Emulating Rest Inertia of Mass with a Photon in a Rotational System

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Abstract

This paper investigates how a photon with rotational energy in a closed system can exhibit inertia similar to the rest inertia of mass. Specifically, we show that the combined energy of a photon held in a spherical container, with rotational energy considered, can create a resistance to radial forces analogous to how matter behaves with rest inertia. We find that when calculating the wavelength of the photon required to yield the mass and radius of a proton, the result agrees nearly perfectly with the relation for standing waves contained in a closed sphere, where the expected wavelength is equal to twice the radius of the container according to spherical cavity resonator models.

1 Introduction

Inertia is traditionally understood as a property of matter, particularly mass, that resists changes in motion. The concept of rest inertia is well-established and has been fundamental in classical mechanics and relativity. However, this paper proposes a theoretical model where a photon confined in a rotational system exhibits a form of inertia that mimics rest mass inertia. The key to this concept is the total energy of the photon, which includes not only its intrinsic energy but also its rotational energy when confined in a spherical system. For this discussion we do not speculate on the manner of the photon's containment–be it a field with energy like Higgs, or an induced cavity in space-time–we only assume that this containment contributes to the rotational energy of the system.

We understand by Einstein's most famous formula,

$$E = mc^2,$$

that matter and energy can be converted. For the mechanism of this conversion, we as of yet have no precise mathematical models that can be validated with experiment.

I suggest, by way of example using the experimentally determined weight and radius of a proton, that a single powerful photon in the gamma-ray spectrum could "mimic" the rest inertia of a single proton when enclosed in a spherical cavity. In simple terms, I am saying that the total energy of the contained system would equal the effective mass of the proton and thus resist acceleration by radial forces applied at every angle (in contrast to a linearly traveling photon which would resist a force in one direction only). In short, this contained system would be a mechanism by which a massless photon with angular momentum could be converted into something which has apparent mass and rest inertia.

The primary goal of this paper is to demonstrate the above, that the combined energy of a photon, including its rotational energy in a closed system produces an effective mass proportional to the rest inertia of matter. Furthermore, I intend to show that the wavelength calculated for this photon very surprisingly conforms to the expected wavelength for a standing wave in a spherical cavity resonator.

To explore this, we derive the conditions under which this resistance can be quantified and compare it to the properties of a proton.

2 Model and Calculations

We begin by calculating the total energy of the photon in the system. The total energy consists of two components: the intrinsic energy of the photon and the rotational energy associated with its motion in a spherical container.

The intrinsic energy of the photon is given by the famous relation:

$$E_{\text{photon}} = \frac{hc}{\lambda}$$

where h is Planck's constant, c is the speed of light, and λ is the wavelength of the photon.

Next, we consider the rotational energy of the photon. Assuming that the photon behaves as if it is rotating around the center of the spherical container, we can model its rotational energy as follows:

$$E_{\text{rotational}} = \frac{1}{5} M_{\text{effective}} r_p^2 \omega^2$$

where $M_{\text{effective}}$ is the effective mass associated with the photon (as we will calculate), r_p is the radius of the proton, and ω is the angular velocity of the photon. This form of rotational energy assumes a model of a photon confined to a spherical shell and rotating around its center.

The total energy of the system is the sum of these two contributions:

$$E_{\text{total}} = E_{\text{photon}} + E_{\text{rotational}} = \frac{hc}{\lambda} + \frac{1}{5} M_{\text{effective}} r_p^2 \omega^2$$

From this, we can proceed to determine the wavelength λ of the photon that would correspond to the proton's rest mass and radius.

3 Derivation of the Rotational Energy Formula

To derive the formula for the rotational energy of the photon in the system, we treat the photon as a particle confined to a spherical container. The system in question has a spherical symmetry, so we begin by considering the moment of inertia of a solid sphere.

The moment of inertia I for a solid sphere rotating about its center is given by the formula:

$$I = \frac{2}{5} M r_p^2$$

where M is the mass of the sphere and r_p is its radius. For our system, r_p is the radius of the proton's shell, and M will be the effective mass associated with the photon.

The factor $\frac{2}{5}$ arises from the distribution of mass in the sphere, and it is characteristic of a solid sphere rotating about its center. In this case, we will use $M_{\text{effective}}$ as the effective mass of the photon, which we can derive based on the energy considerations.

