Lifetimes of Higgs, W and Z Bosons in the Scale-Symmetric Physics

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Abstract: Here, within the Scale-Symmetric Theory (SST), we calculated the rigorous lifetimes of Higgs (H) boson, W and Z bosons expressed in yoctoseconds [ys] (yocto is the inverse of the 24 powers of ten): for H is 0.282 ys, for W is 0.438 ys whereas for Z is 0.386 ys. They are the upper limits for experimental data and it is obvious that the experimental data should be close to such limits. The decay width of H boson (about 3.4 GeV/(cc) gives 0.194 ys, the decay width of W boson (about 2.1 GeV/(cc) gives 0.316 ys whereas the decay width of Z boson (about 2.5 GeV/(cc) gives 0.264 ys. The calculated here theoretical results are consistent with experimental data. The lifetime of Higgs boson predicted within the Standard Model (SM), 0.156 zeptoseconds [zs] (zepto is the inverse of the 21 powers of ten), is inconsistent with experimental data - it suggests that SM is at least incomplete or partially incorrect. The main method to determine the lifetimes of particles follows from measurement of the decay width. But using this widely accepted method, we obtain the lifetime of the Higgs boson a factor of one thousandth of the value predicted by the Standard Model. It caused that there appeared a proposal to change the widely accepted method to obtain from the experimental data the SM value. As usually, when a mainstream theory fails, to fit theoretical results to experimental data, there appear approximations, mathematical tricks and free parameters. The truth is obvious - the experimental lifetime of the composite Higgs boson with a mass of 125 GeV is inconsistent with the SM prediction.

1. Introduction

The succeeding phase transitions of the superluminal non-gravitating Higgs field and the symmetrical decays of bosons, which lead to the atom-like structure of baryons, are the foundations of the Scale-Symmetric Theory (SST) [1].

Within SST, we described internal structure of the detected composite Higgs boson with a mass of 125 GeV, we calculated its mass, solved the hierarchy problem, calculated branching ratios, showed why its mass is very messy, calculated masses of next composite Higgs bosons, described the real Higgs mechanism, quantum entanglement and confinement, and we calculated the coupling constant responsible for interactions of the constituents of the composite Higgs bosons (http://vixra.org/author/sylwester_kornowski).

Here, applying the SST we calculated the rigorous lifetimes of Higgs H with a mass of 125 GeV, W and Z bosons.

2. Calculations

According to SST, the composite H ($spin = 0$) and the W and Z bosons ($spin = 1$) are the condensates composed of the confined Einstein-spacetime components (the W and Z bosons rotate). The luminal Einstein-spacetime components are the still undetected neutrino-antineutrino pairs. They are the carriers of gluons and photons which are their rotational energies. The different properties of the gluons and photons do not follow from different structure of the carriers (their properties are the same and they have the three internal helicities/colours) but due to their internal helicities, they behave differently in fields having internal helicity (the nuclear strong fields have internal helicity so there are 8 different gluons) and in fields without internal helicity (the electromagnetic fields and gravitational fields do not have internal helicity so there is 1 photon). We can see that photons inside the nuclear strong fields behave as gluons [1A].

The coupling constant defining the interactions/confinement of the constituents of the composite H is very small [1A] so the condensates are very unstable. The condensates, as a whole, decay due to the weak interactions characteristic for baryons. The coupling constant for the weak interactions of baryons is $\alpha_{W(proton)} = 0.0187229 \approx 1 / 53.41$ [1A]. The H, W and Z bosons decay due to their weak mass, M_{Weak},

$$M_{Weak} = \alpha_{W(proton)} M = \Gamma / c^2, \qquad (1)$$

where M is the mass of a condensate whereas the $M_{Weak}\, c^2$ is the decay width Γ.

