Advances in Demonstration of the 'Theorem of Gravitational Wave Generation through Photon Reflection' and Technological Applications

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Abstract: First proposed in early studies on gravitational space propulsion, this paper presents a new demonstration of the "Theorem of Gravitational Wave Generation through Photon Reflection" and explores its far-reaching technological applications. Beyond its theoretical significance and in contrast with current models, the theorem offers promising avenues for terrestrial implementation. We show that, at least in the particular case of a sphere with a reflective, massless surface filled with electromagnetic energy E, the external gravitational field of the sphere must consist of gravitons/ gravitational waves generated upon photon reflection at the sphere's surface. (This is a direct consequence of the recently demonstrated Nordstrom-Einstein paradox.)
Furthermore, we demonstrate that the energy of each graviton emitted during the reflection of light scales with the cube of its frequency (ν^3), revealing a direct coupling between electromagnetism and gravitation.
Departing from conventional approaches, this work analyses energy–momentum transfer during photon reflection and demonstrates its ability to induce localized graviton emission along with measurable spacetime perturbations. This mechanism provides an alternative theoretical framework for the quantization of gravity while seamlessly recovering the predictions of general relativity in the classical limit. We further propose experimental equipment based on high-reflectivity optical cavities, which can generate a uniform gravity field with an intensity that can be measured with a high-precision balance. Simultaneously, such equipment allows the demonstration of the proposed theorem as a fundamental physical law. By enabling the laboratory generation of high-frequency, high-intensity gravitational waves, this approach opens new directions for probing the quantum structure of spacetime.

Key-Words: Gravitation, Generation of gravitational waves during light reflection, Nordstrom-Einstein paradox solution, Gravitational field, General Theory of Relativity.

Received: April 25, 2025. Revised: May 11, 2025. Accepted: July 11, 2025. Published: September 11, 2025.

1 Introduction

It is well known that Einstein's General Theory of Relativity (GTR) describes how the gravitational field of matter distorts the spacetime continuum, but does not explain how the gravitational field itself is generated. Moreover, GTR does not address the Nordström-Einstein paradox.

First revealed in 1913 by Finnish theoretical physicist Gunnar Nordström, the Nordström-Einstein paradox highlights a tension in GTR: electromagnetic waves confined within a massless, perfectly reflective box should possess gravitational mass via $E=mc^2$, yet the invariant T of the electromagnetic stress-energy tensor is, according to GTR, identically zero.

The solution to this paradox was first uncovered during our early technological research into electromagnetic-gravitational space propulsion, revealing an unexpected and fundamental connection between electromagnetism and gravitation [1].

More recent studies have elaborated on this solution, culminating in formulating the 'Theorem of Gravitational Wave Generation through Photon Reflection' or the 'Theorem on the Conversion of Electromagnetic Waves into Gravitational Waves' [2, 3, 4].

In the present work, we first revisit the solution to the Nordström-Einstein paradox, focusing on a system consisting of a sphere with a massless, perfectly reflective surface.

We then provide a new demonstration that the graviton's energy E_g, which is radiated during light reflection, depends on the cube of the light frequency (ν^3). The gravitational wave frequency closely matches that of the incident/reflected photons. This frequency is much higher than that of the gravitational waves generated by the binary cosmic systems, which are ripples in space-time and measured by LIGO-Virgo equipment.

Furthermore, we propose a technological device capable of generating high-frequency gravitational waves, which opens the way for the generation of artificial gravity in practical applications.

Our methodology is rooted directly in GTR and involves a comprehensive theoretical analysis demonstrating that graviton emission is directed along the path of reflected photons.

These findings provide new insights into the interplay between gravitational and electromagnetic fields, extending the framework of artificial gravitational physics and offering a new platform for gravitational wave technology using currently available technologies.

2 Theoretical Foundation

The theoretical basis of this study is the General Theory of Relativity (GTR), applied here in its full form, without approximation.

The framework combines conceptual analysis with analytical modelling grounded in general relativity and particle physics.

The core of the theoretical exploration draws from foundational literature in gravitation, particularly works published since 1913, when the Nordström-Einstein paradox was first formulated.

The present approach reviews the main lines of the paradox solution, explores the consequences of electromagnetic wave confinement and reflection, and presents a new demonstration of the 'Theorem of Gravitational Wave Generation through Photon Reflection'.