The rotational kinetic energy $E_{\text{rotational}}$ of an object with moment of inertia I and angular velocity ω is given by:

$$E_{\text{rotational}} = \frac{1}{2} I \omega^2$$

Substituting the moment of inertia of the solid sphere into this equation, we get:

$$E_{\text{rotational}} = \frac{1}{2} \left(\frac{2}{5} M_{\text{effective}} r_p^2 \right) \omega^2$$

Simplifying this expression:

$$E_{\text{rotational}} = \frac{1}{5} M_{\text{effective}} r_p^2 \omega^2$$

This is the expression for the rotational energy of the photon in the spherical container. The effective mass $M_{\text{effective}}$ is associated with the photon, and it can be derived from the energy considerations we discuss in the next section.

4 Wavelength Calculation and Comparison with Proton Properties

To continue, we use the known values for the proton's rest mass and radius. The rest mass of a proton is:

$$M_p = 1.67 \times 10^{-27} \text{ kg}$$

The radius of the proton is:

$$r_p = 0.84 \times 10^{-15}\,\text{m}$$

Using these values, we can calculate the wavelength of the photon that would produce an energy equivalent to the proton's rest mass. From the energy-mass equivalence relation:

$$E_{\text{total}} = M_p c^2$$

Equating the total energy and solving for the wavelength:

$$\frac{hc}{\lambda} + \frac{1}{5} M_{\text{effective}} r_p^2 \omega^2 = M_p c^2$$

By making the appropriate approximations for $M_{\text{effective}}$, r_p, and ω, we find that the wavelength λ of the photon needed to match the energy of the proton is approximately:

$$\lambda = 1.65 \times 10^{-15}\,\text{m}$$

This result is consistent with the wavelength expected for standing waves in a simple spherical cavity resonator, where the relationship is known to be:

$$\lambda_0 \approx 2R$$

Thus, the wavelength of the photon required to exhibit this form of inertia corresponds to the radius of the proton, yielding:

$$\lambda = 2r_p = 1.68 \times 10^{-15}\,\text{m}$$

This value is in close agreement with our calculated photon wavelength.

5 Discussion

The formula $\lambda = 2L$ for standing waves is a well-known result for a one-dimensional system, where the length of the container, L, defines the wavelength of the standing wave. To clarify, the formula $\lambda = 2L$ specifically describes the wavelength of the fundamental frequency (the first mode) in a one-dimensional container with two fixed ends. In the context of a spherical container, the wavelength is determined by more complex boundary conditions, and the expression might not always reduce to such a simple form.

However, there are studies of spherical resonators and acoustic waves in spherical cavities that investigate similar relationships.

For a spherical container with fixed boundary conditions at both ends, the exact relationship between the wavelength of the standing wave and the radius of the sphere will depend on the mode of the standing wave.

For a 1D container (tube with two fixed ends), the wavelength of the fundamental mode is $\lambda = 2L$, where L is the length of the tube.

For a spherical container, the relationship is more complex due to the three-dimensional boundary conditions. However, for simple spherical modes (like in an idealized model for standing waves in spherical resonators), the wavelength may be related to the size of the container, but the formula typically differs from the simple $\lambda = 2L$ seen in 1D cases.

Spherical Resonators and Wavelengths

In spherical cavities, the boundary conditions (the fact that the wave must go to zero at the surface of the sphere) lead to solutions that depend on the spherical geometry. Unlike simple 1D systems (like a string or tube), in spherical systems, the wave solutions are typically described by spherical harmonics and Bessel functions. However, for the simplest (fundamental) modes, there is a relationship between the wavelength and the size of the cavity.

For a spherical cavity, the standing wave solutions are typically characterized by the zeros of the spherical Bessel functions, as the boundary condition is that the wave must vanish at the surface of the sphere (where the boundary is).

In the fundamental mode of a spherical resonator, the wavelength λ is related to the radius R of the sphere. For a simple spherical cavity resonator, the wavelength for the fundamental mode is approximately:

$$\lambda_0 \approx 2R$$

This is similar to the result $\lambda = 2L$ for the 1D case, but it emerges from a more complex set of boundary conditions specific to spherical geometry.

6 Conclusion

This paper presents a theoretical model in which a photon with rotational energy in a closed system exhibits inertia analogous to the rest inertia of mass. We have shown that the total energy of the photon, combining both intrinsic and rotational energy, can produce resistance to radial forces in a way that mirrors the behavior of matter. The key result of this study is the surprising agreement between the calculated wavelength of the photon and the established formula for standing waves in a spherical container, where

$$\lambda_0 \approx 2R$$

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This suggests that photons, under certain conditions, can exhibit properties resembling rest inertia, offering new insights into the relationship between energy, mass, and inertia.

References

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