The Complete Solution of the Nordström–Einstein Paradox and Its Implications in the Gravity Fields Generation

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Abstract: This paper's main goal is to solve the Nordström-Einstein paradox in the General Theory of Relativity (GTR) and open a new perspective on understanding the generation of gravitational fields.
It is not exactly known how the gravitational field is generated. This field is responsible for attraction at the distance of bodies in Newton's sense and for the distortion of space-time in Einstein's sense. In 1913, Nordström blamed Einstein's GTR for not explaining why electromagnetic waves confined in a massless box with reflective walls have a gravitational mass, while the invariant of the stress-energy tensor of the electromagnetic field is zero. This is the Nordström-Einstein paradox in GTR. The present paper solves the Nordström-Einstein paradox for the hypothetical case of a sphere with a massless and zero-thickness reflective surface filled with electromagnetic waves. It demonstrates that the gravitational field of such a sphere is generated only during the reflection of electromagnetic waves by the sphere's reflective surface due to Lebedev pressure and not in its volume. The methodology used is specific to GTR, establishing a new form of the stress-energy tensor for the mentioned case. Solving this paradox, which constituted an unexploited niche in GTR for 112 years, has significant implications for understanding the generation and structure of gravitational fields. It can serve as a basis for further theoretical and experimental research, with strong implications for the development of Quantum Gravity, String/Superstring theory, and Unified Field theories.

Key-words: Nordström-Einstein paradox, General Theory of Relativity, Quantum Gravity, Gravitation, Graviton generation mechanism

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1. Introduction

After Albert Einstein published the General Theory of Relativity (GTR) in 1916, the study of gravity took a different direction from the classic vision of Newton's theory. Despite numerous studies, the fundamental mechanisms underlying the phenomenon of gravity remain insufficiently understood. The specialized literature has not yet produced a credible theory about the generation of gravitational fields surrounding condensed matter. Theories such as quantum gravity or string/superstring theory do not offer experimental tests or clear explanations of phenomena related to the generation of gravitational fields.

On the other hand, a credible theory that connects gravitational interaction with the rest of the known interactions is still awaited. This paper aims to find the complete solution to the Nordström-Einstein paradox and to explain the 'mechanism' of generating gravitons and gravitational fields as a consequence of solving this paradox.

The Nordström-Einstein paradox is a long-unresolved and underexplored problem in GTR. Its resolution clarifies how gravitational fields are generated during the reflection of electromagnetic waves by reflective surfaces (mirrors). Chapter Theoretical Foundation details the methodological approach, and Chapter Theoretical Contributions presents the original demonstration related to the unique solution of the Nordström-Einstein paradox. Then, in the Chapter Results, the main consequences of this study are presented, and, in the Chapter Discussions, details regarding the mass, frequency, and direction of the emitted gravitons are discussed. The essential features revealed by the solution of the Nordström-Einstein paradox are summarized in the Conclusions, and the main directions of future research are also indicated.

2. Theoretical Foundation

This study's theoretical foundation is Einstein's General Theory of Relativity. All the post-Einsteinian theories were intentionally ignored to obtain results directly from the source (Einstein's GTR).

The existing theoretical works from 1913, when this paradox was pointed out, and other works in fundamental physics (Fock's, Landau's, Lebedev's, and Schwarzschild's) were also used.

3. Theoretical Contributions

- Einstein's intuition on the solution of the Nordstrom-Einstein paradox
- The Nordström–Einstein paradox in the hypothetical case of a sphere with a massless and zero-thickness reflective surface, that sphere being filled with electromagnetic waves.
- The complete solution of the Nordstrom–Einstein paradox.

3.1 Einstein's intuition on the solution of the Nordstrom-Einstein paradox

In 1913, Gunnar Nordström pointed out to Albert Einstein that the trace T of the stress-energy tensor for the electromagnetic field vanishes, implying, via the Einstein field equations, that the Ricci scalar curvature R must also vanish.

