How to unify families in three steps

Mario Reig López

July 13, 2017

Motivation

- SU(5) and SO(10) GUTs unify interactions in a fancy way

- However, fundamental fermions and families are not unified

- The family structure seems to be a Nature's caprice...

OR NOT?

To get started

- SO(10) spinors unify EACH family

$$\mathbf{16} \to (\mathbf{3}, \mathbf{2}, 1/6) + (\mathbf{1}, \mathbf{2}, -1/2) + (\bar{\mathbf{3}}, \mathbf{1}, 1/3)$$
$$+ (\bar{\mathbf{3}}, \mathbf{1}, -2/3) + (\mathbf{1}, \mathbf{1}, 1) + (\mathbf{1}, \mathbf{1}, 0),$$

- $SO(2n + 2m)$ spinors split as

$$\mathbf{2}^{n+m-1} \to 2^m \times \mathbf{2}^{n-1}$$
$$SO(2n + 2m) \to SO(2n) \tag{1}$$

STEP 1: Choose a group

SO(4N+2) groups are able to reproduce chirality, good candidates are:

- SO(14) spinor contains 4 families (2 of each chirality)

- **SO(18) spinor contains 16 families (8 of each chirality)**

- SO(22) spinor contains 64 families (32 of each chirality)

STEP 2: decouple mirror families

Early attempts got stuck at this point...

- F. Wilczek and A. Zee, Phys. Rev. D25, 553 (1982).

- J. Bagger and S. Dimopoulos, Nucl. Phys. B244, 247 (1984).

SOLUTION

- Promote $\mathbb{M}_4$ to AdS_5

- Use orbifold breaking mechanism to decouple mirror families.
  They become heavy Kaluza-Klein modes

STEP 3: Confine extra families

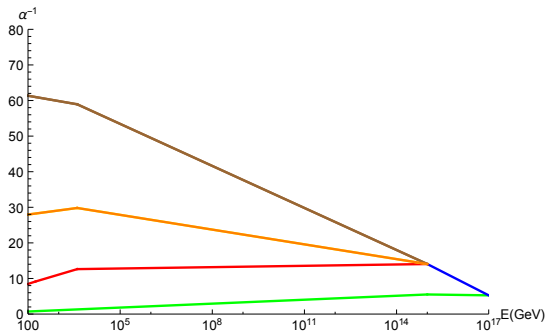$$SO(10) \times SO(8) \to SO(10) \times SO(5)_{HC} \qquad (2)$$

Figure: $SO(5)_{HC}$ gauge coupling (green line) in addition to the SM couplings (red, orange and brown lines).

Hyperbaryons, the smoking gun signature of family unification

SO(5) confinement of extra families offer a good opportunity to test family unification: hyperbaryons

- SO(5) supports a $\mathbb{Z}_2$ conserved quantum number, highly stable

- Hyperbaryons are composed of 5 hyperquarks, with masses at $\sim \mathcal{O}(10)$ TeV

- They constitute a small fraction of the mass density of the universe: look for them at sky!

- Hyperbaryons can be pair produced at colliders: target for LHC