Opinion Article

A possible microscopic model for gravitational interaction

ABSTRACT

Following the discovery of Higgs Bosons (*H*) with a mass of around 126 GeV/c^2, it is hypothesized in this study that the gauge bosons, which are theoretically predicted to be gravitons in the mass interaction, may be produced by *H*, just as photons are produced in the case of electromagnetic (*EM*) interaction. Although the hypothesis is extremely difficult to prove experimentally in gravitation mechanism, from the parallel estimation of "quantum efficiencies" of virtual gravitons produced by virtual *H* annihilation in gravitation and virtual photons produced by virtual electron-positron annihilation in *EM* interaction, due to Heisenberg's Uncertainty Principle (*HUP*), we evaluate that the relative ratio of photon to graviton intensities is in the order of 10^{36} which is in agreement with the relative strength between *EM* and gravitational interactions predicted in Quantum Field Theory (*QFT).*

Keywords: Gravitation, Electromagnetic interaction, Higgs Bosons, Gravitons

I. INTRODUCTION

It has recently been shown by CMS and ATLAS collaborations [1,2] that Higgs Bosons (H) exist with a very high mass of around 126 GeV/c^2, and that proves the existence of Higgs Field that is theoretically predicted over half a century ago, by Higgs [3] and others [4,5]. It was a necessity to assume such field due to the thermodynamic point of view and this also explained symmetry breaking reality of universe between matter and anti-matter. This theoretical assumption of Higgs in 1963 provided him the 2013 Noble Prize in Physics, after 50 years.

Detection of these particles is so difficult due to their very fast decay in space so that these particles exist apparently less than one septillionth of a second [6].

It is well established by the Standard Model (*SM*) [7-8] that gauge bosons; photons, W-Z bosons and gluons (g) perfectly explain the three of the presently known four interaction forces; electromagnetic, weak and strong nuclear interaction except for gravitation. Gravitons (*G*) needed to be theoretically involved in Theory of Everything (*TOE*), filling the fourth corner-stone of the SM in Grand Unified Theory (*GUT*) [9]. The TOE reduces to General Relativity of Einstein [10] and the gravitation law of Newton in the classical and weak field limit as described by Feynman et al [11]. However, while the general theory of relativity is also macroscopic and the geometric theory of gravitation using the space-time curvature, present study for the first time proposes a microscopic model of mediating gravitons due to virtual Higgs boson annihilation, using similar predictions with the SM for the electric charge interaction, and evaluates the recently observed non-stability of these mass charge particles with extremely short lifetimes.

According to the *SM* of universe, interaction between the two species in space occurs when the two have the same kind of charge. A certain type of charge of a particle appears in the forms of electric charge, color charge (strong charge), hypercharge/isospin charge (weak charge) and mass charge (inertial charge) that determine the role of participation in the interaction processes. These interaction processes respectively correspond to electromagnetic interaction, strong nuclear interaction, weak nuclear interaction and gravity. Sub-atomic particles known as leptons and quarks are the key elementary particles that provide the three of the four kinds of charges except the mass charge, within any kind of particle or object. One important piece of the puzzle was missing on the sheet of elementary particles and that was *H* bosons which is responsible for mass charge of elementary particles and that was proven to appear in the Large Hadron Collider of CERN [12]. Gauge bosons can be produced by the annihilation of same kind of particle-antiparticle collisions of Leptons and quarks.

In this paper, it is demonstrated that the relative strength ratio between electromagnetic (*EM*) and gravitational interactions predicted in Quantum Field Theory (*QFT*) can be proven by the ratio of photon to graviton emission intensities produced respectively by an electron in the *EM* interaction and by an *H* in the gravitational interaction. It is proposed that the huge difference between the *EM* and gravitational interaction comes from the fact that the *EM* is a result of very stable source such as electrons while gravitation is a result of very unstable source such as *H* bosons.