On the other hand, lifetime of a condensate is defined as follows

$$\tau = \hbar / \Gamma = \hbar / (M_{Weak}\, c^2) = \hbar / (\alpha_{W(proton)} M c^2). \qquad (2)$$

Applying formula (2) we obtain the rigorous theoretical lifetimes – they are the upper limits for experimental data. It follows from the fact that theoretical decay width always has higher accuracy than experimental ones (it is due to the systematic and statistical errors)

$$\Gamma_{H,theory(SST)} \approx 2.34 \text{ GeV} / c^2 \rightarrow \tau_{H,theory} = 2.82 \cdot 10^{-25} \text{ s}, \qquad (3a)$$

$$\Gamma_{W,theory(SST)} \approx 1.51 \text{ GeV} / c^2 \rightarrow \tau_{W,theory} = 4.38 \cdot 10^{-25} \text{ s}, \qquad (3b)$$

$$\Gamma_{Z,theory(SST)} \approx 1.71 \text{ GeV} / c^2 \rightarrow \tau_{Z,theory} = 3.86 \cdot 10^{-25} \text{ s}. \qquad (3c)$$

Applying formula (2) and knowing the decay widths, [2], we obtain the experimental lifetimes

$$\Gamma_{H,exp.} \approx 3.4 \text{ GeV} / c^2 \rightarrow \tau_{H,exp.} = 1.94 \cdot 10^{-25} \text{ s}, \qquad (4a)$$

$$\Gamma_{W,exp.} \approx 2.1 \text{ GeV} / c^2 \rightarrow \tau_{W,exp.} = 3.16 \cdot 10^{-25} \text{ s}, \qquad (4b)$$

$$\Gamma_{Z,exp.} \approx 2.5 \text{ GeV} / c^2 \rightarrow \tau_{Z,exp.} = 2.64 \cdot 10^{-25} \text{ s}. \qquad (4c)$$

We can see that calculated here theoretical results are consistent with experimental data. The lifetime of Higgs boson predicted within the Standard Model (SM) is inconsistent with experimental data – it suggests that SM is at least incomplete or partially incorrect

$$\tau_{H,theory(SM)} = 1.56 \cdot 10^{-22} \text{ s}. \tag{5}$$

The main method to determine the lifetimes of particles follows from measurement of the decay width. But using this widely accepted method, we obtain the lifetime of the Higgs boson a factor of one thousandth of the value predicted by the Standard Model. It caused that there appeared a proposal to change the widely accepted method to obtain from the experimental data the SM value. As usually, when a mainstream theory fails, to fit theoretical results to experimental data there appear approximations, mathematical tricks and free parameters. The truth is obvious – the experimental lifetime of the composite Higgs boson with a mass of 125 GeV is inconsistent with the SM prediction.

Notice as well that

$$\tau_{theory} / \tau_{exp.} = \Gamma_{exp.} / \Gamma_{theory} = sqrt(2). \tag{6}$$

It suggests that the energy responsible for decay, Γ_{theory}, appears on the Schwarzschild surface for the weak or nuclear strong interactions [1A]. Then, its relativistic mass is $\Gamma_{exp.} = \Gamma_{theory}\ sqrt(2)$, [1A], and it leads to the perfect consistency of the Scale-Symmetric Theory with experimental data concerning the lifetimes of H, W and Z bosons.

The lifetimes of the Type composite-Higgs bosons can be calculated using a different method. At first, before the main decay, the spinless condensates swell in such a way that there appears a condensate composed of the condensates which are in centre of the baryons each with a mass of Y = 424.12 MeV, [1A], – it is the reason that in formula (2) appears $\alpha_{W(proton)}$. Condensates with such a mass are the black holes in respect of the weak interactions i.e. on their surfaces, the neutrino-antineutrino pairs have the luminal spin speed on the orbits with radius equal to the equatorial radius [1A] – it is the reason that there appears the intermediate stage in the decays. The equatorial radius of Y is $r = 0.8710945 \cdot 10^{-17}$ m, [1A], so the characteristic length is $2\pi r$. Before the main decay, all the Type composite-Higgs condensates transform into the associations composed of the masses Y so they all should have similar lifetimes close to

$$\tau_{H,theory(SST),new\text{-}method} = 2\, \pi\, r / c \approx 1.83 \cdot 10^{-25} \text{ s}. \tag{7}$$

This value is very close to the experimental lifetime of the composite Higgs boson with a mass of 125 GeV ($\tau_{H,exp.} = 1.94 \cdot 10^{-25}$ s).

There should be two additional such condensates with a mass of about 742 GeV and 17.1 TeV but no one is the real Higgs boson [3].

