The Origin of the Z and W Bosons

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Abstract: Here, within the Scale-Symmetric Theory (SST), we showed that the Z and W bosons can be created due to two different mechanisms. One mechanism is associated with a transition from electromagnetic interactions to weak interactions of protons with electrons in the presence of dark matter (DM) while the second one concerns a transition from weak interactions of protons to weak interactions of charges of protons, which mimic behaviour of electrons in absence of DM, with muons associated with protons. In the first mechanism, calculated mass of Z is 91.181 GeV whereas of W is 80.428 GeV while in the second mechanism we obtained respectively 91.205 GeV and 80.387 GeV.

1. Introduction

The initial conditions for the Theory of Everything (ToE) [1] lead to the phase transitions of the initial inflation field, to the atom-like structure of baryons, and to structures of other particles. Such problems are described within the Scale-Symmetric Theory (SST) [2], [3]. There is the two-component spacetime i.e. the Higgs field composed of non-gravitating tachyons and the Einstein spacetime (ES) composed of the spin-1 neutrino-antineutrino pairs. All more massive particles are built of the entangled or/and confined ES components – sometime there can be some neutrinos also [2].

Among a thousand theoretical results calculated within SST [2], [3], we can find quantities we will use in this paper (in the parentheses we compare them with experimental central values [4]): the mass of electron, $e^{+,-}$, $m_{electron,SST}$ = 0.5109989 MeV ($m_{electron,exp..}$ = $m_{electron,SST}$ [4]), the mass of muon, $\mu^{+,-}$, $m_{muon,SST}$ = 105.6563 MeV ($m_{muon,exp.}$ = 105.6584 MeV [4]), mass of neutral pion, π^{o}, $m_{pion(o),SST}$ = 134.9767 MeV ($m_{pion(o),exp.}$ = 134.9766 MeV [4]), mass of charged pion, $\pi^{+,-}$, $m_{pion(+,-),SST}$ = 139.57041 MeV ($m_{pion(+,-),exp.}$ = 139.57013 MeV [4]), mass of neutral kaon, K^{o}, $m_{kaon(o),SST}$ = 497.760 MeV ($m_{kaon(o),exp.}$ = 497.611 MeV [4]), mass of charged kaon, $K^{+,-}$, $m_{kaon(+,-),SST}$ = 493.734 MeV ($m_{kaon(+,-),exp.}$ = 493.677 MeV [4]), mass of the electric charge of the core of baryons $X^{+,-}$ = 318.2955 MeV, the coupling constant for the weak interactions of protons: $\alpha_{w(proton)}$ = 0.0187229, the coupling constant for the weak interactions of muons with electrons in the absence of dark matter (DM) (the electrons can be replaced by $X^{+,-}$): $\alpha_{w(electron-muon)} = 9.511082 \cdot 10^{-7}$ ($X_w = \alpha_{w(proton)} / \alpha_{w(electron-muon)}$ = 19,685.3), the fine-structure constant for the electromagnetic interactions: α_{em} = 1 / 137.036, and the coupling constant for the weak interactions of protons with electrons in the presence of dark matter: $\alpha'_{w(proton-electron)} = 1.1194358 \cdot 10^{-5}$ ($Y_w = \alpha_{em} / \alpha'_{w(proton-electron)} = 651.878$).

Here, the symbols of particles denote their masses also.

According to SST, the DM are the structures composed of the entangled (it is the superluminal quantum entanglement [2]) ES components [5]. Such structures cannot annihilate because of perfect stability of the stable neutrinos the ES components consist of.

2. Calculations

Consider a relativistic proton-antiproton pair which interacts electromagnetically with a pair composed of charged pions. To protect the pair of pions from a quick annihilation, it interacts with a spin-1 electron-positron pair. Next there is a transition from the electromagnetic interactions of the proton-antiproton pair with the pair of charged pions to the weak interactions of the proton-antiproton pair with the electron-positron pair in the presence of DM. Due to such transition, the mass of the carrier of interactions, i.e. of $[(\pi^+ e^-) + (\pi^- e^+)]$, increases $Y_w / 2$ times and next decays to Z boson and neutral pion.

