SO(10) → Standard Model Breaking Chain

Pelican's Perspective Mapping Project

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1. Symmetry Breaking Sequence

$$SO(10) \xrightarrow{\langle 45_H \rangle} SU(5) \times U(1)_\chi \xrightarrow{\langle 16_H \rangle, \langle \overline{16}_H \rangle} SU(3)_C \times SU(2)_L \times U(1)_Y$$

- $\langle 45_H \rangle \propto \text{diag}(1,1,1,1,1,-1,-1,-1,-1,-1)$ breaks the vector representation and preserves $SU(5) \times U(1)_\chi$.
- $\langle 16_H \rangle$ and $\langle \overline{16}_H \rangle$ carry $U(1)_\chi$ charge and reduce the rank by one, leaving the Standard Model gauge group.

2. Generator Decomposition

SO(10) Generator	SM Interpretation
$T^a_{SU(3)}$ $(a = 1 \ldots 8)$	Color $SU(3)_C$
$T^i_{SU(2)}$ $(i = 1, 2, 3)$	Weak $SU(2)_L$
$Y = \frac{1}{\sqrt{60}}\text{diag}(2,2,2,-3,-3)$	Hypercharge $U(1)_Y$
$X = U(1)_\chi$	Broken by 16_H VEV

3. Higgs Content

- 45_H: Adjoint, initiates first stage SSB.
- $16_H + \overline{16}_H$: Spinor reps, break to SM; contain right-handed neutrino singlets.
- 10_H: Provides electroweak Higgs doublet after projection onto SM.

4. Vacuum Alignment

The adjoint VEV selects a $B - L$ direction, while the spinor VEV aligns along a SM singlet component, giving masses to right-handed neutrinos and enabling the seesaw.