Consequently, a cavity filled exclusively with electromagnetic radiation would produce no gravitational field. Einstein responded by suggesting that the mechanical stress exerted on the cavity walls by the radiation pressure should contribute to the gravitational field, thereby preserving consistency with the equivalence principle. This early exchange anticipated what is now known as the Nordström–Einstein paradox. Despite its conceptual significance, the paradox remained largely unexplored for over one century.

3.2 The Nordstrom–Einstein paradox for the case of a hypothetical sphere with a massless (thickness 0) reflective surface filled with electromagnetic waves

Consider Einstein's field equations in covariant form:

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

, where i, j=1, 2, 3, 0, with indices 1, 2, 3 representing spatial coordinates and 0 representing the time. R_{ij} is Ricci's tensor, R is Ricci's scalar curvature, g_{ij} is the metric tensor in covariant form, T_{ij} is the stress-energy tensor, G is Newton's gravitational constant, and c is the speed of light.

Consider a hypothetical sphere with a massless reflective surface (thickness 0) filled with electromagnetic waves with the total energy E and total mass M forming an isotropic medium with the density of energy w. Such a sphere would be expected to generate a gravitational field in Newton's sense and warp the space-time continuum in Einstein's sense (fig.1). The accepted stress-energy tensor for such a sphere is:

$$T_{ij} = \begin{bmatrix} T_{11} & T_{12} & T_{13} & T_{10} \\ T_{21} & T_{22} & T_{23} & T_{20} \\ T_{31} & T_{32} & T_{33} & T_{30} \\ T_{01} & T_{02} & T_{03} & T_{00} \end{bmatrix} =$$

$$\begin{bmatrix} p & 0 & 0 & 0 \\ 0 & p & 0 & 0 \\ 0 & 0 & p & 0 \\ 0 & 0 & 0 & w \end{bmatrix} = \begin{bmatrix} w/3 & 0 & 0 & 0 \\ 0 & w/3 & 0 & 0 \\ 0 & 0 & w/3 & 0 \\ 0 & 0 & 0 & w \end{bmatrix}$$

(2) [2]

, where $T_{11}=T_{22}=T_{33}=p=w/3$, p is the pressure of electromagnetic waves inside the sphere and w is the density of energy, $T_{00}=w$, Tij=0 for i ≠j.

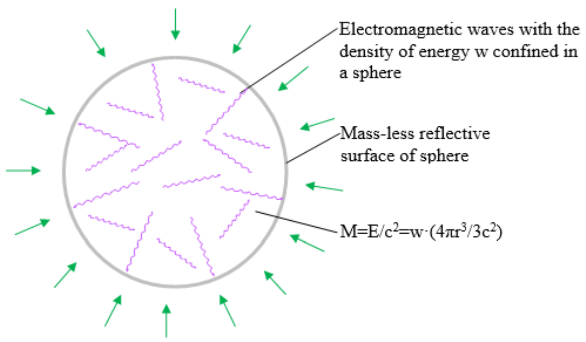

Fig.1-Gravitational field of a hypothetical sphere with massless reflective surface (thickness 0) filled with electromagnetic waves with total mass M, total energy E, and density of energy w

If a 'contraction' of the equations (1) is done by multiplying these equations with the metric tensor expressed in contravariant form g^{ik} (i, j = 1, 2, 3, 0), followed by summation, a new form of Einstein's field equations is derived.