The theoretical development is structured in two main directions -A & B:

A. A short review of the solution of the Nordström-Einstein Paradox

After presenting the Nordstrom-Einstein paradox solution in an initial form in technical papers [1], the authors began to present the solution in more general terms in some physics papers and conferences [2, 3, 4].

Due to its importance, we do a short review of the paradox solution:

The main steps of demonstration are (see point 3.1):
- Formulation of the stress-energy tensor for a hypothetical spherical cavity of mass *M* and energy *E*, filled with electromagnetic radiation and bounded by a perfectly reflective surface;
- Contraction of the Einstein field equations for this specific case, leading to a scalar representation of the field equations;
- Demonstration that the cavity admits the Schwarzschild solution; thus, a sphere filled with electromagnetic radiation behaves gravitationally as a sphere of condensed matter of equivalent mass M.

B. New demonstration of the 'Theorem of Gravitational Wave Generation through Photon Reflection'

The steps of demonstration are (see point 3.2.):
- Presentation of early results;
- Analytical estimation of the energy carried by the gravitational wave (or the associated graviton) emitted at the orthogonal reflection of a photon from a mirror;
- Contraction of the Einstein field equations for this specific case, leading to a scalar representation of the field equations;
- Demonstration that the cavity admits the Schwarzschild solution; thus, a sphere filled with electromagnetic radiation behaves gravitationally as a sphere of condensed matter of equivalent mass M.

3. Methods

3.1 Our modelling assumptions

In our modelling assumptions, we used only Einstein's field equations (GTR). No post-Einstein theory was used because this study demonstrates that GTR is sufficient to deduce the 'Theorem of Gravitational Wave Generation through Photon Reflection on one hand, and, on the other hand, the post-Einstein theories cannot be used because all of them start from the assumption that the energy of graviton depends by ν^1, assumption which was not demonstrated theoretically or experimentally.

3.2 Analytical steps and simplifications

The analytical steps and simplifications in our study are described in detail in Chapter 4.

3.3 Numerical techniques

No numerical technique was used in this study because it is not necessary. Einstein's field equations are sufficient for the complete analytical demonstration of the Theorem of Gravitational Wave Generation through Photon Reflection.

4 Theoretical contributions

4.1 The main steps of resolving the Nordstrom-Einstein paradox

Consider Einstein's field equations in covariant form:

$$R_{ij} - \frac{1}{2} g_{ij} R = \frac{8\pi G}{c^4} T_{ij} \text{ [5] (1)}$$

, where i, j = 0, 1, 2, 3, R_{ij} - the Ricci tensor, R - the Ricci's scalar curvature, g_{ij} is the metric tensor, T_{ij} - the stress-energy tensor, G -Newton's gravitational constant, and c is the speed of light. We consider a hypothetical spherical cavity with a perfectly reflective, massless surface (without thickness), filled with electromagnetic radiation (Fig. 1).

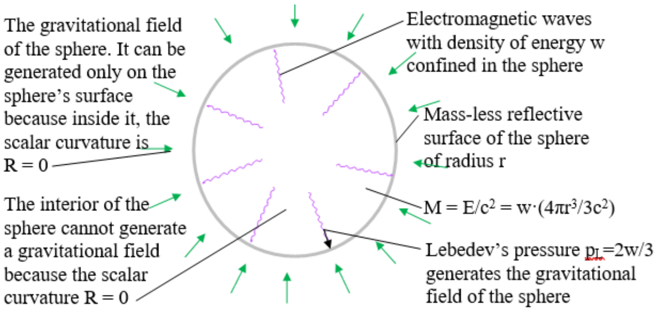


Fig.1-Gravitational field of a sphere surface filled with electromagnetic waves with total mass M, total energy E, and density of energy w

The total energy inside is E, corresponding to an effective mass $M = E/c^2$, and the interior is an isotropic radiation field with energy density w.

According to general relativity, the gravitational field outside such a sphere should be identical to that of a mass M. However, the trace of the standard electromagnetic stress-energy tensor in vacuum is:

$$T = g^{ij}T_{ij} = p + p + p - w = w/3 + w/3 + w/3 - w = 0 \text{ [6] (2)}$$

, where p is the isotropic light pressure, and w is the energy density inside the sphere. Thus, the scalar curvature R (Ricci's scalar) is also null:

$$R = -(8\pi G/c^4)\, T=0 \text{ [7] (3)}$$

This creates a paradox: The Einstein field equations yield zero curvature while the radiation has mass and should curve spacetime. This contradiction was first noted in 1913 by Nordström. [8]

