1995, AT THE TRIBUNALE IN ROME, ITALY,
AGAINST
ROBERTO MIGNANI AND FABIO CARDONE, FIRST UNIVERSITY OF ROME, ITALY
FOR SCIENTIFIC PLAGIARISM, FRAUD, AND DECEPTION
FOLLOWING REPEATED REFUSAL FOR CORRECTIVE MEASURES

NOTE: As of today May 12, 2005, no communication has been received by the Plaintiff from the Criminal Court in Rome, Italy, following the filing of the Complaint reproduced below in September 1995. The Plaintiff has received today May 12, 2005, reliable independent information that the below reproduced complaint has been dismissed by the Rome Tribunal but without ever consulting or sending any communication to the Plaintiff, thus setting up the pre-requisites for a possion abuse of judicial processes and other criminal violation of the law. Consequently, an investigative agency has been hired to identify and document said possible judicial misconducts at the Rome Tribunal as well as to identify the name(s) of the responsible magistrate(s). In the event said misconducts are confirmed and documented, prosecutions will be filed in U.S. Criminal Court against the responmsible magistrate(s) from the Rome Tribunal. All communications pertaining to this case can se sent to the Plaintiff, Prof. R. M. Santilli, P. O. Box 1577, Palm Harbor, FL 34682, U.S.A, e-mail"Prof. R. M. Santilli" .

AL PROCURATORE DELLA REPUBBLICA PRESSO IL TRIBUNALE PENALE DI ROMA
Piazzale Clodio, 00100 Roma

AL PROCURATORE DELLA REPUBBLICA,
c/o CORTE REGIONALE DEI CONTI
Via Viamonti Antonio 25, 00100 Roma

AL MINISTRO DELLA UNIVERSITA' E DELLA RICERCA SCIENTIFICA E TECNOLOGICA (MURST), Piazzale Kennedy 20, 00144 Roma-Eur

AL RETTORE DELLA UNIVERSITA' GREGORIANA
Piazza della Pilotta 4, 00187-Roma

AL RETTORE DELLA III UNIVERSITA' DI ROMA
Via C. Segre 2, 00146 Roma

AL RETTORE DELLA I UNIVERSITA' DI ROMA "LA SAPIENZA"
Piazzale Aldo Moro, 00185 Roma

AL PRESIDENTE DEL CONSIGLIO NAZIONALE DELLE RICERCHE (CNR) Piazzale Aldo Moro, 00185-Roma AL DIRETTORE DELL'ISTITUTO NAZIONALE DI FISICA NUCLEARE (INFN)
Sezione di Roma I, Dipartimento di Fisica, I Universita' la Sapienza
Piazzale Aldo Moro, 00185 Roma

AL DIRETTORE RESPONSABILE DELLA RIVISTA "SYNTHESIS"
Di Rienzo Editore, Viale Manzoni 59, 00185 Roma

OGGETTO: Denuncia-querela per plagio scientifico e diffamazione perpetrati dal fisico italiano Prof. FABIO CARDONE della Universita' Gregoriana di Roma e dal fisico italiano Prof. ROBERTO MIGNANI della I e III Universita' di Roma contro il sottoscritto fisico italo-americano Prof. RUGGERO MARIA SANTILLI. Truffa aggravata di danaro pubblico perpetrata dagli stessi Professori Cardone e Mignani e danno erariale conseguenziale. Richiesta alle autorita' competenti di bloccare qualunque ulteriore erogazione di danaro pubblico e di

COMPLAINT MAILED UNDER EYEWITNESSES TO INFN, CRR, URS, etc

recuperare quello illecitamente speso. K2

Sono il Prof. RUGGERO MARIA SANTILLI, nato a Capracotta, Provincia di Isernia, l'8 settembre 1935, laureato in fisica presso l'Universita' di Napoli, con la specializzazione in fisica teorica conseguita presso l'Universita' di Torino, emigrato negli Stati Uniti d'America nell'agosto 1967, divenuto cittadino degli Stati Uniti nel giugno 1985, con indirizzo negli Stati Uniti: P. O. Box 1577, Palm Harbor, FL 34682, U.S.A. fax 001-813-934 9275, che elegge come domicilio ai fini del presente procedimento quello dell'Avv. DE VIVO UGO, Via umbria, 86170 Isernia, tel. 0865451425.

Il sottoscritto e' stato vittima di plagio e truffa scientifica aggravata da parte degli imputati Professori F. Cardone e Roberto Mignani come descritti in dettaglio nella qui seguente DOCUMENTAZIONE DI PLAGIO, TRUFFA E DISONESTA' SCIENTIFICA DEGLI IMPUTATI PROFESSORI FABIO CARDONE E ROBERTO MIGNANI, e relativa documenta-zione preliminare presentata negli acclusi Allegati.

TANTO PREMESSO, il sottoscritto Prof. Ruggero Maria Santilli formula al Signor Procuratore della Repubblica le seguenti richieste di istruttoria e di incriminazione:

1) Richiesta di sequestro di documenti ai fini di acquisire la piena prova documentale dei plagi scientifici e della conseguenziale diffamazione scientifica ai miai danni. Chiedo pertanto di disporre il sequestro di quanto segue:

a) Sequestro presso il Ministero della Ricerca Scientifica (MURST), Piazzale Kennedy 20, Roma, Ufficio di Gabinetto del Ministro del fascicolo inerente all'accusa di plagio da me fatta contro i Professori Roberto Mignani e Fabio Cardone; il predetto fascicolo probabilmente contiene l'interrogazione parlamentare n. 3-00691 (Allegato XXIV), la mia risposta indirizzata al Ministro Salvini datata 4 luglio 1995 (Allegato XXV), oltre che possibili accertamenti sul plagio in questione;

b) Il sequestro delle comunicazioni scientifiche scritte dagli imputati sin dal 1992 presso l'Universita' Gregoriana, Piazza della Pilotta 4, Roma; presso il Dipartimento di Fisica Amaldi della III Universita' di Roma,Via C. Segre 2; presso il Dipartimento di Fisica Marconi della I Universita' di Roma, Piazzale Aldo Moro; presso il Consiglio Nazionale delle Ricerche, Piazzale Aldo Moro, Roma; e presso l'INFN Sezione I Universita' di Roma, Piazzale Aldo Moro, ivi incluso il sequestro delle comunicazioni portanti i titoli seguenti in cui e' stato documentato il plagio e che quindi costituiscono corpo di reato (vedere anche allegati X, XI, XIV, XV, XVI per la loro identificazione):

> "A nonlocal approach to Bose-Einstein correlation" (comunicazione ufficiale n. 894 dell'8 luglio 1992 del Dipartimento di Fisica e della Sezione INFN della I Univerista' di Roma, Allegato XI),

> "On a nonlocal relativistic kinematics" (comunicazione non datata, prersumibilmente apparsa nell'autunno 1992 e rilasciata come comunicazione ufficiale della Universita' Gregoriana, del Dipartimento di Fisica e della Sezione INFN della I Universita' di Roma, Allegato XI);

> "Relativita' e nonlocalita' " (articolo pubblicato nel numero di settembre-dicembre 1993 della rivista "Syntrhesis" dell'editore Di Rienzo, Viale Manzoni 59, Roma,, Allegato XIV);

> "Special relativity in a deformed Minkowski space" (comunicazione non-datata, presumibilmente apparsa nell'autunno del 1994 e rilasciata come comunicazione ufficiale della Universita' Gregoriana, del Consiglio Nazionale delle Ricerche, dei Dipartimenti di Fisica della III e I Universita' di Roma e della Sezione INFN della I Universita' di Roma, Allegato XV); e

> "Description of fundamental Interactions by energy-dependent metric" (comunicazione non-datata, presumibilmente apparsa verso la fine del 1994 e rilasciata come comunicazione ufficiale della Universita' Gregoriana di Roma del Consiglio Nazionale delle Ricerche, dei Dipartimenti di Fisica della III e I Universita' di Roma e della Sezione INFN della I Universita' di Roma);

Si richiede inoltre il sequestro presso le cinque Istituzioni su indicate degli incartamenti conncernenti gli accertamenti scientifico-amministrativi da parte dei direttori delle suddette Istituzioni sulla mia accusa di plagio formulata per iscritto sin dall'autunno 1992;

c) Sequestro delle domande che ritengo essere state presentate dagli imputati Professori R. Mignani e

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F. Cardone per ottenere fondi di ricerca sull'argomento oggetto del plagio scientifico (isotopie della relativita' ristretta con relative isotopie dello spazio di Minkowski e della simmetria di Lorentz) presso l'Universita' Gregoriana, Piazza della Pilotta 4, Roma; presso il Dipartimento di Fisica Amaldi della III Universita' di Roma, Via C. Segre 2; presso il Dipartimento di Fisica Marconi della I Universita' di Roma, Piazzale Aldo Moro; presso il Consiglio Nazionale delle Ricerche, Piazzale Aldo Moro, Roma; e presso l'INFN Sezione I Universita' di Roma, Piazzale Aldo Moro, Roma.

Chiarisco in punto di diritto che chi fa falsamente apparire come propria una teoria scientifica ed utilizza tale falso assunto come fondamento per una richiesta di fondi per ricerca ottiene indebitamente fondi che la p.a. non erogherebbe qualora fosse consapevole del plagio. In altri termini, avvalersi del plagio per ottenere fondi costituisce ipotesi di truffa aggravata ai danni di ente pubblico ai sensi degli artt. 640-bis e 61 n. 7 del c.p.

Evidenza sufficiente di tale truffa aggravata e' data dal fatto che tutte le spese di battitura, duplicazione e stampa delle comunicazioni scientifiche oggetto di plagio sono state pagate mediante denaro pubblico, come e' d'uso nelle comunicazioni scientifiche in genere. La seconda evidenza e' che dette comunicazioni scientifiche plagiaristiche sono gia' registrate in molte biblioteche di centri di ricerca sparsi per il mondo, confermando cosi' l'esistemza della loro distribuzione al di la' di dubbi credibili. La sola evidenza addizionale che rimane da accertare e' l'ammontare di fondi pubblici ricevuti dagli imputati sin dal 1992 per la conduzione delle ricerche che sono risultate nel plagio scientifico. In altre parole, l'uso improprio gia' avvenuto di fondi pubblici e' al di la' di dubbi credibili. Solo il loro ammontare e' oggetto di indagine.

Naturalmente una indebita erogazione di pubblico denaro costituisce anche danno all'Erario pubblico la cui repressione interessa anche la Procura Regionale della Corte dei Conti a Roma.

d) Sequestro presso l'Editore Di Rienzo in Viale Manzoni 59, 00185 Roma, di tutto l'incartamento riguardante l'articolo scritto dall'imputato Prof. R. Mignani, intitolato "Relativita' e nonlocalita' " e pubblicato nella rivista "Synthesis" nel numero Settembre-Dicembre 1993. In aggiunta alla corrispondenza relativa tra l'editore e l'imputato, l'incartamento dovrebbe contenere anche la richiesta del mio avvocato americato per la pubblicazione di una correzione del plagio, oltre che eventuali lettere di accettazione della comunmicazione da parte degli editori della rivista.

e) Sequestro presso le residenze personali degli imputati, il Prof. Roberto Mignani residente a via Giacomo de Benmedetti, 59, 00144 Roma-EUR , ed il Prof. Fabio Cardone residente a Via Portonaccio 200, 00100 Roma ed a Via Pola 51B, 67039 Sulmona (Aquila), delle comunicazioni scientifiche e di tutto l'incartamento relativo:

> "A nonlocal approach to Bose-Einstein correlation" (comunicazione ufficiale n. 894 dell'8 luglio 1992 del Dipartimento di Fisica e della Sezione INFN della I Univerista' di Roma, Allegato XI),

> "On a nonlocal relativistic kinematics" (comunicazione non datata, prersumibilmente apparsa nell'autunno 1992 e rilasciata come comunicazione ufficiale della Universita' Gregoriana, del Dipartimento di Fisica e della Sezione INFN della I Universita' di Roma, Allegato XI);

> "Special relativity in a deformed Minkowski space" (comunicazione non-datata, presumibilmente apparsa nell'autunno del 1994 e rilasciata come comunicazione ufficiale della Universita' Gregoriana, del Consiglio Nazionale delle Ricerche, dei Dipartimenti di Fisica della III e I Universita' di Roma e della Sezione INFN della I Universita' di Roma, Allegato XV); e

> "Description of fundamental Interactions by energy-dependent metric" (comunicazione non-datata, presumibilmente apparsa verso la fine del 1994 e rilasciata come comunicazione ufficiale della Universita' Gregoriana di Roma del Consiglio Nazionale delle Ricerche, dei Dipartimenti di Fisica della III e I Universita' di Roma e della Sezione INFN della I Universita' di Roma); affinche' se ne impedisca la loro pubblicazione presso qualunque rivista o giornale scientifico, sia esso convenzionale o elettronico. La procedure d'urgenza di questo sequestro e' invocata a causa nella necessita' di una rapidita' d'azione.

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2) Incriminazione, sempre che ne sussistano i presupposti, dei Professori Roberto Mignani e Fabio Cardone per i reati seguenti:

a) Reato p.a.p. dagli artt. 81 e 110 c.p. e 171 comma 1o lettere a) e c) e comma 2o legge 22 aprile 1941 n. 633 sul diritto d'autore per aver, in esecuzione della medesima risoluzione antigiuridica, riprodotto, diffuso e posto in circolazione una serie di pubblicazioni a stampa riproducente in maniera letterale, parola per parola, formula per formula e simbolo per simbolo le teorie sulle isotopie della relativita' speciale, dello spazio di Minkowski e della simmetria di Lorentz enunciate dal Prof. Ruggero Maria Santilli mediante pubblicazione in riviste scientifiche internazionali sin dal 1983 e di cui i suindicati Professori Roberto Mignani e Fabio Cardone avevano preso sicuramente preventiva conoscenza, come dimostrato dal fatto che essi stessi ne avevavo accusato conoscenza in pubblicazioni scientifiche scritte prima del 1992 ed erano stati i revisori delle bozze delle monografie scientifiche del Prof. Santilli intitolate "Isotopic Generalization of Galilei's and Einstein's Relativities", Volumi I e II pubblicate negli Stati Uniti d'America nel 1991, le quali contenevano appunto le su-indicate teorie scientifiche; plagio scientifico espresso dagli imputati nelle comumicazioni scientifiche intitolate:

> "A nonlocal approach to Bose-Einstein correlation" (comunicazione ufficiale n. 894 dell'8 luglio 1992 del Dipartimento di Fisica e della Sezione INFN della I Univerista' di Roma, Allegato XI),

> "On a nonlocal relativistic kinematics" (comunicazione non datata, prersumibilmente apparsa nell'autunno 1992 e rilasciata come comunicazione ufficiale della Universita' Gregoriana, del Dipartimento di Fisica e della Sezione INFN della I Universita' di Roma, Allegato XI);

> "Relativita' e nonlocalita' " (articolo pubblicato nel numero di november-dicembre 1993 della rivista "Synthesis" dell'editore Di Rienzo, Viale Manzoni 59, Roma,, Allegato XIV);

> "Special relativity in a deformed Minkowski space" (comunicazione non-datata, presumibilmente apparsa nell'autunno del 1994 e rilasciata come comunicazione ufficiale della Universita' Gregoriana, del Consiglio Nazionale delle Ricerche, dei Dipartimenti di Fisica della III e I Universita' di Roma e della Sezione INFN della I Universita' di Roma, Allegato XV); e

> "Description of fundamental Interactions by energy-dependent metric" (comunicazione non-datata, presumibilmente apparsa verso la fine del 1994 e rilasciata come comunicazione ufficiale della Universita' Gregoriana di Roma del Consiglio Nazionale delle Ricerche, dei Dipartimenti di Fisica della III e I Universita' di Roma e della Sezione INFN della I Universita' di Roma); diffuse come comunicazioni scientifiche ufficiali delle su-indicate Istituzioni; con l'aggravante della usurpazione della paternita' scientifica delle su-indicate teorie e della conseguente offesa alla reputazione del Prof. Ruggero Maria Santili che appariva cosi', di fronte alla comunita' scientifica, non piu' come autore delle teorie scientifiche, bensi' come propalatore di teorie altrui ed al limite come autore millantato delle stesse; in Roma ed altrove, presumibilmente dal luglio del 1992 in poi.

b) Reato p.a.p. artt. 81, 110 e 595 c.p. perche' in concorso tra loro ed in esecuzione della stessa ideazione antigiuridica mediante le condotte indicate sub a) offendevano la reputazione del Professor Ruggero Maria Santilli diffondendo nella comunita' scientifica italiana ed internazionale comunicazioni scientifiche in cui si arrogavano la qualita' di veri autori delle stesse teorie scientifiche facendo in tal modo apparire il Prof. Santilli come un millantatore delle teorie su-indicate in tal modo danneggiandone gravemente il credito scientifico e prestigio nella comunita' italiana ed internazionale; con l'aggravante di aver commesso il fatto con utilizzazione di mezzi di pubblicita' quali le comunicazioni scientifiche suddette, nonche' col mezzo della stampa, giacche' gli imputati utilizzavano mezzi di riproduzione meccanica per le loro comunicazioni; con l'ulteriore aggravante della implicita attribuzione al Prof. Santilli del fatto determinato di appropriazione delle teorie scientifiche che gli imputati falsamente presentavano come proprie; in Roma ed altrove presumibilmente dal luglio 1992 in poi.

c) Reato p.a.p. degli artt. 1210, 81 e 640-bis c.p. perche' in concorso tra loro ed in esecuzione del medesimo disegno antigiuridico falsamente attribuendo a se stessi la paternita' delle teorie scientifiche chiamate isotopie della relativita' ristretta, degli spazi Minkowskiani e delle simmetrie di Lorentz, che essi invece, ben sapendo appartenere al Prof. Ruggero Maria Santilli, presentando istanze o altrimenti sollecitando la erogazione di fondi per la ricerca scientifica almeno da parte dell'Istituto Nazionale di Fisica Nucleare e del Consiglio Nazionale delle Ricerche, procuravano a se stessi ingiusto profitto, nonche' della pubblicazione con pubblico denaro delle proprie comunicazioni scientifiche oggetto di plagio ed altri benefici accademici; vantaggi che non sarebbero stati conseguiti ove fosse stata palesata la vera paternita' delle teorie stesse da parte del Prof. Santilli e non di loro stessi; con danno ingiusto per l'Universita' Gregoriana, la III e I Universita' di Roma, per l'INFN, per il CNR, e per il Ministero della

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Ricerca,o almeno per taluni dei predetti Enti pubblici; in Roma ed altrove presumibilmente dal luglio 1992 in poi.

3) Al Signor Procuratore Regionale presso la Corte dei Conti di Roma chiedo di voler iniziare procedimenti per responsabilita' contabile. Specifico che le erogazioni di pubblico danaro indebitamente percepite attraverso plagio scientifico di teorie e scoperte dello scrivente Prof. Ruggero Maria Santilli sono da considerarsi illecite. Infatti, se fosse stato rivelato che autore delle teorie scientifiche era il Prof. Santilli e non i Professori R. Mignani e F. Cardone, e' evidente che i fondi per ricerche scientifiche e gli altri vantaggi di tipo accademico non sarebbero stati concessi da parte delle Universita', da parte del CNR, da parte dell'INFN o perlomeno taluni di tali Enti.

4) Al Signor Ministro delle Ricerca Scientifica, ai Magnifici Rettori della Universita' Gregoriana, della III e della I Universita' di Roma, al Presidente del Consiglio Nazionale delle Ricerche ed al Direttore dell'INFN presso il Dipartimento di Fisica della I Universita' di Roma, si chiede di attivarsi per il blocco immediato di qualunque ultreriore somma di denaro pubblico ed il recupero di tutti i fondi erogati sulla falsa prospettazione da parte dei Professori R. Mignani e F. Cardone di essere i veri autori delle isotopie della relativita' ristretta, dello spazio di Minkowski e della simmetria di Lorentz che in realta' erano state scoperte ed elaborate nei necessari dettagli dal Prof. Ruggero Maria Santilli sin dal 1983. E' da ribadire i fatti che quei finanziamenti non sarebbero stati concessi in relazione a plagi scientifici, tanto piu' che per principio generale di diritto il danaro pubblico non puo' essere erogato per favorire attivita' illecite ovvero conseguenti ad illeciti quali sono certamente i plagi scientifici. E' da soggiungere che sono pure da recuperare eventuali altri vantaggi di tipo accademico e non elargiti sulla base della usurpazione della paternita' di teorie scientifiche scoperte ed elaborate dal Prof. R. M. Santilli.

DOCUMENTAZIONE DEL PLAGIO, TRUFFA E DISONESTA' SCIENTIFICA DEGLI IMLPUTATI PROFESSORI F. CARDONE E ROBERTO MIGNANI

PREMESSA SCIENTIFICA. Il sottoscritto e' l'autore di varie teorie scientifiche nel settore della matematica e fisica ed in particolare della cosiddette isotopie (chiamate anche sollevamenti o generalizzazioni isotopiche) della relativita' speciale di Einstein, dello spazio Minkowskiano e della simmetria di Lorentz, ed altri avanzamenti scientifici. La relativita' ristretta, con relativo spazio di Minkowski e la simmetria di Lorentz, e' esattamente valida per le condizioni fisiche identificate da Einstein, ossia per particelle - oppure corpi - che si possono effettivamente approssimare come puntiformi in moto nel vuoto sotto forze agenti a distanza (e.g., una satellite in orbita stabile nel vuoto attorno alla Terra, oppure un elettrone in orbita attorno ad un nucleo in una struttura atomica), mentre la mia relativita' isotopica si applica per particelle estese - o corpi estesi - in moto nell'interno di mezzi fisici sotto l'azione di forze a distanza oltre che forze resistive di contatto (e.g., lo stesso satellite ma in fase di rientro nell'atmosfera terrestre oppure lo stesso elettrone quando immerso nel centro di una stella). In queste ultime condizioni non si puo' dire che la relativita' di Einstein e' violata, ma semplicemente inapplicabile perche' Einstein non concepi' la sua teoria per le stesse. La mia relativita' ristretta isotopica e' stata invece costruita specificatamente per le ultime condizioni fisiche sotto la condizione di ammettere la relativita' speciale di Einstein come caso particolare non appena le particelle - oppure corpi - ritornano a muoversi nel vuoto. Mentre la relativita' speciale e' unica perche' il vuoto e' unico e tale e' la sua rappresentazione mediante lo spazio di Minkowski, la mia relativita' isotopica e' costituita da un numero infinito di realizzazioni diverse come condizione necessaria per la rappresentazione delle infinite possibilita' di mezzi fisici.

