ON STANDARD MODEL HIGGS AND SUPERSTRING THEORIES

AFSAR ABBAS
Institute of Physics, Bhubaneswar-751005, India
(e-mail: afsar@iopb.res.in)

Abstract

It is shown that in the Standard Model, the property of charge quantization holds for a Higgs with arbitrary isospin and hypercharge. These defining quantum numbers of the Higgs remain unconstrained while the whole basic and fundamental structure of the Standard Model remains intact. Hence it is shown that the Higgs cannot be a physical particle. Higgs is the underlying ‘vacuum’ over which the whole edifice of the Standard Model stands. Also on most general grounds it is established here that as per the Standard Model there is no electric charge above the electro-weak phase transition temperature. Hence there was no electric charge present in the Early Universe. The Superstring Theories are flawed in as much as they are incompatible with this requirement.
1 Charge Quantization in the Standard Model

The SM assumes a repetitive structure for each generation of quarks and leptons [1]. Let us start by looking at the first generation [2] of quarks and leptons (u, d, e, ν) and assign them to $SU(N_C) \otimes SU(2)_L \otimes U(1)_Y$ (where $N_C = 3$) representation. To keep things as general as possible this brings in five unknown hypercharges [3]. Let us now define the electric charge in terms of the diagonal generators of $SU(2)_L \otimes U(1)_Y$ as

$$Q = T_3 + bY$$

(1)

In the SM $SU(N_C) \otimes SU(2)_L \otimes U(1)_Y$ is spontaneously broken through the Higgs mechanism to the group $SU(3)_c \otimes U(1)_{em}$. In SM the Higgs is assumed to be a doublet [4]. However we do not use this restriction either and assume the Higgs $\phi$ to have any isospin $T$ and arbitrary hypercharge $Y_\phi$. The isospin $T_3^\phi$ component of the Higgs develops a nonzero vacuum expectation value $< \phi >$. Since we want the $U(1)_{em}$ generator $Q$ to be unbroken we require $Q < \phi > = 0$. This right away fixes $b$ in (3) and we get

$$Q = T_3 - \left( \frac{T^\phi}{Y_\phi} \right)Y$$

(2)

For the SM to be renormalizable we require that the triangular anomaly be canceled. This leads to certain constraints which place some restrictions on the hypercharges. Also the use of the fact that after the spontaneous breaking of $SU(N_C) \otimes SU(2)_L \otimes U(1)_Y$ to $SU(N_C) \otimes U(1)_{em}$, the L- and R-handed charges couple identically with photon helps in pinning down hypercharges in terms of the hypercharge of the Higgs. Hence one obtains quantized electric charges as

$$Q(u) = \frac{1}{2}(1 + \frac{1}{N_c})$$

$$Q(d) = \frac{1}{2}(-1 + \frac{1}{N_c})$$

$$Q(e) = -1$$

(3)

$$Q(\nu) = 0$$

(4)

(5)
For $N_C = 3$ these are the correct charges in the SM. Note that this charge quantization in the SM holds for Higgs for arbitrary $T$ and arbitrary hypercharge. Hence as far as charge quantization is concerned, the values of $T$ and $Y_\phi$ remain unconstrained. This point, for the special case of the Higgs doublet was already noted by the author earlier [4].

2 Higgs particle - a ghost!

Let us continue with the rest of the structure of the SM and see how our general Higgs with unconstrained and unspecified isospin $T$ and hypercharge $Y_\phi$ fits into it. We can write the covariant derivative of the SM as

$$D_\mu = \partial_\mu + ig_1 \frac{T^0}{Y_\phi} Y B_\mu - ig_2 \vec{T} \cdot \vec{W}_\mu$$  \hspace{1cm} (6)

The photon field $A_\mu$ and the orthogonal $Z_\mu$ are written as

$$A_\mu = \frac{g_2 B_\mu + g_1 \frac{2T^0}{Y_\phi} Y_i W^0_\mu}{\sqrt{g_2^2 + (g_1 \frac{2T^0}{Y_\phi} Y_i)^2}}$$ \hspace{1cm} (7)

$$Z_\mu = \frac{-g_1 \frac{2T^0}{Y_\phi} Y_L B_\mu + g_2 W^0_\mu}{\sqrt{g_2^2 + (g_1 \frac{2T^0}{Y_\phi} Y_i)^2}}$$ \hspace{1cm} (8)

