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Summary of the Higgs basis parametrization of the SMEFT

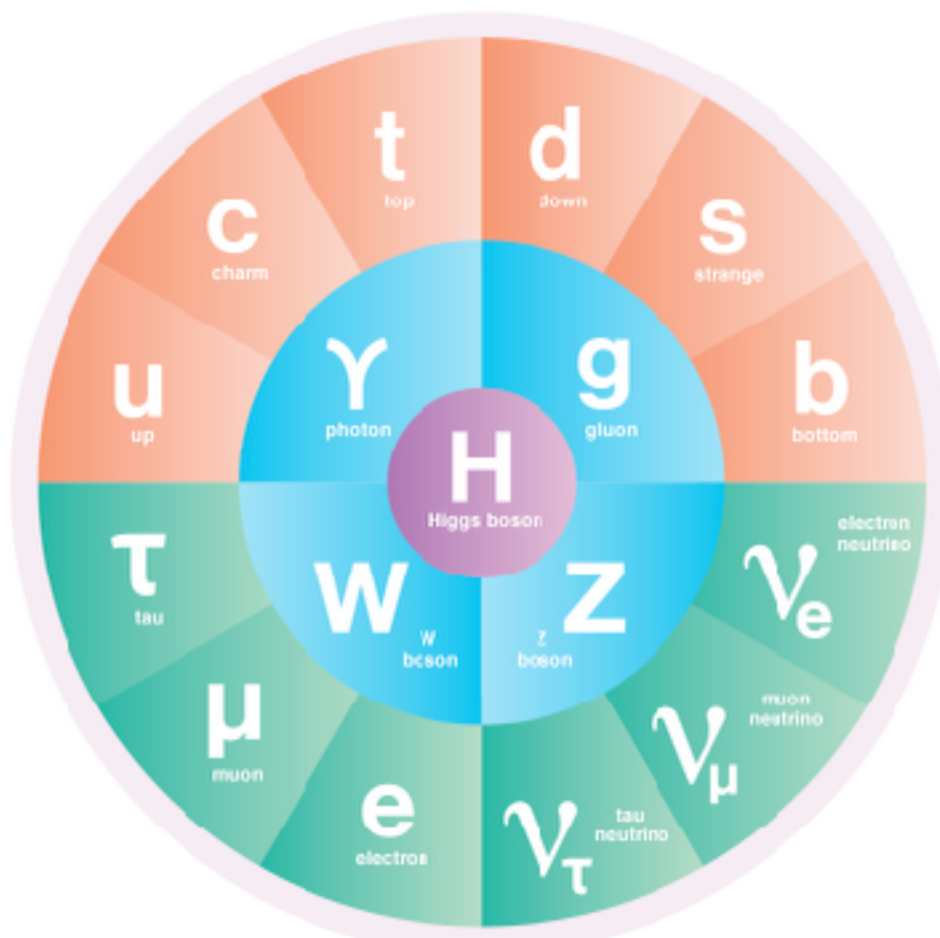
VR, July 8, 2020

SMEFT = minimal EFT above the weak scale

$$\mathscr{L}_{\rm SMEFT} = \mathscr{L}_{\rm SM} + \mathscr{L}_{D=5} + \mathscr{L}_{D=6} + \mathscr{L}_{D=7} + \mathscr{L}_{D=8} + \mathscr{L}_{D=9} + \ldots$$

Known SM Lagrangian

Higher-dimensional $SU(3)_C \times SU(2)_L \times U(1)_Y$ invariant interactions added to the SM



