# SANTILLI ISODUAL THEORY OF ANTIMATTER

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## ABSTRACT

Studies accompanied over the past few decades on the generalization of quantum mechanics, initiated in 1978 by Ruggero Maria Santilli for antimatter. An inspection of the contemporary physics literature reveals that, while matter is treated at all levels of study, from Newtonian mechanics to quantum field theory, antimatter is solely treated at the level of second quantization. For the purpose of initiating the restoration of full equivalence in the treatment of matter and antimatter in due time, and as the classical foundations of an axiomatically consistent inclusion of gravitation in unified gauge theories recently appeared elsewhere. A classical representation of antimatter which begins at the primitive Newtonian level with corresponding formulations at all subsequent levels is presented in this paper. By recalling that charge conjugation of particles into antiparticles is antiautomorphic, the theory of antimatter is based on a new map, called isoduality, yet it is applicable beginning at the classical level and then persists at the quantum level where it becomes equivalent to charge conjugation. Santilli showed the compatibility of the theory with all available classical experimental data on antimatter. The antimatter light has negative energy with negative unit, experiences a negative curvature tensor when in a matter gravitational field and negative refractive index when propagating within a transparent matter medium. Recently Santilli constructed an antimatter telescope and detected antimatter galaxies, antimatter asteroids, annihilation of antimatter cosmic rays and Invisible Terrestrial Entities etc. Santilli isodual theory is applicable for the antimatter with the consideration of negative values of energy, time, gravity, refractive index, momenta etc. with negative unit.

## INTRODUCTION

Newtonian, Galilean and Einsteinian theories had no value for the indicated problem since far away galaxies must be assumed to be neutral, in which case said theories had no distinction whatsoever between matter and antimatter. Santilli discovered that mathematics for the consistent classical treatment of neutral (or charged) antimatter did not exist and had to be built. The resulting mathematics is today known as Santilli isodual mathematics. It may be of some value to indicate that isoduality is a new transformation not reducible to parity and/or other conventional transformations. It should also recall the new symmetry identified by the isodual mathematics, called isoselfduality [1-3], namely, the invariance under the isodual transformation, which is verified by the imaginary number $i \equiv i^d$ as well as by Dirac's equation.
Application of the Isodual mathematics helps to study antimatter galaxy light, since Isodual mathematics is anti-isomorphic to the conventional mathematics used for matter, and used it to the construction of the corresponding Isodual theory of antimatter which is applicable from the classical to the quantum level; and predicts that antimatter light propagating in a matter transparent medium possesses an index of refraction opposite that of matter light, which is referred to as a negative index of refraction [4]. Newton's mechanics, Galileo's relativity, Einstein's special and general relativities were conceived before the discovery of antimatter and, consequently, they have no provisions for the classical representation of neutral antimatter since their only conjugation is the sign of the charge. The rigorous prediction of antimatter via the negative energy solutions of wave equations was done by P. A. M. Dirac [5] in 1928, and experimentally verified in 1933 by C. D. Anderson [6]. However, Dirac noted that particles with negative energy violate causality and other physical laws and was consequently forced to represent antiparticles solely at the level of second quantization in his celebrated equation. Since the time of Dirac's prediction of antiparticles and their detection by Anderson [7], the theory of antimatter has been essentially developed at the level of second quantization.
This occurrence has created an unbalance between the theories of matter and antimatter at the classical and first quantization levels, as well as a number of shortcomings, such as the inability for the classical theory of antimatter to have a quantized formulation which is the correct charge (or **PTC**) conjugate of that of matter. In an attempt to initiate the scientific process toward the future resolution of the above problematic aspects, Santilli proposed in 1985 [8] a new anti-isomorphic image of conventional mathematics charactered by the map of the conventional unit; $+1 \rightarrow 1^d = -1$; called for certain technical reasons isodual map, or isoduality. It should be noted that the change of the basic unit implies a simple, yet unique and nontrivial change of the totality of conventional mathematics, including: numbers and angles; functions and transforms; vector and metric spaces; algebras and geometries; etc. In 1991 Santilli [9] showed that the above isodual mathematics, since it is an anti-isomorphic image of the mathematics of matter, provides a novel classical representation of antimatter. The proof that isoduality on a Hilbert space is equivalent to charge conjugation has first appeared in the paper [10] of 1994. A comprehensive operator treatment subsequently appeared in monographs [11]. The prediction that isoduality implies antigravity for massive antiparticles in the field of matter was submitted in paper [12], which also included the proposal for its experimental verification via the use of a low energy positron beam in horizontal flight in a suitable vacuum tube. The latter experimental proposal was subsequently studied by Mills [13]. This note is devoted to a study of the spectroscopy of antimatter via the isodual characterization of the light emitted by the antihydrogen atom.
In particular, Santilli has shown that isoduality predicts that antimatter emits a new light here called isodual light which can be solely differentiated from the conventional light via gravitational interactions. In the events additional theoretical and experimental studies confirm the above hypothesis; isoduality would therefore permit the future experimental measures whether far away galaxies and quasars are made up of matter or of antimatter [14]. Similarly,

Einsteinian theories predict that matter and antimatter emit the same light, evidently due to the indicated lack of any differentiation between neutral matter and antimatter, light having no charge as is well known. By contrast, isodual theories predict that the light emitted by antimatter is different than that emitted by matter in an experimentally verifiable way. In fact, matter light has a positive energy h x ν referred to positive unit MeV, while antimatter light has a negative energy $E^d = h^d\ x^d\ \nu^d = -E$ referred to a negative unit $MeV^d = -MeV$ [15].

The isodual theory has a number of rather fundamental, experimentally verifiable predictions not tested until now. Einsteinian theories predict that both, matter and antimatter light experience gravitational bending (attraction). By contrast, the isodual theory predicts that antimatter (matter) light experiences gravitational repulsion from a matter (antimatter) gravitational field [15]. In short Santilli has: 1) developed an anti-Hermitean image of the mathematics used for matter characterized by a map called isoduality and denoted with the upper symbol d; 2) achieved the isodual classical representation of neutral (as well as charged) antimatter particles and light via the conjugation of all physical quantities and their units, thus resolving the inconsistencies of negative energies; and 3) shown that the isodual (antimatter) light has negative energy $E^d = -E$, experiences a negative curvature tensor $R^d = -R$ (gravitational repulsion) when in a matter gravitational field, and possesses a negative index of refraction $n^d = -n$ when propagating within a transparent matter medium.

In this paper an attempt is made to present a short review of the Santilli isodual theory of antimatter that helps the detection of antimatter galaxies, antimatter asteroids, annihilation of antimatter cosmic rays and Invisible Terrestrial Entities (ITE) etc. by Santilli and co-workers [16-23].

## FEATURES OF SANTILLI ISODUAL MATHEMATICS OF ANTIMATTER

Following the study of a number of alternatives, Santilli gave priority to the search for new numbers since all mathematics used for physics must be based on a numeric field as a condition for experimental verifications and, in any case, all aspects of applied mathematics can be built on a given numeric field via simple compatibility arguments. In 1993, Santilli [24, 25] finally identified the desired new number under the name of isodual real, complex and quaternionic numbers [26], which verify the condition of being anti-isomorphic to the conventional real, complex and quaternionic numbers, respectively. The word "isodual" was suggested to indicate a duality under the preservation of the conventional abstract axioms of numeric fields. The crucial condition of anti-isomorphism was achieved via the anti-Hermitean conjugation of all elements of a numeric field and all its operations. This implies that, given a field $F(n,\times,1)$ with elements n, m, …, conventional associative product $n\times m = nm$ and trivial unit 1, Santilli isodual fields are indicated with the upper symbols d, $F^d(n^d,x^d,1^d)$, and are characterized by a negative basic unit $1^d = -1^\dagger = -1$, isodual numbers $n^d = n1^d$ and isodual product $n^d\times^d m^d = n^d(-1/-1^d)m^d = nm1^d$.

Following the identification of the desired numbers, Santilli passed to the systematic construction of the isodual image of all main mathematics used for the study of matter, including functional analysis, differential calculus, metric spaces, Lie algebras, symmetries, Euclidean, Minkowskian and Riemannian geometries, etc. These isodual formulations were first presented in the mathematical memoir [1] and first treated systematically in monographs [2]. The resulting mathematics is today known as Santilli isodual mathematics. It may be of some value to indicate that isoduality is a new transformation not reducible to parity and/or other conventional transformations. It should also recall the new symmetry identified by the isodual mathematics, called isoselfduality [1, 2], namely, the invariance under the isodual transformation, which is verified by the imaginary number $i \equiv i^d$ as well as by Dirac's equation. Contrary to a possible perception of mathematical complexities, the isodual mathematics needed for applications can be constructed via the application of the simple anti-Hermitean map $Q \rightarrow Q^d = -Q^\dagger$, provided it is applied to the totality of quantities and to the totality of their operations used for the treatment of matter.