To resolve this, we propose that the gravitational field of such a system is generated not in the interior, but at the reflective boundary. During the reflection of radiation on the cavity surface, both incident and reflected components coexist, effectively doubling the pressure at the boundary. We model this by extending the stress-energy tensor with an additional surface term $T_{ij\,(surf)}$, yielding a total tensor:

$$T_{ij}' = T_{ij\,(vol)} + T_{ij\,(surf)} \text{ (4)}$$

, where $T_{ij\,(vol)}$ = diag (w/3, w/3, w/3, w) is the classic tensor defined only in sphere's volume, and the new surface component $T_{ij\,(surf)}$ = diag (2w/3, 2w/3, 2w/3, w) defined only on the sphere's surface which includes the pressure $p_{surf} = 2p = 2$□$(w/3) = 2w/3$ (Lebedev's pressure, [9]) and the density of energy w which must be considered because the thickness of sphere's surface is zero. It must be understood that the difference between the internal pressure p=w/3 and p_{surf} = 2w/3 is real because p is the isotropic average pressure inside the cavity and $p_{surf} = p_L$ is the Lebedev pressure exerted on the sphere's surface. This does not contradict GTR and is supported in an initial form by some papers. [10]

The trace of the new combined tensor becomes:

$$T' = g^{ij}T_{ij}' = 0 + 2w/3+2w/3+2w/3-w) = 2w - w = w \text{ (5)}$$

Therefore, Ricci's scalar curvature R is now a nonzero number:

$$R = -(8\pi G/c^4)\, T' = -(8\pi G/c^4)\, w \text{ (6)}$$

This is consistent with the gravitational field expected from a concentrated mass (spherical mass) $M = E/c^2$, which admits the Schwarzschild solution [11], and the paradox is resolved.

Equation (6) shows that the mentioned sphere can be used to generate different space-time curvatures by injecting different quantities of light into the sphere.

4.2 New demonstration of the 'Theorem of Gravitational Wave Generation through Photon Reflection'

In a previous paper, we demonstrated that the energy of the graviton radiated at the reflection of a photon must be:

$$E_g = (512Gh^2/5c^5)\, \square\, \nu^3 = h^*\nu^3 \text{ [2] (7)}$$

, where G is Newton's constant, h is Planck's constant, c is the speed of light, ν is the frequency of the reflecting light, and $h^* = 512Gh^2/5c^5$ can be considered a universal constant [2].

The first enunciation of the 'Theorem of Gravitational Wave Generation through Photon Reflection' is:
'During normal reflection of an electromagnetic wave on a reflective surface, electromagnetic energy is partially converted into gravitational energy. The frequency of the emitted gravitational wave is equal to the frequency of the incident wave. The energy of the emitted gravitational wave is proportional to the cube of the frequency of the electromagnetic wave. The direction of the gravitational wave is opposite to that of the incident electromagnetic wave. [2]

The demonstration was done indirectly by considering the radiation of a quadrupole composed of two opposite packets of light moving with the speed of light c on a circular trajectory inside an optical fibre. [2]

A new and direct demonstration of this important theorem is presented below.

It will be demonstrated again using only the basics of GTR that the energy of a graviton emitted during light reflection depends on the cube of the light frequency (ν^3).

We propose a mechanism by which a photon, upon reflection from an idealised, perfectly reflecting, and infinitely massive mirror, may generate a gravitational wave quantised as a graviton. This process is modelled by evaluating the gravitational radiation produced during the short time interval in which the reflection occurs, utilising the standard formalism of time-varying quadrupole moments in general relativity.

Let a single photon of frequency ν and wavelength λ=c/ν impinge perpendicularly on the mirror along the x-axis. The photon's effective inertial mass can be defined via the standard mass-energy equivalence:

$m = h \cdot \nu / c^2$ (8)

We consider a photon of effective mass $m = h\nu/c^2$ oscillating along the x-axis during reflection with:

$x(t) = A \cdot \cos(2\pi\cdot\nu\cdot t)$ (9)

$y(t) = 0$ (10)

$z(t) = 0$ (11)

, where A is associated with the given photon wavelength λ.

y(t), z(t) = 0 is an approximation because the transversal oscillation amplitude of the photon's mass can be considered low.