In termini tecnici, la unicita' della relativita' ristretta e' caratterizzata dalla unicita' della rappresentazione Minkowskiana dello spazio-tempo mediante una metrica unica costituita da una matrice diagonale m a quattro dimensioni con elementi diagonali (+1, +1, +1, -1). Al contrario, le infinite possibilita' di realizzazioni della mia relativita' ristretta isotopica sono rappresentate dal fatto che gli spazi iso-Minkowskian sono caratterizzati da tutte le infinite possibilita' di metriche generalizzate mþ sotto la condizione di ammettere la metrica Minkowskiana m come caso particolare. Caratterizzai originariamente questa infinita' di possibili realizzazioni mediante la relazione mþ = Tm dove T e' una matrice a quattro

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dimensioni completamente arbitraria ad eccezione della condizione di essere non-singolare e quindi invertibile. Una famiglia di casi particolari della mia relativita' ristretta isotopica e' caratterizzata da infinite realizzazioni diagonali della matrice T che puo' allora essere scritta come una matrice 4x4 con tutti gli elementi data da 0 eccetto gli elementi diagonali che io originariamente scrissi [b12, b22, b32, b42] oppure [n1-2, n2-2, n3-2, n4-2], dove le quantita' b = 1/n sono funzioni arbitrarie non-nulle delle caratteristiche fisiche del problema interno considerato, come coordinate, velocita' (e quindi energia), densita', ecc.

Per avere un'idea delle applicazioni della mia relativita' ristretta speciale si ricorda che l'assioma di base della relativita' di Einstein, la nota costanza universale della velocita' della luce, e' una astrazione filosofica perche' nella realta' la velocita' delle onde elettromagnetiche dipende dalle caratteristiche del mezzo in cui si propagano. Per esempio, le onde elettromagnetiche che si propagano nella nostra atmosfera hanno una velocita' dipendente dalla densita' dell'atmospfera per poi assumere valori diversi quando si propagano in altri mezzi trasparenti come vetro, acqua, ecc. Ne consegue che la relativita' ristetta di Einstein e' solo capace di descrivere la velocita' della luce nel vuoto co, mentre la mia relativita' ristretta isotopica puo' descrivere tutte le possibili velocita' delle onde elettromagnetiche in mezzi fisici che sono date dalla nota legge c = cob4 = co/n4, dove n4 e' l'indice di rifrazione con dipendenza appunto della densita' ed altre caratteristiche. Quando le onde elettromagnetiche ritornano a propagarsi nel vuoto, b = n = 1 ri-ottenendo cosi' la relativita' di Einstein identicamente. Al di la' di questa semplice applicazione, la mia relativita' ristretta isotopica ha applicazioni in fisica classica, fisica nucleare, fisica particellare, astrofisica, superconduttivita' ed altre discipline.

Una caratteristica unica della mia relativita' ristretta isotopica e delle relative isotopie dello spazio di Minkowski (che io chiamai originalmente spazi iso-Minkowskiani) e le isotopie della simmetria di Lorentz (che io chiamaisimmetries iso-Lorentziane) caratteristica che le distinguono da qualunque altra generalizzazione - e' di essere basata su una unita' generalizzata dello spazio-tempo data da Iþ = T-1, mentre tutte le altre teorie, incluso la relativita' ristretta di Einstein, sono basate sulla unita' spazio-temporale I = matrice diagonale (+1, +1, +1, +1). Questa caratteristica permette l'identificazione di possibili plagi scientifici in maniera semplicemente incontrovertibile. Infatti, pubblicazioni basate solo sulla generalizzazione della metrica di Minkowski mþ = Tm in cui l'unita' e' convenzionale, I = matrice diagonale (+1,+1,+1,+1), non possono assolutamente essere oggetto di plagio delle mia teorie perche' esse costituiscono teorie diverse sia sul piano matematico che fisico. Il sottoscritto non ha quindi nessuna rivendicazione scientifica di nessuna natura su queste ultime teorie. Al contrario, l'uso delle metriche deformate mþ = TM congiuntamente con l'uso della unita' generalizzata Iþ = T-1, senza la citazione adeguata delle mie pubblicazioni in cui questa teoria fu originariamente scopartaper la prima volta (vedere lista qui di seguito) costituisce chiaro plagio, truffa e disonesta' scientifica quando perpetrata nella consapevolezza documentata di dette pubblicazioni originali. Le mie rivendicazioni sono quindi specificatamente ristrette a teorie scientifiche basate sulle generalizzazioni congiunte delle metriche m ä mþ = Tm e della unita' I ä Iþ = T-1, che e' esattamente il caso considerato in questa Denuncia-Querela contro gli imputati Professori F. Cardone e R. Mignani. Il sottoscritto inoltre rivendica la paternita' elle isotopie di tutti gli altri spazi metrici e relative teorie, come gli spazi Euclidei o quelli Riemanniani.

La deformazione della metrica Minkowskiana m ä mþ = Tm mentre l'unita' e' congiuntamente deformata di una misura inversa, I ä Iþ = T-1, implica l'addizionale caratteristica unica che tutti i possibili spazi iso-Minkowskiani sono isomorfi allo spazio Minkowskiano convenzionale, e la stessa cosa accade per le simmetrie di iso-Lorentz e quella convenzionale di Lorentz (per esempio, dato un bastone misurante 10 centimetri rispetto all'unita' 1 centimetro, se detto bastone viene allungato del doppio mentre l'unita' e' anche rappoppiata, la lunghezza reale rimane la stessa). Questa proprieta' matematica ha la conseguenza fisica fondamentale che gli assiomi di Einstein sono preservati al livello astratto da tutte le possibili isotopie, implicando cosi' una sola serie di leggi fisiche astratte con la realizzazione Einsteiniana per particelle puntiformi nel vuoto ed un numero infinito di realizzazioni piu' generali ti tipo nonlineare, nonlocale e noncanonico per particelle estese in mezzi fisici. Quando la

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metrica e' deformata, m äs mþ = Tm, mantenendo l'unita' originale I = diagonale (+1,+1,+1,+1), il nuovo spazio-tempo non e' piu' in genere isomorfo a quello originario di Minkowski. Ne consegue allora che la teoria risultante e' fisicamente diversa da quella di Einstein. Il sottoscritto non ha alcuna rivendicazione di alcun tipo rispetto a queste ultime teorie, mentre rivendica la priorita' scientifica assoluta e documentata di tutte le teorie isotopiche, dove il termine "isotopico" e' precisamente quello del suo significato greco di preservare gli assiomi generali sebbene al livello astratto.

Rivendico inoltre le isotopie delle rimanenti relativita' di Galileo, per moti interni a velocita' basse, e della relativita' generale di Einstein, per lo studio dei problemi gravitazionali interni, che anche io scoprii per la prima volta e studiai in tutti i dettagli teorici in una varieta' di pubblicazioni attraverso i decenni, alcune delle quali sono identificate qui di sotto.

Da notare che io rivendico la paternita' solo delle teorie isotopiche ed, essendo un fisico teorico-matematico, non ho alcuna rivendicazione sulle applicazioni e verifiche sperimentali delle mie relativita' iso-Galileane ed iso-Einsteiniane speciale e generale.

Tenendo presente che la finalizione degli studi qui considerati richiedera' la partecipazione della comunita' scientifica in generale per un periodo di tempo prevedibilmente protratto, la mia relativita' ristretta isotopica e' stata oggi verificata da vari scienziati nella fisica classica, fisica nucleare, fisica particellare, astrofgisica, cosmologia, superconduttivita' ed altre discipline. In tutti questi case la teoria speciale o generale di Einstein non e' in grado di rappresentare i dati sperimentali interni perche' non concepita per essi, mentre le mie teorie isotopiche sono state in grado di rappresentare tutti i dati sperimentali noti al momento.

E' infine da notare che, a seguito degli studi condotti durante tutto questo secolo da centinaia di migliaia di fisici, le teorie Einsteiniane hanno esaurito tutta le loro capacita' di predire scoperte veramente nuove. Al contrario, le mie nuove relativita' isotopiche permettono previsioni fondamentalmente nuove ed ancora sostanzialmente inesplorate. L'esempio lampante e' dato dal fatto che l'assunzione delle teorie Einsteiniane implica l'assenza di nuove sorgenti di energie, l'impossibilita' del riciclaggio delle scorie nucleari con grandissima vita radioattiva in forme radioattive con vita molto piu' breve, ecc., mentre l'uso delle mie relativita' isotopiche permette la previsione di sorgenti energetiche fondamentalmente nuove a livello subnucleare, la posibilita' di riciclaggio delle scorie nucleari in forme a vita molto breve, ed altre applicazioni pratiche nuove che sono gia' state oggetto di domande di bretto in paesi sviluppati.

Ricordando che le grandi somme di danaro pubblico spesi oggi nelle ricerche fisico-matematiche in Italia ed all'estero sono sostanzialmente basate sulla relativita' ristretta di Einstein, le suddette considerazioni sono importanti per indicare che la mia generalizzazione isotopica della relativita' di Einstein ha grandi implicazioni finanziarie, oltre che accademiche e di altro tipo, perche' offre la possibilita' di avere fondi di ricerche praticamente illimitati in molti settori applicativi, oltre che nuovi brevetti e tecnologie. La mia relativita' ristretta isotopica e' quindi oggetto di notevoli appetiti scientifici, accademici e finanziari. Per raggiungere una maturita' per lo meno preliminare, qualunque analysis di questa denuncia-querela contro fisici delle universita' romane deve necessariamente tenere di conto di tali appetiti.

Siccome la documentazione acclusa stabiliche la complicita' dei dirigenti di universita' romane al di la' di dubbi credibili, il sottoscritto spera di aver dimostrato che indagini su questa denuncia-querela dovrebbero essere estese dalle autorita' competenti penali e civili al di la' del suo ambito. Ad esempio, e' noto che migliaia di miliardi di danaro pubblico sono stati spesi in ricerche fisiche nel passato in Italia e continuano ad essere spesi oggi sotto la condfizione politica di verificare le teorie di Einstein ma per condizioni fisiche in cui le teorie stesse sono note da decenni di non essere valide e quindi di dare risultati essenzialmente sballate come le condizioni fisiche interne a livello classico, particellare e gravitazionale, risultando cosi' in uno sperpero di denaro pubblico di dimensioni veramente notevoli e certamente tali da richiedere tutta l'attenzione delle autorita' competenti penali e civili perche' perpetrato da accademici nella loro piena consapevolezza.

PUBBLICAZIONI SCIENTIFICHE NELLE ISOTOPIE DEL PROF. R.M.SANTILLI.

Il sottoscritto introdusse per la prima volta i metodi matematici isotopici nel 1978 quando, come fisico teorico, ebbe l'onore di essere membro del Dipartimento di Matematica della Universita' di Harvard a Cambridge nel Massachusetts con contratti col Governo degli Stati Uniti n. ER-78-S-02-47420.A000, AS02-78ERO4742, DE-AC02-80ER10651, DE-AC02-80ER10651-A001 e DE-AC02-80ER10651-A002.

Il sottoscritto pubblico' i risultati di questi studi fisico-matematici preliminari in vari articoli nella rivista ufficiale della Societa' Italiana di Fisica, Il Nuovo Cimento, nella rivista ufficiale della Societa' Americana di Fisica Physical Review D, ed altre riviste internazionali il cui elenco e' omesso per brevita'. Il sottoscritto pubblico' infine una presentazione generale di tali risultati matematico-fisici in due monografie stampate dalla prestigiosa casa editrice tedesca Springer-Verlag di Heidelberg nella loro serie piu' prestigiosa Text and Monographs in Physics, sotto il titolo di Fondamenti della Meccanica Teorica, Vol. I (pubblicato nel 1978) e Vol. II pubblicato nel 1982 (referenze [1,2] alla fine del testo di questa denuncia-querela). Il Capitolo 6 del Volume II, pagina 199 porta il titolo Generalizzazione della Relativita' di Galileo e presenta infatti le isotopie della relativita' di Galileo per la sua estensione dal moto di particelle - o corpi - nel vuoto, al moto in mezzi fisici. Queste isotopie della relatuivita' di Galileo furono evidentemente studiate e presentate come la base nonrelativistica delle isotopie delle teorie di Einstein.

Dopo aver completato gli studi Galileani, il sottoscritto passo' allo studio delle isotopie della relativita' ristretta che pubblico' per la prima volta nelle Lettere al Nuovo Cimento del 1983 (referenza [3]). Questa pubblicazione presenta per la prima volta tutte le possibili isotopie infinite dello spazio Minkowskiano, della simmetria di Lorentz e della relativita' speciale. In particolare, questa prima pubblicazione identifica tutte le leggi fisiche isotopiche, incluso la velocita' massima iso-causale, la somma iso-relativistica delle velocita', la contrazione iso-temporale e la dilatazione iso-spaziale, con la sola eccezione delle isotopie della formula di Dopper per l'iso-spostamento delle frequenze verso il rosso quando le onde elettromagnetiche si propagano in mezzi fisici trasparenti come la nostra atmosfera.

Negli anni seguenti il sottoscritto pubblico' una numero considerevole di articoli nel settore su-identificato la cui lista e' anche omessa per brevita'. Nel 1988 il sottoscritto pubblico' una memoria di circa 130 pagine (referenza [4]) contenente una presentazione generale della relativita' ristretta isotopica e delle strutture relative iso-Minkowskiane ed iso-Lorentziane. Quest'ultima memoria identifico' in dettaglio tutte le leggi fisiche isotopiche, incluso la legge iso-Doppler, oltre che a presentare una derivazione dettagliata degli spazi iso-Minkowskiani e delle simmetrie iso-Lorentziane.

Dopo detta memoria del 1988 il sottoscritto continuo' a pubblicare vari articoli addizionali sulla relativita' isotopica (la cui lista e' anche omessa per brevita', ma che e' contenuta nella bibliografia delle pubblicazioni qui elencate). Finalmente nel 1991 il sottoscritto rilascio' per la stampa due monografie su una presentazione generale delle isotopie delle relativita' di Galileo e di Einstein nelle loro versioni per sistemi classici-macroscopici sotto il titolo di Generalizzazione Isotopica delle Relativita' di Galilei ed Einstein, Vol.s I e II, 1991 (referenze [5.6]). Queste monografie contengono anche le isotopie della Relativita' Generale di Einstein identificata dal sottoscritto, incluso le isotopie degli spazi Riemanniani curvi. Queste monografie contengono anche una lista generale di tutte le pubbicazioni nel settore fino al 1991.

Dopo il 1991 il sottoscritto continuo' gli studi iniziati nel 1978 sulla versione quantistica delle stesse relativita' isotopiche pubblicando vari articoli in riviste tecniche, come ad esempio le referenze [7].Il sottoscritto pubblico' anche una presentazione generale della versione quantistica della relativita' ristretta isotopica in una memoria del 1992 (referenza [8]) che fu poi seguita da numerosi articoli addizionali in varie riviste.

Nel 1993-1994 il sottoscritto pubblico' infine due monografie sulla versione quantistica delle isotopie della relativita' convenzionali di Galileo e di Einstein con la prestigiosa Casa Editrice Naukova Dumka

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dell'Accademia delle Scienze dell'Ukraina sotto il titolo di Elementi della Meccanica Adronica, Volumi I (1993) e II (1994) (referenze [9,10]). Dette monografie contengono anche la lista di tutte le referenze nel settore conosciute all'autore al 1994.

Dopo la pubblicazione delle suddette monografie sulle isotopie quantistiche il sottoscritto ha continuato le ricerche nel settore pubblicando vari risultati e scoperte addizionali, incluso le generalizzazioni ulteriori delle teorie isotopiche per condizioni fisiche sempre piu' complesse chiamate dal sottoscritto di tipi genotopico ed iperstrutturale; vedasi per esempio, un articolo sula rivista ufficiale della Societa' di Fisica di Mosca in Russia che presenta la forma piu' recente della relativita' isotopica del sottoscritto, un articolo sulla rivista dei grandi laboratori Russi a Dubna su un aspetto della relativita' speciale isotopica (le isotopie della nozione di spin), tre articoli sulla rivista ufficiale della Societa' di Fisica Abdullah dell'India, tre articoli se una delle piu' importanti riviste tecniche dell'America del Sud, due articoli su un importante giornale tecnico della Cina, ed altri.

Congiuntamente con l'intensa attivita' di produzione scientifica indicata di sopra, il sottoscritto ha organizzato numerosi convegni scientifici per la discussione e diffusione delle sue isotopies e delle loro generalizzazioni. Tra questi si citano i cinque Workshops Internazionali sulle Formulazioni Lie-Ammissibili organizzate dal sottoscritto dal 1978 al 1982 quando era membro della Universita' di Harvard sotto contributo parziale del Governo degli Stati Uniti, la Prima Conferenza Internazionale sulle Formulazioni Lie-Ammissibili organizzata in collaborazione della Universita' di Orle~ans in Francia nel 1982, vari Workshops Internazionali sulla Meccanica Adronica iniziati nel 1982 anche con supporto finanziario parziale del Governo Statunitense (uno dei quali workshops fu condotto al Centro A. Volta nella Villa Olmo a Como con aiuti parziali della Universita' di Milano) ed altri. Questi congressi scientifici internazionali hanno implicato la pubblicazione di oltre venti volumi di atti la cui lista e' omessa per brevita'.

In aggiunta all'organizzazione di congressi scientifici, il sottoscritto e' stato invitato a partecipare a numerosi congressi scientifici internazionali, come la serie di Congressi Internazionali sulle Simmetrie di Dubna in Russia del 1993 e 1995, il Congressi Internazionale di Fisica fatto ad Oxford in Inghilterra nel 1993, il Congresso Internazionale sulla Gravitazione tenuto alla Universita' di Stanford, California nel 1994, il Congresso Internazionale sulla Superconduttivita' tenuto in Florida nel febbraio 1995, ed altri. In particolare il sottoscritto ha pubblicato articoli sulle isotopie, sulle loro applicazioni e sulle loro generalizzazioni negli atti di ciascuno di questi congressi.

In sommario, il sottoscritto Prof. Santilli ha pubblicato sulle isotopie sei monografie con case editrici prestigiose come la Springer-Verlag di Heidelberg in Germania oppure la Naukova Dumka dell'Accademia delle Scienze dell'Ukraina ed oltre cento articoli tecnici in riviste specializzate in numerosi paesi. A seguito di tale produzione scientifica originale, la paternita' del sottoscritto Prof. Santilli delle isotopie della relativita' ristretta, dello spazio di Minkowski e della simmetria di Lorentz e' stata riconosciuta ufficialmente in numerose pubblicazioni scientifiche indipendenti. Tra queste cita alcune monografie che portano il nome "Santilli" nel titolo la cui copertina e' riprodotta negli allegati (vedasi elenco degli allegati in seguito), come una monografia scritta da cinque scienziati dal titolo "Generalizzazione Lie-isotopica di Santilli dele Relativita' di Galileo e di Einstein", una monografia scritta da uno sciwnziato del Kazakstan dal titolo "Isotopie di Santilli della Algebre, Geometrie e Relativita' contemporanee", oppure una monografia scritta da due scienziati greci dal titolo "Fondamenti matematici della teoria di Lie-Santilli". Numerosi articoli sono anche stati pubblicati in varie riviste internazionali da vari scienziati con il chiaro riconoscimento della paternita' del Prof. Santilli delle teorie qui considerate. Tra questi ultimi cita solo un articolo dell'imputato Prof. R. Mignani scritto nel 1990 e riprodotto negli allegati, ma apparso nel 1992 nel quale si puo' vedere il chiaro riconoscimento da parte del Prof. Mignani della paternita' del Prof. Santilli della relativita' speciale isotopica sin dal sommario in cui si legge "Santilli's Lie-isotopic lifting of special relativity" (Sollevamento - inteso come generalizzazione - Lie-isotopico della relativita' speciale di Santilli), con numerose chiare conferme di paternita' da parte dell'imputato della patermita' del sottoscritto Prof. Santilli delle isotopie dello spazio Minkowskiano e della simmetria di Lortentz fatte nel testo dello stesso articolo, oltre che l'importante riconoscimento da parte dell'imputato della paterniota' del Prof. Santilli delle applicazioni delle isotopie

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ad interazioni nonlocali e ad una dipendenza arbitraria della metrica, paternita' successivamente non ammesse dall'imputato dall'imputrato stesso Prof. Mignani. Numerosi riconoscimenti scientifici di paternita' del Prof. Santilli delle teorie considerate da parte di altri scienziati sono omessi per brevita'.

Per brevita' il sottoscritto si limita ad includere i seguenti:
> Allegato I, contenente copie delle prime pagine delle monografie [1,2];
> Allegato II, riproducente per intero l'articolo [3] del 1983;
> Allegato III, riproducente sole le parti piu' salienti della memoria [4] del 1988;
> Allegato IV, riproducente le parti salienti delle due monografie [5,6] del 1991;
> Allegato V, riproducente le prime pagine di monografie portanti il nome "Santilli" nel titolo';
> Allegato VI, contenente commenti sulle scoperte matematico-fisiche del Prof. Santilli rilasciate ufficialmente dall'Accademia delle Scienze dell'Ukraina;
> Allegato VII, riproducente l'inclusione del Prof. Santilli in una lista dei massimi scienziati di tutti i tempi nella fisica matematica rilasciata dall'Accademia delle Scienze dell'Estonia (notare che il Prof. Santilli e' il solo italiano ad essere incluso nella lista); e
>Allegato VIII, riproducente la prima ed ultima pagina dell'articolo dell'imputato Prof. Mignani scritto nel 1990 con il chiaro riconoscimento della paternita' del Prof. Santilli delle isotopie della relativita' ristretta, dello spazio di Minkowski e della simmetria di Lorentz e della loro applicazione ad inrterazioni nonlocali con una dipendenza arbitraria della metrica.

**PUBBLICAZIONI SCIENTIFICHE NELLE ISOTOPIE DEGLI IMPUTATI PROFESSORI R. MIGNANI E F. CARDONE. **

Come ammesso da una commissione indipendente di studio identificata in seguito, gli imputati Professori FABIO CARDONE e ROBERTO MIGNANI non hanno pubblicato in una rivista tecnica qualificata fino ad oggi nessun articolo sulla formulazione teorica della relativita' ristretta isotopica e sulle relative strutture iso-Minkowskiane ed iso-Lorentziane. I pochissimi articoli pubblicati dagli stessi in riviste tecniche sulle isotopie sono chiaramente e solamente stati sulle applicazioni e verifiche della relativita' isotopica del sottoscritto Prof. Santilli, come l'articolo in allegato VIII del Prof. Mignani dedicato chiaramente alla applicazione della relativita' isotopica del Prof. Santilli alle quasars. Altri articoli pubblicati sulle isotopie in riviste qualificate dagli imputati erano in settori completamente diversi da quelli oggetto di plagio, come per esempio nelle isotopie della cosidetta teoria di scattering da potenziale la cui ultima paternita' da parte degli imputati non e' qui nemmeno considerata perche' indiscutibile ed in ogno caso completamento al di fuori di questa denuncia-querela.