There is in existence the superluminal non-gravitating field (i.e. the Higgs field) which during the inflation partially transformed into the luminal gravitating Einstein spacetime. According to the SST, the Einstein spacetime is grainy and consists of the still undetected gravitating neutrino-antineutrino pairs. The real Higgs mechanism described within SST shows how the non-gravitating field transformed into the smallest gravitational masses i.e. the neutrinos. The SST shows as well that the tremendous superluminal non-gravitating energy frozen inside a neutrino (it cannot be observed directly) is about $0.6 \cdot 10^{119}$ higher than the gravitational mass of the neutrino – it is the lacking energy predicted by the mainstream quantum physics [1A], [1B].

In reality, the Planck mass/energy does not concern a gravitational mass. SST shows that the Planck mass/energy is close to the geometric mean of the tremendous superluminal non-gravitating energy frozen inside a neutrino and its gravitational mass. The real Higgs boson must be a spinless particle so the real Higgs boson consists of two confined and entangled neutrino-antineutrino pairs. Its gravitational mass is very small and beyond precision of the present-day detectors but the not observed directly energy frozen in the real Higgs boson is tremendous. It solves the Hierarchy Problem.

The Hierarchy Problem we can solve in a different way as well. Calculate the equivalent abstract mass, $M_{A,max}$, of the maximum energy $E_{max} = h\nu_{max}$ associated with maximum frequency, ν_{max}, of rotating an Einstein-spacetime component i.e. of rotating neutrino-antineutrino pair (the maximum spin speed of such pair is the speed of light in "vacuum" c)

$$M_{A,max} = E_{max} / c^2 = h\nu_{max} / c^2 = \hbar / (R\, c), \tag{8}$$

where R is the radius of maximum circle drawn by the rotating neutrino-antineutrino pair. According to the SST, this radius is

$$R_{\nu\text{-}\nu} = r_{neutrino} (\pi + 1) / 3 = 1.544 \cdot 10^{-35} \text{ m}, \tag{9}$$

where $r_{neutrino} = 1.1184555 \cdot 10^{-35}$ m is the equatorial radius of a neutrino [1A]. Notice that the radius $R_{\nu\text{-}\nu}$ is very close to the Planck length, L_{Planck}, concerning an abstract cube ($L_{Planck} \approx 1.6162 \cdot 10^{-35}$ m) so the abstract mass $M_{A,max} = 2.278 \cdot 10^{-8}$ kg is very close to the Planck mass as well ($M_{Planck} \approx 2.1765 \cdot 10^{-8}$ kg). It solves the Hierarchy Problem also – just the Planck mass is not a gravitational mass but the equivalent non-gravitating rotational energy of rotating with maximum frequency an Einstein-spacetime component. In a collision, such energy cannot transform into gravitational mass of a Type Higgs-boson condensate – it follows from the fact that radius of such condensate should be about $r = 0.271 \cdot 10^{-10}$ m so time of creation cannot be shorter than about $t = 2r/c = 9.04 \cdot 10^{-20}$ s whereas the lifetime of such condensate calculated using formulae (1) and (2) is about $\tau \approx 4.3 \cdot 10^{-50}$ s i.e. speed of decay should be much higher than the maximum speed c for gravitating masses.

Calculate from the condition that time of creation of the Type Higgs-boson condensate, $T_{Creation}$, cannot be longer than its lifetime, $\tau_{Lifetime}$, i.e. $T_{Creation} \leq \tau_{Lifetime}$, the maximum possible mass of the Type Higgs-boson condensates, M_{Max},

$$M_{Max} = (\pi\, \rho / 6)^{1/4} (\hbar / (\alpha_{W(proton)}\, c))^{3/4} \approx 1.4 \text{ TeV}, \tag{10}$$

where ρ is the density of the Type Higgs-boson condensates which is very close to the density of the Einstein spacetime $\rho_E = 1.10220055 \cdot 10^{28}$ kg/m^3 [1A]. Can there appear condensates composed of condensates carrying the maximum possible mass?

The discovered composite Higgs boson with a mass of 125 GeV consists of the confined real Higgs bosons with very low gravitational mass but with tremendous non-gravitating energy frozen inside them.