The standard definition of the mass quadrupole moment tensor for a point-like mass is:

$Q_{i□}(t) = m \cdot [\, x_i(t)\cdot x_□(t) - (1/3)\cdot\delta_{i□}\cdot|r(t)|^2]$ [12] (12)

In this case, since the motion is only along the *x*-axis, we have:

$|r(t)|^2 = x(t)^2 = A^2 \cdot \cos^2(2\pi\cdot\nu\cdot t)$ (13)

Thus, the components of the quadrupole tensor become:

$Q_{xx}(t) = m \cdot [\, A^2\cdot\cos^2(2\pi\cdot\nu\cdot t) - (1/3)\cdot A^2\cdot\cos^2(2\pi\cdot\nu\cdot t)\,] = (2/3)\cdot m\cdot A^2\cdot\cos^2(2\pi\cdot\nu\cdot t)$ (14)

$Q_{yy} = Q_{zz}(t) = -(1/3)\cdot m\cdot A^2\cdot\cos^2(2\pi\cdot\nu\cdot t)$ (15)

$Q_{xy}(t) = Q_{xz}(t) = Q_{yz}(t) = 0$ (16)

Therefore, the quadrupole tensor has the diagonal matrix form:

$Q(t) = m\cdot A^2\cdot\cos^2(2\pi\cdot\nu\cdot t) \cdot \mathrm{diag}\,(2/3, -1/3, -1/3)$ (17)

One can observe that the quadrupole tensor Q(t) is traceless (the sum of diagonal terms is zero).

For simplicity, substituting the expressions for m and A, we can do a new approximation:

$Q(t) \approx Q_{xx}(t) = (2/3)\cdot m \cdot A^2 \cdot \cos^2(2\pi\nu t) = (2/3)\cdot(h\nu/c^2)\cdot\lambda^2\cdot\cos^2(2\pi\nu t) = (h / \nu) \cdot \cos^2(2\pi\nu t)$ (18)

The power radiated in gravitational waves by such a time-varying quadrupole is given by:

$P_g = (G / 5c^5) \cdot \langle(d^3Q_{xx}/dt^3)^2\rangle$ [6] (19)

, where ⟨ ⟩ represents the time average.

The third time derivative of $Q_{xx}(t)$ is computed as:

$d^3Q_{xx}/dt^3 = 32\pi^3□h□\nu^2□\sin(4\pi\nu□t)$ (20)

$(d^3Q_{xx}/dt^3)^2 = 32^2\pi^6□h^2□\nu^4□\sin^2(4\pi\nu□t)$ (21)

One can easily find that the average over one period T=1/ν of the function $f = \sin^2(4\pi\nu□t)$ is:

$$\langle\sin^2(4\pi\nu□t)\rangle = (1/T)\int_0^{1/\nu}\sin^2(4\pi\nu□t) = (1/T)□(1/2\nu) = (1/\nu^{-1}) / 2\nu) = 1/2 \quad (22)$$

Then the average of expression $(d^3Q_{xx}/dt^3)^2$ over a full period T=1/ν cycle yields:

$\langle (d^3Q_{xx}/dt^3)^2 \rangle = 32^2 \cdot \pi^6 \cdot h^2 \cdot \nu^4 \cdot (1/2) = (1024/2) \cdot \pi^6 \cdot h^2 \cdot \nu^4 = 512 \cdot \pi^6 \cdot h^2 \cdot \nu^4$ (23)

Thus, the instantaneous gravitational power during reflection becomes:

$P_g = (512 \cdot \pi^6 \cdot G \cdot h^2/5c^5) \cdot \nu^4$ (24)

Given that the reflection process occurs over a time T=1/ν, in the hypothesis that a single graviton is emitted during the reflection process, its energy is:

$E_g = P_g \cdot T = P_g \cdot (1/\nu) = (512 \cdot \pi^6 \cdot G \cdot h^2/5c^5) \cdot \nu^3 = \chi^* \cdot \nu^3$ (25)

, where $\chi^* = (512 \cdot \pi^6 \cdot G \cdot h^2/5c^5)$ can be considered a universal constant.

This is the second demonstration of 'The Theorem of Gravitational Wave Generation through Photon Reflection'.

It can be observed that the energy of the emitted graviton depends on the power of three of the reflecting light frequency (ν^3) and a universal constant χ^*. This outcome matches the expression derived in the early paper. [2]

Note: Equation (24) states that the reflection of a high quantity of electromagnetic energy, E_t, composed of N photons uniformly distributed on the surface of a mirror, can be used for generating a uniform gravitational field. The higher the frequency, the higher the generated gravitational power.

