Comprehensive Analysis of $SU(6)$ Gauge-Higgs Grand Unified Theory and New Models

Based on: N. Maru, R. Nago, *J. High Energ. Phys.* **2024**, 35

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Summary

- We propose a **method** of building models of **Gauge-Higgs Grand Unified Theory**.
- We adopt a guideline " **NO exotic fermions** " to build simple models.
- Performing **group theoretical analysis**, it is found that models of $SU(6)$ GHGUT on $M^4 \times S^1/Z_2$ without exotic fermions are essentially **only three types**. Two of these are **new**.

1. Introduction

Gauge-Higgs Unification
(a scenario solving the hierarchy problem)

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Grand Unified Theory
(a typical theory having the hierarchy problem)

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Gauge-Higgs Grand Unified Theory

2. Simplest Model Setup

- Gauge group : $SU(6)$
- Time-space : $M^4 \times S^1/Z_2$ (5D)
- Fermions : $SU(6)$ multiplets

3. Previous Study

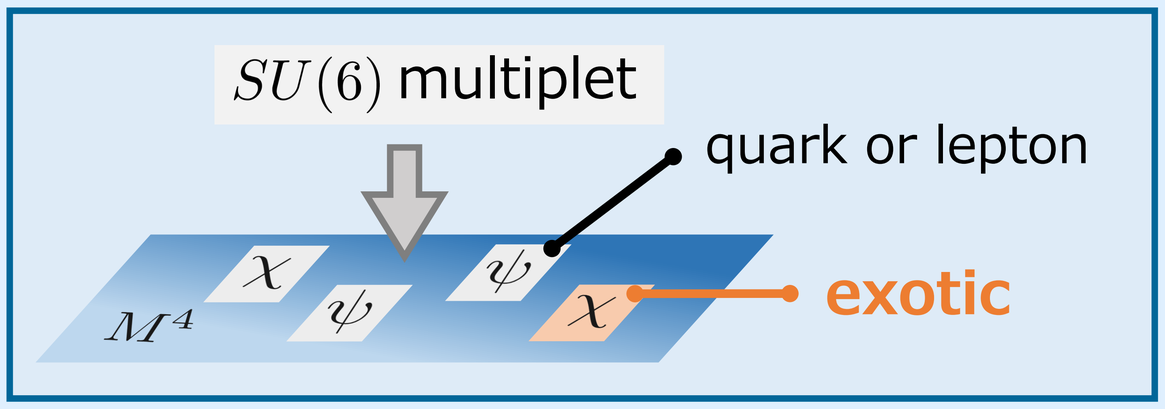
A set of representations was proposed.

$$\mathbf{6} \oplus \mathbf{6}' \oplus \mathbf{20}$$ C.S. Lim and N. Maru, Phys. Lett. B **653** (2007)

- This set contains one generation of quarks and leptons (like as $\mathbf{5} \oplus \mathbf{10}$ of $SU(5)$).
- **This set contains no exotic fermions.**
- **Not all Yukawa terms can be derived.**

4. Exotic Fermions

Exotic fermions :
The fermions that are **absent** from the SM.
(Usually, we don't want to obtain them)



Larger multiplets are expected to contain exotic fermions.

5. Guideline

" NO exotic fermions "

- Only smaller multiplets satisfied.
- We only consider group theory.

6. Results and Future Work

Only three sets satisfy the guideline.

$$\mathbf{6} \oplus \mathbf{6}' \oplus \mathbf{20},\ \underbrace{\mathbf{15} \oplus \mathbf{15}' \oplus \mathbf{1}}_{\textbf{New !}},\ \underbrace{\mathbf{15} \oplus \mathbf{21} \oplus \mathbf{1}}_{\textbf{New !}}$$

The problem of Yukawa terms cannot be solved.

We should consider other setup.

We are applying this method to 6D theory.