## EVIDENCE OF ANTIMATTER IN THE UNIVERSE

The 20th century position on antimatter implied the rather general belief that antimatter galaxies do not exist. This stringent stand eliminated altogether the problem of detecting antimatter asteroids on grounds that they do not exist due to the absence of the antimatter galaxies and related antimatter supernovas needed for their origination. This position was evidently based in the unspoken intent of maintaining the validity of Einstein's theories for all of the universe via the denial of the existence of antimatter galaxies, despite it being disproved by evidence since our Earth has indeed been hit in the past by devastating antimatter asteroids, and similar asteroids have been detected by various observatories [25].

In fact, the catastrophic 1908 Tunguska explosion in Siberia with the power of one thousand Hiroshima nuclear bombs can be solely interpreted in a scientific way as being due to an antimatter asteroid annihilating in our atmosphere [27, 28]. This is due to various reasons, such as the complete absence of debris, let alone of a crater, in the ground [25].

Most importantly, the Tunguska explosion excited the entire Earth's atmosphere for days, to such an extent those two days following the explosion; people could read newspapers in Sydney, Australia, at midnight without artificial light; and other reasons. Such a large excitation of the atomic and molecular constituents of our atmosphere can only be quantitatively represented as being due to huge radiations that, in turn, can only originate from the annihilation of an antimatter asteroid with our matter atmosphere. The widely accepted interpretation of the Tunguska explosion as being due to a matter comet has no scientific credibility due to the impossibility of such an origination to excite the alone with the absence of a crater [25].

**Figure 1:** Pictures of the Siberia area hit by the 1908 Tunguska explosion showing lack debris in the ground.

NASA has been reported explosions in our upper atmosphere that can only be due to small antimatter asteroids because annihilating at the time of contact with the upper portion of our matter atmosphere. Similarly, both astronauts and cosmonauts have observed ashes in our upper atmosphere when on the dark side with respect to our Sun, these ashes can be best interpreted as being due to antimatter cosmic rays that annihilate in our atmosphere, because the only cosmic rays that can reach us at sea level being those due to matter cosmic rays [25].

As indicated above as well as earlier by Santilli and others, the existence of antimatter stars and galaxies is imperative and should not be ignored. As a representative example out of many, we recall antimatter is thought to exist in the Oort cloud in view of a possible explanation for gamma ray bursts [26]. In fact, these phenomena can be explained by the annihilation of matter and antimatter asteroids or small comets. The explosion would create powerful gamma ray bursts and accelerate matter [25]. Besides antimatter asteroids, it is possible that Earth has been hit in the past by antimatter comets as indicated by the old observations, since the biblical times, not only of excessive brilliance but also of trajectories in our atmosphere that cannot be interpreted as being due to matter comets, e.g., because of slow penetration of the said objects in our atmosphere [29]. In conclusion, the evidence on the existence of antimatter asteroids as well as of antimatter comets and their possibility of hitting Earth again is sufficiently serious and consequently the initiation of systematic studies for their detection [25].

## SANTILLI ISODUAL THEORY OF ANTIMATTER

Santilli initiated systematic applications of isodual mathematics to the study of antimatter resulting in the new theory today called *isodual theory of antimatter (or Santilli's Isodual Physics)* as one of the branches of the broader *hadronic mechanics* [30, 31]. Following are some important points for discussion here of this isodual theory of antimatter.

### QFT (And QCD) Violations From Discrete Symmetry Violations (1974)

The rigorous implementation of Lie's theory demands that the fundamental symmetry of special relativity, the Poincare symmetry, is given by a continuous component characterized by the Lorentz symmetry, and discrete components characterized by space and time inversions. In the early part of the 20th century, the entire Poincare symmetry was assumed to be exactly valid throughout the universe. The discovery of parity violation by weak interactions, rather than causing scientific joy, caused panic among the Einsteinian followers because of fear that the entire edifice may collapse. Organized interests on a world wide basis were then activated in the physics community to reach a vast consensus, intentionally without any technical inspection, that "the violation of discrete symmetries does not cause the violation of the continuous component of the Poincare symmetry or of special relativity," a popular political belief without scientific process that is still widespread at mid 2008. Santilli conducted in the 1970s quantitative technical studies as to whether the violation of discrete symmetries implies that of the connected Lorentz symmetry and, consequently, of special relativity. The analysis was conducted with the most advanced and rigorous technical knowledge in quantum field theory of the time, that via Wightman's axioms.

Being an applied mathematician, Santilli was fascinated by the beauty of quantum field theory (QFT) characterized by Whitman axioms. However, being a physicist, he also knew that such a theory had to admit limits of exact applicability because physics will never admit final theories to the end of time. Thus, he initiated comprehensive studies for the identification of such limits of applicability as a necessary foundation for suitable covering theories.

The *discrete symmetries* of quantum field theories are given by the following operations and their combinations:

$$\text{P (space inversion), C (charge conjugation), T (time inversion),} \quad \text{PC, CT, PT, PCT.} \qquad \textbf{(1)}$$

The *PCT theorem* within the context of vacuum expectation values (VEV) verifying Wightman's axioms essentially related the PCT conditions to the weak local commutativity conditions (WLC) under the assumption of Lorentz invariance for the vacuum expectation values plus, boundedness of the energy from below and other conditions permitting smooth analytic continuations.

Santilli achieved the *extension of the PCT theorem to all discrete spacetime symmetries,* a possibility simply unknown at that time. To achieve this goal, he derived the following *dual discrete symmetries*:

$$P^{\#} = (PC)(WLC),\ C^{\#} = WLC,\ T^{\#} = (TC)(WLC),\ PC^{\#} = P(WLC),$$
$$CT^{\#} = T(WLC),\ PT^{\#} = (PCT)(WLC),\ PCT^{\#} = PT(WLC), \qquad \textbf{(2)}$$

and proved the following:

***THEOREM**: Under Lorentz invariance, analyticity and energy boundedness from below, the validity (at a Jost point) of any discrete symmetry in a quantum field theory satisfying the Whitman axioms implies that of its dual and vice versa:*

$$P \leftrightarrow T^{\#},\ C \leftrightarrow PCT^{\#},\ T \leftrightarrow P^{\#},\ PC \leftrightarrow CT^{\#},$$
$$CT \leftrightarrow PC^{\#},\ PT \leftrightarrow C(WLC),\ PCT \leftrightarrow C^{\#}, \qquad \textbf{(3)}$$

The implications of the above discovery presented in the papers quoted below are the following: For quantum field theories admitting discrete symmetries, Santilli's **Theorem** implies the validity of *basically new* discrete symmetry that can be experimentally verified. For theories violating any discrete symmetry, **Theorem** implies that, whenever a discrete symmetry is violated, the corresponding dual symmetry has to be violated too, and vice versa [31-33].

**Apparent Lack Of Visibility Of Antimatter Asteroids With Sun Light**

Santilli has achieved a representation of antimatter at all possible levels, from Newtonian mechanics to second quantization and for conditions of increasing complexity, from fully conservative conditions to the most general possible irreversible non-Hamiltonian conditions, as well as hyperstructural conditions expected in possible antimatter living structures. These studies are far from trivial and have direct implications for the very safety of our planet, since they predict that antimatter asteroids are not visible with the light of our matter Sun. In fact, the studies predict that light emitted by a matter star annihilates when hitting an antimatter body without any refraction. Alternatively, the studies predict that light emitted by an antimatter star, called by Santilli isodual light, annihilates when hitting matter, thus not reaching us on Earth due to annihilation in the upper atmosphere, as it is the case for antimatter cosmic rays. In short, Santilli has initiated an entire new field called "antimatter astrophysics" whose primary aim is the identification of methods for the detection of antimatter stars, by nothing that their isodual light is expected to annihilate even in lenses of telescopes orbiting in space, thus requiring a basically new conception of antimatter telescopes. It should be noted that, Einstein special and general relativity have no means for differentiating between neutral matter and antimatter as expected for asteroids and stars. As a consequence, antimatter has been assumed as being nonexistent in the universe in any appreciable amount. Santilli's discoveries indicates that antimatter has not been detected because of the above indicated occurrences, namely, the annihilation of our Sun light in an antimatter asteroid, or the annihilation of light from an antimatter star in our atmosphere or in orbiting telescopes [31].

**Newton-Santilli Isodual Equation For Antimatter**

No consistent classical theory of antimatter existed prior to Santilli's research, to our best knowledge as yet. For instance, by resuming the use of the conventional associative multiplication a x b = ab, the celebrated Newton's equation,

$$m \times dv/dt = F(t, r, v, \ldots) \qquad \textbf{(4)}$$

or the celebrated Newton's gravitation

$$F = g \times m_1 \times m_2/r^2 \qquad \textbf{(5)}$$

solely apply for matter, and have no means whatsoever to distinguish between matter and antimatter for the very simple reason that antimatter was inconceivable at Newton's times.