4.3 The proposed experiment and practical applications

4.3.1 The proposed experiment

Although it seems small in magnitude due to the expression $G \cdot h^2 / c^5$, the fact that gravitational power P_g depends on ν^4 opens tremendous experimental possibilities by using high-energy/ high-frequency light reflecting between super-reflective mirrors ($R^* \approx 99.999\%$ or more).

Let's consider a significant quantity of light E, uniformly distributed in a sphere of a large radius R and a perfectly reflective surface. The intensity g of the gravitational field (in Newton's sense) at the sphere's surface is given by:

$g = (4/3) \cdot \pi \cdot R^3 \cdot \rho / R^2 = (4/3) \cdot \pi \cdot R^3 \cdot (w / c^2) / R^2 = (4/3) \cdot \pi \cdot (w / c^2) \cdot R$ (26)

, where w is the isotropic energy density of light inside the sphere and ρ is the mass density equivalent to energy density ($\rho = w / c^2$). When R and w increase, g can reach high values, which could be used in practical applications. The gravitational field of such a light-filled sphere has some remarkable characteristics not found in the gravitational fields generated by condensed matter:

- The gravitons/gravitational waves that compose the gravitational field are directed strictly radially.
- The gravitons/gravitational waves are generated only during the reflection of light on the sphere's surface.
- The gravitons/gravitational waves are directed toward the centre's sphere and re-emerge through the diametrically opposite surface point, generating the external gravitational field. These unique characteristics allow the construction of experimental equipment as illustrated in Fig. 2.

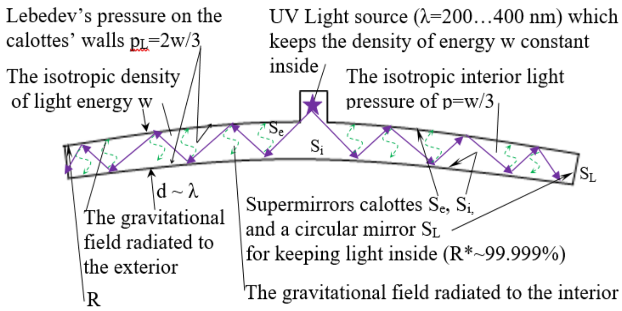


Fig.2-The scheme of the experimental equipment for the generation of high-frequency gravitational waves

The device in Fig. 2 should generate an external gravitational field similar to a large-radius light-filled sphere because the light "does not know" whether it comes from an adjacent reflective calotte or the sphere's interior.

The process is unsteady, as the internal light existing between the two calottes S_e and S_i is rapidly depleted. To maintain the energy density (w), a UV source must continuously inject light into the space enclosed by S_e, S_i, and S_L.

Assuming R = 1, i.e., a perfect reflection, if the light injection stops, the light's frequency decreases, entering consecutively the visible, infrared, microwave, radio, and lower frequency ranges, with the gravitational field intensity decreasing accordingly.

Since perfect mirrors do not exist, a significant portion of light energy is converted into heat.

The manufacturing of the equipment will be expensive because the high-reflectivity mirrors are costly, and the system needs intensive cooling to absorb the heat generated during reflection.

Multiple reflective calottes can be used to generate higher gravitational intensities, g. In such a configuration, the calotte's reflective surfaces are in balance due to Lebedev's pressures, which are exerted on both surfaces of the calottes, allowing a higher energy density w to be used.

Assume that the experimental equipment is composed of an external reflective calotte of radius R and an inner reflective calotte of radius R' = R – λ, and the diameter of the external mirror is R_c. The intensity of the gravitational field at the level of calotte R is given by:

$$g_R = G(4\pi R^3/3)\,\rho / R^2 = G(4\pi R^3/3)\,(w/c^2) / R^2 = G(4\pi R/3)\,(w/c^2) \quad (27)$$

, where G is Newton's constant $G = 6.674\times10^{-11} m^3/kg\ s^2$

Considering that calottes are about flat (e.g., $R = c^2$) and $w = 100\ j/m^3$ (UV light, λ = 300nm, currently found on the market), the intensity of the gravitational field is:

$$g_{c2} = (4\pi c^2/3)\,(w/c^2) = 2.8 \cdot 10^{-8}\ N\ m/s^2 \quad (28)$$

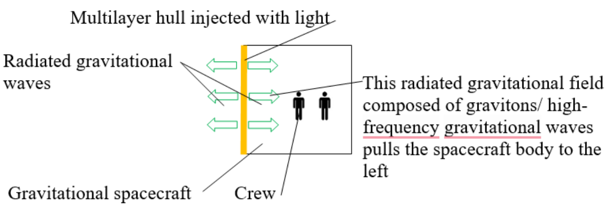
Such a gravitational field can be detected by existing precision balances (1nN). [13, 14]

