The Photon Mass Problem

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Abstract: It is obvious that physical vibrations/rotations/translations cannot be separated from a physical volume i.e. from at least an inertial mass or from the Principle-of-Equivalence (PoE) matter. It should concern the photons and gluons as well. On the other hand, it is argued that a mass of photon causes that its speed is lower than the speed of light in "vacuum" c and depends on its frequency, causes that the Coulomb law is modified, that gauge invariance and charge conservation are not valid, and so on. Here, applying the Scale-Symmetric Theory (SST), we show that the listed above arguments against a massive photon are unfounded. The PoE mass of the present-day photons calculated within SST is about 27 orders of magnitude lower than the rest mass of electron and is invariant (the c is the natural speed of the massive photons in spacetime and is invariant as well) so this result is below the upper limit for photon mass that results from experimental data. We show also that relativistic mass is a real physical quantity, not an artefact/unreal-thing. SST shows that the inner momentum associated with spin and the spin itself, not the rest mass, are the invariants for all frames of reference assuming the special relativity case of flat spacetime (SST shows that contrary to the gravitational fields associated with the non-gravitating Higgs field, the Einstein spacetime associated with the PoE matter is indeed flat and dominates over the Higgs field). It leads to conclusion that the energy-momentum relation is still valid but it fails when we consider the structural changes in the bare fermions dependent on their speed.

1. Introduction

It is obvious that physical vibrations/rotations/translations cannot be separated from a physical volume i.e. from at least an inertial mass or the Principle-of-Equivalence (PoE) matter. It should concern the photons and gluons as well. On the other hand, it is argued that a mass of photon causes that its speed is lower than the speed of light in "vacuum" c and depends on its frequency, causes that the Coulomb law is modified, that gauge invariance and charge conservation are not valid, and so on. Here, applying the Scale-Symmetric Theory (SST) [1], we show that the listed above arguments against a massive photon are unfounded.

SST shows that the succeeding phase transitions of the superluminal non-gravitating Higgs field (HF) during its inflation (the initial big bang) had led to the different mass/energy scales and size scales (bigger structures consist of smaller structures) [1A]. Due to a few new symmetries and 7 parameters only, there appear the superluminal binary systems of closed strings (the spin-1 entanglons) which are responsible for the quantum entanglement (it is the

quantum-entanglement scale), neutrinos and the very stable spin-1 neutrino-antineutrino pairs (NAPs) moving with the speed of light in "vacuum", c, which are the components of the gravitating Einstein spacetime (ES) (it is the Planck scale; mass of lightest neutrino is the smallest gravitational mass; neutrinos acquire their gravitational masses due to their interactions with the Higgs field [1A]; as for electrons, we can define two different masses of a neutrino i.e. particle mass and wave mass (or their geometric mean) [2]), cores of baryons (it is the proton/electric-charge scale), and the cosmic-structure/Protoworld (it is the cosmological scale; Protoworld created the early Universe [1B]) that evolution leads to the dark-matter (DM) structures (they are built of entangled non-rotating-spin NAPs), dark energy (it consists of the additional non-rotating-spin NAPs interacting gravitationally only i.e. they are not entangled i.e. the dark energy is an infinitesimal part of the ground state of ES) and the expanding Universe (the "soft" big bang due to the inflows of the dark energy into the Protoworld) [1A], [1B]. The proton scale leads to the atom-like structure of baryons [1A].

2. Properties of the ES components

The considerations concerning a photon concern as well a gluon because they both are the rotational energies of entangled ES components the photon/gluon consists of [1A]. The photons behave as gluons in fields with internal helicity i.e. in the nuclear strong fields [1A].

A PoE object consists of the entangled or confined ES components and sometimes there can be one or more neutrinos [1A].

Within SST we showed that the c is the natural speed of the neutrino-antineutrino pairs in ES [1A], [3]. Photons (more precisely, the carriers of them i.e. the neutrino-antineutrino pairs), due to the quantum entanglement, have the speed c in relation to their source or a last-interaction object. A detector can measure the speed of a photon c (more precisely, of the carriers of it i.e. of the neutrino-antineutrino pairs) only when the detector and photon are entangled. It means that the Special Theory of Relativity (SR) is valid only if the frames of reference are the last-interaction objects – then the speed c is invariant.

