Higgs Mass from Topological Condensation of Vector Bosons

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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.

Also, 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 show 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 $\Delta = m_H^{\exp} - m_{\Phi_c} = -0.89$ GeV per gluon.

References

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