The UV sensitivity of the Higgs potential in Gauge-Higgs Unification

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Atsuyuki Yamada (Nagoya U.), arXiv:2103.06269 [hep-ph]

Summary

We consider the finiteness of the Higgs potential in an SU(N) gauge-Higgs unification (GHU) model, where the Higgs bosons are identified as the Yang-Mills Aharonov-Bohm (AB) phases defined on a circle which is introduced as an extra-dimension. In the GHU models, it was unclear that the Higgs potential depends on UV theories or not. In this work, we have shown that the four-Fermi operators logarithmically diverge at the two-loop level and that the counter terms for them contribute to the Higgs potential at the four-loop level. Therefore, the Higgs potential is UV sensitive. As a result, imposed validity of the perturbative expansion, the maximum value of the UV cutoff lies around the compactification scale.

Gauge-Higgs Unification (GHU)

SU(N) gauge theory on $\mathbf{M}^4 \times S^1$

$$\mathcal{L} = \mathcal{L}_{gauge} + \mathcal{L}_{fermion},$$

$$\mathcal{L}_{gauge} = -\frac{1}{4} F^a_{MN} F^{aMN},$$

$$\mathcal{L}_{fermion} = \bar{\psi} i\gamma^M (\partial_M - igA_M)\psi,$$

AB phase: $\theta = g \oint_{S^1} dy\, A_5$

Higgs boson = AB phase

(Gauge-Higgs Unification)

Hosotani mechanism

~~Higgs potential~~ @ tree level

→ generated by quant. corr.

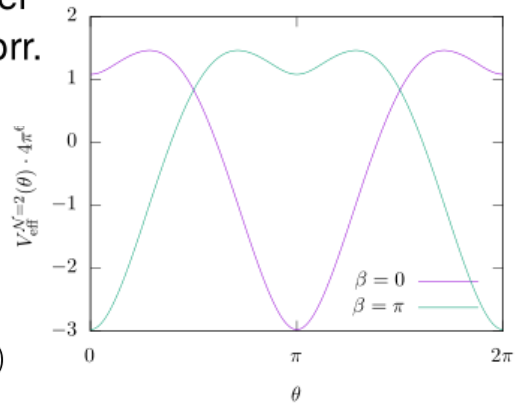
(Hosotani mechanism)

$V_{\rm eff}(\theta)$: Higgs potential

Boundary conditions:

$$\psi(x^\mu, y + 2\pi R) = e^{i\beta}\psi(x^\mu, y)$$

$$A^a_M(x^\mu, y + 2\pi R) = A^a_M(x^\mu, y)$$



$V_{\rm eff}(\theta)$ finiteness

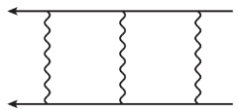
Conjecture: all order finiteness

[Gersdorff, Irges, Quiros, 2002], [Hosotani, 2005]

Finiteness up to 2-loop: [J.Hisano, Y. Shoji, AY, 2019]

UV sensitivity of the Higgs potential

4-Fermi amp. @ 2-loop level → log-divergent e.g.



The contribution to $V_{\rm eff}$ from counter terms for the four-Fermi op. →

$\delta^{\rm fin}_{\rm 4F}$: depends on UV theories