Higgs Mass from Topological Condensation of Vector Bosons

Ervin Goldfain

Research Scholar, Ronin Institute, Montclair, New Jersey 07043

Email: ervin.goldfain@ronininstitute.org

Abstract

We suggest here that the Higgs scalar amounts to a weakly-bounded condensate of gauge bosons. According to this interpretation, the Higgs mass may be approximated from the sum of vector boson masses on spacetime endowed with minimal fractality.

Key words: minimal fractal manifold, fractional field theory, Higgs scalar, topological condensation, vector bosons, gluon-gluon fusion.

In [1-2] 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

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

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* [1-2]. 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 most basic 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 versus 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	~ 125	$\begin{pmatrix}+1\\ +1\end{pmatrix}$	$\begin{pmatrix}+1\\ 0\end{pmatrix}$	0	0
Higgs-like condensate	Φ_C	(1)	~ 126	0	0	0	0

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

Following the way (1) is built up, one needs (at least) a pair of Z^0 bosons to secure a spin-less and neutral mixture of vector particles. As explained in [1, 2], (1) emerges from a mass-generation mechanism rooted in the low fractality of spacetime above the electroweak scale. In particular, the key distinction between *Bose-Einstein condensation* on smooth spacetime and boson condensation on the minimal fractal manifold ($\varepsilon = 4 - D$ << 1) is that the latter resembles localization of quantum waves on random potentials, a phenomenon associated, for example, with *Anderson localization* [5].

It is important to point out that, in line with [2-4], (1) is compatible with the so-called "*sum-of-squares*" relationship constraining particle masses *or* the choice of gauge, Yukawa, and scalar couplings. Taken together, these considerations hint that the condensation mechanism embodied in (1) 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 stemming from the nonperturbative nature of Quantum Chromodynamics (QCD). In this case, the expectation value for the energy deficit carried by the gluon "doublet" amounts to $\Delta = m_H^{\exp} - m_{\Phi_c} = -0.89\ \text{GeV}$.

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 . Same reference can be located at: https://www.researchgate.net/publication/278849474_Introduction_to_Fractional_Field_Theory_%28consolidated_version%29

[3] https://www.researchgate.net/publication/343426122_Derivation_of_the_Sum-of-Squares_Relationship

[4] https://arxiv.org/pdf/1305.4208.pdf

[5] http://web.mit.edu/8.334/www/grades/projects/projects19/GuanChenguang.pdf