SOMMARIO DEL PLAGIO SCIENTIFICO PERPETRATO DAGLI IMPUTATI PROFESSORI R. MIGNANI ED F. CARDONE. Nell'autunno del 1991 il sottoscritto Prof. R. M. Santilli ricevette una visita al suo ufficio in Florida dell'imputato Prof. FABIO CARDONE il quale indico' che era stato inviato dal Prof. G. SALVINI del Dipartimento di Fisica della I Universita' di Rome con spese pagate dall'Istituto Nazionale di Fisica Nucleare della I Universita' di Roma. Lo scopo dichiarato della visita era quello di applicare la relativita' ristretta isotopica del sottoscritto alla cosiddetta Correlazione di Bose-Einstein. Da tener presente che per sua stessa ammissione ed attivita', il Prof. Cardone non e' un fisico teorico, bensi un fisico fenomenologo la cui specialita' e' quella di applicare date teorie fisiche a noti valori sperimentali mediante plots in computers. Durante la sua permanenza in Florida, ed a seguito della richiesta del prof. Cardone, il sottoscritto raggiunse la formula di base per l'applicazione della relativita' isotopica alla Correlazione di Bose Einstein che il Prof. Cardone riporto' con se per farla vedere al Prof. Salvini ed altri dirigenti della I Universita' di Roma. Da indicare che Cardone si presento' anche come collaboratore del Prof. R. Mignani della stessa divisione dell'INFN e dello stesso Dipartimento di Fisica della I Universita' di Roma, benche' nessun contributo scientifico sia noto e documentato da parte del Prof. Mignani nella derivazione teorica della formula di base della correlazione isotopica.

Successivamente, in vista del successo della rappresentazione isotopica dei dati sperimentali sulla Correlazione di Bose-Einstein, il Prof. Cardone fu mandato sempre a detta del Prof. G. Salvini e dietro pagamento dell'INFN Sezione Roma I una seconda volta a visitarmi in Florioda nell'ultima settimana del

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1991. Durante tale seconda visita il Prof. Cardone porto' con se la verifica sperimentale preliminare della relativita' speciale isotopica del sottoscritto Prof. Santilli mediante la Correlazione di Bose Einstein. Il sottoscritto allora completo' l'articolo teorico durante la visita del Prof. Cardone il quale lo riporto' con se' all'INFN ed al Dipartimento di Fisica della I Universita' di Roma per farlo vedere dal Prof. Salvini e dagli altri dirigenti. Da tener presente che a quell'epoca i rapporti tra il sottoscritto ed i Professori Cardone e Mignani erano di estrema cordialita' come provato dal fatto che il sottoscritto aveva eletto i suddetti membri dell'Istituto di Ricerche USA di cui era (ed e') Presidente, l'Institute for Basic Research, oltre che editori di due riviste scientifiche internazionali. In questo suo secondo viaggio il Prof. Cardone si presento' di nuovo come collaboratore del Prof. Mignani anche se, di nuovo, non porto' con se' alcun contributo scientifico di quest'ultimo. Alla sua partenza dalla Florida alla fine del 1991, il Prof. Cardone promise in presenza di testimoni che avrebbe spedito per fax in pochi giorni il plot finale della verifica sperimentale della relativita' isotopica di Santilli perche', da quanto detto dallo stesso Prof. Cardone, egli aveva gia' tutti i dati nel computer e doveva semplicemente fare il run finale.

I rapporti fra il sottoscritto ed i Professori Cardone e Mignani cambiarono in misura drastica ed imprevista dal momento del ritorno del Prof. Cardone alla I Universita' di Roma dal suo secondo viaggio in Florida ed, in particolare, dal momento della presentazione al Prof. G. Salvini ed agli altri dirigenti del Dipartimento di Fisica e dell'INFN della I Universita' di Roma della verifica sperimentale che il Prof. Cardone aveva fatto della relativita' isotopica del Prof. Santilli.

Infatti, con grande sorpresa del sottoscritto, tenendo in vista il fatto che questi li aveva eletti membri di un Istituto di Ricerche USA ed editori di riviste internazionali, i Professori Cardone e Mignani rifiutarono varie volte con scuse non-credibili di fare avere al sottoscritto la versione finale del plot sulla verifica sperimentale della relativita' isotopica mediante la correlazione di Bose-Einstein. Detto plot fu poi rilasciato vari mesi dopo dietro pressioni che il sottoscritto si riserva di documentare in fase di istruttoria. Successivamente, i Professori Cardone e Mignani mandarono per fax una "diffida" al sottoscritto contro l'uso di tale plot. A seguito di questo comportamento chiaramente antiscientifico il sottoscritto allora termino' i Professori Cardone e Mignani per iscritto sia nello loro affiliazione all'Istituto di Ricerche IRB che nelle loro posizioni di editori delle riviste tecniche USA mediante lettera datata 13 Marzo 1992 (Allegato IX).

Per capire la gravita' del comportamento degli imputati Professori Cardone e Mignani, bisogna sapere che il plot prima rifiutato per mesi al Prof. Santilli e poi "diffidato" dall'essere usato, costituisce la prima verifica sperimentale conosciuta della legacy di Enrico Fermi, fatta proprio alla I Universita' di Roma, secondo la quale le interazioni forti sono appunto di tipo nonlocali (ossia non sono riducibili a punti ma richiedono formulazioni su volumi).

Successivamente, nel luglio 1992, i Professori Cardone e Mignani scrissero a loro sola firma la comunicazione intitolata "A nonlocal approach to Bose-Einstein correlation" (Approccio nonlocale alla correlazione di Bose-Einstein) rilasciata come documento ufficiale n. 894 dell'INFN e del Dipartimento di Fisica della I Universita' di Roma (Allegato X). Detta comunicazione copiava ad litteram la mia applicazione della mia relativita' ristretta alla correlazione di Bose-Einstein ma non citava la sua sorgente, ossia l'articolo [5] del 1991 che era ben noto agli imputati perche' inviato sia a loro che ai loro associati alla I Universita' di Roma oltre che scritto e completato in Florida alla presenza dell'imputato Prof. Cardone sotto molteplici testimonianze. In sua vece, gli imputati elencarono nella referenza 11 di pagina 9 di detta comunicazione un fantomatico articolo a nome dei Professori Cardone, Mignani e Santilli che il sottoscritto non aveva mai autorizzato.

Il primo plagio documentato degli imputati Professori F. Cardone e R. Mignani, allora entrambi del Dipartimento di Fisica e dell'INSF, I Universita' di Roma, e' avvenuto precisamente nella comunicazione scientifica in Allegato X a pagina 8 (vedere pagina X-2) in cui gli imputati avevano copiato ad litteram, concetto per concetto, formula per formula e simbolo per simbolo la teoria nonlocale isotopica del sottoscritto nella pubblicazione [5] di un anno prima senza citare questa originazione, plagio che e' dimostrabile al di la' di qualunque dubbio credibile dalla completa identita' delle equazioni dell'Allegato X con quelle corrispondenti pubblicate del sottoscritto nella pubblicazione [5]. In particolare, la formula

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finale e fondamentale per la correlazione nonlocale isotopica, l'equazione (4.9) e relativa sostituzione (4.10) e' assolutamente identica alla corrispondente formula del Prof. Santilli nella pubblicazione [5] di un anno prima come tutti possono verificare in librerie scientifiche senza bisogno alcuno di conoscenza tecnica. In aggiunta, gli imputati scrivono a pagina X-3 "We have thus shown that, in our model, the correlation..." (abbiamo pertanto mostrato che, nel nostro modello, la correlazione...). Gli imputati si sono cosi' impossessati mediante una chiara frode scientifica della teoria sulla correlazione nonlocale isotopica del sottoscritto perche' non hanno citato la referenza [5] dell'anno precedente in cui la teoria era stata completamente sviluppata. La comunicazione dell'Allegato X conteniene anche varie altre disotrsioni scientifiche la cui identificazione e' qui omessa a causa del loro carattere tecnico.

Da notare che il plagio scientifico di detta comunicazione n. 894 in Allegato X fu battuta, copiata e spedita a molti laboratori e dipartimenti di fisica sparsi per il mondo a spese pubbliche mediante fondi concessi dall'INFN e dal Dipartimento di Fisica della I Universita' di Roma.

Dopo questo primo plagio documentato, e presumibilmente nell'autunno 1992 i Professori Cardone e Mignani rilasciarono una seconda comunicazione nell'autunno 1992 intitolata "On a nonlocal relativistic kinematics" (su una cinematica relativista nonlocale) ed anche rilasciata come atto ufficiale del Dipartimento di Fisica e dell'INFN della I-Universita' di Roma (benche' non datata) presentata in Allegato XI, la quale costituisce plagio scientifico documentato delle mie teorie isotopiche anche al di la' di dubbi credibili. Infatti, come stabilito da una semplice ispezione, questa seconda comunicazione copia nella sua integrita' incluso anche i simboli tutte le mie leggi fisiche isotopiche senza indicarne la paternita' nelle precedenti pubblicazioni principali [1,2,3,4,5,6,7]. Per esempio gli imputati derivano la velocita' causale massima isotopica nella equazione (11) dell'Allegato XI - la quale e' la prima a poter essere superiore a quella della luce nel vuoto - (prerservandone anche il nome dato dal sottoscritto) la quale e' assolutamente identica a quella derivata dal sottoscritto sin dal 1983 (vedasi per esempio l'equazione (9.5) dell'Allegato III). Il grave plagio scientifico continua poi con la legge di composizione isotopica delle velocita', l'equazione (22) la quale e' completamente identica a quella del sottoscritto, vedasi per esempio l'equazione (9.7) dell'Allegato III. Il grave plagio scientifico continua le leggi isotopiche nella destra della Tavole I e II le quali sono assolutamente identiche, persino nei simboli, con le leggi isotopiche della relativita' ristretta isotopica del sottoscritto, come ognuno puo' verificare paragonandole a quelle delle referenze degli Allegati II, III e IV. In sostanza, nell'Allegato XI gli imputati si sono appropriati con chiara frode scientifica della relativita' speciale isotopica del sottoscritto per il caso di interazioni nonlocali.

Questo plagio scientifico e' parrticolarmente grave in vista della documentazione secondo cui entrambi gli imputati erano pienamente a conoscenza di tutte le pubblicazioni precedenti del sottoscritto nell'argomento, come le pubblicazioni [1,2,3,4,5]. Infatti, l'imputato Prof. R. Mignani aveva lui stesso ammesso nel suo articolo scritto nel 1990 e riprodotto in Allegato VIII che la paternita' della relativita' ristretta isotopica per il caso nonlocale era del Prof. Santilli (vedasi pagina VIII-1) oltre che aver citato tutte le publicazioni precedenti del Prof. Santilli (vedasi pagina VIII-4), per cui non puo' assolutamente negare la loro esistenza.

La piena consapevolezza degli imputati e' inoltre stabilita dalla testimonianza della Signora PALEMA FLEMING residente della Florida (vedere Allegato XII) la quale documenta per iscritto che sia il Prof. Mignani che il Prof. Cardone erano stati revisori ufficiali delle bozze di stampa delle mie monografie [5,6] stampate nel 1991, oltre un anno prima del loro plagio nell'Allegato XI, monografie dalle quali essi avevavo copiato le leggi di base ad litteram preservandone anche i simboli matematici.

Da notare che anche il plagio dell'Allegato XI fu battuto, copiato e spedito a molti laboratori e dipartimenti di fisica sparsi per il mondo a spese pubbliche mediante fondi concessi dall'INSF e dal Dipartimento di Fisica della I Universita' di Roma.

Una volta messo a conoscenza da scienziati colleghi dei plagi scientifici degli Allegati X ed XI, il sottoscritto fece allora denunciare detti plagi dal suo avvocato americano mediante una lettera datata 9 Dicember 1992 ed indirizzata a: Prof. C. BACCI, Direttore dell'Istituto di Fisica della I Universita' di

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Roma, Prof. D. CIAPETTI, Direttore dell'INFN della I Universita' di Roma, ed al Prof. G. SALVINI dello stesso dipartimento. In particol;are la denuncia richiedeva l'immediato intervento dei qui nominati direttori per tutte le correzioni necessarie per rendere le comumnicazioni degli Allegati X ed XI conformi alle normative di etica scientifica internazionale, oltre che prendere tutti i provvedimenti per impedire che simili plagi possano verificarsi nel futuro.

In data 29 gennaio 1993 il Prof. C. Bacci rispose al mio avvocatoo con una lettera (vedere Allegato XIII) la quale essenzialmente afferma che il Dipartimento di Fisica e l'INFN della I Universita' di Roma si asteneva da qualunque azione al riguardo dei plagi degli Allegati X e XI e che qualunque richiesta doveva essere mandata direttamente ai Professori R. Mignani e F. Cardone. La lettera conclude con chiara diffamazione contro il sottoscritto ed i suoi associati con la frase del paragrafo 3) "Inoltre, il Giornale Adronico del Sig. Santilli non e' cosi' interessante da essere considerato per sottoscrizione dalla nostra biblioteca (e, come sospetto) dalla maggioranza delle librerie scientifiche del mondo).", diffamando cosi' anche tutti i membri del consiglio editoriale dello stesso giornale che include scienziati di altissimo prestigio. Da notare che il Prof. Bacci si riferisce all'imputato Mignani come "Prof." ed al sottoscritto come "Sig.", confermando cosi' il suo supporto per detto imputato, e quindi la sua complicita' al plagio. Rimane eviodentemente da identificare in sede giudiziale i nomi degli altri dirigenti dell'Istituto di Fiisca della e dell'INFN della I Universita' di Roma che sono anche personalmente responsabili per il plagio.

In vista di un tale sostegno da parte dei dirigenti della loro Universita', i Professori Mignani e Cardone continuarono imperterriti nel loro plagio rilasciando una serie di comunicazioni scientificche chiaramente plagiate dalle mie scoperte che sono oggi visibili in tutte le maggiori biblioteche scientifiche del mondo, come quelle dei laboratori Europei CERN a Ginevra, i laboratori tedeschi DESY ad Amburgo, i laboratori russi JINR a Dubna, i laboratori americani Fermilab a Chicago, e tanti altri. Il sottoscritto si riserva di identificare e documentare detti plagi addizionali nel corso dell'azione civile prevista a seguito di questa azione penale.

Un terzo caso di chiaro plagio scientifico e' dato dall'articolo del Prof. R. Mignani intitolato "Relativita' e nonlocalita'" pubblicato nel numero di settembre-dicembre 1993 della rivista italiana Synthesis (Allegato XIV). Come ognuno puo' verificare mediante una semplice ispezione della documentazione, il plagio e' costituito dal fatto che l'imputato Prof. Mignani presenta una "nuova relativita' " dichiarata essere di completa paternita' sua e del Prof. F. Cardone la quale: 1) e' intesa a rappresentare interazioni nonlocali, 2) e' basata sulle isotopie dello spazio di Minkowski e 3) ammette una velocita' causale massima che dipende dalle condizioni considerate senza nessuna citazione dei lavori scientifici del sottoscritto come le referenze [1,2,3,4,5,6,7]. La verita' scientifica al di la' di dubbi credibili e' che: 1') uno degli obiettivi fondamentali della relativita' isotopica e' proprio la rappresentazione di interazioni nonlocali come affermato e ripetuto nelle referenze del sottoscritto, 2') la relativita' isotopica del sottoscritto e' proprio basata sulle isotopie dello spazio di Minkowski e 3') una delle conseguenze principali della relativita' isotopica identificate sin dalla prima pubblicazione [3] e' una velocita' causale massima dipendente dalle condizioni considerate. Il plagio scientifico e' confermato anche al di la' di dubbi credibili dal fatto che il Prof. Mignani aveva gia' chiamato nel suo articolo in Allegato VIII la stessa relativita' come quella di "Santilli" ed era stato il revisore delle bozze delle due monografie [5,6] pubblicate nel 1991 le quali si occupavano esattamente della stessa relativita' generalizzata verificante le condizioni 1), 2) e 3). Il plagio del Prof. Mignani diventa una vera disonesta' scientifica quando si osserva a pagina 56 che, con riferimento alle isotopie dello spazio di Minkowski, egli cita, al posto della origine [3] del Prof. Santilli a lui molto nota una monografia di R. H. Bruck del 1958 in cui lo spazio di Minkowski non viene neanche nominato.

A seguito di questo terzo episodio di plagio scientifico ed in vista del pieno appoggio ricevuto dagli imputati dai dirigenti delle loro Universita' romane, i professori F. Cardone e R. Mignani continuarono negli anni seguenti a duplicare e spedire a tutte le principali biblioteche scientifiche del mondo articoli di plagio delle mie teorie, come il sottoscrttito si riserva di documentare durante i procedimento civile del caso in considerazione dopo questa azione penale.

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Per brevita' mi limito a citare le due ultime comunicazioni che costituiscono chiaro plagio delle teorie scientifiche del sottoscritto rilasciate dai Professori F. Cardone e R. Mignani presumibilmente verso la fine del 1994 sotto i titoli di "Special relativity on deformed space-time" (Relativita' speciale su spazio-tempo deformato), presentato in Allegato XV e "Description of fundamental interactions by energy-dependent metrics" (Descrizione delle interazioni fondamentali mediante una metrica dipendente dall'energia), presentato in Allegati XVI, ufficialmente rilasciati dalla Universita' Gregoriana di Roma, e dai Dipartimenti di Fisica della III e I Universita' degli Studi di Roma , dal Gruppo Nazionale di Fisica Matematica (G.N.F.M.) del Consiglio Nazionale delle Ricerche e dall'Istituto Nazionale di Fisica Nucleare presso il Dipartimento di Fisica della I Universita' degli Studi di Roma.

Come ognuno puo' verificare mediante una semplice ispezione e senza bisogno di conoscenze tecniche, la comunicazione in Allegato XV rappresenta un serio plagio scientifico delle mie teorie isotopiche. Infatti, i Professori Cardone e Mignani si assumono la paternita' di tutte le mie teorie isotopiche, ossia si assumono la paternita' della mia relativita' speciale isotopica, dei miei spazi iso-Minkowskiani e delle mie simmetrie di iso-Lorentz, senza nessuna citazione scientificamente corretta delle mie pubblicazioni su tali scoperte. Il plagio inizia col titolo della sezone 3, p. 4, "Deformed Minkowski space-time" (spazio-tempo Minkowskiano deformato) mentre il contenuto tecnico e' esattamente quello degli spazi iso-Minkowskiani della ref. [3]. Il prof. Mignani aveva gia' chiamato detti spazi nella referenza dell'Allegato VIII come "isotopici" e "dovuti a Santilli". Il cambiamento del nome di tali spazi e' quindi apparentemente dovuto all'intenzione dei Professori Cardone e Mignani di impossessarsi della loro paternita'. Da notare che l'uso del termine "deformato" per gli spazi "isotopici" e' scientificamente scorretto perche' e' noto in tutto il mondo scientifico che negli spazi deformati la metrica cambia ma l'unita' rimane quella vecchia, mentre solo negli spazi isotopici del sottoscritto abbiamo la combinazione della deformazione della metrica Minkowskiana indicata precedentemente, m ä mþ = Tm, mentre l'unita' e' deformata della quantita' inversa I ä Iþ = T-1. Il plagio della sezione 3 dell'Allegato XV continua con la derivazione senza alcuna citazione di paternita' della formula fondamentale della relativita' ristretta isotopica, l'equazione (3.12) di pagina 7, quella sulla velocita' causale massima, che e' assolutamente identica anche nei simboli usati a quella fondamentale della relativita;' ristretta isotopica, come ognuno puo' verificare ispezionando l'equazione (9.5), pagina 356 dell'Allegato III.

Il plagio scientifico dell'Allegato XV continua nella sezione 4, pagina 8, intitolata "Metric description of interactions" (descrizione metrica delle interazioni). Infatti i Professori Cardone e Mignani in detta sezione si assumono la completa paternita' della funzione della metrica iso-Minkowskiana dall'energia, Equazione (4.1) pagina 9, in piena consapevolezza, essendo essi stati revisori delle bozze, che il Professor Santilli stabilisce ripetutamente nelle monografie [5,6], che la dipendenza della metrica iso-Minkowskiana e' completamente arbitraria, mentre quella piu' usata per problemi interni e' la dipendenza dalla velocita'. Tutti i fisici a partire dal primo anno del corso di laurea in fisica, e quindi incluso i Professori Cardone e Migani, sanno che una dipendenza arbitraria dalla velocita' e' completamente equivalente ad una dipendenza arbitraria dall'energia perche' l'energia cinetica e' proporzionale al quadrato della velocita', stabilendo cosi' il plagio intenzionale degli imputati. Detto plagio, nella stessa sezione 4, pagina 9 al centro, raggiunge poi veri eccessi quando si legge al centro della pagina 9: (...). Infatti, cosa anche trattata ripetutamente nelle pubblicazioni del sottoscritto, e che tutti possono verificare senza bisogno di conoscenza tecnica, gli spazi iso-Minkowskiani furono proposti dal Prof. Santilli proprio per la "geometrizzazione" di interazioni piu' generali di quelle derivanti da potenziale.

Il plagio scientifico dell'Allegato XV diventa ancora piu' serio nella sezione 5 intitolata "Relativity in a deformed space-time" (Relativita' in uno spazio-tempo deformato). Infatti, gli imputati Professori Cardone e Miganni scrivono a pagina 11 () le trasformate assolutamente fondamentali della relativita' speciale isotopica del Prof. Santilli, le equazioni (5.1) dell'Allegato XV, assumendosene cosi' la paternita', mentre le STESSE TRASFORMATE ESATTAMENTE NEGLI STESSI SIMBOLI ERANO STATE PUBBLICATE DAL PROF. SANTILLI SIN DAL 1983, vedere le equazioni (15) di pagina 551 della referenza [3], allegato II. Il plagio continua a pagina 12 in cui i Professori Cardone e

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Mignani dichiarano di aver raggiunto una nuova versione di queste trasformate fondamentali, le equazioni (5.6) dell'Allegato XV mentre in realta' dette trasformazioni sono assolutamente identiche alle trasformazioni (15), pagina 551 della pubblicazione [3], Allegato II, solo scritte con una piccola variazione di simboli.