4.3.2 Practical Applications

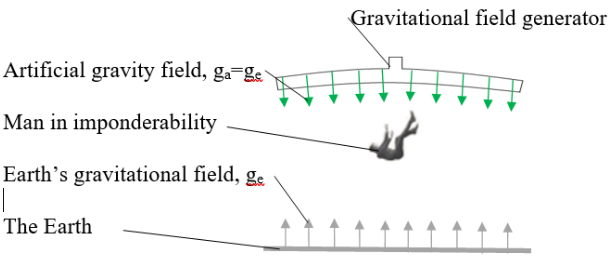
Potential applications include:
- The Gravitational Spacecraft
- Zero-gravity spaces at ground level

Although these applications were presented in detail in some early technology papers [1], we present them here for a better understanding of physical phenomena:

a) The gravitational spacecraft



b) The zero-gravity room



Notes:
- For the development of practical applications, intensive research in Solid Physics and the technology of high-power light sources is necessary.
- Materials that are reflective for very high frequencies must be found.
- Alternatively, technologies for increasing the reflectivity at high frequencies can be researched.
- Powerful light sources are necessary, especially in the case of the gravitational spacecraft, where the generated gravitational radiation pulls the spacecraft's body in the direction of the gravitational radiation.

5. Results

The solution of the Nordström-Einstein Paradox and the Theorem of Conversion of Electromagnetic Waves into Gravitational Waves

A review of the theoretical framework presented herein addresses the resolution of an over 100-year-old paradox referred to as the Nordström-Einstein paradox. For the particular case of a sphere with a reflective surface (of thickness zero), filled with electromagnetic waves (light) with the energy $E = M/c^2$, the gravitational field emerges from the interaction between electromagnetic waves (light) and the reflective boundary (sphere's surface).

This resolution leads to three major conceptual consequences, each with significant implications for the nature of gravitational fields and their underlying structure:

a)-Gravitational Fields Can Originate from Electromagnetic Wave Reflection

The first and most immediate consequence is the demonstration that, as a particular case, a static gravitational field can be generated purely by the reflection of electromagnetic radiation. This implies a functional equivalence between gravitational effects and the energy confinement in the form of high-frequency photons within a closed, reflective geometry. A deeper connection between electromagnetism and gravitation was established for this particular case. In this sense, the gravity acquires an electromagnetic origin.

b)-The Discrete Structure of the Gravitational Field: A Graviton-Based Description

A second, more profound implication concerns the quantization of the gravitational field surrounding such a photonic cavity.

In the Newtonian formulation, the field is described as a continuous potential gradient; in the Einsteinian formulation, as a smooth curvature of spacetime. However, within the proposed model, the field emerges as a consequence of photon reflection events, each of which contributes a discrete quantum of gravitational energy. This strongly suggests that the static gravitational field must consist of a superposition of elementary gravitational quanta, which may be associated with individual gravitons or equivalent gravitational wave packets. Such a description is consistent with quantum field theoretical approaches to gravity and may serve as a bridge between classical field theory and quantum gravity phenomenology.

c)-Gravitational Wave Frequency is Determined by the Source Electromagnetic Frequency

The third major result arises from the temporal localisation of the reflection process. Since the generation of a gravitational disturbance (e.g., a graviton/ gravitational wave) is assumed to coincide precisely with the reflection of an electromagnetic wave on the cavity surface, the frequency of the resulting gravitational quanta must necessarily match that of the incident radiation. That is, the gravitational waves forming the static field are composed of energy quanta with frequency $\nu_g \approx \nu_{fem}$, where ν_{fem} is the frequency of the reflecting or confined electromagnetic waves.

This temporal alignment is not optional; it is dictated by the principle that the gravitational emission begins and ends within a single optical cycle (i.e., during $T = 1/\nu$). As such, gravitational energy is modulated in direct correspondence with the properties of the electromagnetic source.

Extended Consequences and Future Research Directions

These findings offer a novel interpretation of the origin of the static gravitational fields, open pathways for theoretical extensions and experimental verifications, particularly through ultra-high-frequency photonic systems, resonant cavities, and gravitational wave analogues in laboratory settings.