According to SST, there are three species of neutrinos [2]: the electron-neutrinos and muon-neutrinos which are the stable neutrinos and the electron-neutrino-like tau-neutrinos that can decay to three stable neutrinos. Within SST we showed that due to the tremendous non-gravitating energy frozen inside each stable neutrino during the inflation, the gravitating neutrino-antineutrino pairs composed of stable neutrinos are the stable objects with invariant mass [1A]. The observed oscillations of neutrinos are not some changes in their mass and internal structure – they follow from the exchanges of the free neutrinos (then they interact gravitationally only) for the neutrinos in the Cosmic Neutrino Background (CNB) or for the neutrinos in the ES components. Each neutrino is built of tremendous number of the entanglons (of about 10^{20} spin-1 entanglons) [1A]. Neutrinos acquire their gravitational mass due to the dynamic viscosity between the non-gravitating Higgs-field components and the entanglons the neutrinos consist of (the Higgs mechanism for neutrinos) [1A]. Due to exchanges of not numerous entanglons between entangled neutrinos, the gravitational mass of the ES components is invariant with accuracy about 10^{19} to 1 (i.e. there are 19 significant digits in the invariant mass).

Emphasize once more that the gravitational mass and the speed c (in relation to the last-interaction objects) of the ES components are the invariants. It causes that speed of photons cannot be lower than the speed of light in "vacuum" c and that it does not depend on their frequency.

3. The invariant mass of the present-day photons (and gluons)

All photons in the Universe (today there is about 391 photons per cubic centimetre [1B]) are entangled with electrons or/and protons – it follows from the fact that our Universe started from the state composed of neutrons [1B]. In the early Universe there were two loops each containing $2 \cdot 4^{32}$ centres of baryonic plasma [1B]. It caused that initially there were produced the superphotons each composed of $2 \cdot 4^{32}$ entangled and rotating ES components (entangled elementary photons). With time, such superphotons have decayed to photons composed of less ES components. Today each photon consists of 4^{16} entangled ES components (we will call them the photon galaxies) [1B].

It leads to the present-day invariant gravitational mass of photons: about $2.9 \cdot 10^{-57}$ kg [1A], [1B] – **this result is below the present-day upper limit for photon mass** [4], [5].

4. The energy-momentum relation, electric-charge conservation and gauge invariance

As we said, according to SST, fermions at the proton scale are built of the entangled or confined ES components. In each bare fermion, there is the spin-$1/2$ global torus/electric-charge and spin-0 central condensate [1A]. Due to the phenomena responsible for creation of the global tori/electric-charges of proton and electron, the radii of the global tori do not depend on their velocities [1A].

Since spin is an invariant for all frames of reference so the invariance of the radii of the global tori/electric-charges leads to invariance of the inner momentum, p_{inner}**, i.e. to invariance of the product of relativistic mass,** m_{rel}**, and mean spin speed of the global torus/electric-charge,** v_{spin}**, i.e.** $p_{inner} = m_{rel}\, v_{spin}$ **is the invariant.**

To conserve the spin of the electric charges, especially at high speeds, their spin must be parallel or antiparallel to velocity v. The electric charges are built of the ES components so the invariance of the gravitational mass and speed of the ES components and the alignment of the spin and velocity of the charges lead to following formula

$$c^2 = v^2 + v_{spin}^2. \tag{1}$$

We can rewrite formula (1) as follows

$$v_{spin} = c\,(1 - v^2 / c^2)^{1/2}. \tag{2}$$

Emphasize that according to SST (see formula (2)), when v increases then the mean spin speed of the electric charge, v_{spin}, decreases.

Since inner dynamic pressure is directly proportional to squared spin speed ($p_{dyn} = \rho v_{spin}^2/2$**, where** ρ **is the density of the torus/electric-charge) so an increase in velocity** v **decreases dynamic pressure near the surface of the electric charge – it causes that additional ES components accumulate on the surface of the torus/electric-charge. It is the real increase in the rest mass,** m_o**, of the electric charges. Just SST shows that the relativistic mass,** m_{rel}**, is a real physical quantity, not an artefact i.e. unreal thing.**

