The Lagrangian used in 'Heavy_Scalar_EFT' Model File

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Abstract

Here we list the Lagrangian we used in constructing the model files.

I. TWO EXTRA DIMENSION 6 OPERATOR FOR SM HIGGS

We add two extra EFT vertex for SM Higgs:

$$\mathcal{L} = g_h^{\gamma\gamma} h F_{\mu\nu} F^{\mu\nu} + g_h^{Z\gamma} h Z_{\mu\nu} F^{\mu\nu} \tag{1}$$

where

$$g_h^{\gamma\gamma} = -\frac{\alpha_{\rm EW}}{8\pi v} \mathcal{A}_{\gamma\gamma} \tag{2}$$

$$g_h^{Z\gamma} = -\frac{\alpha_{\rm EW}}{4\pi v} \mathcal{A}_{Z\gamma} \tag{3}$$

II. TWO DIMENSION 4 OPERATOR FOR THE HEAVY SCALAR

At dimension-4, we add two operator for the heavy scalar

$$\mathcal{L} = g_{4,H}^{WW} g^{\mu\nu} H W_\mu^+ W_\nu^- + g_{4,H}^{ZZ} g^{\mu\nu} H Z_\mu Z_\nu \tag{4}$$

where we choose the coupling as

$$g_{4,H}^{WW} = g m_W \rho_H \tag{5}$$

$$g_{4,H}^{ZZ} = \frac{g}{2c_W^2} m_W \rho_H \tag{6}$$

with g the weak coupling, c_W the cosine of the Weinberg angle. ρ_H is a factor characterizing the contribution of H to the EWSB (or to m_W/m_Z).

III. DIMENSION 6 OPERATOR FOR THE HEAVY SCALAR

At dimension-6, we have several simplified EFT operators for the heavy scalar

$$\begin{aligned}\mathcal{L} =& g_{6,H}^{WW} (\partial_\nu H) W_\mu^\dagger W^{\mu\nu} + h.c. + g_{6,H}^{\prime WW} H W^{\mu\nu} W_{\mu\nu}^\dagger \\ &+ g_{6,H}^{ZZ} (\partial_\nu H) Z_\mu Z^{\mu\nu} + h.c. + g_{6,H}^{\prime ZZ} H Z^{\mu\nu} Z_{\mu\nu} + \\ &+ g_{6,H}^{Z\gamma} (\partial_\nu H) Z_\mu F^{\mu\nu} + g_{6,H}^{\prime Z\gamma} F^{\mu\nu} Z_{\mu\nu} \\ &+ g_{6,H}^{\gamma\gamma} H F^{\mu\nu} F_{\mu\nu}\end{aligned} \tag{7}$$

where

$$g_{6,H}^{WW} = \frac{g m_W \rho_H f_W}{2\Lambda^2} \tag{8}$$

$$g_{6,H}^{\prime WW} = -\frac{g m_W \rho_H f_{WW}}{\Lambda^2} \tag{9}$$

$$g_{6,H}^{ZZ} = \frac{g m_W \rho_H (c_W^2 f_W + s_W^2 f_B)}{2 c_W^2 \Lambda^2} \tag{10}$$

$$g_{6,H}^{\prime ZZ} = -\frac{g m_W \rho_H (s_W^4 f_{BB} + c_W^4 f_{WW})}{2 c_W^2 \Lambda^2} \tag{11}$$

$$g_{6,H}^{Z\gamma} = \frac{g m_W \rho_H s_W (f_W - f_B)}{2 c_W \Lambda^2} \tag{12}$$

$$g_{6,H}^{\prime Z\gamma} = \frac{g m_W \rho_H s_W (s_W^2 f_{BB} - c_W^2 f_{WW})}{c_W \Lambda^2} \tag{13}$$

$$g_{6,H}^{\gamma\gamma} = -\frac{g m_W \rho_H s_W^2 (f_{BB} + f_{WW})}{2 \Lambda^2} \tag{14}$$

YW: Add references for above Lagrangians.