Cancellation of 1-loop Corrections to Scalar Masses in Yang-Mills Theory with Flux Compactification

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Introduction and Motivation

Higgs particle is discovered in 2012!!
So, Standard Model are established!!

But…

There are some problems…
One of the problems is hierarchy problem

What's Hierarchy Problem??

- Correction to Higgs mass is proportional to square of new physics scale

$$\delta m_H^2 \propto \Lambda^2$$

- We must settle this problem if Higgs mass is observable at 125 GeV

To approach a solution to the hierarchy problem,
We consider a higher dimensional field theory.
In particular, We start with Flux Conpactification

Flux Compactification

Set Up

- a six-dimensional SU(2) Yang-Mills Theory with a constant magnetic flux

$$\mathcal{L}_6 = -\frac{1}{4} F^a_{MN} F^{aMN}$$

- Six-dimensional spacetime is $M^4 \times T^2$
- To quantize gauge fields, we need to introduce gauge-fixing terms and ghost fields.

Magnetic Flux

The magnetic flux is given by the nontrivial background of the fifth and the sixth component of the gauge field $A_{5,6}$

$$\langle A_5^1 \rangle = -\frac{1}{2} f x_6, \qquad \langle A_6^1 \rangle = \frac{1}{2} f x_5,$$
$$\langle A_5^{2,3} \rangle = \langle A_6^{2,3} \rangle = 0$$

f is the magnetic flux.
We define ϕ as

$$\phi = \frac{1}{\sqrt{2}}(A_6 + iA_5)$$

We get mass term for gauge field:

$$\mathcal{L}_{mass} = -\frac{1}{2} \mathcal{D} A^a_\mu \bar{\mathcal{D}} A^{a\mu}$$

$$\mathcal{D} = D_5 - iD_6 = \partial - \sqrt{2} g [\langle \phi \rangle , \cdot]$$

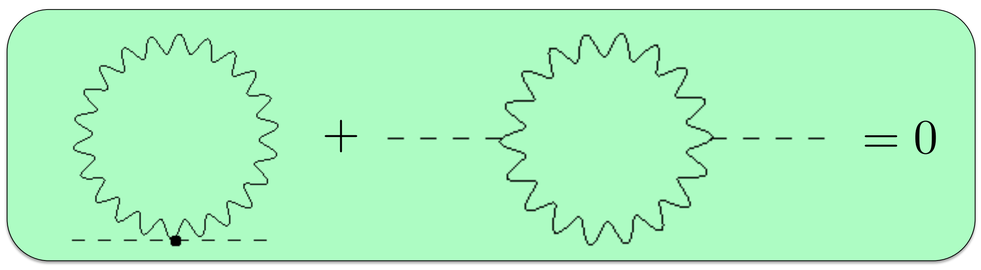
$\mathcal{D}, \bar{\mathcal{D}}$ are identified with creation and annihilation operators.

$$[i\bar{\mathcal{D}}, i\mathcal{D}] = 2gf \quad \Rightarrow \quad a = \frac{1}{\sqrt{2gf}} i\bar{\mathcal{D}}, \ a^\dagger = \frac{1}{\sqrt{2gf}} i\mathcal{D}$$

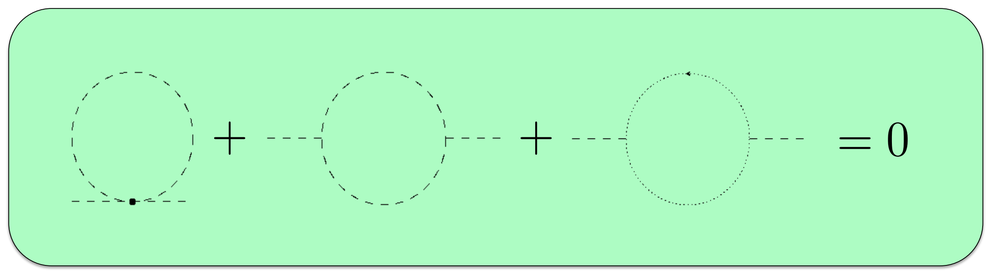
In this way, mass term for gauge field become discrete such as Landau level.
Scalar and ghost masses can be obtained similarly.

Results

- Gauge boson loop (for arbitrary ξ)



- Scalar loop + Ghost loop (Feynman gauge $\xi = 1$)



These cancellation are shown by using this result:

$$\sum_{n=0}^{\infty} \int \frac{d^4p}{(2\pi)^4} \left(-\frac{n}{p^2 + \alpha n} + \frac{n+1}{p^2 + \alpha(n+1)} \right) = 0$$

Physical reason of cancellation

NG boson under shift symmetry of the translation in T^2.
Non-derivative terms are forbidden like a pion

Future Works

- We need to introduce some explicit breaking terms of shift symmetry and scalar boson has to be a pseudo NG boson
- Potential analysis and a study of phase structure
- Extension of Gauge-Higgs Unification