Prior discovery of his isodual mathematics, Santilli developed the isodual theory of antimatter that holds at all levels of study, thus restoring full democracy between matter and antimatter. In essence, in the 20th century antimatter was empirically treated by merely changing the sign of the charge, under the tacit assumption that antimatter exists in the same space as that for matter. Thus, both matter and antimatter were studied with respect to the same numbers, fields, spaces, etc. However, a correct classical representation of antimatter required a mathematics that is antiisomorphic to that used for matter as a necessary condition to admit a charge conjugated operator image. Santilli represents antimatter via his anti-Hermitean isodual map that must be applied to the totality of quantities used for matter and all their operations. Hence, under isoduality, we have not only the change of the sign of the charge, but also the isodual conjugation of all remaining physical quantities (such as coordinates, momenta, energy, spin, etc.) and all their operations. This is the crucial feature that allows Santilli to achieve a consistent representation of antimatter also for neutral bodies.

In this way the Newton-Santilli isodual equation for antiparticles that can be written in the simplified form as,

$$m^d \times^d d^d v^d /^d d^d t^d = F^d(t^d, r^d, v^d, \ldots) \qquad \textbf{(6)}$$

where “d" denotes isodual map, and the same conjugation holds for gravitation, too.
Note that, after working out all isodual maps, antiparticle equation **(6)** merely yields minus the value of the conventional equation for particles in both the l.h.s. and the r.h.s, thus appearing to be trivial. However, a most important feature of the above equation is that it defines antiparticles in a new space, the Euclid-Santilli isodual space, which is coexistent but different than our own space. The Euclidean space and its isodual then form a two-valued hyperspace. In this section we shall show that, starting from the fundamental equation **(6),** the isodual theory of antimatter is consistent at all subsequent levels, including quantization, at which level it is equivalent to charge conjugation. Note that isodual antiparticles have a negative energy. This feature is dismissed by superficial inspections as being nonphysical, thus venturing judgments prior to the acquisition of technical knowledge. In fact, negative energies are indeed nonphysical, but when referred to our space time, that is, with respect to positive units of time. By contrast, when referred to negative units, all known objections on negative energies become inapplicable, let alone resolved.
Note also that isodual antiparticles move backward in time. This view was originally suggested by Stueckelberger in the early 1900s, and then adopted by various physicists, such as Feynman, but dismissed because of causality problems when treated with our own positive unit of time. Santilli has shown that motion backward in time referred to a negative unit of time $t^d = - t$ is as causal as motion forward in time referred to a positive unit of time t, and this illustrates the nontriviality of the isodual map. Moreover, the assumption that particles and antiparticles have opposing directions of time is the only one known giving hopes for the understanding of the process of annihilation of particles and their antiparticles, a mechanisms utterly incomprehensible for the 20th century physics [31].

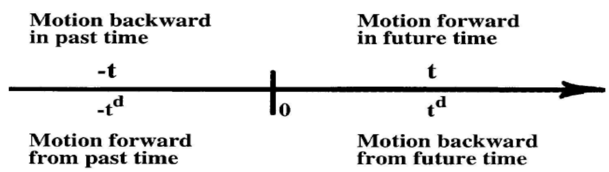



**Figure 2:** Contrary to popular beliefs, time has four directions as depicted by Santilli in this figure to illustrate the need for isoduality. In fact, time reversal can only allow the representation of two time directions. The remaining two time directions can solely be represented via the isodual map [31].

**Isodual Representation Of The Coulomb Force**

The isodual theory of antimatter verifies all classical experimental evidence on antimatter because it recovers the Coulomb law in a quite elementary way. Consider the case of two particles with the same negative charge and Coulomb Law

$$F = (-q_1) \text{ x } (-q_2)/(r \text{ x } r) \quad \textbf{(7)}$$

where the positive value of the r.h.s is assumed as representing repulsion, and the constant is assumed to have the value 1 for simplicity.
Under isoduality, the above expression becomes

$$F^d = (-q_1)^d \text{ x}^d (-q_2)^d/^d(r^d \text{ x}^d r^d) \quad \textbf{(8)}$$

thus reversing the sign of the equation for matter, $F^d = - F$. However, antimatter is referred to a negative unit of the force, charge, coordinates, etc. Hence, a positive value of the Coulomb force referred to a positive unit representing repulsion is equivalent to a negative value of the Coulomb force referred to a negative unit, and the latter also represents repulsion.
For the case of the electrostatic force between one particle and an antiparticle, the Coulomb law must be projected either in the space of matter

$$F = (-q_1) \text{ x } (-q_2)^d/(r \text{ x } r) \quad \textbf{(9)}$$

representing attraction, or in that of antimatter

$$F = (-q_1)^d \times^d (-q_2)/^d(r^d \times^d r^d) \quad \textbf{(10)}$$

in which case, again, we have attraction, thus representing classical experimental data on antimatter [31].

**Hamilton-Santilli Isodual Mechanics**

To proceed in his reconstruction of full democracy in the treatment of matter and antimatter, Santilli had to construct the isodual image of Hamiltonian mechanics because essential for all subsequent steps. In this way he reached what is today called the Hamilton-Santilli isodual mechanics based on the isodual equations

$$d^d r^d/^d d^d t^d = \partial^d H^d(r^d, p^d)/^d \partial^d p^d, \; d^d p^d/^d d^d t^d = -\partial^d H^d(r^d, p^d)/ \partial r \quad \textbf{(11)}$$

and their derivation from the isodual action $A^d$ (a feature crucial for quantization), from which the rest of the Hamilton-Santilli isodual mechanics follows [31].

**Isodual Special And General Relativities**

The special and general relativities are basically unable to provide a consistent classical treatment of antimatter. Santilli has resolved this insufficiency by providing a detailed, step by step isodual lifting of both relativities with a mathematically consistent representation of antimatter in agreement with classical experimental data. The reader should be aware that the above liftings required the prior isodual images of the Minkowskian geometry, the Poincare symmetry and the Riemannian geometry, as well as the confirmation of the results with experimental evidence [31].

**Prediction Of Antigravity**

Studies on antigravity were dismissed and disqualified in the 20th century on grounds that “antigravity is not admitted by Einstein's general relativity." This posture resulted in a serious obscurantism because general relativity cannot represent antimatter, thus being disqualified for any serious statement pertaining to the gravity between matter and antimatter. Thanks to his isodual images of special and general relativity, Santilli has restored a serious scientific process in the field, by admitting quantitative studies for all possibilities, and has shown that once antimatter is properly represented, matter and antimatter must experience antigravity (defined as gravitational repulsion) because of supporting compatible arguments at all levels of study, with no known exclusion. In fact, all known “objections" against gravitational repulsion between matter and antimatter become inapplicable under Santilli isoduality, let alone meaningless.
The arguments in favor of the above conclusion are truly forceful because differentiated and mutually compatible. As a trivial illustration, we have the repulsive Newton-Santilli force between a particle and an isodual particle (antiparticle) both treated in our space

$$F = g \times m_1 \times m^d{}_2/r^2 = -g \times m_1 \times m_2.r^2 \quad \textbf{(12)}$$

which is indeed repulsive. The same conclusion is reached at all levels of study.
It should be indicated that a very compelling aspect supporting antigravity between matter and antimatter is Santilli's identification of gravity and electromagnetism. In fact, the electromagnetic origin of exterior gravitation mandates that gravity and electromagnetism must have similar phenomenologies, thus including both attraction and repulsion [31].

**Test Of Antigravity**

Santilli has proposed an experiment for the final resolution as to whether antiparticles in the gravitational field of Earth experience attraction or repulsion. The experiment consists in the measure of the gravitational force of a beam of positrons in flight on a horizontal vacuum tube 10 m long at the end of which there is a scintillator. Then, the displacement due to gravity is visible to the naked eye under a sufficiently low energy (in the range of the $10^{-3}$ eV). The experiment was studied by the experimentalist Mills and shown to be feasible with current technologies and resolutory [13, 31].

**Isodual Quantum Mechanics**

Santilli constructed a step-by-step image of quantum mechanics under his isodual map based on the Heisenberg-Santilli isodual time evolution for an observable Q

$$i^d x^d d^dQ^d/^dd^dt^d = [Q, H]^d = H^d x^d Q^d - Q^d x^d H^d \quad \textbf{(13)}$$

and related isodual canonical commutation rules, Schrodinger-Santilli isodual equations, etc.
He then proved that, at the operator level, isoduality is equivalent to charge conjugation. Consequently, the isodual theory of antimatter verifies all experimental data at the operator level too. Nevertheless, there are substantial differences in treatment, such as:
1) Quantum mechanics represents antiparticles in the same space of particles, while under isoduality particles and antiparticles exist in different yet coexisting spaces;
2) Quantum mechanics represents antiparticles with positive energy referred to a positive unit, while isodual antiparticles have negative energies referred to a negative unit;
3) Quantum mechanics represents antiparticles as moving forward in time with respect to our positive time unit, while isodual antiparticles move backward in time referred to a negative unit of time [31].

