Higgs Scalar as Topological Condensate of Gauge Bosons

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Abstract

The purpose of this brief note is to point out that, to the best of our knowledge, the first rationale for modeling the Higgs scalar as mixture of electroweak bosons was disclosed in refs. [1-3]. According to this interpretation, the Higgs scalar is a topological condensate of gauge bosons on spacetime having minimal fractality.

In [1-3] we have advanced the idea that a four-dimensional spacetime with minimal fractality ($\varepsilon << 1,\ \varepsilon = 4 - D$) favors the emergence of a *Higgs-like* condensate of gauge bosons. It can be described by

$$\Phi_C = \tfrac{1}{4}[(W^+ + W^- + Z^0 + \gamma + g) + (W^+ + W^- + Z^0 + \gamma + g)] \tag{1}$$

where $W^{\pm}, Z^0$ are the massive bosons of the electroweak model and γ, g the photon and gluon, respectively.

A remarkable feature of (1) is that it represents a weakly coupled cluster of gauge fields having *zero topological charge* [1-3]. Compliance with this requirement motivates the duplicate construction of (1), which contains (W^+W^-), (Z^0Z^0), photon and gluon doublets. Stated differently, (1) is the only inclusive combination of gauge field doublets that is free from all gauge and topological charges. Tab. 1 presents a comparative display of properties carried by the Standard Model (SM) Higgs and the Higgs-like condensate:

Scalar field	Form	Composition	Mass (GeV)	Weak hypercharge	Electric charge	Color	Topological charge
SM Higgs	$\begin{pmatrix}\varphi^+\\ \varphi^0\end{pmatrix}$	none	~ 126	$\begin{pmatrix}+1\\ +1\end{pmatrix}$	$\begin{pmatrix}+1\\ 0\end{pmatrix}$	0	0
Higgs-like condensate	Φ_C	(1)	~ 126	0	0	0	0

Tab. 1: SM Higgs doublet versus the Higgs-like

By contrast, [4] makes the wrong claim that the Higgs scalar is a weakly coupled hybrid of electroweak bosons, whose mass is given by

$$m_H = \frac{M_{W^+} + M_{W^-} + M_{Z^0}}{2} \tag{2}$$

The hidden mistake of (2) is that a typical combination of three electroweak bosons gives a total spin of either 1 or 3, which is in manifest contradiction with the spin-less nature of the Higgs scalar. One needs (at least) a pair of Z^0 bosons to secure a spin-less and neutral mixture of vector particles, following the way relation (1) is built up. It is also apparent that, since the SM Higgs boson is the source of $W^{\pm}, Z^0$ masses, the claim of [4] amounts to a *circular argument*. As explained in [1, 2], (1) arises from a mass-generation mechanism rooted in the low fractality of spacetime above the electroweak scale. This mechanism bypasses the standard electroweak symmetry breaking, yet it replicates its function.

A final observation is now in order. The most recent estimate places the SM Higgs boson mass at $m_H^{\exp} = 125.09 \pm 0.24\,\text{GeV}$, whereas the mass of the Higgs-like condensate computed from (1) is $m_{\Phi_c} = 125.98\,\text{GeV}$. The slight deviation between the two numbers may be tentatively attributed to the binding energy of *gluon-gluon fusion*, a process required by the fact that gluons are unobservable as free vector particles. In this case, the expectation value for the deficit of energy carried by the gluon "doublet" amounts to $\Delta = m_H^{\exp} - m_{\Phi_c} = -0.89$ GeV.

References

[1] Goldfain E., "*Fractal Spacetime as Underlying Structure of the Standard Model*", Quantum Matter, **3**(3), (2014), pp. 256-263. A draft of this article can be located at:

http://www.researchgate.net/publication/268391330_Fractal_Space-Time_as_Underlying_Structure_of_the_Standard_Model

[2] Goldfain E., "*Introduction to Fractional Field Theory*", (2015), Aracne Editrice (in press). Same reference can be located at:

https://www.researchgate.net/publication/278849474_Introduction_to_Fractional_Field_Theory_%28consolidated_version%29

[3] http://vixra.org/pdf/1305.0101v1.pdf

[4] http://vixra.org/pdf/1509.0268v1.pdf