II. BASIC PREDICTIONS AND DISCUSSION

In the *SM* of particle physics it is predicted that, within the duration of any kind of interaction, the gauge or interaction bosons (photons, *W-Z* bosons and g) are produced due to the well-known fact, the Heisenberg uncertainty principal (*HUP*),

$$\Delta x \Delta p \approx \hbar \quad \text{or} \quad \Delta E \Delta t \approx \hbar \tag{1}$$

corresponding to emissions of particle or energy of

$$\Delta m \approx \frac{\Delta E}{c^2} = \frac{\hbar}{c^2 \Delta t} \quad \text{or} \quad \Delta E \approx \frac{\hbar}{\Delta t} \tag{2}$$

This means a particle with a mass of Δm can exist if its duration is less than Δt. In other words non-existence of a particle due to the Δx and Δt uncertainties results in an emission of particle, Δm or energy, ΔE. This is probably a rather unusual interpretation of *HUP* as such "something may appear from nothing if something returns to nothing within very short Δt amount of time defined by Heisenberg's Uncertainty relation". Although it is most of the times considered to be *micro violations of energy conservation*, all of the production mechanisms can be demonstrated by the energy-time diagrams of Feynman [13] involving unstable particle-antiparticle annihilations of the *SM*.

These force carrying particles are known as "virtual particles" since they are produced by many virtual annihilation phenomenon occurring around an actual particle, per time duration defined by Δt, as a consequence of *HUP*. The more mass these virtual particles have the shorter the time they can exist, according to Eq.2. Because photons and gravitons are massless, they live forever and the electromagnetic and gravitational interaction can reach infinite distances with the speed of light, while the other two short distance interactions involving heavy *W-Z* bosons and gluons (g) occur only within the nuclei. Although g is considered to be massless and may have possibility to reach infinite distances, they cannot exhibit long distance effect due to g-g coupling, confining the particles within the nuclei [14].

As can be seen in the Feynman diagrams of Fig. 1 (a)-(c), annihilation of positrons with electrons produces the three known gauge bosons; respectively photons, *W-Z* bosons and gluons except the gravitons which are not yet observable. Existence of carrier bosons that are needed for gravitational interaction is a mystery. One should think that gravitons can also be produced by the annihilation of these elementary particles. The question is could this be annihilation of *H*?

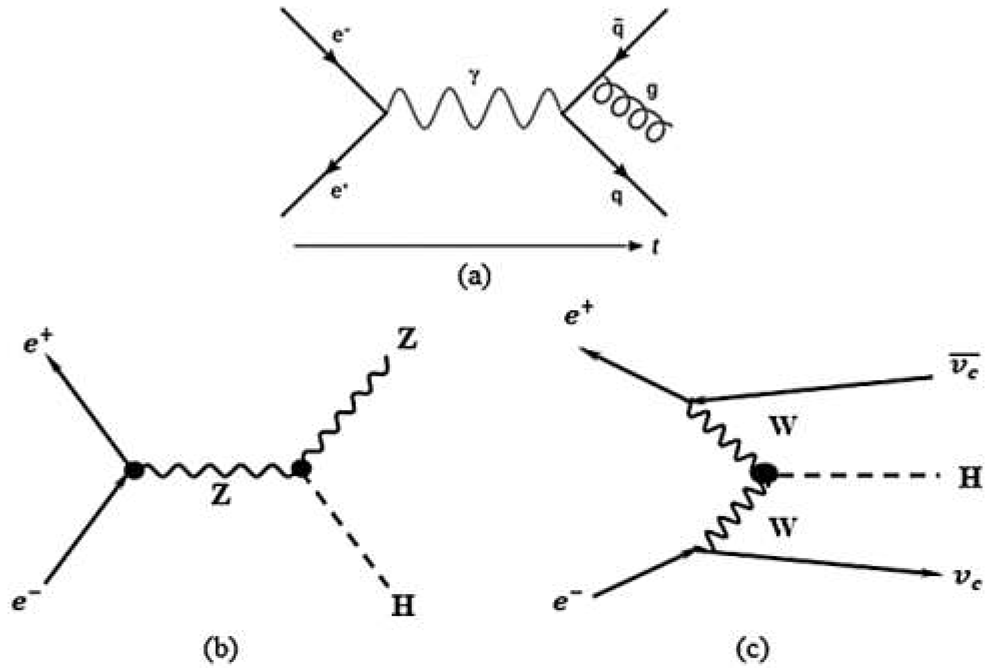

FIG.1: Three possible positron annihilations shown by Feynman diagrams.