**Santilli's Comparative Test Of The Gravity Of Electrons And Positrons In A Horizontal Supercooled And Supervacuum Tube: Proposed Experiments On The Gravity Of Antimatter**

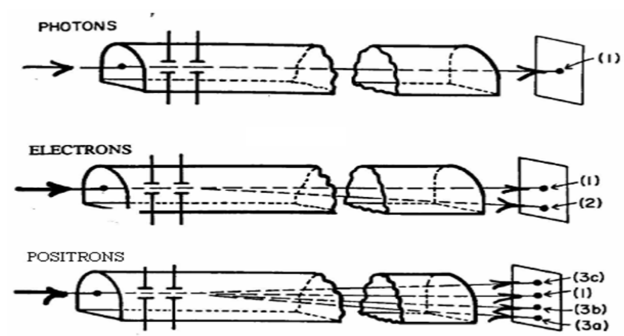



**Figure 3:** The original illustration used by Santilli for the 1994 proposal to test the gravity of positrons in horizontal light in a vacuum tube. The proposal has been qualified by experimentalists as being technically feasible nowadays and resolutory because the displacement due to gravity on a scintillator at the end of a 10 m light for positrons with milli-eV energy is visible to the naked eye. The usual criticisms based on disturbances caused by stray fields have been disqualified as political for a tube with at least 50 cm diameter. Virtually all major physics laboratories around the world have rejected even the consideration of the test, despite its dramatically lower cost and superior scientific relevance compared to preferred tests, on grounds that "Einstein theories do not admit antigravity," although with documented knowledge that said theories cannot consistently represent antimatter as reviewed in the test [31].

The gravitational repulsion (antigravity) between matter and antimatter was suspected immediately following the discovery of antimatter, although without any possible theoretical treatment due to the absence of a theory capable of representing the gravitational field of neutral antimatter [28]. This insufficiency has been resolved by Santilli's works on antimatter. In fact, the isodual theory of antimatter predicts in a consistent and systematic way at all levels of study, from Newtonian mechanics to the Riemannian geometry, that matter and antimatter must experience gravitational repulsion [12, 28]. It can conceptually say that antigravity between matter and antimatter is a necessary consequence of the very existence of a "classical" gravitational representation of “neutral" antimatter because, since the charge is null, such a representation requires the sign conjugation of all physical quantities, thus including the sign of the gravitational force and, therefore, of the curvature tensor. On quantitative grounds, we refer to monograph [28] for the gravitational representation of antigravity via the Riemannian geometry for matter and its isodual for antimatter. For the limited scope of this paper, it is sufficient to recall the most primitive prediction of antigravity, that in Newtonian mechanics, since all subsequent levels of study are evidently compatible to such a primitive one.

In fact, the Newton-Santilli isodual equation clearly predict gravitational repulsion between matter and antimatter both in our space as well as in the isodual space, according to the respective the laws,

$$F = g \times m_1 m^d_2 / r^2 < 0, \qquad \textbf{(14)}$$

$$F^d = g^d \times^d m^d_1 \times^d m_2 / r^{d2d} > 0, \qquad \textbf{(15)}$$

where in our world we have a repulsion because the gravitational force is negative, $F < 0$, and referred to a positive unit of force, while in the isodual world we equally have a repulsion because the gravitational force is positive, $F^d > 0$, but it is referred to a negative unit of force.

The first experimental test of the gravity of positrons was formulated by W. E. Fairbanks and E. C. Witteborn at SLAC in 1967 [34] via the use of low energy positrons in vertical upward flight in a vacuum and cooled tube. Regrettably, the experiment could not be completed due to the unavailability at that time of detectors with the extreme sensitivity needed for meaningful measurements. Numerous additional experiments have been proposed to test the gravity of positrons in vertical flights, either upwards or downwards, such as the tests of Refs. [35, 36] and others. However, the gravitational force on particles is notoriously very weak, as a consequence of that the measurements with the most sophistical neutron interferometric or other techniques are expected to remain ambiguous. Thus, the class of proposed experiments to measure the gravity of positrons in vertical flight cannot possibly be as resolutory as necessary for the safety of our planet and, consequently, this class of experiments will not be considered herein.

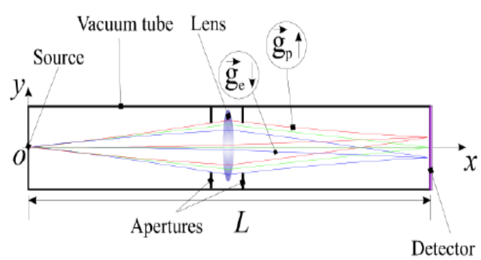



**Figure 4:** Principle set-up of Mills’s adaptation of Santilli’s comparative test of the gravity of electrons and Positrons. :→ shows the gravitational attraction on a collimated beam of electrons that, when having a very low energy of the order of meV, is of the order of 1 cm following a flight of 10 m, thus being visible to the naked eye [13].

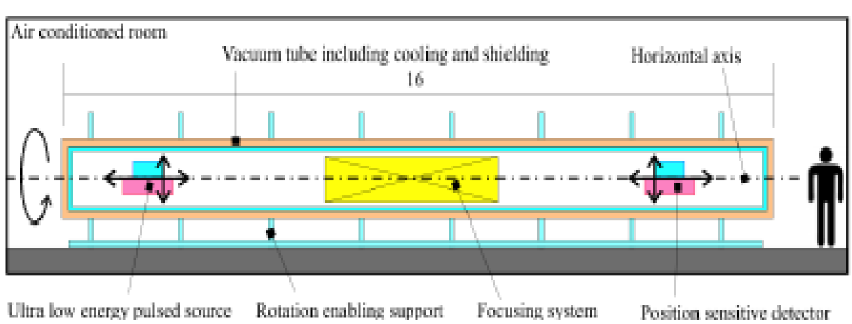


**Figure 5:** The possible alternatives for a collimated beam of positrons. Santilli's isodual theory of antimatter predicts gravitational repulsion (antigravity) at all its levels for positrons in a horizontal flight on Earth that, for very low energy of the order of meV, is of the order of 1 cm following a 10 m flight, thus being visible to the naked eye on the scintillator at the end of the tube. For that reason, Santilli's proposed experiment has been stated to be “resolutory" by experimentalists in the field [13, 37]. The lower two renderings are from the technical realization of the test [38] by the R. M. Santilli Foundation on the technical realization of proposal [12] (forth view from the top) and illustration of its size compared to a person [39].

In view of the indicated limitations of testing the gravity of positrons in a vertical flight, Santilli proposed in paper [12] of 1994 the experimental verification or dismissal of the predicted gravitational repulsion between matter and antimatter via measurements of the comparative behavior of very low energy electrons and positrons moving in a 10 m long horizontal supercooled and super-vacuum tube **(Figs. 3 to 5).**

It is evident that Santilli's gravity experiment via positrons in horizontal flight is strikingly better than preceding proposed tests [34-36] via positrons in a vertical flight. While the measurements in the latter tests are expected to remain ambiguous due to the smallness of the effect, in Santilli's experiment [12], for very low energy electrons and positrons of the order of meV in horizontal flight in a 10 m long supercooled and super-vacuum tube, the displacement due to gravity detected on a scintillator at the end of the tube is of the order of 1 cm, thus being visible to the naked eye. The preference of Santilli's test [12] over the tests of Refs. [34-36] is confirmed by a number of experimentalists in the field. For instance, during the International Conference on Antimatter held in Sepino, Italy, in June 1996, the experimentalist A. P. Mills declared Santilli's gravity experiment as being “resolutory" [13] and, therefore, is preferable over the others not equally resolutory experiments. Similarly, during the Third International Conference on the Lie-Admissible Treatment of Irreversible Processes, held at the University of Kathmandu, Nepal, in January 2011, the experimentalist V. de Haan [37] confirmed Mills analysis and also declared Santilli's gravity experiment as being “resolutory”.

Besides the above proposed experiments via the use of positrons, the only remaining proposed experiments are those based on anti-hydrogen atoms produced at CERN. Among the latter tests, we have pointed out the test proposed in Ref. [40] by the AEGIS Collaboration outlined in **Figures 6 and 7,** and the test proposed in Ref. [41] by the ALPHA Collaboration outlines in **Figures 6 and 7**. By assuming a technical knowledge of these proposed experiments, we here limit ourselves to the following comments.

To begin, the tests of Refs. [40, 41] have the same ambiguities in measurements as those of the tests with vertically moving positrons [34-36], since the former too deal with extremely small effects requiring extremely sensitive detectors under these conditions. The “experimental results" are inevitably prone to the approximations and/or manipulations that occurred in similar tests.

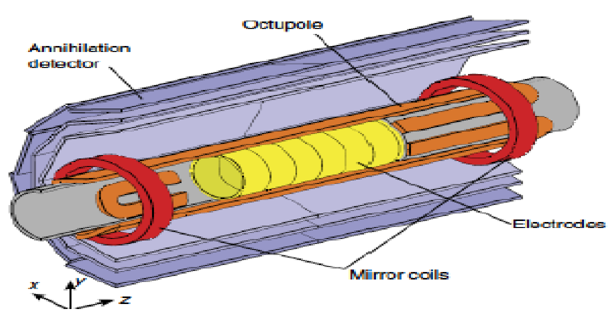



**Figure 6:** An illustration from Ref. [41] providing a cut-away diagram of the antihydrogen production and trapping of the ALPHA Collaboration, showing the relative positions of the cryogenically cooled Penning- Malmberg trap electrodes and other features.

