# THE HIGGS FIELD CAN BE EXPRESSED THROUGH THE LEPTON AND QUARK FIELDS.

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Abstract. The Higgs field is a central point of the Standard Model supplying masses to other fields through the symmetry breaking mechanism. However, it is associated with an elementary particle which is not yet discovered experimentally. In this short note I suggest a way for expressing the Higgs field through other fields of the Standard Model. If this is the case, being not an independent field, the Higgs field does not require an elementary particle to be associated with it.

## 1. Matter fields of the Standard Model.

At the present moment the Standard Model is a commonly admitted and to a sufficient extent experimentally confirmed theory describing the electromagnetic, weak, and strong interactions. Elementary particles in the Standard Model are represented by matter fields. They include the lepton fields $\overset{\circ}{\psi}{}^{a}_{111111}[i]$, $\overset{\bullet}{\psi}{}^{a\alpha}_{111}[i]$ and the quark fields $\overset{\bullet}{\psi}{}^{a1\alpha\beta}[i]$, $\overset{\circ}{\psi}{}^{a1111\beta}[i]$, $\overset{\circ}{\psi}{}^{a\beta}_{11}[i]$. The bullet over a $\psi$-function is the sign of chiral (left) components, while the circle is the sign of antichiral (right) components (see details in [1]). Through $a = 1, \ldots, 4$ we denote a spinor index; $\beta = 1, \ldots, 3$ is a color index, it is peculiar to quark wave functions only. The index $\alpha = 1, 2$ is a doublet index, $\psi$-functions possessing this index form doublets. Other $\psi$-functions are singlets. The index $i = 1, \ldots, 3$ is enclosed into square brackets. It enumerates three generations of leptons and three generations of quarks. And finally, each of the above $\psi$-functions has some definite number of indices taking the only value $\gamma = 1$.

Apart from lepton and quark fields, there are gauge fields in the Standard Model. They are introduced as connection components in covariant derivatives. For instance, we have the following formula:

$$\begin{aligned}\nabla_q\overset{\bullet}{\psi}{}^{a1\alpha\beta}[i] &= \nabla_q[vac]\overset{\bullet}{\psi}{}^{a1\alpha\beta}[i] - \frac{i\,e\,g_1}{\hbar\,c}\,\mathcal{A}^1_{q1}\,\overset{\bullet}{\psi}{}^{a1\alpha\beta}[i] -\\ &-\frac{i\,e\,g_2}{\hbar\,c}\sum^{2}_{\theta=1}\mathcal{A}^{\alpha}_{q\theta}\,\overset{\bullet}{\psi}{}^{a1\theta\beta}[i] - \frac{i\,e\,g_3}{\hbar\,c}\sum^{3}_{\theta=1}\mathcal{A}^{\beta}_{q\theta}\,\overset{\bullet}{\psi}{}^{a1\alpha\theta}[i].\end{aligned}\tag{1.1}$$

The quantities $\mathcal{A}^{\beta}_{q\theta}$ correspond to the gluon field. The quantities $\mathcal{A}^1_{q1}$ and $\mathcal{A}^{\alpha}_{q\theta}$ correspond to the electromagnetic and weak fields respectively. Upon applying the Higgs mechanism they mix and form the 4-potential of the electromagnetic field $A_q$

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and the fields of massive bosons $Z_q$ and $W^{\pm}_{q111111}$. Here $q=0,\,\ldots\,,\,3$ is a covectorial index. The nature of the index $\theta$ in the formula (1.1) is clear from the formula itself. It is sufficient to look at the ranges of this index in sums. Through $g_1$, $g_2$, and $g_3$ we denote three purely numeric constants, they are parameters of the Standard Model. And finally, $e$, $\hbar$, and $c$ in the formula (1.1) are the charge of electron, the Planck constant, and the light speed respectively:

$$
\begin{aligned}
&e\approx 4.80420440\cdot 10^{-10}\,g^{1/2}\cdot cm^{3/2}\cdot sec^{-1},\\
&\hbar\approx 1.05457168\cdot 10^{-27}\,g\cdot cm^{2}\cdot sec^{-1},\\
&c\approx 2.99792458\cdot 10^{10}\,cm\cdot sec^{-1}.
\end{aligned}
$$

The above data are taken from the site http://physics.nist.gov/cuu/Constants of the US National Institute of Standards and Technology.

The Higgs field $\varphi^{\alpha 111}$ is the most mysterious field of the Standard Model. It is associated with an elementary particle (the Higgs boson) which is not detected experimentally. This fact gives an opportunity for various Higgsless models, i. e. theories explaining the absence or invisibility of Higgs boson in collider experiments. Looking through the review [2] and some recent papers [3 – 7], I have found that most of these Higgsless models are produced as reductions of some higher-dimensional models. However, there is a much more simple purely 4-dimensional approach for eliminating the Higgs field from the stage. It is described below.