Let us think about the two long distance interactions; the *EM* and the gravitation. In the *EM* interaction, there appear force carrying virtual photons as gauge bosons due to *HUP*, and the most basic annihilation process is the electron-positron annihilation producing the two γ-photons. Similarly, in gravity, there appear gauge bosons, hypothetically named gravitons and let us assume that the utopic *H* annihilation continuously seething with gravitons in vacuum as proposed by *HUP* before the actual *H* boson decays. This annihilation energies with an *H* mass of around $126\ GeV/c^2$ corresponds to virtual graviton frequencies in the order of $\nu \cong 10^{24}\,Hz$ which is nearly 10^4 times greater than the most energetic $\hbar\nu$ γ-ray energy observed in the *EM* spectra. In the case of actual gravitons, such frequency corresponds to a wavelength of around 10 attometers for an individual graviton and cannot have interaction by any kind of "baryonic matter" so that it cannot be sensed by any kind of presently known detectors. These highly energetic particles might only be sensed by a detector mainly consisting of particles with less than 10 attometers diameter.

Gravitons having a wavelength of around 10 attometers probably would have a planar wave structure similar to an *EM* wave such as two planar fields perpendicular to each other with possibly the one known as Higgs field. Since *EM* fields affect the particles that create *EM* wave, fields of gravitons should also affect the particles that create gravitons. Due to the fact that the "Higgs field" affects *H* bosons, our predictions might likely be true. Photon is created by the annihilation of two fermions and gravitons are created by the annihilation of two bosons. One can re-consider the "Maxwell like" equations and their corresponding equations in *QFT* in terms of the two perpendicular fields of gravitons, consisting of at least Higgs field.

One important issue that we have to raise is that how the angular momentum is conserved in the *H* annihilation process. Since the H^0 and anti-H^0 (a-H) system would have zero spins, $S=0$ and $M_S=0$, the system preferentially decays into two gravitons with spins of 2 in opposite directions just as in the case of para-positronium decaying into two photons in its annihilation [15].