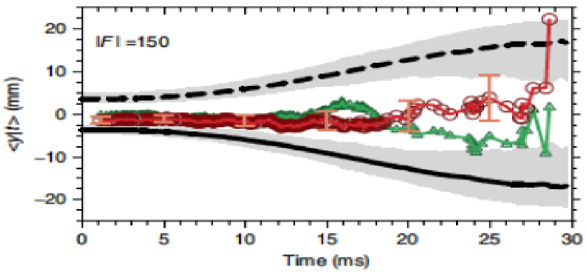



**Figure 7:** A second illustration from Ref. [41] on the proposed test of the gravity of antihydrogen atoms via their fall downward when released from the ALPHA antihydrogen trap of the preceding figures. The illustration depicts one of several simulated reverse cumulative average analysis. Compared to the event data to the reverse cumulative average. The green-triangle line is the reverse cumulative average of the x annihilation positions of the event data, and is included as a comparison. The black solid line is the represents 900,000 simulated antihydrogen atoms. The black dashed line mirrors the black-solid line, and is equivalent to a simulation study of antigravity. The grey bands separate the 90% confidence region. Again, the complexity of the apparatus and the high sensitivity of the detectors should be compared to corresponding data of Santilli's gravity test [12, 38].

Besides that, the main problematic aspect of tests of Refs. [40, 41] is the one identified by Santilli [28] according to which, despite a popular beliefs at CERN and elsewhere, the "antiprotons" produced at CERN are not necessarily antiparticles, unless verified as such via annihilation processes, because at least in part, they can be anomalous protonic states created by the embedding of a singlet electron pairs inside ordinary protons. These states are called by Santilli the pseudoproton and denoted with the symbol $\hat{p}^-$. Consequently, no gravity experiment based on "antihydrogen atoms" produced at CERN can be considered as being resolutory under such a serious ambiguity. It is important for this paper to provide an outline of the above ambiguity. Besides the study of antimatter, Santilli has dedicated decades of his research life also to the synthesis of neutrons inside a star according to Rutherford's historical conception that neutrons are synthesized by the "compression" of hydrogen atoms in the core of a star, nowadays represented with reaction

$$p^+ + e^- \rightarrow \eta + \nu \qquad \textbf{(16)}$$

It is well known that the energies needed to achieve the synthesis of the neutron are fully available at CERN. In particular, Santilli has shown that neutrons can also be synthesized in laboratory from a hydrogen gas traverses by a DC arc, thus taking place at energies much smaller than those available at CERN. The experimental information important for the test of the gravity of antimatter obtained by Santilli is that Rutherford's compression is also achievable for an electron pair in singlet coupling (that occurs for valence electron pairs) resulting in the creation of pseudoproton according to the reaction

$$p^+ + (e_{\uparrow}^- + e_{\downarrow}^-) \rightarrow \hat{p}^- \qquad \textbf{(17)}$$

where $\hat{p}^-$ is predicted to have a mean life essentially similar (if not longer) than that of the neutron due to the similarities of the two syntheses.

As a matter of fact, Santilli has shown that synthesis [38] is more probable than synthesis [31] for various reasons, such as: synthesis [38] does not require the emission of a neutrino for the conservation of the total angular momentum as necessary for synthesis [34], Rutherford's compression of a single electron pair inside the proton is statistically more probable than the compression of the electron due to spin zero of the electron pairs (thus requiring no special proton-pair coupling), compared to the need for a singlet proton-electron coupling for synthesis [31] and other reasons. It should be stressed that quantum mechanics does not allow a quantitative representation of synthesis [31] because the rest energy of the neutron is bigger than the sum of the rest energies of the proton and the electron, thus requiring a "positive binding energy" which is anathema for quantum mechanics, since in this case the Schrodinger equation no longer admits physically meaningful solutions [2].

Thanks to its non-unitary invariant character, hadronic mechanics has resolved these insufficiencies by achieving, for the first time to our knowledge, a numerically exact representation of “all" characteristics of the neutrons in synthesis [31] at both non-relativistic and relativistic levels [2, 31]. In particular, the use of Santilli's non-unitary invariant methods that have permitted a representation of synthesis [31] when applied to synthesis [38], show that the rest energy of the pseudoproton can be close to that of the antiproton, although expecting of exact numerical values are premature at this time since the sole experimentations to date have been conducted is by Santilli. Therefore, Santilli stresses that the distinction between the antiproton and the pseudoproton cannot be solely based on their charge and rest energy, their only resolutory distinction being that based on annihilation processes. Needless to say, the antimatter nature of the “antiprotons" claimed at CERN cannot be denied. The point is that the antimatter character has to be proved beyond doubt prior to any true scientific claim. Now, as it is well known, the production of “antiprotons" at CERN is based on hitting a target with the 26 GeV proton beam produced by the old Proton Synchrotron (PS). It is then evident to all that, during the collision of protons with matter target, Santilli synthesis [38] is indeed possible, resulting in the synthesis of the pseudoproton. In fact, at the time of the impact, protons collide first with electrons clouds in general, including precisely the valence electron pairs of synthesis [38]. Once the pseudoproton has been synthesized, its capability to capture a positron in the anti-hydrogen trap is established by quantum mechanical laws, resulting in a neutral state ($\hat{p}^-$; $e^+$) which is similar to, but not necessarily, the anti-hydrogen atom ($\bar{p}^-$, $e^+$).

In short, the mathematical, theoretical and experimental studies illustrate Santilli's main objection against the test of the gravity of antimatter via “antihydrogen atoms" currently produced at CERN because of the lack of clear proof that they are indeed antimatter and the absence of experiments for the resolution of the ambiguities because, being necessarily beyond quantum mechanics, the said experiments are notoriously not even plausible at CERN under current control. In conclusion, both classes of tests of the gravity of antimatter, those based on vertical motion of positrons and those based on the ”anti-hydrogen atoms” produced at CERN, are not resolutory on grounds of our current knowledge. Consequently, Santilli's gravity test is and remains the best measurement of the gravity of antimatter since it is the only experiment whose results would be visible to the naked eye [39].

**Experimental Detection Of Antimatter Galaxies**

The isodual theory of antimatter was born out of Santilli's frustration as a physicist for not being able to ascertain whether a far away star, galaxy or quasar is made up of matter or of antimatter. Santilli has resolved this uneasiness via his isodual photon $\gamma^d$ namely, photons emitted by antimatter that have a number of distinct, experimentally verifiable differences with respect to photons $\gamma$ emitted by matter,

$$\gamma^d \neq \gamma \qquad \textbf{(18)}$$

thus allowing, in due time, experimental studies on the nature of far away astrophysical objects. A most important difference between photons and their isoduals is that the latter have negative energy, as a result of which, isodual photons emitted by antimatter are predicted to be repelled in the gravitational field of matter. A possibility for the future ascertaining of the character of a far away star or quasar is, therefore, the test via neutron interferometry or other sensitive equipment, whether light from a far away galaxy is attracted or repelled by the gravitational field of Earth [31].

**The New Isoselfdual Invariance Of Dirac Equation**

Santilli has released the following statement on the Dirac equation**:** I never accepted the interpretation of the celebrated Dirac equation as presented in the 20th century literature, namely, as representing an electron, because the (four dimensional) Dirac's gamma matrices are generally believed to characterize the spin 1/2 of the electron. But Lie's theory does not allow the SU (2) spin symmetry to admit an irreducible 4-dimensional representation for spin 1/2, and equally prohibits a reducible representation close to the Dirac's gamma matrices. Consequently, Dirac equation cannot represent an electron intended as an elementary particle since elementarily requires the irreducible character of the representation. In the event Dirac's gamma matrices characterize a reducible representation of the SU (2)-spin, Dirac's equation must represent a composite system. I discovered the isodual theory of antimatter by examining with care Dirac's equation. In this way, I noted that its gamma matrices contain a conventional two-dimensional unit $I_{2X2}$ = Diag. (1, 1), as well as a conjugate negative-definite unit - $I_{2X2}$. That suggested me to construct a mathematics based on a negative definite unit. The isodual map come from the connection between the conventional Pauli matrices $\sigma_k$, k = 1, 2, 3, referred to $I_{2x2}$ and those referred to $-I_{2x2}$. In this way I reached the following interpretation of Dirac's gamma matrices as being the tensorial product of $I_{2x2}$, $\sigma_k$ times their isoduals,

$$\{I_{2x2}, \sigma_k, k = 1, 2, 3\} \times \{I^d_{2x2}, \sigma_k^d, k = 1, 2, 3\} \qquad \textbf{(19)}$$

Therefore, I reached the conclusion that the conventional Dirac equation represents the tensorial product of an electron and its isodual, the positron. In particular, there was no need to use the "hole theory" or second quantization to represent antiparticles since the above re-interpretation allows full democracy between particles and antiparticles, thus including the treatment of antiparticles at the classical level, let alone in first quantization. By continuing to study Dirac's equation without any preconceived notion learned from books, I discovered yet another symmetry I called isoselfduality, occurring when a quantity coincides with its isodual, as it is the case for the imaginary unit $i^d = i$. In fact, Dirac's gamma matrices are isoselfdual,

$$\gamma_\mu{}^d = \gamma_\mu, \ \mu = 0, 1, 2, 3. \qquad \textbf{(20)}$$

This new invariance can have vast implications, all the way to cosmology, because the universe itself could be isoselfdual as Dirac's equation, in the event composed of an equal amount of matter and antimatter. In conclusion, Dirac's equation is indeed one of the most important discoveries of the 20th century with such a depth that it could eventually represent features at the particle level that actually hold for the universe as a whole [31].