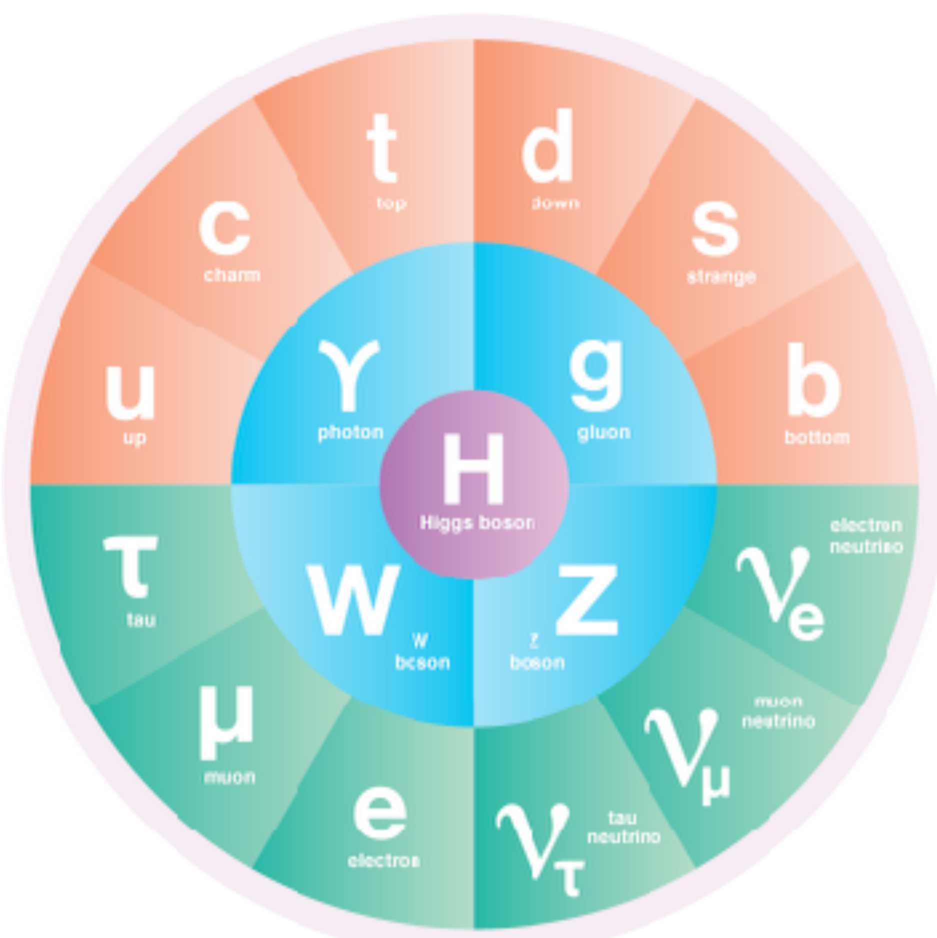
<u>Assumption:</u>
at energies of interest no other relevant degrees of freedom than those of the SM

SMEFT = minimal EFT above the weak scale

$$\mathscr{L}_{\text{SMEFT}} = \mathscr{L}_{\text{SM}} + \cancel{\mathscr{L}_{D=5}} + \mathscr{L}_{D=6} + \cancel{\mathscr{L}_{D=7}} + \cancel{\mathscr{L}_{D=8}} + \cancel{\mathscr{L}_{D=9}} + \dots$$

Known SM Lagrangian

In this talk only dimension-6 operators are taken into account



$$\mathscr{L}_{D=6} = \sum_i C_i\, Q_i$$

Wilson coefficients

Gauge-invariant dimension-6 operators

Dimension-6 operators

Warsaw basis

Grządkowski et al. 1008.4884

Bosonic CP-even		Bosonic CP-odd	
O_H	$(H^\dagger H)^3$		
$O_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$		
O_{HD}	$\left\lvert H^\dagger D_\mu H\right\rvert^2$		
O_{HG}	$H^\dagger H\, G^a_{\mu\nu}G^a_{\mu\nu}$	$O_{H\widetilde{G}}$	$H^\dagger H\, \widetilde{G}^a_{\mu\nu}G^a_{\mu\nu}$
O_{HW}	$H^\dagger H\, W^i_{\mu\nu}W^i_{\mu\nu}$	$O_{H\widetilde{W}}$	$H^\dagger H\, \widetilde{W}^i_{\mu\nu}W^i_{\mu\nu}$
O_{HB}	$H^\dagger H\, B_{\mu\nu}B_{\mu\nu}$	$O_{H\widetilde{B}}$	$H^\dagger H\, \widetilde{B}_{\mu\nu}B_{\mu\nu}$
O_{HWB}	$H^\dagger\sigma^i H\, W^i_{\mu\nu}B_{\mu\nu}$	$O_{H\widetilde{W}B}$	$H^\dagger\sigma^i H\, \widetilde{W}^i_{\mu\nu}B_{\mu\nu}$
O_W	$\epsilon^{ijk}W^i_{\mu\nu}W^j_{\nu\rho}W^k_{\rho\mu}$	$O_{\widetilde{W}}$	$\epsilon^{ijk}\widetilde{W}^i_{\mu\nu}W^j_{\nu\rho}W^k_{\rho\mu}$
O_G	$f^{abc}G^a_{\mu\nu}G^b_{\nu\rho}G^c_{\rho\mu}$	$O_{\widetilde{G}}$	$f^{abc}\widetilde{G}^a_{\mu\nu}G^b_{\nu\rho}G^c_{\rho\mu}$