In the case of a small quantity, M, of the electromagnetic waves confined in the sphere, the contravariant metric tensor g^{ij} can be approximated with great precision by the metric tensor for flat space:

$$g^{ij} = \begin{bmatrix} g^{11} & g^{12} & g^{13} & g^{10} \\ g^{21} & g^{22} & g^{23} & g^{20} \\ g^{31} & g^{32} & g^{33} & g^{30} \\ g^{01} & g^{02} & g^{03} & g^{00} \end{bmatrix} =$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix} \quad (3)\ [3]$$

The tensor g^{ij} results from the condition:

$$g_{ji}\square g^{ij} = \delta^i_j = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (4)\ [3]$$

, where i, j =1, 2, 3, 0

$$\text{and } g_{ji} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix} \quad (5)\ [3]$$

Contraction of the right side of Einstein's field equations (1):
The stress-energy tensor T_{ij} (equation (2)) is multiplied by the metric tensor g^{ij} (equation (3)), followed by summation. These operations lead to the invariant T of the stress-energy tensor, which in the present case is a null scalar:

$$T = g^{ij} \cdot T_{ij} = 1 \cdot w/3 + 1 \cdot w/3 + 1 \cdot w/3 - 1 \cdot w = 0 \quad (6)$$

Contraction of the left side of Einstein's field equations (1):
Multiplying the left side of Einstein's field equations (1) by g^{ij} followed by summation, leads to:

$$g^{ij}(R_{ij} - \tfrac{1}{2} g_{ij} R) = g^{ij} R_{ij} - \tfrac{1}{2} g^{ij} g_{ij} R = R - \tfrac{1}{2} 4R = -R \quad (7)$$

because,

$$g^{ij} \cdot R_{ij} = R\ [4]$$

and,

$$g^{ij} \cdot g_{ij} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}$$

$$= 1 \cdot 1 + 1 \cdot 1 + 1 \cdot 1 + (-1) \cdot (-1) = 4$$

In this way, the scalar expression of Einstein's field equations is obtained:

$$R = -\frac{8\pi G}{c^4} T \quad (8)$$

According to expression (6), T=0. So, according to (8), Ricci's scalar curvature R must be 0, too. This is the Nordstrom–Einstein paradox:
On one hand, a mass M must be surrounded by a gravitational field according to Newton and warp space-time according to Einstein. On the other hand, if that mass is composed of electromagnetic waves, it cannot warp space-time because R = T = 0. This paradox has remained unexplained for 112 years since 1913, when it was exposed during the debates between Nordstrom and Einstein [5].
The only explanation given by Einstein at that time was that: "*...the electromagnetic radiation enclosed within a mass-less box having reflective walls would not acquire a gravitational mass, although that radiation would exert pressure on the walls of the box. These walls would become stressed and, simply because of this stress, the walls would acquire a gravitational mass*" [5].
Today, it is very clear to everybody that such a massless wall cannot be stressed simply because such stress can have no physical sense in the absence of a mass.
Einstein did not mention this paradox in his General Theory of Relativity from 1916, and he never returned to this subject again.
For this reason, the paradox remains unexplained to this day.

3.3 The solution of the Nordstrom–Einstein paradox

Nobody can admit today that a spherical mass M of condensed matter generates a gravitational field, but a sphere with a massless reflective surface, filled with electromagnetic waves, does not generate a gravitational field.
As the scalar curvature R of the sphere filled with electromagnetic waves is a null scalar (as specified by equation (8)), something important must happen on the sphere's surface. While a sphere of condensed matter with mass M (e.g., a sphere filled with dust) generates a gravitational field at every point of its volume, a sphere with a

massless reflective surface, filled with electromagnetic waves with the same mass M, must generate its gravitational field only on its surface. This must happen obviously, during the reflection of electromagnetic waves by the sphere's surface (Fig. 2). The paradox is solved if the stress-energy tensor is completed with an additional tensor for the sphere's surface, $T_{ij\text{-}ss}$. In this case, the stress-energy tensor from the Einstein field equations must be:

$$T'_{ij} = T_{ij(sv)} + T_{ij(ss)} = \begin{bmatrix} \frac{w}{3} & 0 & 0 & 0 \\ 0 & \frac{w}{3} & 0 & 0 \\ 0 & 0 & \frac{w}{3} & 0 \\ 0 & 0 & 0 & w \end{bmatrix}_{sv} + \begin{bmatrix} 2w/3 & 0 & 0 & 0 \\ 0 & 2w/3 & 0 & 0 \\ 0 & 0 & 2w/3 & 0 \\ 0 & 0 & 0 & w \end{bmatrix}_{ss} \quad (9)$$

, where $T_{ij(sv)}$ is the classic stress-energy tensor for the sphere's volume (equation (3)).