**Dunning-Davies Thermodynamics For Antimatter**

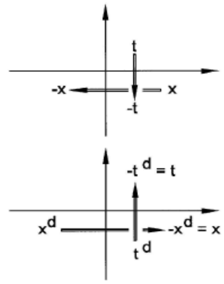



**Figure 8:** A schematic view of the additional peculiar property that the projection in our spacetime of the isodual space inversion appears as a time inversion and vice versa. In fact, a point in the isodual spacetime is given by $(x^d, t^d) = (-x, -t)$. The projection in our spacetime of the isodual space inversion $(x^d, t^d) \rightarrow (-x^d, t^d)$ is then given by $(x, -t)$, thus appearing as a time (rather than a space) inversion. Similarly, the projection in our spacetime of the isodual time inversion $(x^d, t^d)$ ! $(x^d, -t^d)$ appears as $(-x, t)$, that is, as a space (rather than time) inversion. Despite its simplicity, the above occurrence has rather deep implications for all discrete symmetries in particle physics.

As well known, the sole formulation of thermodynamics of the 20th century was for matter. The first consistent formulation of thermodynamics for antimatter has been reached by J. Dunning-Davies with intriguing implications for astrophysics and cosmology yet to be explored, (see the original contribution by Dunning Davies quoted below) [31]. An important contribution to the isodual theory has been made by J. Dunning-Davies [42] who introduced in 1999 the first, and only known consistent thermodynamics for antimatter, here called Dunning-Davies antimatter thermodynamics with intriguing results and implications. As conventionally done in the field, let us represent heat with Q, internal energy with U, work with W, entropy with S, and absolute temperature with T. Dunning-Davies isodual thermodynamics of antimatter is evidently defined via the isodual quantities

$$Q^d = -Q, \quad U^d = -U, \quad W^d = -W, \quad S^d = -S, \quad T^d = -T \qquad \textbf{(21)}$$

on isodual spaces over the isodual field of real numbers $R^d = R^d(n^d, +^d, \times^d)$ with isodual unit $I^d = -1$.

It is also seen that isodual differentials are isoselfdual (that is, invariant under isoduality).

Dunning-Davies then has the following theorem:

**THEOREM** [43]: Thermodynamical laws are isoselfdual.

**Proof:** For the First Law of thermodynamics we have

$$dQ = dU - dW \equiv d^dQ^d = d^dU^d - d^dW^d. \qquad \textbf{(22)}$$

Similarly, for the Second Law of thermodynamics we have

$$dQ = T \times dS \equiv d^dQ^d = T^d \times^d S^d, \qquad \textbf{(23)}$$

and the same occurs for the remaining laws.

Despite their simplicity, Dunning-Davies results [43] have rather deep implications. First, the identity of thermodynamical laws, by no means, implies the identity of the thermodynamics of matter and antimatter. In fact, in Dunning-Davies isodual thermodynamics the entropy must always decrease in time, since the isodual entropy is always negative and is defined in a space with evolution backward in time with respect to us. However, these features are fully equivalent to the conventional increase of the entropy tacitly referred to positive units. Also, Dunning-Davies results indicate that antimatter galaxies and quasars cannot be distinguished from matter galaxies and quasars via the use of thermodynamics, evidently because their laws coincide, in a way much similar to the identity of the trajectories of particles and antiparticles of *Lemma: The trajectories under the same magnetic field of a charged particle in Euclidean space and of the corresponding antiparticle in isodual Euclidean space coincide* [2]. This result indicates that the only possibility known at this writing to determine whether far away galaxies and quasars are made up of matter or of antimatter is that via the predicted gravitational repulsion of the light emitted by antimatter called isodual light.

**Isoselfdual Spacetime Machine**

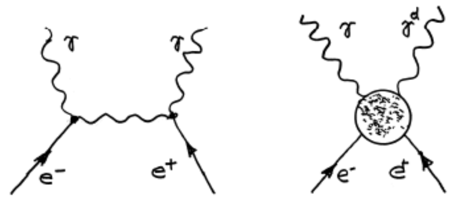


**Figure 9:** An illustration of the serious implications of Santilli's isodual theory of antimatter: the need for a revision of the scattering theory of the 20th century due to its violation of the isoselfdual symmetry of Dirac's equation. The diagram in the left illustrates the isoselfduality of the initial particles (an electron and a positron) but its violation in the final particles (two identical photons). The diagram in the right illustrates one of the several needed revisions, the use for final particles of a photon and its isodual as a necessary condition to verify the new isoselfdual symmetry. Additional dramatic revisions are due to the purely action-at-a-distance, potential interactions of the conventional scattering theory (represented with a waving central line in the left diagram), compared to the non-Hamiltonian character of the scattering region caused by deep penetrations of the wave packets of particles (represented with a circle in the right diagram) [31].

A “spacetime machine" is generally referred to a *mathematical* process dealing with a closed loop in the forward spacetime cone, thus requiring motions forward as well as backward in time. As such, the “machine" is not permitted by causality under conventional mathematical treatment, as well known. Santilli discovered that *isoselfdual matter,* namely, matter composed by particles and their antiparticles such as the positronium, have a null intrinsic time, thus acquiring the time of their environment, namely, evolution forward in time when in a matter field, and motion backward in time when in an antimatter field. Consequently, Santilli showed that *isoselfdual systems can indeed perform a closed loop in the forward light cone without any violation of causality laws,* because they can move forward when exposed to a matter and then move backward to the original starting point when exposed to antimatter [31].

**Original Literature**

To best knowledge, Santilli's first paper on the isodual theory of antimatter is the one dating to 1994 [44] (following the 1993 paper on isodual numbers). The first presentations of the classical isodual theory, antigravity, the isodual photon and the isoselfdual spacetime machine appeared in papers [45-48]. An independent study by an experimentalist on the feasibility and resolutory character of the proposed measurements of the gravity of positron in horizontal flight on Earth can be found in paper [13]. Comprehensive presentations of the isodual theory of antimatter are available in the monographs [2, 4]. The first formulation of thermodynamics for antimatter was reached by J. Dunning Davies in paper [42, 49].

**Main Features Of Santilli Isodual Theory Of Antimatter**

The main feature of Santilli isodual theory [30, 31] is that all quantities that are positive (negative) for the study of matter become negative (positive) for the study of antimatter, with the clarification that all positive and negative matter quantities are referred to positive units of measurements for matter, while all negative and positive antimatter quantities are referred to negative units. In particular, antimatter is predicted to have negative energy $E^d = -E$ exactly as conceived by Dirac [50] and evolve along a negative time $t^d = -t$ according to an old attempt to understand annihilation of matter and antimatter. Causality and other physical problems are resolved by the isodual mathematics, since negative quantities are measured in terms of negative units. Hence, antimatter evolving backward in time with respect to negative units of time is as causal as matter evolving forward in time with respect to positive units of time. The same holds for negative energy referred to negative units, and of other negative quantities.

The first known formulation of Newton equation for antiparticles is based on the Newton-Santilli isodual equations, and confirmed their verification of all known experimental data on the classical behavior of antiparticles [1]. A systematic presentation of the isodualities of Euclidean, Minkowskian and Riemannian geometries, Lie theory, rotational, Galilean, Lorentz and Poincaré symmetries, Galilean and special relativities, and other basic formulations is provided which in particular, presented the first known consistent representation of the gravitational field of an antimatter body via the Riemann-Santilli isodual geometry [2]. New isoselfdual cosmology at the limit of equal amounts of matter and antimatter, in which case all total quantities of the universe, such as total time, total mass, total energy, etc., are identically null to avoid a discontinuity at creation and set up the basis for continuous creation [51].

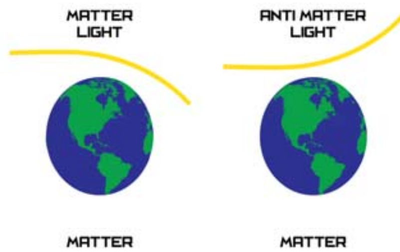



**Figure 10:** A view of the repulsion of antimatter light by a matter gravitational field predicted by the isodual theory of antimatter: The repulsion of antimatter light by a matter gravitational field which is a consequence of the classical conjugation of neutral matter into antimatter.

The light emitted by antimatter, also called isodual light, resulting in a prediction of main character for the detection of antimatter galaxies according to which antimatter light is physically different than matter light in an experimentally verifiable way. Since the photon has no charge, the only possible conjugation is that for all other physical quantities. As a result, antimatter light is predicted to possess negative energy while all other characteristics are opposite to those of matter light. In particular, antimatter light is predicted to be repelled by matter gravity **(Fig. 10),** thus permitting the conception of experiments, e.g. via neutron interferometry, to verify whether one of the two photons emitted in electron-positron annihilation experiences repulsion in our gravitational field [14, 16-23, 46].