Future work should focus on the numerical simulation of such photonic gravitational sources as well as possible experimental achievements involving high-reflectivity optical cavities under extreme electromagnetic energy densities.

The potential detection of the gravitational emissions can first be done using an existing precise balance (1 nN).

6. Discussion

In this paper, a review of the main steps of the Nordström-Einstein paradox solution is done to highlight its importance in theoretical and experimental physics.

This solution offers a new perspective on the origin and nature of gravitational fields. Perhaps most significantly, it challenges the prevailing assumption within both classical and quantum gravitational frameworks that gravitational fields are fundamental constructs independent of electromagnetic processes.

No theory of gravity provides a fully explanatory mechanism for the origin of the gravitational field. GTR treats gravity as a manifestation of spacetime curvature in the presence of energy and momentum, and the gravitational waves are considered only as perturbative ripples in this continuum. These gravitational waves are detectable only in extreme astrophysical events such as binary neutron star mergers or black hole collisions. These waves are generated at relatively low frequencies (typically in the range of $10\ldots10^4$ Hz) and are inherently macroscopic.

In contrast, the theoretical construct explored in this particular case, where gravitational fields arise from the reflection of high-frequency electromagnetic radiation in highly confined geometries, suggests a new class of gravitational phenomena. The mechanism proposed enables the continuous generation of a gravitational field through a purely electromagnetic process, without the need for astronomical masses.

The resulting field is not a static consequence of mass-energy distribution alone, but an emergent phenomenon driven by energy confinement and boundary interaction.

Crucially, the frequency of the gravitational quanta generated in such a configuration would match that of the incident electromagnetic waves, in stark contrast to the low-frequency gravitational radiation associated with cosmic events. This theoretical prediction opens the possibility of laboratory-scale production of high-frequency gravitational fields, a concept currently absent from mainstream gravitational physics.

From the standpoint of quantum gravity, the dependence of the graviton energy by its frequency at the power of three ($E_g = \chi^* \square \nu^3$) at least in the mentioned particular case, is a great challenge.

As the gravitational quanta are indeed emitted during each photon reflection, the mechanism described here could serve as a foundational scenario for understanding graviton emission and absorption, and for modelling gravitational interactions in a quantized spacetime.

Moreover, these insights hold deep implications for string theory and superstring frameworks, where gravitons naturally emerge as vibrational modes of fundamental strings. The coupling mechanism suggested between electromagnetic fields and gravitational emission could inform the development of effective field theories that integrate gauge bosons (e.g., photons) and gravity under a unified interaction scheme.

From a broader perspective, the results support a hierarchy of interactions in which the electromagnetic field appears as more fundamental than the gravitational field, at least in terms of field generation. This concept aligns with the notion that gravity may not be a fundamental interaction in itself, but rather an emergent or residual effect of other field dynamics under specific boundary or energy conditions.

In summary, presenting a new demonstration for the 'Theorem of Gravitational Wave Generation through Photon Reflection' not only provides the need for reinterpretation of gravitational phenomena but also contributes to a better understanding of fundamental forces.

The proposed model encourages further theoretical development and experimental exploration, particularly in the context of high-intensity photonic systems and precision gravitational measurements at small scales.

7. Conclusions

- After a short review of the first vision of the solution Nordström-Einstein paradox solution, this study presents a new demonstration of ‘The Theorem of Gravitational Wave Generation through Photon Reflection’ starting directly from the quadrupole expression approximated for one photon that reflects perpendicularly on a fixed perfect mirror.

- The ’Theorem of Gravitational Wave Generation through Photon Reflection’ is a direct consequence of the solution of Nordstrom - Einstein paradox.

- The ’Theorem of Gravitational Wave Generation through Photon Reflection’ can be found in early technology or physics papers as the ‘Theorem of Conversion of Electromagnetic Waves into Gravitational Waves’.

- The ’Theorem of Gravitational Wave Generation through Photon Reflection can be demonstrated as a Law of physics using the experimental equipment indicated in Fig.2.

- The experimental equipment indicated in Fig.2 will be a basis for the manufacturing of future gravitational space propulsion systems or the building of zero-gravity rooms on the ground.