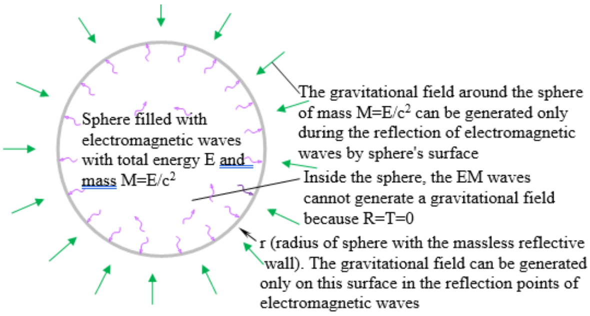

Fig.2-Generation of the gravitational field of a hypothetical sphere with a mass-less reflective wall filled in with electromagnetic waves with total mass $M=E/c^2$

$T_{ij(ss)}$ can be called 'Lebedev tensor', and it was added to describe the influence of the massless, reflective surface of the sphere.

The terms of the second part of the stress-energy tensor $T_{ij\text{-}ss}$ are $T_{11\text{-}ss} = T_{22\text{-}ss} = T_{33\text{-}ss} = p_{ss}=2w/3$ and $T_{00\text{-}ss} = w$, where p_{ss} is the pressure of light on the sphere's surface and w is the density of energy. One can observe the exceptional fact that the pressure of light on the sphere's surface p_{ss} = 2w/3, is two times higher than the pressure p_{sv} = w/3, inside the sphere's volume. This is happening because, near the sphere's wall, there are both the incident and reflected rays. [6].

Doing the contraction of the new stress-energy tensor T'_{ij} as before, the new invariant T' is:

$$T'=g^{ij}\cdot T'_{ij}= (1\cdot w/3+1\cdot w/3+1\cdot w/3-1\cdot w)_{(sv)}+(1\cdot 2w/3+1\cdot 2w/3+1\cdot 2w/3-1\cdot w)_{(ss)}= 0+(2w-w) = w \quad (10)$$

In this case, the scalar form of Einstein's field equations becomes:

$$R = -\frac{8\pi G}{c^4} w = -\frac{8\pi G}{c^2} \rho \quad (10)$$

, where $\rho = w/c^2$ is the density of matter.

In this case, the invariant of the stress-energy tensor is the same as in the case of a sphere filled with dust of density ρ and the total mass M, where Einstein's field equations admit a Schwarzschild solution for the space element ds. [7] The sphere filled with electromagnetic waves of mass M will have around the same gravitational field as a sphere composed of condensed matter (dust) of the same mass, and the paradox is definitively solved in this way.

4 Results

The analysis of the stress-energy content of the system consisting of a perfectly reflective spherical cavity filled with electromagnetic radiation reveals a dual tensorial structure, which is critical for resolving the Nordstrom-Einstein paradox.

Firstly, the classical stress-energy tensor within the volume of the sphere, $T_{ij(sv)}$, describes the energy density and isotropic pressure of the contained electromagnetic radiation. The diagonal terms satisfy $T_{\_11(sv)} = T_{\_22(sv)} = T_{\_33(sv)}$ = w/3 and $T_{00(sv)}$ = w, where w is the radiation energy density. Off-diagonal terms vanish, reflecting the isotropic nature of the radiation pressure. Importantly, this volume tensor has a vanishing scalar invariant, indicating that it alone cannot generate a gravitational field according to standard general relativity.