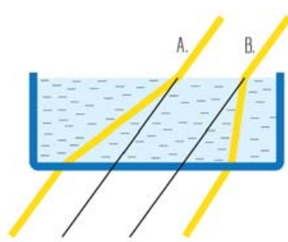



**Figure 11:** The prediction of negative index of refraction of antimatter light within matter water: The negative index of refraction of antimatter light which is a consequence of the repulsion of antimatter light from a matter gravitational field.

The first known hypothesis presented that the antimatter light possesses a negative index of refraction $n^d = -n$ when propagating within a transparent matter medium. Again, the consistent characterization of neutral antimatter requires the conjugation of all quantities with no exclusion to avoid catastrophic inconsistencies. This implies the necessary conjugation of the index of refraction into a negative value referred to our positive units of measurements since it is observed in our matter world **(Fig. 11)** [16-23].

An important implication of the isodual theory of antimatter is the clarification that *the conventional Dirac equation characterizes the tensorial product of one point like particle with spin ½ and its antiparticle without any need for second quantization* [30]. Santilli could not accept the conventional 20th century view that Dirac's equations represents only one particle with spin ½ because there exists no irreducible or reducible representation of the SU(2) spin symmetry with the structure of Dirac's gamma matrices. Therefore, the author re-inspected Dirac's equation and showed that $\gamma^k = \sigma^k \times \sigma^{dk}$. And $\gamma^4 = \text{Diag.}(I_{2x2}, - I_{2x2})$ thus yielding the indicated characterization of a spin ½ particle and its antiparticle. Dirac himself provided the true foundation of the isodual theory of antimatter by characterizing antiparticles with the *negative unit* $-I_{2x2}$. Dirac merely missed the *mathematics* for the consistent physical treatment of negative energies. Note that there is no contradiction for a representation of antiparticle at the quantum mechanical level because the isodual theory of antiparticles applies at the classical level, let alone that of first quantization. It should be aware that a negative index of refraction implies that antimatter light propagates within a transparent matter medium at superluminal speeds. A conceptual interpretation of this prediction is that the ordinary (positive) index of refraction for matter light propagating within a transparent matter medium is due to various, ultimately attractive interactions that slow down the speed of matter light. By contrast, when antimatter light propagates within a transparent matter medium, for consistency, all features of matter have to be conjugated, resulting in new repulsive interactions between antimatter light and the matter medium that, as such, accelerate antimatter light to superluminal speeds.

## APPLICATION OF SANTILLI'S ISODUAL THEORY OF ANTIMATTER

### Santilli Telescope and Experimental Details For Detection of Antimatter Galaxies, Antimatter Cosmic Rays, Invisible Terrestrial Entities (ITE) Etc.

Santilli has been constructed a new refracting telescope with "concave" lenses; known as Santilli telescope; for detection of antimatter light from distant sources, because a conventional telescope with convex lenses will disperse light with a negative index of refraction. For that Santilli secured the design and fabrication of two identical Galileo refracting telescopes; without the star diagonal viewer to avoid any unnecessary reflection of antimatter light. One of the two telescopes converted to a concave version with identical but conjugated foci. The transformation of the telescope from the Galileo form with 100 mm effective convex primary lenses, to the Santilli's antimatter telescope with features identical to those the Galileo one but conjugated based on Santilli's isodual mathematics as described above. Since the camera is directly attached to the telescope without the eyepiece, this conversion essentially consisted in the fabrication and assembly of concave lenses as per the data of **Fig. 12 and Fig. 13** provides a comparative view of the Galileo and the Santilli's antimatter telescope [16].

He secured one single suitably selected camera to obtain pictures from both the Galileo and the Santilli telescopes. He also secured a tripod with mount suitable for the parallel housing of the two telescopes. He optically aligned the two telescopes on the tripod by keeping in mind the evident impossibility of doing visual alignments with the antimatter telescope and conducted a number of day views with the so mounted and aligned pair of Galileo and Santilli telescopes to verify that astronomical objects visible in the former are not visible in the latter **(Fig.14).** A number of night views of the same region of the sky via the so mounted and aligned Galileo and Santilli telescopes was conducted and obtained a number of pictures from both telescopes via the selected camera; and finally conducted a comparative inspection of the pictures from both telescopes under a variety of enlargements and contrasts to see whether the pictures from the antimatter telescope contained focused images absent in the pictures from the Galileo telescope under the same enlargement and contrast [16].

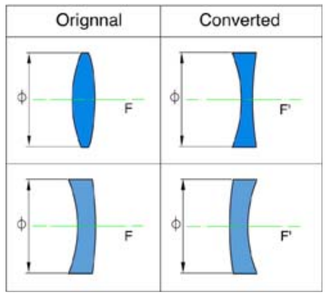



**Figure 12:** Main characteristics of the Galileo and antimatter primary lenses

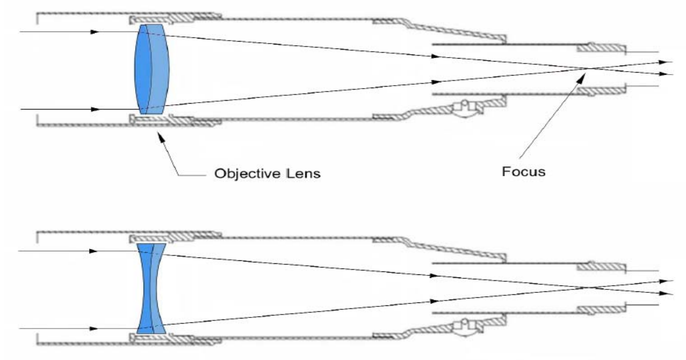



**Figure 13:** Schematic view of the telescopes with convex and concave lenses [16].

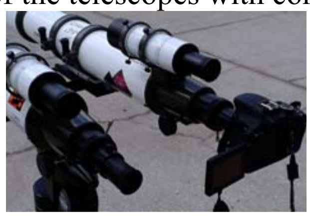


**Figure 14:** A close up view of the mounting of the camera directly in the telescope in place of the eyepieces [16].

The primary objective was to see whether or not antimatter galaxies can be detected with the concave lens telescope (Santilli telescope) since the identification of their precise location was quite unrealistic for these initial tests due to the current complete lack of knowledge of the optics of antimatter light. Following the availability of the so mounted and aligned pair of telescopes, Santilli initiated night views by first confirming that, as expected, any celestial object visibly focused by the Galileo telescope was not focused at all with the antimatter telescope. In particular, the view of details of our Moon, which were very nicely focused by the Galileo telescope, resulted in a diffuse light when seen from the antimatter telescope without any possible identification. The same occurred for planets and nearby matter stars. Then Santilli finally initiated preliminary views of the sky at night with said pair of telescopes. He reported the tests conducted at the Gulf Anclote Park, Holiday, Florida, GPS Coordinates: Latitude = 28.193, Longitude = - 82.786 [16]. The camera was set at the exposure of 15 seconds for the specific intent of having streaks of light from far away matter stars caused by Earth rotation, since streaks can be better identified with the limited capabilities of the available telescopes compared to individual dots of light in the pictures. Additionally, streaks from matter stars have a clear orientation as well as length that are important for the identification of possible streaks from antimatter light. Following various tests, he selected the 10 setting of the camera at ISO 1600 because various tests with smaller and bigger ISO resulted inconclusive and ambiguous for various reasons. All pictures were analyzed with particular reference to the identification of the background as well as impurities in the camera sensors that are evidently present in both pictures from the Galileo and the Santilli telescope [26]. Due to the limitations of the paper size only some of the recorded photographs (without their explanations; available in Refs. [16, 18, 21, 23]) are shown in following sections.

**Images of Antimatter Galaxies Antimatter Cosmic Rays Etc.**

A) Apparent Detection Of Antimatter Galaxies By Santilli On Dated November 7, 2013

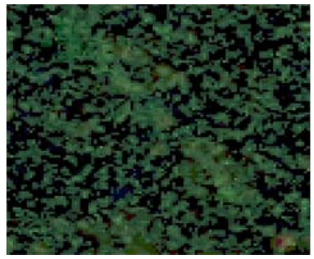
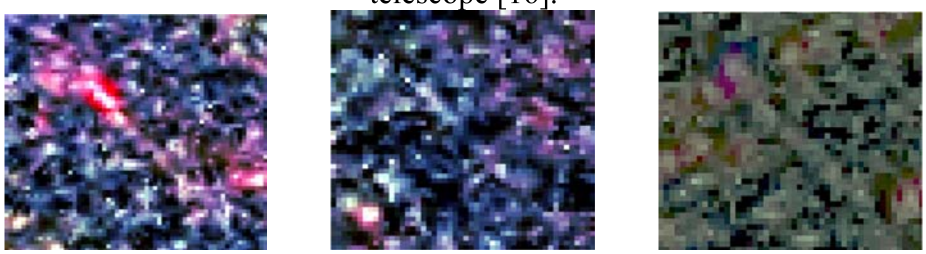


**Figure 15:** View of one of the streaks of matter light representing a far away matter star or galaxy identified in the Epsilon Alpha and Beta region of the night sky near Vega via the Galileo telescope [16].