Why there is $Y_w / 2$ instead Y_w? According to SST, coupling constant for weak interactions is directly proportional to the product of mass of ES condensate responsible for the interaction and sum of masses of exchanged condensates. For a pair, number of exchanged condensates is 2 so coupling constant is two times higher i.e. instead α_w is $2\alpha_w$ so instead Y_w is $Y_w / 2$. This problem does not concern X_w because in both the nominator and denominator there are the coupling constants for weak interactions.

For Z boson we obtain following relation

$$[(\pi^+ + e^-) + (\pi^- + e^+)]\, Y_w / 2 \rightarrow Z + \pi^o . \qquad (1)$$

Emphasize that spin of the $e^+ e^-$ pair is unitary so of the Z boson as well.

Applying the SST results, we obtain mass of Z boson equal to $m_{Z.} = 91.181$ GeV – this value is very close to the experimental result: 91.1876 ± 0.0021 GeV [4].

One of the two charged pions can be neutral. But initially all particles must be electrically charged because of the α_{em} in the nominator of Y_w. It leads to conclusion that initially the neutral pion must decay to muon and electron. For W boson we obtain following relation

$$[((\mu^- e^+) + e^-) + (\pi^- + e^+)]\, Y_w / 2 \rightarrow W^- . \qquad (2)$$

Emphasize that spin of the $\mu^- e^+$ pair is zero whereas of the $e^+ e^-$ pair is unitary so of the W^- boson is unitary also.

Applying the SST results, we obtain mass of W^- boson equal to $m_{W.} = 80.429$ GeV – this value is very close to the experimental result: 80.385 ± 0.0015 GeV [4].

We can calculate the masses of Z and W bosons applying the second mechanism as well. Notice that the objects carrying mass equal to the mass distances between charged pion and neutral pion or between neutral kaon and charged kaon are electrically charged. Initially, the charged objects with masses equal to the mass distances interact weakly with proton. Next, the created $X^- X^+$ pair, which mimics behaviour of electron-positron pair in absence of DM, interacts weakly with a muon-antimuon pair associated with proton. Why, contrary to $e^+ e^-$ pair, the $X^- X^+$ pair does not interact with DM? SST shows that a particle can behave in a quantum way only when its mass density or surface density is close to mass density or surface density of field in which the particle is embedded. Then such particle can disappear in one place and appear in another one, and so on – it leads to the wave function. Surface density of the charges $X^{-,+}$ is about 300,000 times higher than the Einstein spacetime [2] so they behave classically. Such behaviour does not lead to wave function so $X^{-,+}$ cannot interact with DM which occupies the part of the Universe filled with baryonic matter.

The second mechanism leads to following relation for Z boson (it is an analogue to relation (1))

$$[(\pi^+ - \pi^o)\, X_w + X^-] + (\pi^- + X^+) \rightarrow Z + \pi^o\,. \tag{3}$$

Emphasize that spin of the $X^-\,X^+$ pair is unitary so of the Z boson as well.

Applying formula (3) and the SST results, we obtain mass of Z boson equal to $m_{Z.}$= 91.205 GeV.

The second mechanism leads to following relation for W boson (it is an analogue to relation (2))

$$[(K^o - K^+)\, X_w + X^-] + (K^o + X^+) \rightarrow W^+\,. \tag{4}$$

Applying formula (4) and the SST results, we obtain mass of W^+ boson equal to $m_{W.}$= 80.387 GeV.

Notice that the transitions between interactions can change masses of the cosmic antiprotons also. For example, $p_{anti}\,/\,\alpha_{w(proton)} \approx 50.1$ GeV, and so on. It suggests that the recent cosmic-ray antiproton data from AMS-02 [6], [7], can not concern DM annihilation.

3. Summary

The two mechanisms of creations of the Z and W bosons described within SST lead to masses very close to experimental results. It shows that within SST we can calculate the initial parameters applied in the Standard Model (SM) [2]. This leads to conclusion that SST is the more fundamental theory than SM.

References

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