Secondly, introducing the surface stress-energy tensor, $T_{ij(ss)}$, located at the sphere's boundary, fundamentally alters the system's gravitational characteristics. This tensor carries the components $T_{11(ss)} = T_{22(ss)} = T_{33(ss)}$ = 2w/3 (Lebedev pressure) and $T_{(00\hat{}ss}$ = w, with zero off-diagonal terms. Unlike the volume tensor, the surface tensor has a nonzero invariant, which produces a nonvanishing Ricci scalar curvature. This surface contribution accounts for the energy and momentum flux associated with the reflection of photons at the cavity boundary, a process neglected in prior treatments.

Together, these two tensors fulfill Einstein's field equations by producing a nonzero curvature localized at the sphere's surface, while the interior remains flat from a gravitational perspective. This result reconciles the apparent contradiction between the vanishing volume stress-energy tensor invariant and the existence of a measurable gravitational field. Moreover, the classical Schwarzschild solution emerges naturally from this configuration, demonstrating that gravitational fields can arise from boundary interactions without requiring bulk mass or energy accumulation.

Additionally, the study highlights the discrete, quantized nature of the gravitational field generated in this scenario. Each photon reflection event contributes an elementary quantum of gravitational radiation/ gravitons, with frequencies directly corresponding to those of the confined electromagnetic waves. This finding suggests a profound coupling between electromagnetic radiation dynamics and quantum gravitational phenomena, potentially offering new insights into graviton generation mechanisms.

These results mark a significant conceptual shift, implying that gravitational fields may originate not only from mass-energy distributions within spacetime volumes but also from dynamic processes occurring at reflecting boundaries. This insight enriches the theoretical framework of general relativity by incorporating boundary-induced stress-energy effects and opens new avenues for experimental verification through high-precision measurement of photon-induced gravitational fields.

5 Discussions

5.1 Consequences of Resolving the Nordström–Einstein Paradox

1. The reflection of electromagnetic waves can generate a gravitational field. Technological equipment for generating artificial gravity can be built using this first consequence.
2. At least in the mentioned configuration, the gravitational field has an electromagnetic origin.
3. The gravitational field surrounding a sphere filled with electromagnetic waves of frequency ν, interpreted classically via Newtonian attraction and as space-time curvature according to GTR, must exhibit a discrete, quantized structure composed of elementary energy quanta, which may be identified with gravitons or gravitational wave packets.
4. The frequency of the emitted gravitational waves forming the external gravitational field must match the frequency of the confined electromagnetic radiation. Since gravitational wave generation occurs during each reflection event on the sphere's surface, the process begins and ends within a single electromagnetic cycle of duration $T=1/\nu$, where ν is the frequency of the confined radiation.

5.2 Implications of Resolving the Nordström–Einstein Paradox

The resolution of the Nordström–Einstein paradox proposed in this work prompts a fundamental re-evaluation of the interaction between electromagnetic radiation and gravitational field generation.

The primary implication is that a gravitational field can be generated not solely by conventional rest mass or spatial energy density, but also by the radiation pressure arising from photon reflection. This implies that, in specific configurations, gravity may have an electromagnetic origin. Beyond ensuring mathematical consistency, this suggests a physical coupling mechanism between radiation dynamics and spacetime curvature, possibly extending into the quantum domain.

Secondly, the gravitational field surrounding a perfectly reflective spherical cavity filled with electromagnetic radiation must be discrete, composed of contributions emitted during each photon reflection event. This naturally leads to an interpretation in which the gravitational field is structured in gravitons/high-frequency gravity wavelets, each corresponding to a localized radiation–boundary interaction.

The frequency of the emitted gravitational waves must match the frequency of the incident and reflected photons. This results from the temporally localized nature of the reflection process: each photon transfers energy and momentum over an interval $T=1/\nu$ where ν is the photon's frequency. Hence, the gravitational wave spectrum corresponds to the confined electromagnetic spectrum.