With $D_\mu$ we can write the lepton part of the SM Lagrangian as

$$\mathcal{L}(\text{lepton}) = \bar{q}_L i\gamma^\mu (ig_1 \frac{T^0}{Y_\phi} Y_i B_\mu) q_L + e_R i\gamma^\mu (ig_1 \frac{T^0}{Y_\phi} Y_L B_\mu) e_R$$

$$- \bar{q}_L i\gamma^\mu \left[ ig_2 \vec{T} \cdot \vec{W}_\mu \right] q_L$$ \hspace{1cm} (9)

We find that with the hypercharges as specified above the complete structure of the Standard Model stands intact [5]. The point to be emphasized is that all this is independent of Higgs isospin and hypercharge, which all throughout remain unconstrained and undetermined. One should not fix any arbitrary values for them as nothing in the theory demands it.
We find that from rho parameter also the solutions for the isospin of the Higgs are infinite in number. Again, nothing in the theory demands that one fixes the isospin to a particular value.

The point is that the full structure of the SM stands intact without constraining the quantum numbers isospin and/or the hypercharge of the Higgs to any specific value. All the particles that have been isolated in the laboratory or have been studied by any other means, besides having a specific mass, have definite quantum numbers which identify them. In the case of Higgs here, no one knows of its mass and more importantly its quantum numbers like isospin and hypercharge, as shown above, are not specified. The hypercharge of all the other particles are specified as being proportional to the Higgs hypercharge which itself remains unconstrained. That is, all the hypercharges of particles are rooted on to the Higgs hypercharge which itself remains free and unspecified. Hence Higgs is very different from all known particles. Because of the above reasons Higgs cannot be a physical particle which may be isolated and studied. It must be just the ‘vacuum’ which sets up the structure of the whole thing. So Higgs is a ghost which shall not manifest itself as a genuine particle in the laboratory.

3 Superstring Theories-intrinsically flawed!

Now we ask the question, with this generalized picture what happens to the electric charge when the full Standard Model symmetry is restored.

Note that the expression for Q in (2) arose due to spontaneous symmetry breaking of $SU(N_C) \otimes SU(2)_L \times U(1)_Y$ (for $N_C = 3$) to $SU(N_C) \times U(1)_{em}$ through the medium of a Higgs with arbitrary isospin $T$ and hypercharge $Y_{\phi}$. What happens when at higher temperature, as for example found in the early universe, the $SU(N_C) \otimes SU(2)_L \otimes U(1)_Y$ symmetry is restored? Then the parameter ‘b’ in the electric charge definition remains undetermined. Note that ‘b’ was fixed above due to spontaneous symmetry breaking through Higgs. Without it ‘b’ remains unknown. Hence when the electroweak symmetry is restored, irrespective of the Higgs isospin and hypercharge the electric charge disappears as a physical quantity. Therefore we find that there was no electric charge in the early universe.

Here attention is drawn to the fact that all putative extensions of the Standard Model should reduce smoothly and consistently to the Standard
Model at low energies. Not only that, all these extensions should be consistent with the predictions of the Standard Model at very high temperatures. Contrary to naive expectations, the SM does make specific predictions at very high temperatures too. For example one clear-cut prediction of the Standard Model as shown here and also shown earlier, is that at high enough temperatures (as in the early universe) when the unbroken $SU(3) \otimes SU(2) \otimes U(1)$ symmetry was restored, there was no electric charge. GUTs and other standard extensions of the SM are incompatible with this requirement [6].

What about Superstring Theories? Quite clearly, generically in Superstring Theories electric charge exists right up to the Planck Scale [7]. Hence as per this theory the electric charge, as an inherent property of matter, has existed right from the beginning [8]. This is not correct in the SM. As shown here and earlier, the electric charge came into existence at a later stage in the evolution of the Universe when the $SU(2)_L \otimes U(1)_Y$ group was spontaneously broken to $U(1)_{em}$. It was never there all the time. This is because electric charge is a derived quantity. Hence we find that in this regard the Superstring Theories are inconsistent with the SM and hence flawed [9].
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