- Key Theoretical Outcomes

The implications of the ’Theorem of Gravitational Wave Generation through Photon Reflection’ (or the ‘Theorem of Conversion of Electromagnetic Waves into Gravitational Waves’) are far-reaching for gravitation theory and beyond:

- Electromagnetic origin of gravity: The gravity field can arise not only from condensed matter, but also from the reflection of electromagnetic waves, implying a deep coupling between electromagnetism and gravity.

- During reflection of a photon by a mirror, a graviton with the same frequency is radiated.

- The energy of a graviton radiated during the reflection of a photon by a mirror is proportional to the cube of frequency, ν^3.

- Discrete gravitational structure: Since the gravitational field originates from quantized photon reflection, it must exhibit a discrete composition, consistent with a field of gravitons/high-frequency gravitational waves. This represents a natural bridge between classical general relativity and quantum gravity.

- Frequency coupling: The gravitational field's constituents are generated synchronously with the electromagnetic field, meaning their frequency content is identical.

- Applications

Beyond its theoretical impact, the model opens the door to practical gravitational field generation in laboratory settings. The proposed mechanisms enable gravitational effects at scales previously considered inaccessible, using high-intensity electromagnetic fields and engineered reflective cavities.
The main potential applications presented in this work include:

a) The gravitational spacecraft

b) The zero-gravity room and other applications will be presented in subsequent papers.

References:

[1] Sandu C. and Brasoveanu D., Sonic-Electromagnetic-Gravitational-Spacecraft, Parts 1…10, *Proceedings of the AIAA SPACE 2007 Conference & Exposition*, Long Beach, California, September 18-20, 2007, paper AIAA-2007-6203;

[2] Sandu, C., Brasoveanu, D., On the Theoretical Possibility to Generate Gravitational Waves Using Electromagnetic Waves, *Journal of Advances in Physics*, ISSN 2347–3487, Volume 13 Number 2I,

[3] Sandu, C., On a Possible Solution of Nordstrom-Einstein Paradox referring to the Nullity of Stress-Energy Tensor Invariant of EM field and Consequences, *2nd International Summit on Gravitation, Astrophysics & Cosmology,* March 18-20, 2024, Florence, Italy;

[4] Sandu C, On the Possibility to Manufacture an Equipment for the Generation of Gravitational Radiation with Significant Power for Practical Applications, *Euro Global Congress of Physics and its Applications*, 21-23 March 2024, Rome, Italy;

[5] A. Einstein, The Foundation of the General Theory of Relativity (translated from 'Die Grundlage der allgemeinen Relativitatstheorie', *Annalen der Physik*, 49, 1916), The Principle of Relativity, *Dover Publications Inc.*, ISBN 0-486-60081-5;

[6] L.D. Landau, E.M. Lifshitz, The Classical Theory of Fields, Third revised English edition, *Pergamon Press (1971);*

[7] V. Fock, The Theory of Space, Time and Gravitation, *Pergamon Press (1959*);

[8] J. Earman, M. Janssen, J. Norton, 993, Einstein Studies, Volume 5, Part.1-Disputes with Einstein, Einstein and Nordstrom - Some Lesser Known Thought Experiments in Gravitation, *Birkhauser (1993),* pages 17-18;

[9] A.V. Masalov, First Experiments on Measuring Light Pressure (Pyotr Nikolaevich Lebedev), *Springer Series in Optical Sciences (2019)*, DOI: 10.1007/978-3-319-98402-5_12;

[10] W. Israel, "Singular hypersurfaces and thin shells in general relativity," *Nuovo Cimento B*, 44B, 1–14 (1966);

[11] K. Schwarzschild, Uber das Gravitationsfeld eines Massenpunktes nach der Einsteinschen Theorie, *Sitzungsberichte der Preussischen Akademie der Wissenschaften (1916*);

[12] C.W. Misner, K.S. Thorne, J.A. Wheeler, Gravitation, *W. H. Freeman and Company (1973).*

[13] M. Tajmar, O. Neunzig and M. Weikert, High-accuracy Thrust Measurements of the EM Drive and Elimination of False Positive Effects, *Space Propulsion 2020*, 7 – 18 – 19 MARCH 2021

[14] Matthias Kößling & Martin Tajmar, Design and performance of a nano-Newton torsion balance, *Review of Scientific Instruments 93 (7),* 074502 (2022).

Data Availability Statement:

No data associated with the manuscript

Statements and Declarations:

This paper represents original research supported by the Romanian Research and Development Institute for Gas Turbines COMOTI

Competing Interests:

No financial interest is directly or indirectly related to the work submitted for publication.