Table 2.2: Bosonic D=6 operators in the Warsaw basis.

Yukawa	
$[O^\dagger_{eH}]_{IJ}$	$H^\dagger H e^c_I H^\dagger \ell_J$
$[O^\dagger_{uH}]_{IJ}$	$H^\dagger H u^c_I \widetilde{H}^\dagger q_J$
$[O^\dagger_{dH}]_{IJ}$	$H^\dagger H d^c_I H^\dagger q_J$

Vertex	
$[O^{(1)}_{H\ell}]_{IJ}$	$i\bar{\ell}_I\bar{\sigma}_\mu\ell_J H^\dagger \overleftrightarrow{D}_\mu H$
$[O^{(3)}_{H\ell}]_{IJ}$	$i\bar{\ell}_I\sigma^i\bar{\sigma}_\mu\ell_J H^\dagger\sigma^i \overleftrightarrow{D}_\mu H$
$[O_{He}]_{IJ}$	$ie^c_I\sigma_\mu\bar{e}^c_J H^\dagger \overleftrightarrow{D}_\mu H$
$[O^{(1)}_{Hq}]_{IJ}$	$i\bar{q}_I\bar{\sigma}_\mu q_J H^\dagger \overleftrightarrow{D}_\mu H$
$[O^{(3)}_{Hq}]_{IJ}$	$i\bar{q}_I\sigma^i\bar{\sigma}_\mu q_J H^\dagger\sigma^i \overleftrightarrow{D}_\mu H$
$[O_{Hu}]_{IJ}$	$iu^c_I\sigma_\mu\bar{u}^c_J H^\dagger \overleftrightarrow{D}_\mu H$
$[O_{Hd}]_{IJ}$	$id^c_I\sigma_\mu\bar{d}^c_J H^\dagger \overleftrightarrow{D}_\mu H$
$[O_{Hud}]_{IJ}$	$iu^c_I\sigma_\mu\bar{d}^c_J \tilde{H}^\dagger D_\mu H$

Dipole	
$[O^\dagger_{eW}]_{IJ}$	$e^c_I\sigma_{\mu\nu}H^\dagger\sigma^i\ell_J W^i_{\mu\nu}$
$[O^\dagger_{eB}]_{IJ}$	$e^c_I\sigma_{\mu\nu}H^\dagger\ell_J B_{\mu\nu}$
$[O^\dagger_{uG}]_{IJ}$	$u^c_I\sigma_{\mu\nu}T^a\widetilde{H}^\dagger q_J\, G^a_{\mu\nu}$
$[O^\dagger_{uW}]_{IJ}$	$u^c_I\sigma_{\mu\nu}\widetilde{H}^\dagger\sigma^i q_J\, W^i_{\mu\nu}$
$[O^\dagger_{uB}]_{IJ}$	$u^c_I\sigma_{\mu\nu}\widetilde{H}^\dagger q_J\, B_{\mu\nu}$
$[O^\dagger_{dG}]_{IJ}$	$d^c_I\sigma_{\mu\nu}T^a H^\dagger q_J\, G^a_{\mu\nu}$
$[O^\dagger_{dW}]_{IJ}$	$d^c_I\sigma_{\mu\nu}\bar{H}^\dagger\sigma^i q_J\, W^i_{\mu\nu}$
$[O^\dagger_{dB}]_{IJ}$	$d^c_I\sigma_{\mu\nu}H^\dagger q_J\, B_{\mu\nu}$