Within the Special Theory of Relativity (SR), assuming the special relativity case of flat spacetime (SST shows that contrary to the gravitational fields associated with the non-gravitating Higgs field, the Einstein spacetime associated with the PoE matter is indeed flat and dominates over the Higgs field [1A]), we obtain

$$m_{rel} = m_o / (1 - v^2 / c^2)^{1/2} . \tag{3}$$

From invariance of the inner momentum and formulae (2) and (3) we obtain

$$p_{inner} = m_{rel}\, v_{spin} = m_o\, c . \tag{4}$$

Formula (4) causes that we can rewrite the SR energy-momentum relation as follows

$$E^2 / c^2 = p^2 + m_{rel}^2\, v_{spin}^2 . \tag{5}$$

Formulae (4) and (5) lead to conclusion that the SR energy-momentum relation is still valid but it fails when we consider the structural changes in the bare fermions dependent on their speed.

Within SST we derived formula for electric charge, e, from the beginning [1A]

$$e = m_{electron} (G\, \rho_E\, 10^7 / \rho_N)^{1/2} / c = 1.60217642 \cdot 10^{-19} \text{ C}, \tag{6}$$

where $m_{electron}$ is the mass of electron, G is the gravitational constant, ρ_E is the density of ES, and ρ_N is the inertial-mass density of the Higgs field [1A]. All phenomena considered within SST show that after the inflation, the physical quantities in formula (6) can change infinitesimally only i.e. electric charge is an invariant. We know that the gauge invariance results from the invariance of the electric charge so SST shows that the massive photons do not destroy it.

SST shows as well that electromagnetic interactions follow from creation in the ES the virtual electron-positron pairs and from their polarization caused by the superluminal quantum entanglement between the real electric charge and the virtual pairs – the electromagnetic interactions do not depend on the invariant mass of the photons. It means that the Coulomb law is still valid as well.

5. Summary

The tens unsolved basic problems in physics and cosmology follow from the fact that we neglect the internal structure of spacetime and bare fermions. We have to use unconventional methods to solve these problems because we see that the standard methods fail. Just Nature does not behave as expected under the leading theories of physics.

For example, we try to unify gravity (GR) and quantum physics (QP) within the same methods. But Nature shows that such unification is impossible. The real problem is very different – we just need to seek answer to the following question: why can not we unify GR and QP? And the answer is very simple. Gravity is classical, not quantum. Gravitational fields are the gradients in the non-gravitating classical Higgs field (HS) whereas quantum particles are the entangled states of the gravitating ES components. SST shows that properties of HF and ES are very different and were fixed irreversibly during the inflation. In the two-component spacetime there are the closed strings but their properties differ significantly from those postulated in the string/M theory. Instead the higher spatial dimensions, there are the

HF, the entanglons, and the ES characterized by respectively 6, 10 and 26 degrees of freedom.

Here we showed that some unconventional methods within SST lead to conclusion that the invariant mass of photons does not cause that their speed is lower than the speed of light in "vacuum" or that their speed depends on their frequencies. We showed that the Coulomb law, gauge invariance and charge conservation are still valid.

The SST teaches that we should not enter into our theories some phenomena that can not be realized by Nature. We often do this to any cost to solve any problems and get results consistent with experimental data.

According to SST, SR is the theory of observer/detector, and only partially is a theory of Nature itself. When a field accelerates a PoE particle then the rate of increase in mass (it does not concern neutrinos that are the PoE particles also) of both the particle and a standard mass, say 1 kg, is the same so measured ratio of these two masses is the same i.e. the relative rest mass in all frames of reference is an invariant but emphasize that in reality, mass of the accelerated particle increases i.e. mass is not an invariant. SST shows that invariant is the inner momentum associated with spin: $m_{rel}\, v_{spin} = m_o\, c$. It is the reason that formula $E^2/c^2 = p^2 + invariant$ (i.e. $invariant = m_o^2 c^2$) is still valid whereas the last formula for $c = 1$: $E^2 = p^2 + m_o^2$ has no physical meaning i.e. cannot be realized by Nature. It follows from the fact that inner spin velocity and inner mass depend on kinetic velocity of a PoE particle besides neutrinos.

Why the mass of neutrinos cannot increase? It is due to the fact that in the two-component spacetime (Higgs field plus Einstein spacetime) there are not free entanglons the neutrinos consist of so mass of neutrinos cannot increase.

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