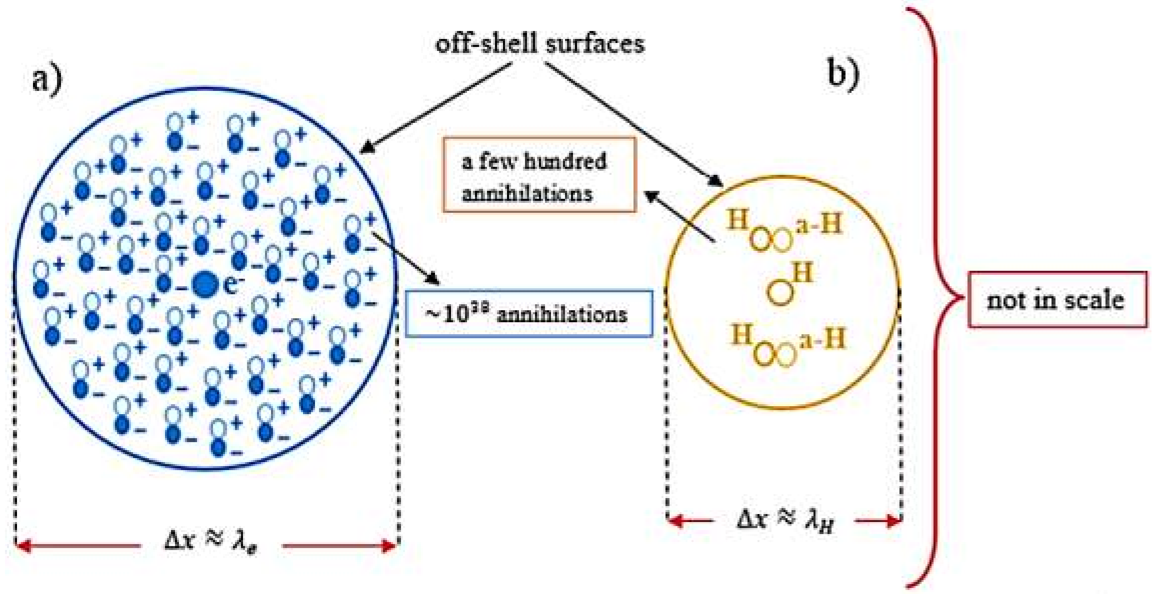

FIG.2: An illustration of (a) an individual electron and (b) an individual H boson having particle-antiparticle pairs appearing as a consequence of HUP at random around actual particles at the center.

Let us now consider, in parallel, an individual nonrelativistic electron and an individual nonrelativistic *H* as sources of respectively *EM* and gravitational interactions, separately propagating the particular force carrying bosons due to the requirement of *HUP*. Assuming Δx uncertainties are in the order of "the thermal de Broglie wavelengths" of each individual particle, as schematically illustrated in Fig.2. The ratio of the thermal de Broglie wavelengths is given by

$$\frac{\lambda_H}{\lambda_e} = \sqrt{\frac{m_e}{m_H}} \qquad (3)$$

where m_e and m_H are respectively the electron and *H* masses. Intensities of propagated gauge bosons into empty space from the off-shells of related spheres with surface areas of $4\pi r^2$ in

Fig.2(a) and (b) with diameters in the orders of the thermal de Broglie wavelengths $\left(\lambda = 2r\right)$ of each individual particle can be written as follows:

$$I_P = \frac{1}{(4\pi r^2)_e}(\eta_P \hbar \omega_P) = \frac{1}{\pi \lambda_e^2}(\eta_P \hbar \omega_P) \qquad \text{(4-a)}$$

$$I_G = \frac{1}{(4\pi r^2)_H}(\eta_G \hbar \omega_G) = \frac{1}{\pi \lambda_H^2}(\eta_G \hbar \omega_G) \qquad \text{(4-b)}$$

where η_P is the photon emission rate and η_G is the *G* emission rate, i.e. numbers of emitted force carrying bosons per second, and ω_P and ω_G are the gauge photon and gauge *G* angular frequencies, respectively. One should notice that Eqs. (4a and b) explain the inverse square rule $1/r^2$ of respectively Coulomb's and Newton's Laws.

Using Eq.(3) and considering photon and *G* energies ($\hbar\omega_P = m_e c^2$ and $\hbar\omega_G = m_H c^2$ respectively) correspond to Einstein's equivalent mass energy of annihilating particles, the ratio of photon to *G* intensities is given by the direct proportion of photon and *G* emission rates in respectively *EM* and gravitational interactions as follows:

$$\frac{I_P}{I_G} = \frac{\eta_P}{\eta_G} \qquad \text{(5)}$$

It is important to notice that Eq.(5) only depends on the emission rates, i.e. the "quantum efficiency" ratio of photon to G, and not any of the parameters described earlier. If it was, the *EM* interaction and the gravity would not have been universal or they might have been temperature dependent, for instance.

The emission rates are basically given by the virtual annihilation rates around the actual particles and that depends on the availability of a certain particle defined by its lifetime. In the first case, electron-positron pair appears and annihilates and in the latter, *H* and a-*H* pair appears and annihilates in every short enough Δt time duration given by *HUP* in Eqs(1) and (2). In other words the quantum efficiency (Q) of each interaction is proportional with the life times;

$$Q \propto \tau \tag{6}$$

where τ is the lifetime of each particle acting role in the interaction processes.