These findings indicate that gravitational field generation can, under certain conditions, arise

from boundary interactions rather than bulk properties. In the case of the electromagnetic cavity, while the standard volume stress-energy tensor vanishes in the interior, the gravitational field emerges exclusively from the surface stress-energy tensor.
This approach does not violate general relativity; rather, it extends its domain of applicability by incorporating boundary contributions to the energy-momentum tensor - specifically, those arising from photon reflection on ideal mirrors. Conceptually, this is consistent with Einstein's early reflections on radiation pressure and stress on the reflective box walls.
Importantly, this framework may offer a novel pathway for reconciling general relativity with quantum field theory. It supports the hypothesis that gravitons could be generated in laboratory-scale experiments involving high-frequency photons confined in reflective cavities. Such an effect could be tested using ultra-sensitive thrust balances (precision in the nanonewton range), which are already operational in European laboratories.
The resolution of the Nordström–Einstein paradox thus reveals that gravitational fields can, in principle, arise from confined electromagnetic radiation via reflection-induced boundary interactions. This insight opens new conceptual and experimental directions for quantum gravity and gravitational wave research.
Moreover, this solution provides a fresh perspective on gravitational field generation - a fundamental question still unresolved in modern physics. In general relativity, gravitational waves are regarded as ripples in spacetime, typically generated only in large-scale cosmic events such as neutron star mergers. Yet, the nature of these waves should be fundamentally the same as those generated by electromagnetic reflections in confined systems, differing primarily in frequency: kilohertz for astrophysical events versus potentially gigahertz or higher for cavity-confined photons.
Finally, it is worth emphasizing that the gravitational waves observed from cosmic events may represent perturbations to pre-existing gravitational fields, whereas those generated in electromagnetic cavities would be primordial, constituting the very gravitational field surrounding the system. As established in Section 3.3, the gravitational field of the mentioned sphere must originate solely at its reflective surface, not within its interior.

Finally, two natural questions arise from the mechanism proposed here:
First, what is the direction of the graviton/ gravitational wavelet emitted during the reflection of an electromagnetic wave from a perfectly reflective surface?
In the specific case when the incident photon impinges normal to the surface, i.e., with incidence angle $\theta = 0$, the direction of the emitted graviton must be opposite to the incoming electromagnetic wave. In other words, the graviton propagates in the same direction as the reflected photon. While this result may appear counterintuitive at first glance, it is a direct consequence of linear momentum conservation.
Let us denote:
m_{iph}: the effective mass associated with the incident photon,
m_{rph}: the mass of the reflected photon,
m_g: the mass-equivalent of the emitted graviton.
c: the speed of light
Momentum conservation in the normal direction yields:

$$m_{iph}\cdot c + m_{rph}\cdot (-c) + m_g\cdot (-c) = 0 \quad (11)$$

Solving for m_g, we obtain:

$$m_g = m_{iph} - m_{rph} \quad (12)$$

This implies that the graviton carries away the net momentum difference between the incident and reflected photon. If the reflection is perfectly elastic ($m_{iph} = m_{rph}$), no graviton is emitted. However, in our model, reflection involves the creation of a gravitational wave due to a localized stress-energy event, suggesting a small but finite mass-equivalent difference.
Second, when the incident photon strikes the surface at an angle θ relative to the surface normal, the projection of the momentum vectors leads to: we must consider the projection of the momentum vectors. Conservation of linear momentum projected onto the normal axis yields:

$$m_{iph}\cdot c\cdot \cos\theta + m_{rph}\cdot (-c\cdot \cos\theta) + mg\cdot (-c) = 0 \quad (13)$$

This simplifies to:

$$m_g = (m_{iph} - m_{rph})\cdot \cos\theta \quad (14)$$

The associated energy conservation equation for the perpendicular case is:

$m_g \cdot c^2 = m_{iph} \cdot c^2 - m_{rph} \cdot c^2$ (15)

confirming again:

$m_g = m_{iph} - m_{rph}$ (16)

Hence, the effective mass and consequently the energy of the emitted graviton decrease with increasing angle of incidence. This angular dependence could, in principle, be tested experimentally by analyzing the anisotropy of gravitational wave emission in engineered cavities.
This implies that the graviton carries away the net momentum difference between the incident and reflected photon. If the reflection is perfectly elastic (m_{iph}=m_{rph}), no graviton is emitted. However, in our model, reflection involves the creation of a gravitational wave due to a localized stress-energy event, suggesting a small but finite mass-equivalent difference.

5.3 Frequency of Gravity Wavelet

Another question concerns the frequency of the reflected photon and the emitted graviton.
Since the photon loses a quantity of mass m_g during the reflection, the frequency of the reflected photon must be slightly smaller than that of the incident photon. Using the mass-energy-frequency relation:

$\nu_{rph} = m_{rph} \cdot c^2 / h = (m_{iph} - m_g) \cdot c^2 / h$ (17)

Because the gravitational field of an elementary particle (such as an electron or proton) is many orders of magnitude weaker than its electrostatic field, the graviton's mass, m_{gm}, must be much smaller than the photon mass-equivalent. This has important implications:

- It justifies the near equality between the frequencies of the incident (ν_{iph}) and reflected photon (ν_{rph}). Consequently, the frequencies of the incident photon, the reflected photon, and the emitted graviton (ν_g) are approximately equal:

$\nu_{rph} \approx \nu_{iph} \approx \nu_g$ (18)

- It challenges the assumptions in quantum gravity models, such as those in string theory and superstring theory, where the initial hypothesis is that the energy of a graviton (E_g) depends on the frequency ν to the power of 1(E_g=hν).

6 Conclusions

▪ This paper solves the Nordstrom-Einstein paradox, which remained unsolved for 112 years since 1913.

▪ The solution shows that the stress-energy tensor of a hypothetical sphere with a massless surface filled with electromagnetic waves is composed of two tensors:
- The classical stress-energy tensor $T_{ij(sv)}$ for the sphere's volume, with components $T_{11(sv)} = T_{22(sv)} = T_{33(sv)} = w/3$, $T_{00(sv)} = w$, and zero off-diagonal terms.
- The stress-energy tensor on the sphere's surface $T_{ij(ss)}$, with components $T_{11(ss)} = T_{22(ss)} = T_{33(ss)} = 2w/3$, $T_{00(ss)} = w$, and zero off-diagonal terms for $i \neq j$.
▪ While the invariant of the volume stress-energy tensor $T_{(sv)}$ is a null scalar and the Ricci scalar curvature $R_{(sv)}$ is also zero, the invariant of the surface stress-energy tensor $T_{(ss)}$ equals w (not zero), and the corresponding Ricci scalar curvature $R_{(ss)}$ equals – $(8\pi G/c^4)$ w. This implies that Einstein's field equations admit the Schwarzschild solution, definitively solving the Nordstrom-Einstein paradox.
▪ The consequences of this result are significant for the development of physics:
- The gravitational field can be generated by the reflection of electromagnetic waves, implying that in this particular case, the gravitational field has an electromagnetic origin.
- The gravitational field around the sphere, in both Newtonian and Einsteinian frameworks, must have a discrete quantum structure composed of elementary quanta of energy, identified as gravitons or gravitational waves.
- The frequency of the radiated gravitational waves constituting the sphere's gravitational field corresponds to the frequency of the confined reflecting electromagnetic waves.
▪ The solution to the Nordstrom-Einstein paradox should be considered a fundamental basis for future developments in Quantum Gravity and String/Superstring theories, as it explicitly defines the physical process of graviton/ high-frequency gravitational wavelets generation in this case.
▪ Beyond its theoretical importance, this solution has multiple technological applications, which will be detailed in a forthcoming paper.

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