Questo plagio costituisce vera disonesta' scientifica da parte dei Professori Cardone e Mignani perche' entrambi conoscono molto bene, per ammissione nei loro articoli e corrispondenza precedenti al 1992 oltre che per la testimonianza dell'Allegato XII, la proprieta' di base delle trasformate di iso-Lorentz del Prof. Santilli che queste ultime sono "direttamente universali" [3,4,5,6] nel senso indicato prima. Le affermazioni contenute nella sezione 5 della comunicazione in Allegato XV equivale quindi alla affermazione, per esempio, che i Professori Cardone e Mignani hanno scoperto la nuova generalizzazione E = 2mc2/2 della legge Einsteiniana dell'equivalenza della massa con l'energia E = mc2, mentre in effetti la "nuova legge" 2mc2/2 e' completamente identica alla vera legge mc2.

Il plagio e la disonesta scientifica dei Professori Cardone e Mignani raggiungono estremi veramente incredibili nella sezione 6 dell'Allegato XV intitolata "Kinematics in a deformed space-time" ("Cinematica in uno spazio-tempo deformato). Infatti, dopo essersi appropriato in una maniera scientificamente fraudolenta nelle sezioni precedenti delle trasformate di iso-Lorentz del Prof. Santilli e della sua relativita' ristretta isotopica, i Professori Cardone e Mignani si impossessano in una maniera ancora piu' fraudolenta di tutte le leggi fisiche della relativita' speciale isotopica del sottoscritto. Le prime leggi fisiche della sezione 6, le equazioni (6.1) e (6,.2), sono un chiaro plagio. Infatti dette leggi fisiche, che riguardano la somma iso-relativistica delle velocita' negli spazi iso-Minkowskiani, sono assolutamente identiche persino nei simboli con le stesse leggi derivate per prima dal sottoscritto, per esempio l'equazione al centro della pagina 553 della pubblicazione [3], Allegato II. Dopo aver continuato la loro analisi scientificamente fraudolenta, i Professori Cardone e Mignani raccolgono nelle tavole I e II di pagine 15 e 16, rispettivamente, dell'Allegato XV tutte le leggi di base della relativita' ristretta isotopica del sottoscritto senza alcuna citazione della loro paternita', per il chiaro intento di assumersene la paternita' scientifica mediante plagio. Come chiunque puo' verificare senza busogno di conoscenze matematiche, LE LEGGI FONDAMENTALI DELLE SUDDETTE TAVOLE I E II SONO COMPLETAMENTE IDENTICHE ALLE LEGGI CORRISPONDENTI ORIGINARIAMENTE PUBBLICATE DAL PROF. SANTILLI ANNI PRIMA. Piu' precisamente, l'identita' della prima legge della tavola I, quelle sulle somme iso-relativistiche delle velocita', e' stata gia' stabilita in precedenza. La seconda legge della tavola I sulla dilatazione isotopica del tempo coincide identicamente con la legge (9.20), pagina 364 della pubblicazione [4] Allegato III del Prof. Santilli.La terza legge della tavola I, quella sulla contrazione iso-spaziale, coincide identicalente con la legge (9.21) della stessa pagina della stessa referenza riprodotta nello stesso Allegato III. Lo stesso vale per tutte le altre leggi plagiate dai Professori Mignani e Cardone mediante una fraudolenza scientifica veramente incredibile. Il plagio della tavola II di pagina 16 e' ancora piu' lampante perche' i Professori Cardone e Mignani semplicemente riscrivono le stesse leggi considerate prima ma con una diversa funzionalita' anche ammessa dalla universalita' della relativita' isotopica di Santilli facendo cosi' di nuovo la scoperta del "principio di equivalenza di Cardone e Mignani" E = 2mc2/2 che rimane identico a quello vero di Einstein E = mc2.

La disonesta scientifica raggiunge l'apice nelle referenze dell'Allegato XV. Infatti, nella referenza n. 1 di pagina 20, che e' veramente fondamentale per la comunicazione stessa, gli imputati Professori Cardone e Mignani restringono con chiara fraudolenza scientifica la citazione della pubblicazione [3] del sottoscritto sulle isotopie con l'affermazione che essa era solo "formale" e limitata alle isotopie dello spazion di Minkowski, mentre la pubblicazione [3] e' intesa principalmente per le isotopie della relativita' speciale come indicato sin dal suo titolo (vedasio Allegato II). Questa fraudolenza scientifica e' chiaramente intesa per acquisire la paternita' della nuova relativita' da parte degli imputati mediante plagio. Il completamento della referenza 1 dell'Allegato XV e' scientificamente disonesto fino all'inverosimile. Infatti gli imputati uniscono la vera pubblicazione [3] del sottoscritto sulle isotopie con un articolo dei fisici H. B. Nielsen e I. Picek che non contiene neanche l'ombra della nozione di isotopia. Ne consegue che, tutte le volte che la referenza 1 e' citata nella comunicazione dell'Allegato XV al riguardo delle isotopie, essa da' uguale credito sia al Prof. Santilli che hai Professori Picek e Nielsen che non hanno fatto nullla nel campo, rendendo quindi tutte le citazioni della referenza 1 scientificamente

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invalide.

Il plagio, la frode e la disonesta' di natura scientifica dei Professori Cardone e Mignani nell'ultima comunicazione qui considerata, l'Allegato XVI, e' talmente schiacciante da non richiedere commenti estesi. Infatti, la totalita' dell'articolo e' dedicata alle applicazioni della rerlativita' ristretta isotopica del Prof. Santilli, dei suoi spazi iso-Minkowskiani e delle sue simmetrie iso-Lorentz senza alcuna citazione dei lavori in cui tale scoperte furono fatte per la prima volta. Nemmeno una citazione marginale ! Infatti, il "nome Santilli" non e' nemmeno citato in nessuna parte dell'Allegato XVI, anche se la totalita' dell'articolo e' nel settore dei suoi studi isotopici.

A parte questa chiara disonesta' e frode scientifica, il danno maggiore dell'Allegato XVI e' dato da inconsistenze fisiche veramente grosse, come il fatto che gli studi implicano l'identificazione della velocita' causale massima nell'acqua con la velocita' della luce nello stesso mezzo, mentre e' noto che elettroni possono viaggiare nell'acqua a velocita' superiori a quelle della luce nello stesso mezzo (questo evento crea la luce bluastra che si puo' vedere nei reattori nucleari). Cosa ancora piu' grave, la presentazione degli imputati proibisce la rappresentazione della velocita' della luce in mezzi fisici secondo la formula stabilita c = co/n dove n e' il noto indice di rifrazione e co e' la velocita' della luce nel vuoto.Queste incosistenze fisiche ed altre simili dell'Allegato XVI fanno grave danno scientifico alle scoperte del sottoscritto perche' esse danno l'impressione che la relativita' isotopica e' sbagliata, mentre in verita' le inconsistenze precedenti non esistono quando la stessa relativita' e' trattata in maniera tecnicamente corretta ed onesta. Infatti, nelle pubblicazioni [4,5,6] uno puo' leggere che la velocita' causale massima nell'acqua rimane quella della luce nel vuoto nel qual caso gli elettrroni che originano la luce bluastra dei reattori continuano a viaggiare a velocita' inferiori a quella causale. Similmente, la versione corretta della relativita' isotopica del sottoscritto e' basata sulla legge della velocita' locale della luce c = co/n eliminando cosi' questa inconsistenza addizionale. Tutte le atre grosse inconsistenze fisiche nell'uso improprio della relativita' isotopica del sottoscritto nell'Allegato XVI sono ugualmente eliminate dal suo uso appropriato.

RIFIUTI EDITORIALLI DELLE COMUNICAZIONI SCIENTIFICHE DEGLI IMPUTATI PER PLAGIO.

Il Prof. R.M.Santilli e' riuscito a pubblicare in riviste tecniche con revisori oltre cento comunicazioni scientifiche indicate precedentemente e molte sono state accettate per la stampa dagli editori a seguito di lungo ed attento esame.

Al contrario, il motivo principale per cui, nonostante vari tentativi sin dal 1992, i Professori F. Cardone e R. Mignani non sono riusciti ad avere una sola comunicazione scientifica accettata per la pubblicazione da una rivista tecnica con revisori nelle isotopie considerate e' la natura plagiaria dei loro studi che e' nota a tutti i redattori di riveste scientifiche (spesso chiamati "editori") in tutto il mondo. Anzi, le motivazioni apportate dagli editori per la rifiuto delle comunicazioni scientifiche sono una prova indipendente ed inconfutabile del plagio, truffa e disonesta' scientifica degli imputati.

E' sufficiente al riguardo ispezionare la documentazione della rigezione per la pubblicazione delle comunicazioni negli Allegati XV e XVI da parte della rivista Chinese Journal of System Engineering and Electronics rilasciata dal suo Redattore Capo Prof. KEXI LIE in Cina e dal Redattore Associato Prof. H. E. WILHELM negli Stati Uniti.

La cronologia degli eventi e' la seguente. E' prassi universale negli atti editoriali scientifici mandare articoli ai massimi esperti nel settore. Siccome gliAllegati XV e XVI trattavano le isotopie, fu allora naturale per i Redattori Liu e Wilhelm mandare le comunicazioni stesse per rivista all'Institute for Basic Research in Florida, essendo esso noto come la massima autorita' indiscussa nel settore, cosa che fecero nel marzo del 1995. Un'ispezione di pochi minuti da parte dei miei associati rivelo' immediatamente il plagio, la frode e la disonesta' scientifica degli imputati perche': 1) nella referenza fondamentale 1 della prima comunicazione avevavo omesso di citare le pubblicazioni piu' importanti del sottoscritto a loro ben note, oltre che, cosa anche particolarmente grave, avevano associato come referenza di base delle

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isotopie un lavoro dei Professori Nielsen e Picek che non aveva connessione alcuna con le isotopie; 2) la seconda comunicazione non faceva referenza alcuna ai lavori precedenti del sottoscritto pur essendo essa interamente nel settore; e 3) nel contenuto delle comunicazioni stesse, essi si erano impradoniti con fraudolenza scientifica veramente incredibile delle principali leggi matematiche e fisiche pubblicate molti anni prima dal sottoscritto, copiandole ad litteram persino nei simboli.

Dopo essere stato informato di tale plagio, truffa e disonesta' scientifica verso la meta' di marzo 1995, il sottoscritto preparo' in collaborazione con i suoi associati una prima lettera indirizzata agli editori Liu e Wilhelm con copia ai Professori Cardone e Mignani in cui si chiedevano dovute correzioni.

Il Prof. Mignani rispose con una lettera datata 20-4-95 mediante carta da lettera intestata all'Istituto Nazionale di Fisica Nucleare, e quindi come atto ufficiale dello stesso (Allergato XVII), rifiutando in maniera categorica qualunque cambiamento. Nella stessa lettera il Prof. Mignani indica chiaramente che lui ed il suo associato Prof. Cardone agivano a seguito di consenso da parte dei dirigenti della I Universita' di Roma di cui non rivelavano il nome per non farli "disturbare" da missive non desiderate. In particolare, invece di correggere la loro disonesta' scientifica chiara e documentata, essi risposero con gravi offese e diffamazione contro il sottoscritto ed i suoi associati trattati piu' avanti in questa denuncia-querela.

Il sottoscritto preparo' allora a sua firma il 1o maggio 1995 un documento intitolato "Docunmentation of plagiarism by R. Mignani and F. Cardone ..." (Documentazione di plagio da parte di R. Mignani ed F. Cardone...), Allegato XVIII, che fu mandato in copia a redattori Liu e Wilhelm ed ai Professori Cardone e Mignani.

In data 18 maggio 1995 su carta semplice i Professori Cardone e Mignani risposero agli Editori Liu e Wilhelm rifiutando di nuovo in misura categorica qualunque cambiamento alle comunicazioni (Allegati XIX). In tale lettera essi inoltre raggiungono il parossismo ultimo di disonesta' scientifica accusando il sottoscritto di aver plagiato il loro Allegato XVII del 1992 nelle sue monografie del 1994, in piena conoscenza che la loro comunicazione del 1992 era un plagio scientifico delle mie monografie a lavori precedenti al 1992, come documentato dal mio avvocato americano agli stessi imputati ed ai dirigenti della I Universita' di Roma nell'autunno 1992.

Il sottoscritto allora rispose preparando in data 22 maggio 1995 un secondo documento intitolato "Second Documentation on the plagiarism by R. Mignani and F. Cardone..." (Seconda documentazione del plagio da parte di R. Mignani ed F. Cardone...), Allegato XX, in cui presento' documentazione e testimonianze inconfutabili da parte di terze persone che gli imputati erano pienamente a conoscenza delle monografie e lavori del sottoscritto precedenti la loro comunicazione del 1992 di cui avevano copiato ad litteram le leggi fisiche e matematiche senza nessuna citazione delle stesse, con particolare riguardo proprio alla rappresentazione della nonlocalita' cla cui rappresentazione e' uno degli obiettivi principali delle isotopie come scritto nelle pubblicazioni sin dal 1978 [1,2].

Due commissioni di studio del caso furono allora organizzate, una in Cina ed una negli USA. Al termine dei loro lavori le due commissione conclusero indipendentemente che le comunicazioni degli Allegati XV e XVI costituivano grave plagio scientifico. Con una lettera datata il 29 maggio 1995 ed indirizzata al Prof. R. Mignani l'Editore Capo della rivista CJSE&E Prof. Liu rigetto' entrambi le comunicazioni degli Allegati XV e XVI per plagio scientifico (Allegato XXI. Con una lettera indirizzata al sottoscritto in data 7 giugno 1995 l'Editore Capo della stessa rivista Prof. Liu accetta invece due delle mie comunicazioni scientifiche, le referenze [15,16], Allegato XXII.

Il caso e' presentato in sommario in una lettera datata 6 giugno 1995 dell'Editore Associato Prof. Wiljelm all'Editore Capo Liu in cui chiunque puo' leggere le seguenti affermazioni (Allegato XXIII): 1) la disonesta' scientifica degli imputati accusata senza mezzi termini; 2) la completa mancanza di pubblicazioni scientifiche da parte degli imputati in riviste tecniche qualificate mentre il sottoscritto ha un grande numero di tali pubblicazioni oltre che sei monografie nel settore stampate da Case Editrici di estremo prestigio come la Springer-Verlag di Heidelberg in Germania oppure l'Accademia delle Scienze

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dell'Ukraina; e 3) L'autorita' massima per la paternita' scientifica, il cosiddetto "Indice delle citazioni" di Filadelfia negli USA attribuisce in misura incontrovertibile la sola parternita' delle isotopie al Prof. Santilli. Il Prof. Wilhelm infine conclude , suggerimento che sara' considerato dal sottoscritto a seguito di questa azione penale.

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p; Come commenti finali si deve notare che, prima degli eventi qui riportati, il sottoscritto aveva solo incontrato brevemente il Prof. Wilhelm in un congresso scientifico internazionale in Europa qualche anno fa, non aveva mai sentito parlare del Prof. Liu prima dell'episodio qui riportato, ed a tutt'oggi egli non conosce nemmeno il nome dei membri della commissione cinese e di quella americana.

E' bene inoltre ricordare le norme di etica scientifica che sono universalmente accettate nel mondo accademico, secondo le quali qualunque comunicazione scientifica deve: a) Citare tutte le pubblicazioni primarie che precedono ogni comunicazione scientifica; b) Rivedere i risultati principali delle stesse, e c) Dopo, e solo dopo il compimento di a) e b) , presentare i propri risultati dimostrando la loro originalita' su una base comparativa coi risultati pre-esistenti. Se gli autori delle comunicazioni scientifiche non citano pubblicazioni precedenti in buona fede, essi sono tenuti a citarle ed a correggere le loro comunicazioni immediatamente dopo aver ricevuto notifica di queste ultime.

Il plagio, la frode e la disonesta' scientifica degli imputati sono dimostrati al di la' di qualunque ombra di dubbio credibile dall'ampia documenmtazione secondo la quale (si veda per esempio le lettere datate 20 aprile 1995 e 18 maggio 1995, Allegati XVII e XIX) gli imputati rifiutarono categoricamente e ripetutamente la citazione delle pubblicazioni precedenti del Prof. Santilli a seguito di richieste specifiche scritte dei Redattori-Editori.

Da notare infine che le modifiche richieste dagli editori erano assolutamente minime e consistevano nel: 1) Completare la referenza 1 dell'Allegato XV con tutte le pubblicazioni precedenti primari, citando le pubblicazioni [3,4,5,6,7] e rimuovendo dalla stessa la citazione dissonante del lavoro di Nielsen e Picek; 2) aggiungere il numero 1 come referenza a tuttre le leggi matematiche e fisiche primarie dell'Allegato XV, e c) ripetere la stessa referenza 1 nella seconda comunicazione in Allegato XVI e citarla in congiunzione di tutte le leggi matematiche e fisiche trattate.

MANCANZA DI CREDIBILITA' DEGLI ARGOMENTI SCIENTIFICI DEGLI IMPUTATI.

Il motivo appportato dagli imputati come giustificazione della mancata citazione delle pubblicazioni del Prof. Santilli sulle isotopie e' che loro hanno scoperto una nuova versione delle stesse teorie. Ammesso che tale affermazione fosse vera, la mancata citazione delle pubblicazioni primarie nel settore resta sempre un caso di immoralita' scientifica per il fatto evidente che il rifiuto della richiesta da parte di redattori di citare pubblicazioni direttamente connesse alle comunicazioni puo' solo essere fatto per uno schema fraudolento e certamente no per un vero processo scientifico.

La realta' e' che l'affermazione degli imputati che essi hanno coperto una versione nuova delle isotopie e' completamente falsa, come confermato indipendentemente dagli editori Professori Liu e Wilhelm. Infatti, le isotopie delle spazio di Minkowski scoperte per la prima volta dal Prof. Santilli e pubblicate nella rivista ufficiale della Societa' Italiana di Fisica, referenza [3], sono "direttamente universali", ossia, come indicato precedentemente, esse contengono tutte le infinite generalizzazioni possibili dello spazio Minkowskiano capaci di preservarne gli assiomi geometrici direttamente nelle coordinate dell'osservatore. L'affermazione degli imputati che essi hanno scoperto una nuova realizzazione delle isotopie Minkowskiane e' quindi completamente falsa. Ne consegue che e' ugualmente falsa l'affermazione degli imputati di aver scoperto una nuova versione delle trasformate isotopiche di Lorentz perche' esse sono note essere derivate dagli spazi iso-Minkowskiana e quindi godono della stessa universalita' diretta. Ugualmente falsa e' l'affermazione degli impiutati che essi hanno scoperto una nuova relativita' isotopica. Infatti, e' stato dimostrato nella letteratura scientifica (per esempio dal fisico A.K.

Aringazin [nel 1989) che tutte le leggi generalizzate esistenti sono un caso particolare della universalita' delle leggi isotopiche del Prof. santilli.

Un'altra scusa addotta dagli imputati per la mancata citazione delle referenze primarie nel campo e' che la "loro" teoria non richiede il valore assoluto nella definizione della quantita iso-relativistica chiamata iso-gamma mentre le teorie del sottoscritto richiedono tale valore assoluto, risultando cosi' in diverse teorie. Chiara evidenza stabilisce che anche questa affermazione e' completamente falsa. Infatti, per cominciare, la definizione della quantita' iso-gamma data nelle pubblicazioni originali [3,4] e' completamente senza il valore assoluto ed e' data esplicitamente in una dimensione spaziale dalla espressione matematica ©þ = 1_[1 - v2b2_cob42]1_2dove co e' la velocita' della luce nel vuoto e le quantita' b, b4 sono funzione reali arbitrarie delle velocita' (e quindi dell'energia) ma non-nulleþ. La realta' scientifica e' che gli imputati hanno plagiato in maniera identica in tutte le loro comunicazioni scientifiche (Allegati X, XI, XIV, XV e XVI l'espressione esplicita della quantita' di iso-gamma su riportata SENZA il valore assoluto come data nell'equazione (15), pagina 551 della pubblicazione [3] del 1983 (Allegato II) oppure nella pubblicazione [x4] del 1988 (Allegato III).

A riguardo dell'AGGIUNTA del valore assoluto nella forma ©þ = 1_ | 1 - v2b2_cob42 | 1_2 che il sottoscritto ha introdotto in pubblicazioni piu' recenti, come nelle monogreafie [5.6], si ricorda che detto valore assoluto e' usato solo quando la quantita' [1 - v2b2_cob42] 1_2 puo' assumere valori immaginari. Ricordiamo a tal riguardo che, nella relativita' speciale isotopica del Prof. Santilli la velocita' causale massima e' data da vmax = cob4_b. E' allora facile vedere che la quantita' vb_c0b4 puo' al massimo essere uguale ad uno e la quantita' 1 - v2b2_cob42 puo' al massimo essere uguale a zero e mai assumere valori negativo. La quantita' [1 - v2b2_cob42] 1_2 puo' allora assumere solo valori reali positivi e negativi oppure il valore limite nullo. Il significato pratico del valore assoluto nell'espressione | 1 - v2b2_cob42 | 1_2 e' allora ristretto alla mera eliminazione dei valori negativi, senza nessuna implicazione matematica, teorica o pratica di qualunque tipo rispetto alla versione senza il valore assoluto perche' nella pratica solo i valori positivi delle radici quadrate sono usate, ossia [1 - v2b2_cob42] 1_2 , | 1 - v2b2_cob42 | 1_2. L'argomento degli imputati che loro hanno scoperto una nuova relativita' isotopica perche' hanno inventato una teoria in cui non c'e' bisogno del valore assoluto e' quindi DOPPIAMENTE FALSO, prima di tutto perche' la teoria originaria senza il valore assoluto l'ha inventata il sottoscritto come ben noto agli imputati, e secondo perche' le due teorie senza e con il valore assoluto sono completamente identiche.

Nella realta', l'aggiunta del valore assoluto fu sugggerita al Prof. Santilli precisamente dall'imputato Prof. Mignani, sia durante la sua revisione delle bozze delle monografie [5,6] che durante le conferenze fatte dal Prof. Santilli all'Istituto matematico Castelnuovo della I Universita' di Roma nel 1991 alla presenza di vari testimoni. Il sottoscritto accetto' il suggerimento perche' veniva da un correttore di bozze e perche' completamente innocuo. Al contrario, l'imputato Mignani non era in buona fede quando suggeri' l'aggiunta del valore assoluto al sottoscritto. Infatti l'imptato aveva il chiaro scopo fraudolendo di sviare il Prof. Santilli su una strada sbagliata e poi suggerire la "sua"teoria senza il valore assoluto come quella giusta.

Questo schema di fraudolenza scientifica e' stato annullato dalla mancanza di conoscenza tecnica sufficiente dell'imputato Prof. Mignani il quale non e' stato in grado di capire che il sottoscritto ha accettato il suo suggerimento di aggiunghere il valore assoluto perche' completamente inutile ed innocuo.