Mean lifetime of Higgs bosons is in the order of $\tau_H = 1.56x10^{-22}\ s$ as predicted in the *SM*. However the width of the *H* lifetime was originally measured by reconstructing many Higgs bosons from its well-known decay products and then mapping their masses. Because of very limited detector resolutions, apparently this measurement can only be estimated within a factor of 1000 of the value predicted by the *SM* [16]. Therefore we take the lifetime for H as one septillionth of a second $(\tau_H \approx 10^{-24} s)$ as also mentioned in the introduction, which fits in the width of the *H* lifetime within a factor of 1000 around the time predicted in the *SM*.

According to *HUP*, average life of a virtual *H* pair around the incident *H* sketched in Fig.2(b) can only be;

$$\Delta t \approx \frac{\hbar}{\Delta E} = 5.2x10^{-27}\, s \tag{7}$$

where the reduced Planck constant, $\hbar \approx 6.6\times10^{-16} eV.s$ and $\Delta E \approx 126\ \ GeV$ for an *H*. This means that only around $(\tau_H / \Delta t) \approx 200$ virtual *H* annihilation is permitted producing virtual immortal *G* (since they are massless) before the actual unstable *H* boson decays within its lifetime which is assumed to be in the order of $\sim 10^{-24} s$ in this study.

On the other hand, electrons, the basic source of *EM* interaction, are very stable and the electron's mean lifetime is given as $4.6x10^{26}$ years, at very high confidence level [17,18], which is much longer than the life of universe. Therefore we should consider that any electron of the incidence exists since the beginning of the universe for over 14 billion years $\tau_e = 14x10^9\, years = 4.4x10^{17} s$. Bearing in mind that the similar arguments in the above paragraph for the lifetime of virtual electron-positron pair around an actual electron having Einstein's equivalent mass energy of $0.511\ MeV$ works out to be

$$\Delta t \approx \frac{\hbar}{\Delta E} = 1.3x10^{-21} s \tag{8}$$

Therefore, huge numbers of around $(\tau_e / \Delta t) \approx 3.4x10^{38}$ virtual electron-positron annihilations have occurred around the actual electron illustrated in Fig.2(a) since the beginning of universe, producing immortal gauge photons for the EM interaction.

This means that photon to graviton intensity ratio in Eq.(5) is in the order of $(3.4x10^{38} / 200) \approx 1.7x10^{36}$ which is also equals to the ratio of photon to graviton emission rates produced in respectively *EM* and gravitational interactions. This should also correspond to the relative strength of the *EM* in comparison to the gravitation which is given as in the order of 10^{36} too, determined from "coupling constant" arising in the *QFT*. This result implies the fact that mean lifetime of *H* is in the order of $10^{-24} s$ and is almost 100 times less than it is predicted in the *SM*.

The fact that the strength ratio very slightly increases with the intervals of quintillionth, i.e. in the order of 10^{18} per s as the time passes, meaning gravitational force relatively reduces and that may also explain the expansion of universe. It follows that relative strength ratio of the *EM* to gravitational interaction became in the order of 10^{18} at one second after the universe began.

III. CONCLUSION

It has been proposed that gauge bosons (theoretically predicted to be gravitons) in the mass charge interaction may be produced by the annihilation of these mysterious *H* bosons with their anti-character just as photons are produced as gauge bosons in the case of electric charge interaction, due to *HUP* predicted in quantum electrodynamics. This would be the first evidence to explain gravitation mechanism with gravitons in mass charge interaction. It has been proposed that gravitons should have a very short wavelength of around 10 attometers and very high energy so that such particles cannot be sensed by any kind of presently known detector. From the estimated "quantum efficiencies" of gravitons and photons emitted around an actual *H* and electron, respectively, it has been comparatively shown that relative strength of gravitational interaction initiated by an *H* is in the order of undecillionth $\left(10^{-36}\right)$ of the *EM* interaction initiated by an electron and the ratio found by the predictions in this letter is quite consistent with the *QFT*. The huge difference between the *EM* and gravitational interaction comes from the fact that the *EM* is produced by a very stable source such as electrons with very long lifetimes while gravitation is produced by a very unstable source such as *H* bosons with lifetimes in the order of $10^{-24}\,s$.

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