(a) (b) (c)

**Figure 16:** Views of (a) First Streak, (b) Second streak and (c) Third streak of light detected in the Epsilon Alpha and Beta region with the Santilli telescope of antimatter galaxies [16].

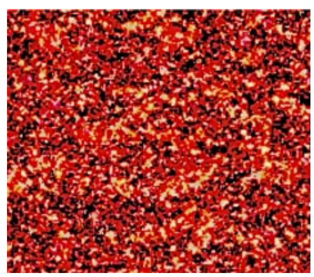
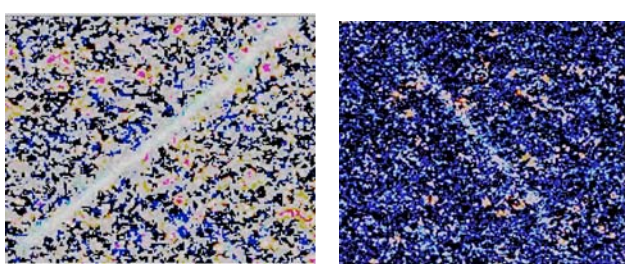


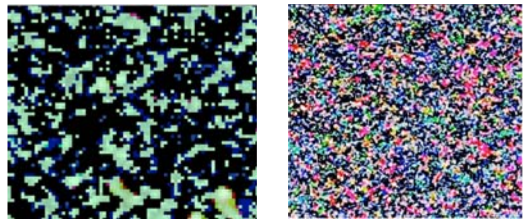
**Figure 17:** The first of numerous circular traces identified in a picture of Vega regions of the night sky on November 7, 2013, with the Santilli's antimatter telescope that could be due to the annihilation of an antimatter cosmic ray [16].

B. Preliminary Experimental Confirmations of Antimatter Detection using Santilli's Antimatter Telescope By Co-workers On Dated November 30, 2013



(a) (b)

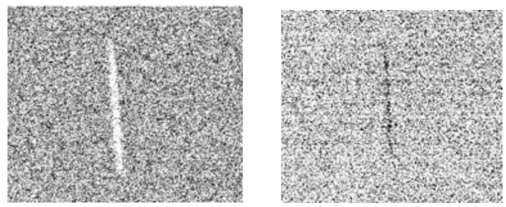
**Figure 18:** Pictures from the Galileo Telescope of (a) a star and (b) another star in the Epsilon region of the sky from Sebring, Florida [18].



*(a)* *(b))*

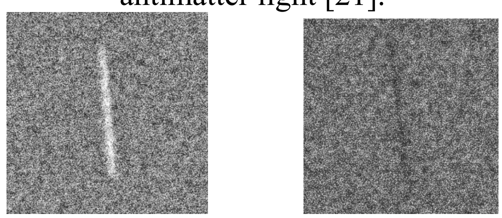
**Figure 19:** Picture from the Santilli telescope of (a) a black streak and (b) another black streak in the Epsilon region of the sky from Sebring, Florida [18].

(C) Confirmation of Santilli's detection of antimatter galaxies via a telescope with concave lenses By Co-workers On Dated October 27, 2014



(a) (b)

**Figure 20:** Images from the Vega region of the night sky showing (a) a streak due to matter light from the Galileo telescope and (b) a streak of darkness from the Santilli telescope caused by antimatter light [21].



(a) (b)

**Figure 21:** Images from the Draco region of the night sky showing a streak caused by (a) matter light from the Galileo telescope and (b) a streak of darkness from the Santilli telescope caused by antimatter light [21].

D) Apparent Detection Via Santilli's New Telescopes With Concave Lenses of Otherwise Invisible Terrestrial Entities (ITE)By Santilli On Dated September 5, 2015

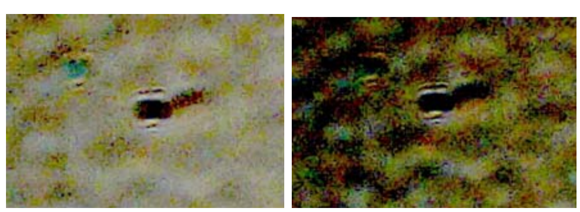


**Figure 22:** A view of an Invisible Terrestrial Entity of the first kind (ITE-1) detected in two different photos on September 5, 2015, in the evening sky over Tampa Bay. Florida, via the pair of 100 mm Galileo and Santilli telescopes with Sony Camera SLT-A58K set at ISO automatic and 15 seconds exposure. The entity is classified as an ISE-1 because it is solely detected via the Santilli telescope (thus emitting light with negative index of refraction), and it leaves a black image in the background of the digital camera (thus emitting light with negative energy). Since we are dealing with two different photos each taken with 15 seconds exposure, the entity moves at a relative small speed. Note the ridges of ordinary light surrounding the entity, which can only be explained quantitatively via the gravitational repulsion of ordinary light by the entity because, in the absence of such repulsion, ordinary light should merely experience diffraction. Note additionally that the entity "cannot" be composed of antimatter because, being within our atmosphere, it would annihilate with a cataclysmic explosion [23].

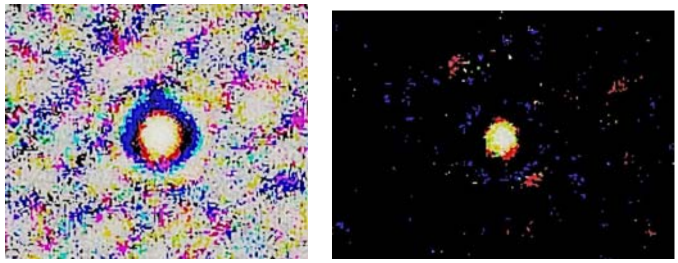


**Figure 23:** A view in the top of an Invisible Terrestrial Entity of the second kind (ITE-2) taken on September 5, 2015, in the night sky of the Tampa Bay, Florida, from room 775 of the Vinoy Hotel in St. Petersburg at 9.15 pm via the 100 mm Santilli telescope. We have an ITE-2 because the entity is in our terrestrial environment; it is only visible in the Santilli telescope and it produces a bright image in the digital background, as established by the fact that ordinary light remains visible under strong contrast (bottom view) These data imply that the entity produces light with a negative index of refraction, but with positive energy, thus constituting discovery of a basically new form of light here presented apparently for the first time. In the Santill's opinion, ITE-2 are indications of structures composed by ordinary matter which emit ordinary light, but achieve invisibility to the human eye as well as to conventional refractive telescopes via the inversion of its index of refraction. This paper [23] has been motivated by the need for our monitoring the possible presence of ITE-1 and/or ITE-2 over sensitive civilian, industrial and military installations since they could be conducting unauthorized surveillance [23].

**Figure 24:** A view of the 50 mm, 70 mm, 100 mm, 150 mm and 200 mm pairs of Galileo and Santilli telescopes used for the detections presented in this paper, that are under production and subsequent sale by the U. S. publicly traded company Thunder Energies Corporation (***www.thunderenergies*.com**). Santilli telescopes cannot be efficiently used alone because the human eye has a convex cornea, thus being unable to focus images of antimatter-light. The efficient use Santilli telescopes is that of pairing them with optically aligned, Galileo telescopes of the same size with exactly the same, yet opposite curvatures of the primary lenses and focal distances (**Figs. 12 and 13**). The Galileo telescope is then used for focusing images of matter-light. The related settings are then transferred to the Santilli telescope. Images in the Santilli telescope are considered for analysis if and only if they do not appear in the Galileo telescope, are not caused by impurities in the lens and verify other conditions. Note that the pairs of telescopes depicted in this figure are equipped with two identical cameras, one per telescope, however, detections selected for publication are generally achieved via one single camera, first used in the Galileo telescope to verify focusing, and then transferred to the Santilli telescope [21].

## CONCLUSIONS

In the event it is concluded that, Santilli's isodual theory does indeed provide a consistent and time invariant, classical and operator description antimatter in a way compatible with available experimental data at both, the classical and quantum levels. In particular, our analysis confirms that; 1) a consistent classical representation of neural antiparticles in a way compatible with the known quantum description can be achieved via negative-definite physical quantities such as energy, momentum, time, etc., under the consistency condition that they are measured with negative-definite units,

2) Santilli's isodual mathematics is applicable for the antimatter and the fundamental laws of physics for the antimatter may be explained with the consideration of negative values of energy, time, gravity, refractive index, momenta etc. with negative unit and

3) the focusing of images by a telescope with concave lenses (Santilli telescope) appears to be the first experimental evidence of antigravity between matter and antimatter because the negative index of refraction for isodual light propagating within a matter medium necessary for said focusing can only be explained via repulsive interactions between the isodual light and the matter field.

In short, Santilli isodual theory is applicable for the antimatter with the consideration of negative values of energy, time, gravity, refractive index, momenta etc. with negative unit.

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