On Light Dilaton Extensions of the Standard Model

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1Supported by the European Union under a Marie Curie IEF, PIEF-GA-2013-623806

3. Electroweak breaking

We now consider the SM propagating in the 5D space described above. In addition to the 5D SU(2)\(_L\) × U(1)\(_Y\) gauge bosons, we define the SM Higgs as

\[ H(x, y) = \frac{1}{\sqrt{2}} e^{-i(y-x)\phi} \left( h(y) + i(x, y) \right), \]

where h(y) is the Higgs background. The action of the model is [7]

\[ S_5 = \int d^4dy \sqrt{-\bar{g}} \left( \frac{1}{2} (\partial_5 \phi)^2 - \frac{1}{2} \phi V(\phi) - \frac{1}{2} \overline{D_\mu H^*} - V(\phi) \right), \]

Electroweak symmetry breaking will be triggered on the IR brane.

To compare the model predictions with electroweak precision tests (EWPT) a convenient parameterisation is using the (S, T, U) variables in [8, 7]. From the fitted values for S and T as [9]

\[ T = 0.05 \pm 0.07, \quad S = 0.00 \pm 0.08, \quad (90\% \text{ c.l.}), \]

one gets the result in the plot.

We find a region in which m_{KK} < \mathcal{O}(2\text{TeV}) and m_{\mu} \lesssim \mathcal{O}(850\text{ GeV}) for e < 1. The realization of the dilaton for e \approx 0.9 (\lesssim 0.1) is hard (soft). Other values of e lead to similar results.

4. Coupling of the radion to SM matter fields

A light dilaton has similar interactions with matter as the Higgs [4, 8], so we may wonder whether it can be a Higgs imitator. In this work we are assuming that the matter and Higgs fields are localised in the bulk. We are interested in the coupling of the radion F(z, y) = F(\phi)\eta(z) to massive gauge fields (W, Z) and Z, normalized as

\[ C_4 = \frac{1}{\sqrt{2}} \left( N_\mu N_\mu W_\mu W^\mu + c_2 m_\mu^2 Z_\mu Z^\mu \right), \]

where c_2 = 246 GeV (r(x) = \mathcal{O}(300) GeV) and the canonical normalized radion field. The case c_2 = 2 corresponds to the SM radion coupling. After expanding (35) to linear order in the perturbations, and using the massless radion action \( S = \phi^2 \), one gets the result for c_4 (V = W, Z)

\[ |c_4| = \left( \frac{m_\mu^2 + m_e^2}{f}, \left( \frac{f}{m_{5\text{ TeV}}} \right)^{1/2} \right) \int_0^{1/2} d\xi \frac{1}{\xi} \xi^{1/4 - \Delta} \xi^{\Delta - 1} = \frac{\phi^2}{2}. \]

The numerical values of |c_4| are very small so that the Higgs phenomenology (Higgs contribution to the unification of the Y_\mu elastic and inelastic scattering, the Higgs strengths...) will be affected by a per mil effect. The tiny deviations with respect to the SM predictions would be unobservable at the LHC. For the same reason the possibility of a Higgs imitator is excluded for the present model.

5. Conclusions

We have studied a mechanism in holobiology that allows for naturally light dilatons in CFTs defined by single trace deformations nearly marginal \( \phi \). The dilaton mass is controlled by the value of the \( \beta \)-function in the IR.

The extension of the SM with a light dilaton in a 5D warped model leads to dilaton masses close to the Higgs mass, and KK vector masses of the order of TeV.

A first study of the coupling of the radion to massive gauge fields suggests that the dilaton cannot be a Higgs imitator. However, some modifications of the warped model that would allow for a sizeable coupling are under study [5].

The mechanism presented here could be extended and applied to other fields, in particular ii) the study of the dilaton as a (light) Dark Matter candidate (additional symmetries may be required) and iii) the Cosmological Constant problem.