There appeared papers with mathematical tricks to fit the experimental width of the composite Higgs boson with a mass of 125 GeV (about 3.4 GeV [4]) to the Standard Model value (the width should be about 800 times lower (!)). On the CERN public website (30 March 2014), [4], we can read as follows: "The best bound one could obtain directly from the Higgs peak in the data was that the width was less than 3.4 GeV."

There was a suggestion that we can calculate the composite-Higgs width from the mass distribution of it at much higher energy than 125 GeV. A quantitative analysis leads to decay width approximately 17 MeV [4]. The error is obvious. It is the decay width of a condensate with a mass of nucleon ($M_{Nucleon} \approx 939$ MeV). Its decay width is

$$\Gamma_{Condensate,nucleon(SST)} = M_{Nucleon}\, \alpha_{W(proton)} = 17.58 \text{ MeV}. \quad (11)$$

It leads to the lifetime of such condensate

$$\tau_{Condensate,nucleon(SST)} = \hbar / \Gamma_{Condensate,nucleon(SST)} = 0.3744 \cdot 10^{-22} \text{ s}. \quad (12)$$

It is about 4.17 times shorter lifetime than the SM lifetime of the SM Higgs boson (see formula (5)).

Moreover, in the colliding nucleons there are the three very dense fields composed of the carriers of gluons with the approximate masses 212 MeV, 318 MeV and 424 MeV, [1A], so in the spectrum of the composite Higgs boson there can appear the corresponding condensates with width (see formulae (1) and (6)) equal to about 4 MeV, 5.6 MeV, 6 MeV, 8.4 MeV, 7.9 MeV and 11.2 MeV. The first width, i.e. the about 4 MeV, mimics the decay width of the SM Higgs boson.

3. Summary

Here, within the Scale-Symmetric Theory, we calculated the rigorous lifetimes of composite Higgs boson H with a mass of 125 GeV, W and Z bosons. The calculated here theoretical results are consistent with experimental data.

The lifetime of Higgs boson predicted within the Standard Model (SM), is inconsistent with experimental data – it suggests that SM is at least incomplete or partially incorrect.

The main method to determine the lifetimes of particles follows from measurement of the decay width. But using this widely accepted method, we obtain the lifetime of the Higgs boson a factor of one thousandth of the value predicted by the Standard Model. It caused that there appeared a proposal to change the widely accepted method to obtain from the experimental data the SM value. As usually, when a mainstream theory fails, to fit theoretical results to experimental data, there appear approximations, mathematical tricks and free parameters. The truth is obvious – the experimental lifetime of the composite Higgs boson with a mass of 125 GeV is inconsistent with the SM prediction.

Here we proved that the highest width about 3.4 GeV (and the next lower width 2.34 GeV) is correct and that the papers containing the mathematical tricks to decrease the experimental decay width of the detected composite Higgs boson are incorrect. The main decay width of the composite Higgs boson with a mass of 125 GeV consists of a set of narrower decay widths which follow from production inside such condensate the condensates with masses of the nucleons and with masses of the three very dense fields inside nucleons – one of such condensate mimics the lifetime of the SM Higgs boson.

There should be two additional Type Higgs-boson condensates with a mass of about 742 GeV and 17.1 TeV but the second is outside the upper limit about 1.4 TeV which follows from the fact that lifetime cannot be shorter of time of creation. Can there be condensates composed of condensates carrying the upper limit of energy?

SST shows that the calculated within the quantum physics the lacking energy about 120 powers of ten higher than the observed energy is frozen inside the Einstein-spacetime components (the neutrino-antineutrino pairs) and inside neutrinos – it is the non-gravitating energy.

The Planck mass is not a fundamental gravitational mass. We interpret this mass as the maximum rotational energy of an Einstein-spacetime component (the photons and gluons are the rotational energies of entangled, or not, the Einstein-spacetime components). We showed as well that the geometric mean of the gravitational mass of neutrino and the superluminal non-gravitating tremendous energy frozen inside a neutrino is close to the Planck mass. These two interpretations solve the Hierarchy Problem i.e. we explained why the SM particles carry masses much smaller than the Planck mass.

Photons inside nuclear strong fields behave as gluons. Their different properties and different numbers of Types (respectively 1 and 8) follow from the different interactions of them with electromagnetic fields and gravitational fields (they have not an internal helicity) and with nuclear strong fields (they have an internal helicity i.e. colour).

References

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