Bifurcations of the Higgs Potential and the Top Quark Mass

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Abstract

We have recently conjectured that the Standard Model gauge group unfolds sequentially from bifurcations of the Higgs potential driven by the Renormalization scale. This brief report points out that the maximal fixed-point solution of the bifurcation diagram coincides with a top-antitop quark condensate.

Key words: Bifurcations, Feigenbaum route to chaos, gauge symmetries, Higgs potential, top quark.

It can be argued that the flow of the classical Higgs potential with the Renormalization scale takes the form [1]

$$\dot{y} = my(1-y^2) \tag{1}$$

in which y is given by

$$y = \frac{\sqrt{2}}{\mathrm{v}}\varphi \tag{2}$$

and where φ denotes the complex-scalar field amplitude whose vacuum expectation value is $\mathrm{v} = 246$ GeV. The control parameter of (1) contains the self-interaction coupling λ and a reference scale m_0 as in

$$m = \frac{2\lambda \mathrm{v}^2}{m_0^2} \tag{3}$$

The map analog of (1) may be written as

$$y_{n+1} = f(m, y_n) = m y_n (1 - y_n^2) \tag{4}$$

There are two trivial fixed points of (1) and (4), given by: a) $m = 0,\ \lambda = 0$, which corresponds to massless free photons, b) a pair of maximal massive solutions arisen in the limit of large number of iterations ($n \to \infty$), namely,

$$y_\infty^* = \pm 1 \tag{5}$$

whose separation along the y - axis is

$$\Delta y_\infty^* = +1 - (-1) = 2 \tag{6}$$

As suggested in [2-5], the fermionic sector of the Standard Model unfolds as the last segment of the bifurcation diagram. Based on this conjecture and by (6) and (2), gives a separation in field space closely approximating a *top-antitop condensate*, that is,

$$\Delta\varphi_{\infty}^{*} = \sqrt{2}\mathrm{v} = 347.9 \text{ GeV} \tag{7a}$$

$$\Delta\varphi_{\infty}^{*} \approx 2m_t \tag{7b}$$

where $m_t \approx 173\text{GeV}$ is the experimental value of the top quark mass [6]. This finding brings additional support for the *self-contained flavor composition* of the Standard Model near the Fermi scale [7].

References

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