PARAGONE DEL COMPORTAMENTO SCIENTIFICO DEL PROF. SANTILLI E DEGLI IMPUTATI. Un altro aspetto importante per una giusta prospettiva del caso e' il paragone tra il comportamento scientifico, da una parte, del Prof. Santilli come scienziato americano di origine ed etica molisana e, dall'altra parte, degli imputati.

Da premettere che il Prof. Mignani ha dato dei contributi nelle isotopie, sebbene non nei settori da lui pretesi (le isotopies della relativita' ristretta e relativi spazi iso-Minkowskiani e simmetrie iso-Lorentziane), ma bensi' in settori completamente diversi, come le isotopie della cosiddetta theoria

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dello scattering.

Chiara evidenza stabilisce quanto segue. Da una parte c'e' l'evidenza secondo cui il Prof. Mignani si e' macchiato di plagio, frode e disonesta' scientifica astenendosi dal citare e rifiutandosi di citare lavori precedenti del Prof. Santilli nelle isotopie anche dopo richieste ufficiali di editori di riviste scientifiche. Dall'altra parte, anche dopo essere stato vittima di tanti plagi scientifici e dopo che il suo avvocato ne aveva formalmente comunicato l'esistenza ai direttori della I Universita' di Roma, il sottoscritto non solo ha continuato sempre a citare tutte le publicazioni scientificamente valide degli imputati, ossia quelle stampate in riviste scientifiche qualificate, ma e' arrivato addirittura agli estremi di correttezza scientifica e di riconoscimenti scientifici a favore degli imputati mettendo il nome di uno di essi nei TITOLI di capitoli e sezioni delle sue monografie. Come documentazione si acclude in Allegato V copia della pagina 507 della monografia [10] in cui uno puo' leggere il nome "Mignani" nel TITOLO del capitolo 12, oppure copia delle prime pagini dell'Appendice 3.E e Sezionme 7.9 della stessa monografia in cui uno puo' anche vedere il nome "Mignani" nel titolo.

La differenza di comportamento scientifico, etico ed umano tra il Professor Santilli e gli Imputati e' quindi semplicemente abissale.

DIFFAMAZIONE.

Durante le loro azioni di plagio, frode e disonesta' scientifica attraverso gli anni, gli imputati hanno seriamente diffamato il sottoscritto non solo mediante il plagio per se', ma anche per le azioni perpetrate dagli imputati in suo sostegno.

Innanzitutto gli imputati hanno accusato il sottoscritto di gravi infamie immaginarie sia a voce che per iscritto, incluso la paranoia, l'aver scritto articoli falsi per autolodarsi, ecc.

Secondo, ancora scontenti del rifiuto scritto per plagio scientifico delle loro comunicazioni negli Allegati XV e XVI da parte di due commissioni scientifiche, una in Cina ed una negli USA, gli imputati promossero l'Interrogazione Parlamentare n. 3-00691 indirizzata al Signor Ministro della Universita' e della Ricerca Scientifica e Tecnolologica, il Professor G. SALVINI (Allegato XXIV), in cui, cosa veramente incredibile, si chiede a detto Ministro di esprimere parere favorevole per la publicazione delle comunicazioni scientifiche oggetto di plagio acclarato e nella forma plagiaria in cui erano state rigettate ! In tale interrogazione parlamentare si puo' leggere, tra le altre calunnie e diffamazioni che <... tale Ruggero Maria Santilli, cittadino americano, il quale, con evidente raggiro, riusciva ad indurre il menzionato dottor Liu ad asternersi dalla pubblicazione dei lavori che lo stesso Liu aveva richiesto al professor Mignani>, affermazione che costituisce vera e seria diffamazione. Una tale affermazione non e' peraltro credibile da persone in buona fede perche' l'indipendenza scientifica degi redattori di riviste tecniche qualificate e' nota al mondo intero per cui l'ipotesi che il sottoscritto riuscisse "con evidenti raggiri" a convincere due editori indipendenti a rigettare per iscritto a causa di plagio documentato gli articoli degli imputati non ha assolutamente alcuna credibilita'.

Laonde prevenire una possibile dichiarazione favorevole da parte dell'attuale ministro per la pubblicazione degli Allegati XV e XVI nonostante il loro carattere plagiariustico documentato, cosa peraltro plausibile in vista del chiaro supporto da parte dei dirigenti della I Universita' di Roma come documenmtato dalla lettera del Prof. C. Bacci del 1993 (Allegato XIII), il sottoscritto fu allora costretto a scrivere una lettera al Ministro Salvini (Allegato (Allegato XXV) in cui si raccomanda l'astensione da un possibile giudizio favorevole.

Una volta registrata l'interrogazione parlamentare 3-00691 (Allegato XXIV), gli imputati l'hanno usata per continuare la diffamazione del sottoscritto rendendo cosi' mandatoria l'inizio di questa azione penale e la considerazione di azioni legali successive.

REFERENZE

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[2] R. M. Santilli, Foundations of Theoretical Mechanics, Vol. II (1982), Springer-Verlag, Heidelberg, Germania
[3] R. M. Santilli, Lettere al Nuovo Cimento volume 37, pagiina 545 e seguenti (1983)
[4] R. M. Santilli, isotopic Lifting pf Einstein's Special Relativity for Interior Dynamicxal Systems, Hadronic Journal Supple,ment Volume 4A, pagina 267 e seguenti (1988),
[5] R. M. Santilli, Isotopic Generalization of Galilei's and Einstein's Relativities, Volume I (1991), Hadronic Press, Florida;
[6] R. M. Santilli, Isotopic Generalization of Galilei's and Einstein's Relativities, Volume II (1991), Hadronic Press, Florida;
[7] R. M. Santilli, Lettere Nuovo Cimento volume 37, pagina 337 e seguenti (1983) e volume 38 pagina 509 e seguenti (1983), hadronic Journal volume 8 paginma 25 e seguenti e pagina 36 e seguenti (1984)
[8] R. M. Santilli, Nonlocal isotopic formulation of the Bose-Einstein correlation, Hadronic Journal Volume 15, pagina 1 e seguenti (gennaio 1992)
[9] R. M. Santilli, Elements of Hadronic Mechanics, Volume I (1993), Naukova Dumka, Accademia delle Scienze dell'Ucraina, Kiev ;
-[10] R. M. Santilli, Elements of Hadronic Mechanics, Volume II (1994), Naukova Dumka, Accademia delle Scienze dell'Ucraina, Kiev .

CONCLUSIONI

Lo scrivente Prof. Ruggero Maria Santilli ha riportato notevoli danni di prestigio scientifico e di altro tipo, sia per mancato riconoscimento della vera paternita' delle scoperte che per altri motivi a causa del plagio scientifico perpetrato dagli imputati Professori Roberto Mignani e Fabio Cardone.

Il sottoscritto pertanto conferma e ribadisce le richieste per azioni penali e civili contro detti imputati come presentati nei paragrafi 1), 2), 3) e 4) di questa denuncia-querela, con la preghiera di attivare le procedure d'urgenza onde bloccare ed impedire ulteriori sperperi di danaro pubblico ed ulteriori plagi.

Qualora un Ente chiamato ad intervenire nella presente denuncia-querela veda la necessita' di costituire una commissione di studio tecnico del plagio, il sottoscritto richiede che: 1) tutti i nomi di detta possibile Commissione di studio debbono essere resi pubblici onde impedire azione antiscientifiche che sono generalmente permesse dall'anonimato; 2) della possibile Commissione di studio deve essere composta da veri esperti nel settore, ossia da scienziati che hanno pubblicato articoli tecnici nel settopre specifico del plagio come prova necessaria della loro qualificazione e competenza, risultando quindi nella conseguenza necessaria che detta Commissione sia di carattere internazionale; e 3) qualunque conclusione di una possibile Commissione di studio deve provare false le accuse di plagio raggiunte dalla Commissione cinese del Prof. Liu ed, indipendentemente, dalla Commissione americana del Prof. Wilhelm, come condizione necessaria per la sua credibilita'.

Il sottoscritto Prof. Ruggero Maria Santili si riserva inoltre:

> il diritto ad ogni altra azione legale contro tutte le persone, Enti ed Istituzioni responsabili dei plagi scientifici a suo danno considerati in questa denuncia-querela per il dovuto risarcimento finanziario stimato essere dell'ordine di cinque miliardi di Lire italiane;

> il diritto di esporre denuncia-querela contro gli onorevoli BEVILACQUA, VEVANTE SCIOLETTI, PRESTI E BATTAFGLIA firmatari della interrogazione al Ministro n. 3-00691 (Allegato XXIV) dietro copmpletamento dell'iter parlamentare necessario;

> il diritto di iniziare nuove azioni legali penali e civili qualora gli imputati Professori Mignani e Cardone continuino nei loro plagi scientifici nonostante la presente denuncia-querela;

> il diritto di iniziare azioni legali internazionali perche' il plagio, truffa e disonesta' scientifica da parte degli imputati Professori F. Cardone e R. Mignani hanno implicato la soppressione fraudolenta pienamente consapevole di pubblicazioni ufficiali del Dipartimento dell'Energia degli Stati Uniti d'America come identificate a pagina 11, causando evidente danno, offesa ed ingiuria agli Stati Uniti d'America, alle sue Istituzioni ed ai suoi Cittadini che vanno trattati in sede legale separata ed

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appropriata; ed

> il diritto di promuovere interrogazioni parlamentari e processi penali e civile contro il recente decadimento veramente impressionante della moralita' scientifica della fisica italiana, senza il cui contenimento, mediante azioni pubbliche penali e civili a livello italiano ed internazionale, nessun avanzamento della conoscenza scientifica umana di carattere veramente fondamentale e' possibile.

Questa denunciaquerela composta da 32 (trentadue) pagine piu' XXV Allegati e' firmata dal sottoscritto nella sua qualita' di Cittadino degli Stati Uniti d'America sotto la protezione del Primo Amendamento della Costituzione Americana che garantisce la liberta' di espressione di opinioni personali, senza nessun riferimento, diretto o indiretto, alle varie vistituzioni accademiche in diversi paesi a cui egli e' affiliato.

In Fede il giorno ..... del mese di .... dell'anno ....

Ruggero Maria Santilli
Domicilio permanente:
P.O.Box 1577, Palm Harbor, FL 34682, U.S.A., fax 001-1-813-934 9275

Traduzione della testimonianza della Fleming
A CHI PUO INTERESSARE

Questo e' per certificare che: I - Durante le vancanbze di natale del 1991 ho incontrato il fisico italiano F. Cardone mentre visitava Ik'Institute for Basic Research nella Florida; II - Il Sig. Cardone fece personalmente il revisore delle bozze di due volumi scritti dal R. M. Santilli ed intitolati "Generalizzazione Isotopica delle Relativita' di Galileo ed Einstein", Voklume I e II, che furopno allora pubblicati a seguito di tale revisione delle bozze poco prima della fine del 1991. Le copie delle bozze di tali due volumi con tutti i segni apportati personalmente dal Sig. Cardone sono ancora nell'archivio dell'Editore ; III - Ho spedito personalmente copie addizionali delle bozze di tali due volumi al Sig. R. Mignani al suo indirizzo al Dipartimento Marconi alla Universita' di Roma, Italia . L'Editore ha ancora nel suo archivio la documentazione dei suggerimenti su questi due volumi chhe furono mandati dal Sig. Mignani anche nel 1991 prima della loro pubblicazione.

In Fede

Signora Pamela Fleming
Residente della Contea Pinellas
Florida, USA

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July 31, 2007

Attorney BRYANT BOYDSTUN, jr
Fisher & Sauls PA
100 2-th Ave $ 701
ST. PETERSBURG, FL 33731
Via fax 727-822 1633

RE: Federal Lawsuit #807-cv-308 Santilli vs Cornell University

Dear Attorney Boydstun, jr,

This is to confirm our phone conversation of today to the effect that I am available for an out of court settlement for the purpose of removing Cornell University from an internationally observed Federal Lawsuit with rather severe allegations. In the event such a settlement is possible in the near future prior to entering into expected large expenditures, and only in that event, my sole request is the implementation of scientific ethics at that campus without request for financial compensation. I would like to be on record to express my appreciation for your cooperation toward such a possibility showing sincere loyalty to Coirnell University beyond your personal financial interest in the event of a full litigation.

The fact that forced the filing of the lawsuit are internationally known. The anonymous editors of Cornell's arxiv systematically allowed to upload in the hep-th and other sections papers by defendants Fabio Crdone and Roberto Mignani that were: 1) notoriously plagiarizing my work and that by other distinguished scholars; 2) catastrophically inconsistent for technical reasons presented in the Complaint and confirmed by experts; and 3) unpublished as well as rejected by various journals, of course, to prevent lawsuits.

By comparison, said anonyumous editors at Cornell refused the uploading of my papers in the same conduit despite the fact that they: 1) were written by the originator of the field, 2) had been accepted for publication in leading refereed journals, 3) resolve said catastrophic inconsistencies as per view by serious experts, 4) had all needed endorsments by hep-th colleagues, and, most unreassuringly, 5) are known to be devoted to the search of new clean energies and fuels so much needed by society, search so severely jeopardized by the suppression of their listing with the coordinated, conspiratorial suppression of the very motivation of the arxiv, scientific exhanges on issue of direct societal relevan ce.

The sole possibility for an out of court settlement with Cornell University without financial compensation is what I respectfully asked to President Skorton, namely, that: 1) I have a contractual assurance by Cornell University allowing me unobstructed uploading of papers in hep-th, hep-exp and other archives in exactly the same way, no more but positively no less, than the access available to other senior scholars with my qualifications, and 2) the plagiarizing and catastrophically inconsistent papers by defendants Cardone and Mignani are removed from the arxiv.

Additionally, I "recommend", but I do not request, that the ongoing anonymity of the editors of the arxiv be terminated and their names be listed in the main page of the arxiv. This recommendation appears necessary to correct the world wide damage caused by said anonymity to Cornell University, as well as for the very legal protection of President Skorton who, according to my advisors, is currently seen personally responsible for the arxiv.

In closing permit me to indicate that formal proceedings pro se will continue evidently to prevent a dismissal of the case while this possibility is being explored. This includes the initiation of the Interrogatory to mandate Cornell University to disclose to the world wide scientific community the names of the anonymous editors of the arxiv. Also, please understand that, in the event I perceive the intent at Cornell University of continuing an unethical conduct of science, I reserve the right to withdraw my opening for the above possible settlement via notification to you and appoint a federally accredited lawfirm , in which case the lawsuit will be conducted to its end, including judicial securing of due financial compensations.

Yours, Truly

Ruggero Maria Santilli
acting pro Se
25146 US 19 NO # 215
Palm Harbor, Fl 34684
Tel. 727-688 3992
Fax 727-934 3448

Copy to
Prof. David J. Skorton
President
Cornell University
Ithaca, NY 14853
via fax 607-255 9924

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HADRONIC JOURNAL
and
HADRONIC JOURNAL SUPPLEMENT

NOBEL PRIZE WINNER

DEFENDANTS

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VERY URGENT

RE: PROPOSAL FOR AN OUT OF COURT SETTLEMENT OF THE LAWSUIT AT THE U.S. FEDERAL COURT NUMBER 8:07-CV-00308-T-23MSS

Palm Harbor, Florida August 23, 2007

Prof. FERDINANDO DI ORIO
President, Universita' dell'Aquila (UdA)
P.zza Vincenzo Rivera, I - 67100 L'Aquila, Italy
Tel. 0862/432091, Fax 0862/412948, email rettore@cc.univaq.it

Dear Prof. Di Orio,

This document is intended to make sure you are aware of the following facts:

1) On July 31, 2007, I contacted your representative, Attorney C. PHILLIP CAMPBELL, JR, suggesting an Out of Court Settlement of the lawsuit without compensation to me.

2) Your attorney rejected my proposal and threatened me of a counter-lawsuit unless I "immediately withdraw" you and your institution without any compensation for me..

3) I then filed a Motion to Log Procedural Misconduct by your representative you can read in the original website of the lawsuit at the U. S. Federal Court, or in the mirror site http://www.scientificethics.org/Lawsuit-Cardone-Mignani.htm or in the specific page http://www.scientificethics.org/Procedural-Misconduct.htm

You should be aware that this behavior by your attorney is damaging to you because it can be construed as a confirmation of complicity in a paternity fraud, misuses of public funds, and other violations of international laws. Since I am sure the above action by your representative was undertaken without any previous consultation with you, I want to give you a second and final chance. Please note that, following an Order by the current Federal Judge, I have hired a major local Law Firm that will file the (third and) FINAL COMPLAINT by SEPTEMBER 10, 2007.

My proposal for an Out Of Court Settlement without any financial compensation for me is, quite simply and quite reasonably, that you send me a letter along the lines proposed below, signed and faxed to me at 001-727-934 9275 on or before September 7, 2007. As you can see, the letter merely indicates that F. cardone, R. Mignani, and A. Marrani will not piublish any additional paper in my field without the proper quotation of my work. I will then sign such a settlement "without prejudice", according to Federal Rules of Civil Procedures, namely, that I have the right to sue again you and your institution in the event of a future violation of the Settlement on your part.

Please note that I can accept an Out of Court Settlement without financial compensation IF AND ONLY IF the requested letter is signed and faxed by you on or before FRIDAY SEPTEMBER 7, 2007. If, for any reason, said letter is not signed and/or faxed on or before said date, the new Final Complaint will be recorded with your name and your institution as Defendants. Following that, I will always remain available for an out of court settlement, but, in view of the large financial expenditures I have to sustain in hiring a large Law Firm

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and for other reasons, please be aware that a settlement will be possible only jointly with a large financial compensation for damages suffered and expenses occurred.

In closing, please note that, according to unanimous consensus by serious scholar, the paternity fraud by F. Cardone, R. Mignani and A. Marrani of my "isotopies of special relativity", of the "isotopies of the Minkowskian space", the "isotopies of the Lorentz symmetry", "isotopies of quantum mechanics" and related topics is simply beyond any possible or otherwise credible doubt. In fact, said physicists published several papers up to 1992 with a full admission of my paternity (see the Exhibits of the current Complaint). Subsequent to 1992, said physicists published several papers and a book by copying ad litteram my work (including the symbols !!) under the fraudulent names of "deformed special relativity", "deformed Minkowski space", "deformed Lorentz symmetries" and "deformed quantum mechanics" without any quotation at all of my work initiated Lettere Nuovo Cimento Vol. 37, p. 545 (1983) and then developed in numerous papers and monographs.

Even assuming you might have some political doubt, I suggest you should personally inspect the several papers uploaded by said physicists in the arxiv.org (following search under "Fabio Cardone") where said physicists copied my preceding work ad litteram, but abstained from any quotation whatever of my preceding work, thus perpetrating an unquestionable violation of the most elementary rules of scientific ethic s and accountability in the use of public funds under your backing.

Even assuming you still have doubt on, you should personally verify that the papers are fraudulent because they activate the known Theorems of Catastrophic Inconsistencies of Noncanonical and Nonunitary Theories [see their latest formulation and large bibliography in Il Nuovo Cimento B Vol 121 B, pages 443-486 (2006)]. The fraud occurred because the authors participated in the formulation of these Inconsistency Theorems, yet they failed to identify the inconsistencies of their formulations of my isotopies when formulated in conventional fields, rather than then on Santilli isofields, namely, without extending the isotopies to the basic numbers for evident reason of consistency.

Finally, you should be aware that my Federal Lawsuit 8:07-CV-00308-T-23MSS is now inspected by scientists the world over, and essentially establishes that, after an initial legal action against said physicists filed in Italy in 1992 (see the web site http://www.scientificethics.org/Mignani-Cardone-ir00001.htm),
legal action totally ignored by the responsible Italian institutions despite their documented awareness, a senior U. S. scientist such as myself has been forced to file a lawsuit in Federal Court just to have his work quoted by Italian physicists, of course jointly with other works BUT in their chronological order. This lawsuit establishes the existence of a truly incredible decay of scientific ethics and accountability in Italy of which I recommend you not to be part of.

In the event of any need, or if I can help you in any way , please do not hesitate to call me.

Yours, Truly

Ruggero Maria Santilli
U. S. Citizen acting pro se
35246 US 19 No PMB 215,
Palm Harbor, FL 34684
Mobile 001-727-688 3992, fax 001-727-934 9275, email <ibr@gte.net>

H3

COPIES TO

Attorney ANDREA PONTECORVO
Viale Carso 77
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Tel. 06-320 2452 , Fax 06-361 2745 Email <slp@studiolegalepontecorvo.191.it>

Attorney C. Phillip Campbell, jr
Shumaker. Loop& Kendrick
Bank of America Plaza. suite 2800
101 East kennedy Blvd
Tampa, FL 33602, Tmpa, FL 33602

****

PROPOSED SETTLEMENT LETTER TO BE SIGNEDD AND FAXED TO 001-727-934 9275 ON OR BEFORE SEPTEMBER 7, 2007

Date xxx, xx, 2007
Prof.. RUGGERO MARIA SANTILLI
35246 US 19 No. # 215
Palm Harbor, FL 34684
Via fax 001-727-934 9275

Dear Prof. santilli,

This is to warrant that, following your filing of Lawsuit number 8:07-CV-00308-T-23MSS at the U. S. Federal; Court, the Italian Universita' dell'Aquila (UdA), will not authorize any additional papers authored by the Italian physicists Fabio Cardone, Roberto Mignani and Alessio Marrani under the UdA affiliation in the field of the isotopies of special relativity, the Minkowski space, the Lorentz symmetries, quantum mechanics and related topics, without the quotation of your originating works, such as Lettere al Nuovo Cimento Vol. 37, p. 545 (1983), Hadronic Journal Vol. 1, p. 547 (1978) and "Elements of Hadronic Mechanics", Volumes I and II, Ukraine Academy of Sciences (1991), said works to be quoted jointly with others, provided that the latter are directly relevant to the field and the quoptations are in chronological order. Following reception of this letter on or before the requested date of September 7, 2007, you assume the obligation of removing "without prejudice" my name and the UdA as defendants from the continuation of said lawsuit.
In faith

–

____
Prof. Ferdinando di Orio
President, Universita' dell'Aquila

____
For acceptance without prejudice by
Prof. Ruggero Maria Santilli

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H4

VERY URGENT

RE: PROPOSAL FOR AN OUT OF COURT SETTLEMENT OF THE LAWSUIT AT THE U.S. FEDERAL COURT NUMBER 8:07-CV-00308-T-23MSS

Palm Harbor, Florida August 23, 2007

Prof.GUIDO FABIANI
President, Universita' di Roma Tre (UR3)
Via Ostiense, 161, I-00154 Rome, Italy
Tel. 06 57067403, Fax 06 57067300 email <rettore@uniroma3.it>

Dear Prof. Pistella,

Since you have decided not to elect your representation in the above quoted lawsuit until now, please be informed that a Motion of judgment for default was entered for payment to me on damages and costs of twenty five millions dollars. Subsequently, following an Order by the current Federal Judge, I have hired a major local Law Firm that will file the (third and) FINAL COMPLAINT by SEPTEMBER 10, 2007. The amount of new charges against you and your university are unknown at this writing.