$(\bar{R}R)(\bar{R}R)$	
O_{ee}	$\eta(e^c\sigma_\mu\bar{e}^c)(e^c\sigma_\mu\bar{e}^c)$
O_{uu}	$\eta(u^c\sigma_\mu\bar{u}^c)(u^c\sigma_\mu\bar{u}^c)$
O_{dd}	$\eta(d^c\sigma_\mu\bar{d}^c)(d^c\sigma_\mu\bar{d}^c)$
O_{eu}	$(e^c\sigma_\mu\bar{e}^c)(u^c\sigma_\mu\bar{u}^c)$
O_{ed}	$(e^c\sigma_\mu\bar{e}^c)(d^c\sigma_\mu\bar{d}^c)$
O_{ud}	$(u^c\sigma_\mu\bar{u}^c)(d^c\sigma_\mu\bar{d}^c)$
O'_{ud}	$(u^c\sigma_\mu T^a\bar{u}^c)(d^c\sigma_\mu T^a\bar{d}^c)$

$(\bar{L}L)(\bar{R}R)$	
$O_{\ell e}$	$(\bar{\ell}\bar{\sigma}_\mu\ell)(e^c\sigma_\mu\bar{e}^c)$
$O_{\ell u}$	$(\bar{\ell}\bar{\sigma}_\mu\ell)(u^c\sigma_\mu\bar{u}^c)$
$O_{\ell d}$	$(\bar{\ell}\bar{\sigma}_\mu\ell)(d^c\sigma_\mu\bar{d}^c)$
O_{eq}	$(e^c\sigma_\mu\bar{e}^c)(\bar{q}\bar{\sigma}_\mu q)$
O_{qu}	$(\bar{q}\bar{\sigma}_\mu q)(u^c\sigma_\mu\bar{u}^c)$
O'_{qu}	$(\bar{q}\bar{\sigma}_\mu T^a q)(u^c\sigma_\mu T^a\bar{u}^c)$
O_{qd}	$(\bar{q}\bar{\sigma}_\mu q)(d^c\sigma_\mu\bar{d}^c)$
O'_{qd}	$(\bar{q}\bar{\sigma}_\mu T^a q)(d^c\sigma_\mu T^a\bar{d}^c)$

$(\bar{L}L)(\bar{L}L)$	
$O_{\ell\ell}$	$\eta(\bar{\ell}\bar{\sigma}_\mu\ell)(\bar{\ell}\bar{\sigma}_\mu\ell)$
O_{qq}	$\eta(\bar{q}\bar{\sigma}_\mu q)(\bar{q}\bar{\sigma}_\mu q)$
O'_{qq}	$\eta(\bar{q}\bar{\sigma}_\mu\sigma^i q)(\bar{q}\bar{\sigma}_\mu\sigma^i q)$
$O_{\ell q}$	$(\bar{\ell}\bar{\sigma}_\mu\ell)(\bar{q}\bar{\sigma}_\mu q)$
$O'_{\ell q}$	$(\bar{\ell}\bar{\sigma}_\mu\sigma^i\ell)(\bar{q}\bar{\sigma}_\mu\sigma^i q)$

$(\bar{L}R)(\bar{L}R)$	
O_{quqd}	$(u^c q^j)\epsilon_{jk}(d^c q^k)$
O'_{quqd}	$(u^c T^a q^j)\epsilon_{jk}(d^c T^a q^k)$
$O_{\ell equ}$	$(e^c\ell^j)\epsilon_{jk}(u^c q^k)$
$O'_{\ell equ}$	$(e^c\bar{\sigma}_{\mu\nu}\ell^j)\epsilon_{jk}(u^c\bar{\sigma}^{\mu\nu}q^k)$
$O_{\ell edq}$	$(\bar{\ell}\bar{e}^c)(d^c q)$

Alonso et al 1312.2014,
Henning et al 1512.03433

Full set has 2499 distinct operators, including flavor structure and CP conjugates

Wilson coefficient of these operators can be connected (now semi-automatically) to fundamental parameters of BSM models like SUSY, composite Higgs, etc.

