Physics Beyond the Standard Model

Extended Higgs sector: Higgs Triplet models

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$SO(3)$ is the adjoint representation of $SU(2)$: identical groups.

$SU(N)$:generators T^a, $(N \times N)$ matrices, $a = 1...(N^2 - 1)$,

$\mathrm{Tr}[T^a] = 0,\ T^a = T^{a\dagger}$, $[T^a, T^b] = if_{abc} T^c$,

f_{abc}=Structure Constants (antisymmetric)

Adjoint representation $\tilde{T}^a$, its matrix elements defined as $(\tilde{T}^a)_{bc} = -if_{abc}$

Jacobi identity: $[T^a, [T^b, T^c]] + [T^c, [T^a, T^b]] + [T^b, [T^c, T^a]] = 0$

$[T^a, if_{abd} T^d] + [T^b, if_{cad} T^d] + [T^d, if_{abd} T^d] = 0$

$\rightarrow [\tilde{T}^a, \tilde{T}^b] = if_{abc} \tilde{T}^c$

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$SU(2)$: generagors $T^a = \frac{\sigma^a}{2}$, σ^a=Pauli matrices. $[T^a, T^b] = i\epsilon_{abc} T^c \Rightarrow$

$f_{abc} = \epsilon_{abc}$

Simply apply $(\tilde{T}^a)_{bc} = -if_{abc}$

$$\tilde{T}^1 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & -i \\ 0 & i & 0 \end{pmatrix}$$

$\tilde{T}^2, \tilde{T}^3$

$$[\tilde{T}^i, \tilde{T}^j] = i\epsilon_{ijk} \tilde{T}^k$$

Higgs Triplet: $\Delta = (\Delta_1, \Delta_2, \Delta_3)^T$

The covariant derivative: $D^\mu = \partial^\mu + ig_W \tilde{T}^a W^{a\mu} + ig_Y Y_\Delta B^\mu$.

$$D^\mu \Delta = \partial^\mu \Delta + ig_W W^{a\mu} \tilde{T}^a \Delta + ig_Y Y_\Delta B^\mu \Delta$$

$$D^\mu \Delta_i = \partial^\mu \Delta_i - g_W (\vec{W}^\mu \times \Delta)_i + ig_Y Y_\Delta B^\mu \Delta_i$$

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Higgs Triplet: $\Delta_{zero} = Y_\Delta = 0$, $\langle \Delta_{zero} \rangle = (0, 0, v_o)^T$

$Q_{em} \langle \Delta_{zero} \rangle = 0$, neutral

$$D^\mu = \partial^\mu + i g_W \tilde{T}^a W^{a\mu} + \cancel{i g_Y Y_D B^\mu}$$

$$(D^\mu \Delta_{zero})^\dagger D_\mu \Delta_{zero} =$$

Mass terms: $(D^\mu \Delta_{zero})^\dagger D_\mu \Delta_{zero} \ni (W_1^\mu, W_2^\mu, W_3^\mu, B^\mu) M^2_{zero} (W_{1\mu}, W_{2\mu}, W_{3\mu}, B_\mu)^T$

$$M^2_{zero} = \begin{pmatrix} \\ \\ \\ \end{pmatrix},$$

$M_W^2 =$, $M_Z^2 =$, $M_A^2 =$

Higgs Triplet: $\Delta_{one} = Y_\Delta = 1$, $\langle \Delta_{one} \rangle = \frac{1}{\sqrt{2}}(v_1, -iv_1, 0)^T$

$$Q_{em}\langle \Delta_{one} \rangle =$$

$$D^\mu \Delta_{one\ i} = \partial^\mu \Delta_{one\ i} - g_W(\vec{W}^\mu \times \Delta_{one})_i + ig_Y B^\mu \Delta_{one\ i}$$

$$(D^\mu \Delta_{one})^\dagger D_\mu \Delta_{one} =$$

$$M^2_{one} = \left(\quad \right)$$

$M^2_{zero} =$, $M^2_{one} =$

$M^2_{zero} + M^2_{one} =$

SM $+\Delta_{zero} + \Delta_{one}$:

$M^2_{SM+\Delta_{one}+\Delta_{zeor}} =$