In the hope of halting these legal actions, I am here offering you an <u>Out Of Court Settlement without any financial compensation</u> for me that is, quite simply and quite reasonably, given by a letter along the lines proposed below, signed and faxed to me at 001-727-934 9275 on or before *September 7, 2007*. As you can see, the letter merely indicates that F. Cardone, R. Mignani, and A. Marrani will not publish any additional paper in my field under your affiliation without the proper quotation of my originating work. I will then sign such a settlement "without prejudice" according to Federal Rules of Civil Procedures, namely, that I have the right to sue again you and your institution in the event of a future violation of the Settlement on your part.

Please note that I can accept an Out of Court Settlement without financial compensation IF AND ONLY IF the requested letter is signed and faxed by you on or before FRIDAY SEPTEMBER 7, 2007. If, for any reason, said letter is not signed and/or faxed on or before said date, the new Final Complaint will be recorded with your name and your institution as Defendants. Following that, I will always remain available for an out of court settlement, but, in view of the large financial expenditures I have to sustain in hiring a large Law Firm and for other reasons, please be aware that a settlement will be possible only jointly with a large financial compensation for damages suffered and expenses occurred.

In closing, please note that, according to unanimous consensus by serious scholar, the paternity fraud by F. Cardone, R. Mignani and A. Marrani of my "isotopies of special relativity", of the "isotopies of the Minkowskian space", the "isotopies of the Lorentz symmetry", "isotopies of quantum mechanics" and related topics is simply beyond any possible or otherwise credible doubt. In fact, said physicists published several papers up to 1992 with a full admission of my paternity (see the Exhibits of the current Complaint). Subsequent to 1992, said physicists published several papers and a book by copying ad litteram my work (including the symbols !!) under the fraudulent names of "deformed special relativity", "deformed Minkowski space", "deformed Lorentz symmetries" and "deformed quantum mechanics" without any quotation at all of my work initiated Lettere Nuovo Cimento Vol. 37, p. 545 (1983) and then developed in numerous papers and monographs.

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Even assuming you might have some political doubt, I suggest you should personally inspect the several papers uploaded by said physicists in the arxiv.org (following search under "Fabio Cardone") where said physicists copied my preceding work ad litteram, but abstained from any quotation whatever of my preceding work, thus perpetrating an unquestionable violation of the most elementary rules of scientific ethic s and accountability in the use of public funds under your backing.

Even assuming you still have doubt on, you should personally verify that the papers are fraudulent because they activate the known Theorems of Catastrophic Inconsistencies of Noncanonical and Nonunitary Theories [see their latest formulation and large bibliography in Il Nuovo Cimento B Vol 121 B, pages 443-486 (2006)]. The fraud occurred because the authors participated in the formulation of these Inconsistency Theorems, yet they failed to identify the inconsistencies of their formulations of my isotopies when formulated in conventional fields, rather than then on Santilli isofields, namely, without extending the isotopies to the basic numbers for evident reason of consistency.

Finally, you should be aware that my Federal Lawsuit 8:07-CV-00308-T-23MSS is now inspected by scientists the world over, and essentially establishes that, after an initial legal action against said physicists filed in Italy in 1992 (see the web site http://www.scientificethics.org/Mignani-Cardone-ir00001.htm), legal action totally ignored by the responsible Italian institutions despite their documented awareness, a senior U. S. scientist such as myself has been forced to file a lawsuit in Federal Court just to have his work quoted by Italian physicists, of course jointly with other works BUT in their chronological order. This lawsuit establishes the existence of a truly incredible decay of scientific ethics and accountability in Italy of which I recommend you not to be part of.

In the event of any need, or if I can help you in any way , please do not hesitate to call me.

Yours, Truly

Ruggero Maria Santilli
U. S. Citizen acting pro se
35246 US 19 No PMB 215,
Palm Harbor, FL 34684
Mobile 001-727-688 3992, fax 001-727-934 9275, email <ibr@gte.net>

COPY TO

Attorney ANDREA PONTECORVO
Viale Carso 77
00195 Roma, Italy
Tel. 06-320 2452 , Fax 06-361 2745 Email <slp@studiolegalepontecorvo.191.it>

H6

****

PROPOSED SETTLEMENT LETTER TO BE SIGNEDD AND FAXED TO 001-727-934 9275 ON OR BEFORE SEPTEMBER 7, 2007

Date xxx, xx, 2007
Prof.. RUGGERO MARIA SANTILLI
35246 US 19 No. # 215
Palm Harbor, FL 34684
Via fax 001-727-934 9275

Dear Prof. santilli,

This is to warrant that, following your filing of Lawsuit number 8:07-CV-00308-T-23MSS at the U. S. Federal; Court, the Italian Universita' di Roma Tre (UR3), will not authorize any additional papers authored by the Italian physicists Fabio Cardone, Roberto Mignani and Alessio Marrani under the UR3 affiliation in the field of the isotopies of special relativity, the Minkowski space, the Lorentz symmetry, quantum mechanics and related topics, without the quotation of your originating works, such as Lettere al Nuovo Cimento Vol. 37, p. 545 (1983), Hadronic Journal Vol. 1, p. 547 (1978) and "Elements of Hadronic Mechanics", Volumes I and II, Ukraine Academy of Sciences (1991), said works to be quoted jointly with others, provided that the latter are directly relevant to the field and the quotations are in chronological order. Following reception of this letter on or before the requested date of September 7, 2007, you assume the obligation of removing "without prejudice" my name and the UR3 as defendants from the continuation of said lawsuit.
In faith

____
Prof. Guido Fabiani
Rettore, Universita' di Roma Tre

____
For acceptance without prejudice by
Prof. Ruggero Maria Santilli

************************************** adsdsdsd

#7

VERY URGENT

RE: PROPOSAL FOR AN OUT OF COURT SETTLEMENT OF THE LAWSUIT AT THE U.S. FEDERAL COURT NUMBER 8:07-CV-00308-T-23MSS

Palm Harbor, Florida August 23, 2007

Prof. FABIO PISTELLA
President, Consiglio Nazionale Ricerche (CNR)
Piazzale Aldo Moro,7 , I-00185, Roma, Italy
Via Fax : +39 06 4461954 and email <presidenza@cnr.it>

Dear Prof. Pistella,

This document is intended to make sure you are aware of the following facts:

1) On July 31, 2007, I contacted your representative, Attorney C. PHILLIP CAMPBELL, JR, suggesting an Out of Court Settlement of the lawsuit without compensation to me.

2) Your attorney rejected my proposal and threatened me of a counter-lawsuit unless I "immediately withdraw" you and your institution without any compensation for me..

3) I then filed a Motion to Log Procedural Misconduct by your representative you can read in the original website of the lawsuit at the U. S. Federal Court, or in the mirror site http://www.scientificethics.org/Lawsuit-Cardone-Mignani.htm or in the specific page http://www.scientificethics.org/Procedural-Misconduct.htm

You should be aware that this behavior by your attorney is damaging to you because it can be construed as a confirmation of complicity in a paternity fraud, misuses of public funds, and other violations of international laws. Since I am sure the above action by your representative was undertaken without any previous consultation with you, I want to give you a second and final chance. Please note that, following an Order by the current Federal Judge, I have hired a major local Law Firm that will file the (third and) FINAL COMPLAINT by SEPTEMBER 10, 2007.

My proposal for an <u>Out Of Court Settlement without any financial compensation</u> for me is, quite simply and quite reasonably, that you send me a letter along the lines proposed below, signed and faxed to me at 001-727-934 9275 on or before September 7, 2007. As you can see, the letter merely indicates that the CNR will not provide again any affiliation to F. Cardone, R. Mignani and A. Marrani. I will then sign such a settlement "without prejudice" per Federal Rules of Civil Procedures, namely, that I have the right to sue again you and your institution in the event of a future violation of the Settlement on your part.

Please note that I can accept an Out of Court Settlement without financial compensation IF AND ONLY IF the requested letter is signed and faxed by you on or before FRIDAY SEPTEMBER 7, 2007. If, for any reason, said letter is not signed and/or faxed on or before said date, the new Final Complaint will be recorded with your name and your institution as Defendants. Following that, I will always remain available for an out of court settlement, but, in view of the large financial expenditures I have to sustain in hiring a large Law Firm

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and for other reasons, please be aware that a settlement will be possible only jointly with a large financial compensation for damages suffered and expenses occurred.

In closing, please note that, according to unanimous consensus by serious scholar, the paternity fraud by F. Cardone, R. Mignani and A. Marrani of my "isotopies of special relativity", of the "isotopies of the Minkowskian space", the "isotopies of the Lorentz symmetry", "isotopies of quantum mechanics" and related topics is simply beyond any possible or otherwise credible doubt. In fact, said physicists published several papers up to 1992 with a full admission of my paternity (see the Exhibits of the current Complaint). Subsequent to 1992, said physicists published several papers and a book by copying ad litteram my work (including the symbols !!) under the fraudulent names of "deformed special relativity", "deformed Minkowski space", "deformed Lorentz symmetries" and "deformed quantum mechanics" without any quotation at all of my work initiated Lettere Nuovo Cimento Vol. 37, p. 545 (1983) and then developed in numerous papers and monographs.

Even assuming you might have some political doubt, I suggest you should personally inspect the several papers uploaded by said physicists in the arxiv.org (following search under "Fabio Cardone") where said physicists copied my preceding work ad litteram, but abstained from any quotation whatever of my preceding work, thus perpetrating an unquestionable violation of the most elementary rules of scientific ethic s and accountability in the use of public funds under your backing.

Even assuming you still have doubt on, you should personally verify that the papers are fraudulent because they activate the known Theorems of Catastrophic Inconsistencies of Noncanonical and Nonunitary Theories [see their latest formulation and large bibliography in Il Nuovo Cimento B Vol 121 B, pages 443-486 (2006)]. The fraud occurred because the authors participated in the formulation of these Inconsistency Theorems, yet they failed to identify the inconsistencies of their formulations of my isotopies when formulated in conventional fields, rather than then on Santilli isofields, namely, without extending the isotopies to the basic numbers for evident reason of consistency.

Finally, you should be aware that my Federal Lawsuit 8:07-CV-00308-T-23MSS is now inspected by scientists the world over, and essentially establishes that, after an initial legal action against said physicists filed in Italy in 1992 (see the web site http://www.scientificethics.org/Mignani-Cardone-ir00001.htm), legal action totally ignored by the responsible Italian institutions despite their documented awareness, a senior U. S. scientist such as myself has been forced to file a lawsuit in Federal Court just to have his work quoted by Italian physicists, of course jointly with other works BUT in their chronological order. This lawsuit establishes the existence of a truly incredible decay of scientific ethics and accountability in Italy of which I recommend you not to be part of.

In the event of any need, or if I can help you in any way , please do not hesitate to call me.

Yours, Truly

Ruggero Maria Santilli
U. S. Citizen acting pro se
35246 US 19 No PMB 215,
Palm Harbor, FL 34684
Mobile 001-727-688 3992, fax 001-727-934 9275, email <ibr@gte.net>

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COPIES TO

Attorney ANDREA PONTECORVO
Viale Carso 77
00195 Roma, Italy
Tel. 06-320 2452 , Fax 06-361 2745 Email <slp@studiolegalepontecorvo.191.it>

Attorney C. Phillip Campbell, jr
Shumaker. Loop& Kendrick
Bank of America Plaza. suite 2800
101 East kennedy Blvd
Tampa, FL 33602, Tmpa, FL 33602

****

PROPOSED SETTLEMENT LETTER TO BE SIGNEDD AND FAXED TO 001-727-934 9275 ON OR BEFORE SEPTEMBER 7, 2007

Date xxx, xx, 2007
Prof.. RUGGERO MARIA SANTILLI
35246 US 19 No. # 215
Palm Harbor, FL 34684
Via fax 001-727-934 9275

Dear Prof. santilli,

This is to warrant that, following your filing of Lawsuit number 8:07-CV-00308-T-23MSS at the U. S. Federal; Court, the Italian Consiglio nazionale Ricerche (CNR_) will not grant again any additional affiliation in any scientific works to Italian physicists Fabio Cardone, Roberto Mignani and Alessio Marrani. Following reception of this letter on or before the requested date of September 7, 2007, you assume the obligation of removing "without prejudice" my name and the CNR as defendants from the continuation of said lawsuit.
In faith

____
Prof. Fabio Pistella
Presidente, Consiglio nazionale Ricerche
Rome, Itraly

____
For acceptance without prejudice by
Prof. Ruggero Maria Santilli

****

N10

VERY URGENT

RE: PROPOSAL FOR AN OUT OF COURT SETTLEMENT OF THE LAWSUIT AT THE U.S. FEDERAL COURT NUMBER 8:07-CV-00308-T-23MSS

Palm Harbor, Florida August 23, 2007

Prof. ROBERTO PETRONZIO
President, Istituto Nazionale Fisica Nucleare (INFN)
Piazza dei Caprettari, 70, I-00185 Rome, Italy
Via Fax +39 06 68307924 and e-mail <presidenza@presid.infn.it>

Dear Prof. Petronzio,

This document is intended to make sure you are aware of the following facts:

1) On July 31, 2007, I contacted your representative, Attorney C. PHILLIP CAMPBELL, JR, suggesting an Out of Court Settlement of the lawsuit without compensation to me.

2) Your attorney rejected my proposal and threatened me of a counter-lawsuit unless I "immediately withdraw" you and your institution without any compensation for me..

3) I then filed a Motion to Log Procedural Misconduct by your representative you can read in the original website of the lawsuit at the U. S. Federal Court, or in the mirror site http://www.scientificethics.org/Lawsuit-Cardone-Mignani.htm or in the specific page http://www.scientificethics.org/Procedural-Misconduct.htm

You should be aware that this behavior by your attorney is damaging to you because it can be construed as a confirmation of complicity in a paternity fraud, misuses of public funds, and other violations of international laws. Since I am sure the above action by your representative was undertaken without any previous consultation with you, I want to give you a second and final chance. Please note that, following an Order by the current Federal Judge, I have hired a major local Law Firm that will file the (third and) FINAL COMPLAINT by SEPTEMBER 10, 2007.

My proposal for an <u>Out Of Court Settlement without any financial compensation</u> for me is, quite simply and quite reasonably, that you send me a letter along the lines proposed below, signed and faxed to me at 001-727-934 9275 on or before September 7, 2007. As you can see, the letter merely indicates that no additional paternity fraud or copyrights violation will occur under INFN support. I will then sign such a settlement "without prejudice", according to Federal Rules of Civil Procedures, namely, that I have the right to sue again you and your institution in the event of a future violation of the Settlement on your part.

Please note that I can accept an Out of Court Settlement without financial compensation IF AND ONLY IF the requested letter is signed and faxed by you on or before FRIDAY SEPTEMBER 7, 2007. If, for any reason, said letter is not signed and/or faxed on or before said date, the new Final Complaint will be recorded with your name and your institution as Defendants. Following that, I will always remain available for an out of court settlement, but, in view of the large financial expenditures I have to sustain in hiring a large Law Firm

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In closing, please note that, according to unanimous consensus by serious scholar, the paternity fraud by F. Cardone, R. Mignani and A. Marrani of my "isotopies of special relativity", of the "isotopies of the Minkowskian space", the "isotopies of the Lorentz symmetry", "isotopies of quantum mechanics" and related topics is simply beyond any possible or otherwise credible doubt. In fact, said physicists published several papers up to 1992 with a full admission of my paternity (see the Exhibits of the current Complaint). Subsequent to 1992, said physicists published several papers and a book by copying ad litteram my work (including the symbols !!) under the fraudulent names of "deformed special relativity", "deformed Minkowski space", "deformed Lorentz symmetries" and "deformed quantum mechanics" without any quotation at all of my work initiated Lettere Nuovo Cimento Vol. 37, p. 545 (1983) and then developed in numerous papers and monographs.

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Finally, you should be aware that my Federal Lawsuit 8:07-CV-00308-T-23MSS is now inspected by scientists the world over, and essentially establishes that, after an initial legal action against said physicists filed in Italy in 1992 (see the web site http://www.scientificethics.org/Mignani-Cardone-ir00001.htm), legal action totally ignored by the responsible Italian institutions despite their documented awareness, a senior U. S. scientist such as myself has been forced to file a lawsuit in Federal Court just to have his work quoted by Italian physicists, of course jointly with other works BUT in their chronological order. This lawsuit establishes the existence of a truly incredible decay of scientific ethics and accountability in Italy of which I recommend you not to be part of.

In the event of any need, or if I can help you in any way , please do not hesitate to call me.

Yours, Truly

Ruggero Maria Santilli
U. S. Citizen acting pro se
35246 US 19 No PMB 215,
Palm Harbor, FL 34684
Mobile 001-727-688 3992, fax 001-727-934 9275, email <ibr@gte.net>

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COPIES TO

Attorney ANDREA PONTECORVO
Viale Carso 77
00195 Roma, Italy
Tel. 06-320 2452 , Fax 06-361 2745 Email <slp@studiolegalepontecorvo.191.it>

Attorney C. Phillip Campbell, jr
Shumaker. Loop& Kendrick
Bank of America Plaza. suite 2800
101 East kennedy Blvd
Tampa, FL 33602, Tmpa, FL 33602

****

PROPOSED SETTLEMENT LETTER TO BE SIGNEDD AND FAXED TO 001-727-934 9275 ON OR BEFORE SEPTEMBER 7, 2007

Date xxx, xx, 2007
Prof.. RUGGERO MARIA SANTILLI
35246 US 19 No. # 215
Palm Harbor, FL 34684
Via fax 001-727-934 9275

Dear Prof. santilli,

This is to warrant that, following your filing of Lawsuit number 8:07-CV-00308-T-23MSS at the U. S. Federal; Court, the Italian Istituto nazionale Fisica Nucleare (INFN), will not authorize any direct or indirect use of our public funds in papers authored by the Italian physicists Fabio Cardone, Roberto Mignani and Alessio Marrani in the field of the isotopies of special relativity, the Minkowski space, the Lorentz symmetries, quantum mechanics and related topics without the quotation of your originating works, such as Lettere al Nuovo Cimento Vol. 37, p. 545 (1983), Hadronic Journal Vol. 1, p. 547 (1978) and "Elements of Hadronic Mechanics", Volumes I and II, Ukraine Academy of Sciences (1991). Following reception of this letter on or before the requested date of September 7, 2007, you assume the obligation of removing "without prejudice" my name and the INFN as defendants from the continuation of said lawsuit.
In faith

____
Prof. Roberto Petronzio
President, Istituto Nationale Fisica Nucleare,
Rome, Italy

____
For acceptance without prejudice by
Prof. Ruggero Maria Santilli

****

01

AFFIDAVIT OF SERVICE

SHERIFFS NUMBER Law 227171
TYPE OF SERVICE

DEFENDANT 1 OF 1

July 19, 2007
BERGEN COUNTY SHERIFF DEPT
MARTHA

I, LEO P. MCGUIRE, SHERIFF OF BERGEN COUNTY, DO HEREBY DEPUTIZE S/O James Delasbey
AND APPOINT TO BE MY DEPUTY, TO EXECUTE AND RETURN THE WRIT ACCORDING TO LAW.

ATTORNEY
RUGGERO MARIA SANTILLI PRO SE
35246 US 19 NO PMB 215
PALM HARBOR, FL 34684

CHECK #
8729738

AMOUNT
$ 33.28

CONTROL # 107428-1

COURT DATA

COURT US DISTRICT
DOCKET CV00308T23MSS

STATE FL

COUNTY OF VENUE PINELLAS

CAPTION OF CASE

RUGGERO MARIA SANTILLI
VS
FABIO CARDONE ET ALS

NAMED WITHIN TO BE SERVICE

NAME K.K. PHUA
ADDRESS 1060 MAIN ST SUITE 1B
CITY, STATE, ZIP RIVER EDGE, NJ 07661

PAPERS SERVED
SUMMMON AND AMENDED COMPLAINT

SERVICE DATA RECORDED

[ ] SERVED [X] UNABLE TO SERVE (1) ________ DATE [8] / [1] / [07]

ATTEMPTS ________ (2) ________ TIME [13] : [55] : [ ]

REMARKS: per Chris Ibay, of FilorDental - dentist & building manager defendant no longer at this address

PERSON SERVED: ________

[ ] COPY PERSONALLY DELIVERED
[ ] COPY LEFT WITH:
COMPETENT HOUSEHOLD MEMBER OVER 14 YRS OF AGE RESIDING THEREIN
[ ] OFFICER
[ ] MANAGING or GENERAL AGENT, PARTNER
[ ] REGISTERED AGENT
[ ] AGENT AUTHORIZED TO ACCEPT
[ ] DIRECTOR, TRUSTEE

[ ] IS IN THE MILITARY [ ] NOT IN THE MILITARY

SEX: [ ] MALE [ ] FEMALE
SKIN: [ ] WHITE [ ] BLACK [ ] YELLOW [ ] BROWN [ ] RED
HEIGHT: [ ] UNDER 5 FEET [ ] 5.0 – 5.6 FT [ ] 5.7 – 6.0 FT [ ] OVER 6 FT
WEIGHT: [ ] UNDER 100 LBS [ ] 100-150 LBS. [ ] 151-200 LBS [ ] OVER 200 LBS
HAIR: [ ] BLACK [ ] BROWN [ ] BLOND [ ] GRAY [ ] RED [ ] WHITE [ ] BALDING
AGE: [ ] 14-20 [ ] 21-35 [ ] 36-50 [ ] 51-65 [ ] OVER 65

SWORN AND SUBSCRIBED TO BEFORE ME
THIS 3 DAY OF 8 2007

Kimberly Provenzano

Delasbey 603

DEPUTY SHERIFF OF BERGEN COUNTY
STATE OF NEW JERSEY

KIMBERLY D. PROVENZANO
COMMISSION EXPIRES
7-13-09

RUS11

AO 440 (Rev. 8/01) Summons in a Civil Action

62

UNITED STATES DISTRICT COURT

MIDDLE District of FLORIDA

Ruggero Maria Santilli
v.
Fabio Cardone, Roberto Mignani
K. K. Phua, World Scientific Publishing Co., Inc.,
Istituto NaZionale Fisica Nucleare ,
Consiglio Nazionale Ricerche,
Universita' di Roma Tre,
Universita' dell'Aquila, Cornell University
Alessio Marrani

SUMMONS IN A CIVIL CASE

CASE NO: 8:07-CV-00308-T-23MSS

TO: (Name and address of Defendant)

K. K. Phua
1060 Main Street, Suite 1B,
Riiver Edge, NJ 07661 U.S.A.,

YOU ARE HEREBY SUMMONED and required to serve on PLAINTIFF'S ATTORNEY (name and address)

Ruggero Maria Santilli
35246 US 19 No PMB 215,
Palm Harbor, FL 34684, U.S.A.,

an answer to the complaint which is served on you with this summons, within 20 days after service of this summons on you, exclusive of the day of service. If you fail to do so, judgment by default will be taken against you for the relief demanded in the complaint. Any answer that you serve on the parties to this action must be filed with the Clerk of this Court within a reasonable period of time after service.