## 2. Composite Higgs fields.

As we have seen in the beginning of the previous section (see also [8]), the lepton and quark fields in the Standard Model are represented by $\psi$-functions with some definite number of indices. We can perform tensor products and contractions over some pairs of indices of the same nature. For example, we can write

$$
f^{\,\alpha 111}[i]=\sum_{a=1}^{4}\sum_{\bar a=1}^{4}D_{a\bar a}\,\overline{\overset{\circ}{\psi}{}^{\bar a}_{111111}[i]}\;\overset{\bullet}{\psi}{}^{a\alpha}_{111}[i]\,\text{Đ}^{11}\,\text{Đ}^{11}\,\text{Đ}^{11}\,\text{Đ}^{11}\,\text{Đ}^{11}\,\text{Đ}^{11}. \tag{2.1}
$$

In a more general case we can mix the wave functions from different generations and write an expression similar to (2.1) for them:

$$
f^{\,\alpha 111}[ij]=\sum_{a=1}^{4}\sum_{\bar a=1}^{4}D_{a\bar a}\,\overline{\overset{\circ}{\psi}{}^{\bar a}_{111111}[i]}\;\overset{\bullet}{\psi}{}^{a\alpha}_{111}[j]\,\text{Đ}^{11}\,\text{Đ}^{11}\,\text{Đ}^{11}\,\text{Đ}^{11}\,\text{Đ}^{11}\,\text{Đ}^{11}. \tag{2.2}
$$

Here $D_{a\bar a}$ are the components of the Hermitian metric $\mathbf{D}$ in the bundle of Dirac spinors $DM$ over the space-time manifold $M$. Similarly, $\text{Đ}^{11}$ are the contravariant components of the Hermitian metric $\mathbf{D}$ in the one-dimensional bundle $UM$ (see [8], [9], and [10] for more details).

The functions (2.1) and (2.2) have the same list of indices as the Higgs filed $\varphi^{\alpha 111}$. They are so called composite Higgs fields produced from the lepton fields.

The quark fields are also capable to produce composite Higgs fields:

$$\hat{F}^{\,\alpha 111}[ij]=\sum_{a=1}^{4}\sum_{\bar{a}=1}^{4}\sum_{\beta=1}^{3}\sum_{\bar{\beta}=1}^{3}\sum_{\theta=1}^{2}\sum_{\bar{\alpha}=1}^{2}\not{d}^{\alpha\theta}\,\not{D}_{\theta\bar{\alpha}}\,D_{a\bar{a}}\,\not{D}_{\beta\bar{\beta}}\,\times \\ \times\,\overline{\overset{\bullet}{\psi}{}^{\bar{a}1\bar{\alpha}\bar{\beta}}[i]}\;\overset{\circ}{\psi}{}^{a1111\beta}[j]\;\not{D}_{11}. \tag{2.3}$$

This is not the only way for producing composite Higgs fields from the quark fields. Here is the other formula for other composite Higgs fields:

$$\check{F}^{\,\alpha 111}[ij]=\sum_{a=1}^{4}\sum_{\bar{a}=1}^{4}\sum_{\beta=1}^{3}\sum_{\bar{\beta}=1}^{3}D_{a\bar{a}}\,\not{D}_{\beta\bar{\beta}}\;\overline{\overset{\circ}{\psi}{}^{\bar{a}\bar{\beta}}_{11}[i]}\;\overset{\bullet}{\psi}{}^{a1\alpha\beta}[j]\;\not{D}^{11}\,\not{D}^{11}. \tag{2.4}$$

In addition to $\mathbf{D}$ and $\not{\mathbf{D}}$, in (2.3) and (2.4) we have the components $\not{D}_{\beta\bar{\beta}}$ of the Hermitian metric $\not{\mathbf{D}}$ in three-dimensional color-bundle $S\not{U}M$ over the space-time manifold $M$, the components $\not{D}_{\theta\bar{\alpha}}$ of the Hermitian metric $\not{\mathbf{D}}$ in two-dimensional bundle $S\not{U}M$, and the components $\not{d}^{\alpha\theta}$ of the skew-symmetric metric tensor $\not{\mathbf{d}}$ in the same bundle $S\not{U}M$ (see [10] again).

Composite Higgs fields (2.2), (2.3), and (2.4) can be used in order to construct the actual Higgs field $\varphi^{\alpha 111}$ as a linear combination:

$$\varphi^{\alpha 111}=\sum_{i=1}^{3}\sum_{j=1}^{3}C[ij]\,f^{\,\alpha 111}[ij]\,+ \\ +\sum_{i=1}^{3}\sum_{j=1}^{3}\hat{C}[ij]\,\hat{F}^{\,\alpha 111}[ij]\,+\sum_{i=1}^{3}\sum_{j=1}^{3}\check{C}[ij]\,\check{F}^{\,\alpha 111}[ij]. \tag{2.5}$$

The formula (2.5) leads to a theory very similar to the Standard Model. This theory will be considered in a separate paper.

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