SHERYL L. LOESCH
CLERK

25 JUN 2007
DATE

(By) DEPUTY CLERK

03

OFFICE OF THE BERGEN COUNTY SHERIFF
BERGEN COUNTY JUSTICE CENTER
HACKENSACK, NJ 07601
(201) 646-2200

Leo P. McGuire
Sheriff

AMONG HIS MANY DUTIES, THE SHERIFF OF BERGEN COUNTY IS RESPONSIBLE FOR THE LEGAL SERVICE OF CIVIL COMPLANITS FILED IN A COURT OF LAW. THIS DEPARTMENT DOES NOT INSTITUTE THE PROCEEDINGS NOR ARE WE INVOLVED IN THE ULTIMATE OUTCOME OR LITIGATION THEREOF.

OUR OFFICERS ONLY ATTEST THAT THE DOCUMENTS WERE PROPERLY DELIVRED OR SERVED UP0N YOU OR A MEMBER OF YOUR HOUSEHOLD. YOU MAY BE REQUIRED BY LAW TO RESPOND TO THESE DOCUMENTS WITHIN A SPECIFC TIME PERIOD. I THEREFORE SUGGEST THAT YOU READ THEM CAREFULLY, THEN CONTACT THE ATTORNEY AT THE TOP OF THE PAPERS YOU WERE SERVED.

IF THIS DEPARTMENT CAN BE OF FUTHER ASSISTANCE, PLEASE DO NOT HESITATE TO CONTACT THE CIVIL PROCESS DISIVION AT (201) 646-2200 BETWEEN THE HOURS OF 9:00 AM AND 4:00 PM.

UNITED STATES DISTRICT COURT
MIDDLE DISTRICT OF FLORIDA
TAMPA DIVISION

P1

RUGGERO MARIA SANTILLI,

Plaintiff,

v.

Case No. 08:07-cv-308-SDM-MSS

FABIO CARDONE, K.K. PHUA, ALESSIO MARRANI, ROBERTO MIGNANI, WORLD SCIENTIFIC PUBLISH CO., INC., CORNELL UNIVERSITY, INSTITUTO NAZIONALE FISICA NUCLEARE, CONSIGLIO NAZIONALE RICERCHE, UNIVERSITA' DI ROMA TRE, AND UNIVERSITA' DEL L'AQUILA,

Defendants.

_______________________________________/

AFFIDAVIT OF ROBERTO PETRONZIO IN SUPPORT OF DEFENDANT, THE INSTITUTO NAZIONALE FISICA NUCLEARE'S, MOTION TO DISMISS <u>PLAINTIFF'S THIRD AMENDED COMPLAINT</u>

REPUBLIC OF ITALY)
)
PROVINCE OF ____________________)

CITY OF ________________________)

BEFORE ME, this day personally appeared ROBERTO PETRONZIO, who deposes and says:

1. This Affidavit is submitted in support of the Motion to Dismiss Plaintiff's Third Amended Complaint brought by Defendants, Instituto Nazionale Fisica Nucleare ("INFN") and the Universita' Del L'Aquila ("University").

EXHIBIT
2

P2

2. My name is Roberto Petronzio. I am the President of INFN. The facts set forth in this Affidavit are based on my personal knowledge and personal recollection, or I have determined such facts from an examination of business records kept by INFN. All of the business records are made and kept by INFN in the regular course of its business and are made at or near the time by, or from information transmitted by, persons with personal knowledge of the facts contained in such business records. It is the regular practice of INFN to make and keep these business records.

3. INFN is a public Italian research institute dedicated to the study of the fundamental constituents of matter, and conducts theoretical and experimental research in the fields of subnuclear, nuclear, and astroparticle physics.

4. Groups from the universities of Rome, Padua, Turin, and Milan founded INFN on August 8, 1951.

5. To conduct its research activities, INFN utilizes cutting-edge technologies and instrumentation, which INFN develops both in its own laboratories and in collaboration with the world of industry. These activities are also conducted in close collaboration with the academic world.

6. I have examined all relevant records and documents maintained by INFN concerning whether INFN transacts business in the State of Florida.

7. INFN does not conduct regular, routine, or substantial business activity in the State of Florida. Any business transactions conducted by INFN in the State of Florida are infrequent.

8. INFN has not advertised any product directly in the State of Florida.

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9. INFN has never employed, utilized as an agent for INFN, or exercised control over the research activities of Fabio Cardone, Roberto Mignani, or Alessio Marrani.

10. I have read paragraph 11 of the Third Amended Complaint in which the Plaintiff alleges that INFN has been "engaged in selling, marketing, advertising, and promoting books, journals, conventional publications and electronic publications in the State of Florida, as well as in the rest of the world by therefore deriving an income from their business in the State of Florida".

11. It is not a true statement that INFN has been "engaged in selling, marketing, advertising, and promoting books, journals, conventional publications and electronic publications in the State of Florida".

12. In addition, INFN has not derived income from "selling, marketing, advertising, and promoting books, journals, conventional publications and electronic publications in the State of Florida".

13. I have read paragraph 69 of the Third Amended Complaint in which the Plaintiff alleges that INFN "conducts routine business, specifically, in the state of Florida, including the sale, promotions and advertisement of published work, exchange of students and faculty and participation to conferences and meetings, specifically, in the State of Florida".

14. As stated in Paragraph 7, above, INFN does not conduct regular, routine, or substantial business activity of any nature whatsoever in the State of Florida. Thus, the statement set forth in Paragraph 69 of the Third Amended Complaint is not true.

FURTHER THE AFFIANT SAYETH NAUGHT.

ROBERTO PETRONZIO
President
Instituto Nazionale Fisica Nucleare

Sworn to and subscribed before me the 14 day of february, 2008, by ROBERTO PETRONZIO, President of Instituto Nazionale Fisica Nucleare, who [X] is personally know to be or [ ] produced ______________ as identification and did take an oath.

ITALIAN NOTARY REPUBLIC – Province of ROMA
Name: Giovanna Petrella
My Commission Expires: ______________

[Notary Seal]

SLK_TAM: #850261v1

Ex 1

UNITED STATES DISTRICT COURT
MIDDLE DISTRICT OF FLORIDA
TAMPA DIVISION

RUGGERO MARIA SANTILLI,

Plaintiff,

v.

Case No. 08:07-cv-308-SDM-MSS

FABIO CARDONE, K.K. PHUA, ALESSIO MARRANI, ROBERTO MIGNANI, WORLD SCIENTIFIC PUBLISH CO., INC., CORNELL UNIVERSITY, INSTITUTO NAZIONALE FISICA NUCLEARE, CONSIGLIO NAZIONALE RICERCHE, UNIVERSITA' DI ROMA TRE, AND UNIVERSITA' DEL L'AQUILA,

Defendants.

______________________________________/

AFFIDAVIT OF FERDINANDO DI ORIO IN SUPPORT OF DEFENDANT, THE UNIVERSITA' DEL L'AQUILA'S, MOTION TO DISMISS THE PLAINTIFF'S THIRD AMENDED COMPLAINT

REPUBLIC OF ITALY)

PROVINCE OF ____________________)

CITY OF __________________________)

BEFORE ME, this day personally appeared FERDINANDO DI ORIO, who deposes and says:

1. This Affidavit is submitted in support of the Motion to Dismiss Plaintiff's Third Amended Complaint brought by Defendants, Instituto Nazionale Fisica Nucleare ("INFN") and the Universita' Del L'Aquila ("the University").

EXHIBIT
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2. My name is FERDINANDO Di Orio. I am the President of the University. The facts set forth in this Affidavit are based on my personal knowledge and personal recollection, or I have determined such facts from an examination of business records kept by the University. All of the business records are made and kept by the University the regular course of its business and are made at or near the time by, or from information transmitted by, persons with personal knowledge of the facts contained in such business records. It is the regular practice of the University to make and keep these business records.

3. Originally established in 1458, and then reestablished in 1964, the University is located in L'Aquila, Italy and is one of the oldest colleges in Europe. The University has a student enrollment of over sixteen thousand, and is both a teaching and research institute that collaborates with various research centers worldwide.

4. I have examined all relevant records and documents maintained by the University concerning whether the University transacts business in the State of Florida.

5. The University does not conduct regular, routine, or substantial business activity in the State of Florida. Any business transactions conducted by the University in the State of Florida are infrequent.

6. The University has not advertised any product directly in the State of Florida.

7. The University has never employed, utilized as an agent, or exercised control over the research activities of Fabio Cardone, Roberto Mignani, or Alessio Marrani.

8. I have read paragraph 11 of the Third Amended Complaint in which the Plaintiff alleges that the University has been "engaged in selling, marketing, advertising, and promoting books, journals, conventional publications and electronic publications in the State of Florida, as well as in the rest of the world by therefore deriving an income from their business in the State of Florida".

9. It is not a true statement that the University has been "engaged in selling, marketing, advertising, and promoting books, journals, conventional publications and electronic publications in the State of Florida".

10. In addition, the University has not derived income from "selling, marketing, advertising, and promoting books, journals, conventional publications and electronic publications in the State of Florida".

11. I have read paragraph 87 of the Third Amended Complaint in which the Plaintiff alleges that the University "conducts routine business, specifically, in the State of Florida, including the sale, promotions and advertisement of works exchange of students and faculty and partecipating to meetings and conferences".

12. As stated in Paragraph 5, above, the University does not conduct regular, routine, or substantial business activity of any nature whatsoever in the State of Florida. Thus, the statement set forth in Paragraph 87 of the Third Amended Complaint is not true.

13. Furthermore, the University is immune from suit as an agency or instrumentality of Italy, pursuant to the FSIA, 28 U.S.C. §§ 1602 et seq.

14. Section 1603(b) of the FSIA provides that an "agency or instrumentality of a foreign state is any entity that is an "organ of a foreign state".

15. The Italian government created the University. The University receives approximately seventy-five percent (75%) of its funding from the Italian government. The Italian government oversees and controls the University's budget, and the University must account to the Italian government for the spending of the funds.

16. The University conducts research that serves a national purpose.

FURTHER AFFIANT SAYETH NAUGHT.

FERDINANDO DI ORIO
President
The Universita' Del L'Aquila

Sworn to and subscribed before me the _____ day of ____________________, 2008, by FERDINANDO DI ORIO, President of the Universita' Del L'Aquila, who [ ] is personally know to be or [ ] produced ________________ as identification and did take an oath.

____
ITALIAN NOTARY REPUBLIC – Province of ____________
Name: ____
My Commission Expires:_____________________________

[Notary Seal]

SLK_TAM: #850264v1

Imposta di bollo assolta in modo virtuale
Autorizzazione Intendenza di Finanza di AQ del 03-12-1987 N. 23291

Io sottoscritto Dr. Vincenzo GALEOTA, Notaio in L'Aquila iscritto nel ruolo del Collegio Notarile dell'Aquila senza l'assistenza dei testimoni per espressa rinunzia col mio consenso, della parte, della cui identità personale io Notaio sono certo, CERTIFICO vera ed autentica la firma apposta in mia presenza dal Signor

- Di Orio Ferdinando, nato a Roma il 23 febbraio 1948, nella sua qualità di Rettore pro-tempore e legale rappresentante della "Università degli Studi di L'Aquila", con sede a L'Aquila, Piazza Vincenzo Rivera n. 1, (Italia).-

L'Aquila 13 febbraio 2008

V. Galeota

VINCENZO GALEOTA FU CARLO NOTAIO IN L'AQUILA

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EXHIBIT C RI

SAO/NASA ADS Physics Abstract Service

Title: High Resolution Spectroscopy of BΛ12 by Electroproduction

Authors: Iodice, M.; Cusanno, F.; Acha, A.; Ambrozewicz, P.; Aniol, K. A.; Baturin, P.; Bertin, P. Y.; Benaoum, H.; Blomqvist, K. I.; Boeglin, W. U.; Breuer, H.; Brindza, P.; Bydžovský, P.; Camsonne, A.; Chang, C. C.; Chen, J.-P.; Choi, Seonho; Chudakov, E. A.; Cisbani, E.; Colilli, S.; Coman, L.; Craver, B. J.; de Cataldo, G.; de Jager, C. W.; de Leo, R.; Deur, A. P.; Ferdi, C.; Feuerbach, R. J.; Folts, E.; Fratoni, R.; Frullani, S.; Garibaldi, F.; Gayou, O.; Giuliani, F.; Gomez, J.; Gricia, M.; Hansen, J. O.; Hayes, D.; Higinbotham, D. W.; Holmstrom, T. K.; Hyde, C. E.; Ibrahim, H. F.; Jiang, X.; Kaufman, L. J.; Kino, K.; Kross, B.; Lagamba, L.; LeRose, J. J.; Lindgren, R. A.; Lucentini, M.; Margaziotis, D. J.; Markowitz, P.; Marrone, S.; Meziani, Z. E.; McCormick, K.; Michaels, R. W.; Millener, D. J.; Miyoshi, T.; Moffit, B.; Monaghan, P. A.; Moteabbed, M.; Muñoz Camacho, C.; Nanda, S.; Nappi, E.; Nelyubin, V. V.; Norum, B. E.; Okasyasu, Y.; Paschke, K. D.; Perdrisat, C. F.; Piasetzky, E.; Punjabi, V. A.; Qiang, Y.; Raue, B.; Reimer, P. E.; Reinhold, J.; Reitz, B.; Roche, R. E.; Rodriguez, V. M.; Saha, A.; Santavenere, F.; Sarty, A. J.; Segal, J.; Shahinyan, A.; Singh, J.; Širca, S.; Snyder, R.; Solvignon, P. H.; Sotona, M.; Subedi, R.; Sulkosky, V. A.; Suzuki, T.; Ueno, H.; Ulmer, P. E.; Urciuoli, G. M.; Veneroni, P.; Voutier, E.; Wojtsekhowski, B. B.; Ye, Y.; Zheng, X.; Zhou, S.; Zorn, C.

Affiliation: AA(Istituto Nazionale di Fisica Nucleare, Sezione di Roma Tre, I-00146 Roma, Italy), AB(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, Piazza Aldo Moro, Rome, Italy), AC(Florida International University, Miami, Florida 33199, USA), AD(Florida International University, Miami, Florida 33199, USA), AE(California State University, Los Angeles, Los Angeles, California 90032, USA), AF(Rutgers, The State University of New Jersey, Piscataway, New Jersey 08855, USA), AG(Université Blaise Pascal/IN2P3, F-63177 Aubière, France), AH(Syracuse University, Syracuse, New York 13244, USA), AI(Universität Mainz, Mainz, Germany), AJ(University of Maryland, College Park, Maryland 20742, USA), AK(University of Maryland, College Park, Maryland 20742, USA), AL(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA),

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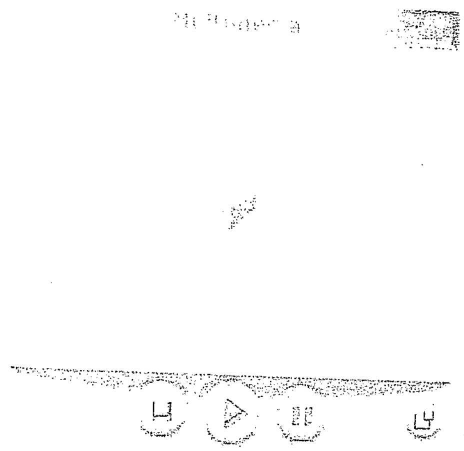
"I neutrini dal Sole e dalla Terra - La fisica di Borexino"

Laboratori Nazionali del Gran Sasso, 30 novembre 2006

Multimedia



Giovedì 30 novembre, in occasione del completamento della fase preparatoria dell'esperimento Borexino, l'Ambasciatore degli Stati Uniti in Italia, Ronald P. Spogli, ha partecipato alla conferenza "I neutrini dal Sole e dalla Terra - La fisica di Borexino" organizzata dall' Istituto Nazionale di Fisica Nucleare ai Laboratori Nazionali del Gran Sasso.

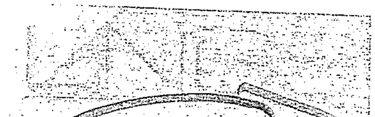
Alla manifestazione hanno partecipato personalità politiche della Regione Abruzzo e rappresentanze delle Istituzioni americane che partecipano all'esperimento Borexino, quali l'Università di Princeton, il Massachusetts Institute on Technology e il Virginia Politechnic Institute. Alla conferenza e' seguita una visita dei laboratori sotterranei del Gran Sasso dove l'Ambasciatore ha incontrato numerosi ricercatori americani impegnati da anni nelle attività di ricerca.

L'Ambasciatore ha sottolineato il contributo scientifico ed economico sostenuto dall'Italia e dagli Stati Uniti per preparare l'esperimento Borexino e sostenere il laboratorio del Gran Sasso e l'importanza della ricerca di base come sorgente di scoperte scientifiche e quindi di applicazioni tecnologiche. I laboratori nazionali del Gran Sasso ne sono un tipico esempio: la ricerca fondamentale che qui si svolge ha permesso all'INFN di sviluppare tecnologie all'avanguardia in diagnostica e terapia medica, in information tecnology e per la datazione di opere d'arte antiche.

Discorso dell'Ambasciatore Ronald P. Spogli Laboratorio Nazionale del Gran Sasso, 30 novembre 2006

[...] La ricerca sta migliorando la sanità e l'efficienza energetica, sta diminuendo la fatica fisica del lavoratore ed espandendo la nostra comprensione sia del cosmo che del nostro pianeta. Ma dovremmo ricordare dove nascono questi miglioramenti della vita quotidiana. Sono frutto della ricerca fondamentale o "di frontiera". Se non ci fossero i programmi di ricerca come quelli condotti qui al Gran Sasso, ci sarebbero sempre meno scoperte scientifiche e quindi sempre meno prodotti innovativi. In breve, la ricerca di base è la sorgente della ricerca applicata. Testo completo

Internet Resources



INFN Istituto Nazionale di Fisica Nucleare

Collaborazioni con gli U.S.A.

Progetto Borexino

- Princeton University
- Massachusetts Institute of Technology
- Virginia Politechnic Institute

Progetto Cuoricino

- Department of Physics and Astronomy, University of South Carolina
- Nuclear Science Division and Physics Division – Lawrence Berkeley National Laboratory
- Department of Physics, University of California
- Department of Materials Science and Material Engineering, University of California
- Lawrence Livermore National Laboratory
- Department of Physics, University of Wisconsin

Progetto Xenon

- Columbia University
- Yale University
- Brown University
- Case Western University
- Rice University
- University of Florida

Progetto Warp

- Princeton University

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ISTITUTO NAZIONALE DI FISICA NUCLEARE

Preventivo per l'anno *2004*

Codice	Esperimento	Gruppo
	AIACE	3
Rapp. Naz.: ~~Patrizia~~ ROSSI – M. RIPANI		

Rappresentante nazionale: Patrizia ROSSI – M. RIPANI
Struttura di appartenenza: LNF – GE
Posizione nell'I.N.F.N.:

INFORMAZIONI GENERALI	
Linea di ricerca	Fisica adronica
Laboratorio ove si raccolgono i dati	TJNAF – USA
Sigla dello esperimento assegnata dal laboratorio	CLAS/AIACE
Acceleratore usato	CEBAF – HALL B
Fascio (sigla e caratteristiche)	Elettroni e fotoni di energia fino a 6 GeV
Processo fisico studiato	Elettro– e foto–reazioni su protone e nuclei.Produzione di risonanze barioniche
Apparato strumentale utilizzato	Spettrometro magnetico a grande angolo solido CLAS
Sezioni partecipanti all'esperimento	LNF,GE.
Istituzioni esterne all'Ente partecipanti	"Armenia: Yerevan Physics Institute; Francia: DAPNIA–Saclay e IPN–Orsay; Korea: Kyungpook Nat. U.; Russia: ITEP–Mosca; U.K.: Edinburgh U.; USA: 27 Istituti (Arizona U., Carnegie Mellon U., Catholic U., Christofer Newport U., College William and Mary, Duke U., Florida State U., Florida Int. U., G. Washington U., J. Madison U., MIT, Norfolk U., Ohio U., Old Dominion U., Rensselner P.I., Rice U., TJNAF, UCLA, U. of Connecticut, U. of Massachussets; U. of New Hampsire, U. of Pittsburg, Richmond U., S. Carolina U., Texas U., Virginia U.,Virginia P.I.
Durata esperimento	2005

Mod EC. 1

(a cura del responsabile nazionale)

Publication: Physical Review Letters, vol. 99, Issue 5, id. 052501 (PhRvL Homepage)
Publication Date: 08/2007
Origin: APS

DOI: 10.1103/PhysRevLett.99.052501
Bibliographic Code: 2007PhRvL..99e2501I

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Abstract

An experiment measuring electroproduction of hypernuclei has been performed in hall A at Jefferson Lab on a C12 target. In order to increase counting rates and provide unambiguous kaon identification two superconducting septum magnets and a ring imaging Cherenkov detector were added to the hall A standard equipment. An unprecedented energy resolution of less than 700 keV FWHM has been achieved. Thus, the observed BΛ12 spectrum shows for the first time identifiable strength in the core-excited region between the ground-state s-wave Λ peak and the 11 MeV p-wave Λ peak.

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AM(Nuclear Physics Institute, Řež near Prague, Czech Republic), AN(Université Blaise Pascal/IN2P3, F-63177 Aubière, France), AO(University of Maryland, College Park, Maryland 20742, USA), AP(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), AQ(Temple University, Philadelphia, Pennsylvania 19122, USA), AR(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), AS(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), AT(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), AU(Florida International University, Miami, Florida 33199, USA), AV(University of Virginia, Charlottesville, Virginia 22904, USA), AW(Istituto Nazionale di Fisica Nucleare, Sezione di Bari and University of Bari, I-70126 Bari, Italy), AX(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), AY(Istituto Nazionale di Fisica Nucleare, Sezione di Bari and University of Bari, I-70126 Bari, Italy), AZ(University of Virginia, Charlottesville, Virginia 22904, USA), BA(Université Blaise Pascal/IN2P3, F-63177 Aubière, France), BB(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), BC(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), BD(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), BE(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), BF(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), BG(Massachussets Institute of Technology, Cambridge, Massachusetts 02139, USA), BH(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), BI(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), BJ(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), BK(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), BL(Old Dominion University, Norfolk, Virginia 23508, USA), BM(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), BN(College of William and Mary, Williamsburg, Virginia 23187, USA), BO(Old Dominion University, Norfolk, Virginia 23508, USA; Université Blaise Pascal/IN2P3, F-63177 Aubière, France), BP(Old Dominion University, Norfolk, Virginia 23508, USA), BQ(Rutgers, The State University of New Jersey, Piscataway, New Jersey 08855, USA), BR(University of Massachusetts Amherst, Amherst, Massachusetts 01003, USA), BS(Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047, Japan), BT(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), BU(Istituto Nazionale di Fisica Nucleare, Sezione di Bari and University of Bari, I-70126 Bari, Italy), BV(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), BW(University of Virginia, Charlottesville, Virginia 22904, USA), BX(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), BY(California State University, Los Angeles, Los Angeles, California 90032, USA), BZ(Florida International University, Miami, Florida 33199, USA), CA(Istituto Nazionale di

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Fisica Nucleare, Sezione di Bari and University of Bari, I-70126 Bari, Italy), CB(Temple University, Philadelphia, Pennsylvania 19122, USA), CC(Rutgers, The State University of New Jersey, Piscataway, New Jersey 08855, USA), CD(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), CE(Brookhaven National Laboratory, Upton, New York 11973, USA), CF(Tohoku University, Sendai, 980-8578, Japan), CG(College of William and Mary, Williamsburg, Virginia 23187, USA), CH(Massachussets Institute of Technology, Cambridge, Massachusetts 02139, USA), CI(Florida International University, Miami, Florida 33199, USA), CJ(CEA Saclay, DAPNIA/SPhN, F-91191 Gif-sur-Yvette, France), CK(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), CL(Istituto Nazionale di Fisica Nucleare, Sezione di Bari and University of Bari, I-70126 Bari, Italy), CM(University of Virginia, Charlottesville, Virginia 22904, USA), CN(University of Virginia, Charlottesville, Virginia 22904, USA), CO(Tohoku University, Sendai, 980-8578, Japan), CP(University of Massachusetts Amherst, Amherst, Massachusetts 01003, USA), CQ(College of William and Mary, Williamsburg, Virginia 23187, USA), CR(School of Physics and Astronomy, Sackler Faculty of Exact Science, Tel Aviv University, Tel Aviv 69978, Israel), CS(Norfolk State University, Norfolk, Virginia 23504, USA), CT(Massachussets Institute of Technology, Cambridge, Massachusetts 02139, USA), CU(Florida International University, Miami, Florida 33199, USA), CV(Argonne National Laboratory, Argonne, Illinois 60439, USA), CW(Florida International University, Miami, Florida 33199, USA), CX(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), CY(Florida State University, Tallahassee, Florida 32306, USA), CZ(University of Houston, Houston, Texas 77204, USA), DA(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), DB(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), DC(St. Mary's University, Halifax, Nova Scotia, Canada), DD(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), DE(Yerevan Physics Institute, Yerevan, Armenia), DF(University of Virginia, Charlottesville, Virginia 22904, USA), DG(Department of Physics, University of Ljubljana, Slovenia), DH(University of Virginia, Charlottesville, Virginia 22904, USA), DI(Temple University, Philadelphia, Pennsylvania 19122, USA), DJ(Nuclear Physics Institute, Řež near Prague, Czech Republic), DK(Kent State University, Kent, Ohio 44242, USA), DL(College of William and Mary, Williamsburg, Virginia 23187, USA), DM(Tohoku University, Sendai, 980-8578, Japan), DN(Yamagata University, Yamagata 990-8560, Japan), DO(Old Dominion University, Norfolk, Virginia 23508, USA), DP(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, Piazza Aldo Moro, Rome, Italy), DQ(Istituto Nazionale di Fisica Nucleare, Sezione di Roma1, gruppo collegato Sanità, and Istituto Superiore di Sanitá,I-00161 Roma, Italy), DR(LPSC, Université Joseph Fourier, CNRS/IN2P3, INPG, F-38026 Grenoble, France), DS(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA), DT(University of Science and Technology of China, Hefei, Anhui, China), DU(Argonne National Laboratory, Argonne, Illinois 60439, USA), DV(China Institute of Atomic Energy, Beijing, China), DW(Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA)

UNIVERSITA' DEGLI STUDI - L'AQUILA

UFFICIO RELAZIONI INTERNAZIONALI

BANDO DI CONCORSO PER LO SCAMBIO STUDENTI

NELL'AMBITO DELLE CONVENZIONI CON:

University of Miami (USA)

Shibaura Institute of Technology – Tokyo (Giappone)

University of Technology - Sydney (Australia)

C.I.N.V.E.S.T.A.V – Guadalajara (Messico)

A.A. 2007/2008

VISTO il verbale della Commissione per le Relazioni Internazionali del 19.10.2006;

VISTE le delibere del Senato Accademico del 14.12.2006 e del Consiglio di Amministrazione del 15.12.2006;

l'Università degli Studi dell'**Aquila** bandisce il presente concorso nell'ambito delle convenzioni con le Università sopra elencate, al quale sono ammessi tutti gli studenti iscritti almeno al secondo anno di corso, così come specificato nell'allegato elenco. Gli studenti interessati devono presentare all'Ufficio Relazioni Internazionali, Via Paganica 21 - 67100 L'**Aquila**, domanda di partecipazione alla selezione per titoli *entro e non oltre 15 gg. dalla data di pubblicazione all'Albo ufficiale di Ateneo.*

Potrà essere presentata domanda per una sola sede estera.

La Commissione esaminatrice sarà presieduta dal Delegato del Rettore per le Relazioni Internazionali o suo rappresentante, composta dai Responsabili delle singole convenzioni (o loro delegati) ed integrata da un Funzionario Amministrativo con funzioni di Segretario.

Entro e non oltre la data di scadenza gli interessati dovranno presentare, presso l'Ufficio Relazioni Internazionali, la seguente **DOCUMENTAZIONE**:

- *DOMANDA IN CARTA SEMPLICE*, indirizzata al Magnifico Rettore, di partecipazione alla selezione (modulo allegato al presente bando);
- *CERTIFICATO DI ISCRIZIONE CON ESAMI SOSTENUTI* e relativo Piano di Studi, in carta

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semplice (oppure fotocopia completa del libretto universitario e autocertificazione del piano di studi);

- *COPIA CERTIFICATO TOEFL*
- *EVENTUALI ALTRI TITOLI*, in carta semplice, che il candidato ritenga opportuno presentare.

La selezione verrà effettuata in base all'esame dei curricula.

I vincitori delle borse di studio per le università di Miami e Sydney dovranno sostenere l'esame TOEFL ufficiale (esplicitamente richiesto dalle dette università) riportando le seguenti votazioni minime:

Universiy of Miami ____550____

University of Technology – Sydney ____580____

Sarà quindi loro cura ottenere il certificato TOEFL da una delle strutture autorizzate. Si evidenzia che senza tale certificazione l'Università ospitante permetterà l'iscrizione al solo corso di lingua inglese.

Le graduatorie dei vincitori saranno comunicate per mezzo di affissione all'Albo dell'Ufficio Relazioni Internazionali e pubblicate sul sito internet dell'Università (www.univaq.it)

I criteri per la valutazione dei titoli verranno determinati dalla Commissione nelle sedute preliminari.

Informazioni sulle Università di destinazione potranno essere reperite sul sito web dell'Ateneo, presso l'Ufficio Relazioni Internazionali o contattando i seguenti Docenti responsabili delle Convenzioni:

Delegato del Rettore alle Relazioni Internazionali Prof.ssa Anna Tozzi – Fac. Scienze mmffnn

University of Miami (USA) Dott. Marano – Fac. di Lettere e Filosofia

Shibaura Institute of Technology – Tokyo (Giappone) Prof. Beomonte Zobel – Fac. di Ingegneria

University of Technology - Sydney (Australia) Prof. Di Gregorio - Fac. di Lettere e Filosofia

C.I.N.V.E.S.T.A.V – Guadalajara (Messico) Prof Di Gennaro – Fac. di Ingegneria

L'Aquila, 8 giugno 2007

IL DIRETTORE AMMINISTRATIVO

Dott. Filippo Del Vecchio

IL RETTORE

Prof. Ferdinando di Orio

R9

__l__ sottoscritt__ allega alla presente:

1) certificato di iscrizione con esami, in carta semplice, oppure fotocopia del libretto universitario con gli esami ed il bollo dell'iscrizione;

2) piano di studi prescelto presso la propria Università, in carta semplice, oppure autocertificazione dello stesso;

3) copia certificato TOEFL

4) altri titoli:____

L'**Aquila**, _________________.

In Fede

____

SCAMBIO STUDENTI NELL'AMBITO DELLE CONVENZIONI CON:

University of Miami (USA)

Shibaura Institute of Technology – Tokyo (Giappone)

University of Technology - Sydney (Australia)

A.A. 2007/2008

ELENCO SEDI DISPONIBILI

N°	Università convenzionate	N° Borse	Durata	Livello di studio	Docente	Importo

Ord.		di studio		Aree disciplinari	responsabile	Borsa EURO
1	**University of Miami** **Florida** (USA)	4	1 semestre (valido solo per il secondo semestre)	**Laureandi** *Tutte le Facoltà ad eccezione dei corsi di laurea in Medicina e Odontoiatria*	Dott. A.Marano	2.500,00
2	S.I.T. – Tokyo (Giappone)	1	1 semestre	**Laureandi** *Ingegneria Meccanica*[1]	Prof. Beomonte Zobel	1.050,00[2]
3	UTS - Sydney (Australia)	1	1 semestre (valido solo per il secondo semestre)	**Laureandi** Ingegneria, Scienze mm.ff.nn., Lettere, Lingue, Economia, Infermiere, Scienze dell'educazione	Prof. M.Di Gregorio	2.500,00
4	C.I.N.V.E.S.T.A.V – Guadalajara (Messico)	1	1 semestre (valido solo per il secondo semestre)	**Laureandi** *Ingegneria Automatica e Informatica*	Prof. S.Di Gennaro	800,00

[1] **Alla data di presentazione della domanda, agli studenti non dovranno mancare più di 6 esami alla laurea.**

[2] **Corrisponde al contributo concesso dall'Università dell'Aquila per le spese di viaggio. La borsa di studio è finanziata direttamente dall'Università di Tokyo, che corrisponderà un contributo mensile per le spese di vitto e alloggio.**

The arXiv: 14 years of open access scientific communication

Simeon Warner
Cornell Information Science, Ithaca, NY 14850, USA,
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http://www.cs.cornell.edu/people/simeon

Date: 2005/09/14 20:22:09

Abstract

The arXiv was started in 1991 as a way for high-energy physicists to share preprints fairly and efficiently. Since then it has evolved into an archive of more than 330,000 articles in physics, mathematics and computer science. Within certain disciplines, the arXiv is now the primary means of scholarly communication and has changed the way that scientists work.

This paper charts the development and use of the arXiv e-print archive over the past 14 years in the context of changes in scholarly publishing. Lessons learned from this development include the importance of community and critical mass, and the difficulty of balancing openness with fairness and keeping submissions appropriate and relevant. I discuss how journal publishers have reacted to the arXiv, and ask what the arXiv reveals about the established system of journals and the importance of peer review. Finally, I consider the role the arXiv should play in the future scholarly communication landscape and ask how arXiv fits with emerging institutional repositories?

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In 1996 the web submission interface was added. The facilities and scope of arXiv stabilized somewhat and arXiv offered most of the features that it does today. Submission rates and readership continued to increase steadily, and the mirror network was enlarged.

The year 2001 marked the start of the most recent phase for arXiv. Metadata was made available for harvesting via an OAI [9] interface and could thus be added to other services (such as the NASA ADS [10]). The move to Cornell spurred a process of institutionalization which has included the development of a new user registration and authentication system, formalization of procedures and policies, and even scheduled holidays.

The overall submission rate to arXiv has increased approximately linearly since 1991, as shown in figure 2. Starting around 1995 the growth in the submission rate to the high-energy physics categories (hep-th, CORNELL

T-1

Online physics archive that is transforming global science communication, 'arXiv.org,' is moving from Los Alamos to Cornell University

FOR RELEASE: July 16, 2001

Contact: Bill Steele
Office: 607-255-7164
E-Mail: ws21@cornell.edu

ITHACA, N.Y. -- The Los Alamos E-Print Archive, which is widely credited with revolutionizing the way physical scientists and mathematicians communicate, is moving from the Los Alamos National Laboratory (LANL) in New Mexico to Cornell University.

Physicist Paul Ginsparg, who created and maintains the archive -- known by scientists around the world as "arXiv.org" -- will join the Cornell faculty this fall, and he is bringing the archive with him. It will become a service of Cornell University Library, which has developed several other digital academic resources. Both Ginsparg and library officials express hope that the archive will improve and expand in its new home.

The archive currently is receiving about 2 million visits a week, more than two-thirds of them from outside the United States.

"There should be many advantages to being at a private educational institution," Ginsparg said. However, he noted, the LANL environment was essential for launching the archive in 1991. "It probably wouldn't have been possible had I been a university faculty member with too many other obligations. But now it has achieved a level of maturity which makes it possible to institutionalize in a new and more appropriate academic setting," he said.

The arXiv has operated with about $300,000 in annual funding from the National Science Foundation, the Department of Energy and LANL. For the time being, Cornell and LANL will share the costs and services previously provided by LANL. The arXiv will remain a cooperative effort between LANL and Cornell, since much key expertise will remain at the LANL library, Ginsparg said. The existing LANL server will become a primary backup.

Ginsparg already has been collaborating with the Digital Library Group in Cornell's computer science department from a distance. He will become a member of Cornell's Faculty of Computing and Information (FCI), a universitywide, interdisciplinary unit, separate from but related to the computer science department. The FCI was formed last year in recognition of the fact that computing has become an integral part of almost every academic discipline. Ginsparg, who earned his Ph.D. in physics at Cornell in 1981, expects to divide his time equally between work on the archive and physics research. His field is string theory, the so-called "theory of everything" that aims to unify all of the forces of nature. "I am eagerly looking forward to having all the routine aspects of the arXiv handled by information professionals so that I can focus again on cutting-edge areas in research," he said.

Ginsparg was named a fellow of the American Physical Society in November 2000 "for his work relating to chiral symmetry on the lattice, for fundamental contributions to string theory and for establishment and development of the revolutionary Los Alamos E-Print Archive."

"I think ultimately it will be seen as a coup for the university to have attracted him and the archive," said Sarah Thomas, Cornell University librarian. "It's a captivating example of how technology has interacted with the advancement of knowledge." But she added that she understands some people are apprehensive about the impact online publishing of scientific information may have on traditional journals.

The arXiv contains some 170,000 brief papers in physics, mathematics and computer science, with almost 3,000 new submissions coming in each month. Unlike articles submitted to professional journals, papers submitted to the archive are immediately available online, at no cost to the user. Also unlike articles submitted to professional journals, postings to arXiv.org are not peer-viewed. Except for some rudimentary screening for inappropriate off-topic submissions, almost anyone can post almost anything. It's up to the reader to decide what is worthwhile.

The result, Ginsparg has said, is to "level the playing field." Researchers in Third World countries, where paper copies of journals may arrive months after publication, if at all, have the same access to research reports as do researchers in industrialized nations. On the other side of the coin, researchers in small, obscure places have just as much chance to make their voices heard as those in Ivy League halls. In one recent incident, Lubos Motl, an undergraduate physics student at Charles University in Prague, Czech Republic, scooped the Ph.D.s with an elegant solution to a major problem. On the Internet, it seems, no one knows you're an undergraduate.

Ginsparg believes that all scientific publishing eventually will move to the Internet, doing away with paper journals. That move will streamline a system where, as Ginsparg puts it, scholars give their material to publishers for free and their institutions then pay thousands of dollars in subscription fees to read it in the journals. The compensation, up to now at least, has been that the leading journals provide "peer review," where respected members of a field of study read submitted articles and report to the journal on whether or not they represent good, original research. The prestige of passing peer review and publishing in an established journal is still important to the careers of academic researchers, as is the quality control provided to the archival literature.

The papers that appear on arXiv.org are technically "preprints," the electronic equivalent of paper reports that researchers circulate among themselves in advance of formal publication. But more and more, at least in the physical sciences, researchers are communicating new results via their online postings, with journal publication a later formality.

Cornell librarians hope to explore the extension of this idea into other disciplines. "There are a number of initiatives to look at how that would work in the biological sciences," Thomas said. "I would want to position Cornell so that we could be a very active contributor to the reconception of scholarly communication." Cornell currently is engaged in a project to facilitate the electronic publication of mathematics journals, so far with strict controls on access. But, Thomas said, a movement is under way to persuade publishers to allow open access beginning several months after publication. "There are some models that suggest that the economic value of information [to publishers] declines sharply as it ages," she explained.

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Related World Wide Web sites: The following sites provide additional information on this news release. Some might not be part of the Cornell University community, and Cornell has no control over their content or availability.

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Current members are:

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- Eberhard Bodenschatz
- Paul Fendley
- Paul Ginsparg
- Steven Gottlieb
- Joe Halpern
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- Peter Kahn
- Greg Kuperberg
- N. David Mermin
- David Morrison
- David Nelson
- Nickolas Solomey
- Karen Vogtmann
- Ira Wasserman

The physics, mathematics, computer science, quantitative biology, and statistics archives each have advisory committees, which are overseen loosely by the arXiv advisory board.

Physics

- Andrew Connolly
- Bruno Nachtergaele
- Gerd Schon
- Brian Maple
- Debbie Jin
- Jacques Distler
- Nick Solomey (chair)
- Paul Ginsparg (staff ex officio)

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5 arXiv and the conventional journal system

Writing in 1994, Ginsparg said "The rapid acceptance of electronic communication or research information in my own community of high-energy theoretical physics was facilitated by a pre-existing 'pre-print culture', in which the irrelevance of refereed journals to ongoing research has long been recognized." [5]. To read this statement as an assertion that journals are irrelevant is to miss a disconnect between the practice of physics, for which peer review is not considered very important (at least in the short term), and rewarding or professional progression for which the stamp of authority offered by journals is considered indispensable. Thus, physicists somewhat contradictorily argue that arXiv is essential for their work, and is how they communicate, and yet that the conventional journal system must remain as is.

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☐ I certify that the above contact information is correct.

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Abstract

The arXiv was started in 1991 as a way for high-energy physicists to share preprints fairly and efficiently. Since then it has evolved into an archive of more than 330,000 articles in physics, mathematics and computer science. Within certain disciplines, the arXiv is now the primary means of scholarly communication and has changed the way that scientists work.

This paper charts the development and use of the arXiv e-print archive over the past 14 years in the context of changes in scholarly publishing. Lessons learned from this development include the importance of community and critical mass, and the difficulty of balancing openness with fairness and keeping submissions appropriate and relevant. I discuss how journal publishers have reacted to the arXiv, and ask what the arXiv reveals about the established system of journals and the importance of peer review. Finally, I consider the role the arXiv should play in the future scholarly communication landscape and ask how arXiv fits with emerging institutional repositories?

1 Introduction

The arXiv was started by Paul Ginsparg in 1991 at Los Alamos National Laboratory (LANL) as a way for high-energy theoretical physicists to share preprints fairly and efficiently [5]. The initial user-base was an email list of 160 addresses assembled from existing pre-print distribution lists for the hep-th subject area. It has since evolved into an archive of more than 330,000 articles in physics, mathematics and computer science. The arXiv now accepts ~4,000 new articles each month, offers an alerting service, search facilities, and has 17 mirror sites around the world.

Figure 1 picks out some landmarks in the development of arXiv. Much of the history of arXiv is recorded in the logs of "What's New" pages [1, 2, 3]. The first phase was marked by rapid development of new facilities and expansion in subject area coverage. Implementation of automatic TeX processing software in 1995 meant that readers no longer had to download TeX source files and process or compile them to get a readable version of an article (a process akin to compiling a C++ or Java program; rather arcane to many word processor users). Instead, PostScript was available directly.

In 1996 the web submission interface was added. The facilities and scope of arXiv stabilized somewhat and arXiv offered most of the features that it does today. Submission rates and readership continued to increase steadily, and the mirror network was enlarged.

The year 2001 marked the start of the most recent phase for arXiv. Metadata was made available for harvesting via an OAI [9] interface and could thus be added to other services (such as the NASA ADS [10]). The move to Cornell spurred a process of institutionalization which has included the development of a new user registration and authentication system, formalization of procedures and policies, and even scheduled holidays.

The overall submission rate to arXiv has increased approximately linearly since 1991, as shown in figure 2. Starting around 1995 the growth in the submission rate to the high-energy physics categories (hep-th.

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Suffix: ('Jr.', 'II', etc; may be blank)
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Figure 8: License click-through during arXiv submission process

We plan to offer the option of simply granting arXiv a license to distribute, or saying that a Creative Commons license applies which also gives us the permissions we need. Clarke [4] argues that the "Attribution/NonCommercial/No Derivative Rights" (By-NC-ND) license is adequate for e-print use and would certainly give arXiv the necessary rights. However, one might want to encourage the use of the more permissive "Attribution" (By) license used by PLoS (for example).

5 arXiv and the conventional journal system

Writing in 1994, Ginsparg said "The rapid acceptance of electronic communication or research information in my own community of high-energy theoretical physics was facilitated by a pre-existing 'pre-print culture', in which the irrelevance of refereed journals to ongoing research has long been recognized." [5]. To read this statement as an assertion that journals are irrelevant is to miss a disconnect between the practice of physics, for which peer review is not considered very important (at least in the short term), and rewarding or professional progression for which the stamp of authority offered by journals is considered indispensable. Thus, physicists somewhat contradictorily argue that arXiv is essential for their work, and is how they communicate, and yet that the conventional journal system must remain as is.

In the early years of arXiv there was confusion and uncertainty about what the arXiv meant. Publishers had yet to move toward electronic distribution and some did not even understand how arXiv could produce professional quality output for almost no cost or effort. In 1996 the American Physical Society (APS) launched a similar e-print archive which had broader coverage than arXiv (then xxx.lanl.gov) and accepted a wider variety of formats [11]. It turned out that the APS archive was not widely used and ended up with some material that failed to meet the moderation standards of arXiv. It was discontinued in 1998 and the posted content is no longer available (was at http://publish.aps.org/eprint/). The APS were broadly supportive of arXiv during this time and since, including changing their copyright policy to explitly permit submission of author produced versions to e-print archives.

It was recognized early-on that arXiv was not an informal means of communication [5], even though it does not attempt to replicate the journal system. The format of articles is quite conventional and