Warsaw Basis

- Warsaw basis is now commonly used in the literature
- Convenient for many theory applications
- Implemented in many numerical tools
- Interpretation of various Wilson coefficients not always intuitive
- O(200) distinct operators affecting LHC Higgs physics
- Larger correlations between Higgs and other precision measurements

Bosonic CP-even		Bosonic CP-odd	
O_H	$(H^\dagger H)^3$		
$O_{H\Box}$	$(H^\dagger H)\Box(H^\dagger H)$		
O_{HD}	$\left\lvert H^\dagger D_\mu H\right\rvert^2$		
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O_{HW}	$H^\dagger H\, W^i_{\mu\nu}W^i_{\mu\nu}$	$O_{H\widetilde{W}}$	$H^\dagger H\, \widetilde{W}^i_{\mu\nu}W^i_{\mu\nu}$
O_{HB}	$H^\dagger H\, B_{\mu\nu}B_{\mu\nu}$	$O_{H\widetilde{B}}$	$H^\dagger H\, \widetilde{B}_{\mu\nu}B_{\mu\nu}$
O_{HWB}	$H^\dagger\sigma^i H\, W^i_{\mu\nu}B_{\mu\nu}$	$O_{H\widetilde{W}B}$	$H^\dagger\sigma^i H\, \widetilde{W}^i_{\mu\nu}B_{\mu\nu}$
O_W	$\epsilon^{ijk}W^i_{\mu\nu}W^j_{\nu\rho}W^k_{\rho\mu}$	$O_{\widetilde{W}}$	$\epsilon^{ijk}\widetilde{W}^i_{\mu\nu}W^j_{\nu\rho}W^k_{\rho\mu}$
O_G	$f^{abc}G^a_{\mu\nu}G^b_{\nu\rho}G^c_{\rho\mu}$	$O_{\widetilde{G}}$	$f^{abc}\widetilde{G}^a_{\mu\nu}G^b_{\nu\rho}G^c_{\rho\mu}$

Table 2.2: Bosonic D=6 operators in the Warsaw basis.

For example, operator O_{HWB} affects

- Higgs to γγ, Zγ, ZZ decays
- Z pole measurements
- Triple gauge couplings
- W boson mass

Higgs Basis

- **Higgs basis was conceived in 2015 to facilitate practical applications of the SMEFT for LHC Higgs analyses**
- **The construction closely follows the idea introduced by Gupta, Pomarol, and Riva in [arXiv:1405.0181]**

The goals of the Higgs basis

1. **Each Wilson coefficient has a simple physical interpretation**
2. **Higgs observables at leading order are affected by a minimal set of Wilson coefficients**
3. **Large correlations between the Higgs and electroweak constraints are avoided**

In other words, the point is to amend certain impractical features of the Warsaw basis

Higgs Basis - definition

$$\overrightarrow{c}_{\text{HB}} = M_{W\to H}\overrightarrow{C}_{\text{WB}}$$

Vector of 2499 Wilson coefficients in Higgs basis

2499x2499 dimensional numerical invertible matrix

Vector of 2499 Wilson coefficients in Warsaw basis

Alternatively, the same transformation can be defined at the level of gauge-invariant operators

$$Q_{\text{HB}} = M_{W\to H}^{-1\,T} Q_{\text{WB}}$$

Higgs Basis - map part 1

Higgs basis Wilson coefficients

Warsaw basis Wilson coefficients

$$\Delta_{G_F} = [C^{(3)}_{\varphi l}]_{11} + [C^{(3)}_{\varphi l}]_{22} - \frac{1}{2}[C_{ll}]_{1221}$$

$$g_s = 1.2172, \quad g_L = 0.6485, \quad g_Y = 0.3580, \quad v = 246.22 \text{ GeV}$$

$$\begin{aligned}
v^{-2}\delta c_z &= C_{\varphi\Box} - \frac{1}{4}C_{\varphi D} - \frac{3}{2}\Delta_{G_F}, \\
v^{-2}c_{z\Box} &= \frac{1}{2g_L^2}\left(C_{\varphi D} + 2\Delta_{G_F}\right), \\
v^{-2}c_{gg} &= \frac{4}{g_s^2}C_{\varphi G}, \\
v^{-2}c_{\gamma\gamma} &= 4\left(\frac{1}{g_L^2}C_{\varphi W} + \frac{1}{g_Y^2}C_{\varphi B} - \frac{1}{g_L g_Y}C_{\varphi WB}\right), \\
v^{-2}c_{zz} &= 4\left(\frac{g_L^2 C_{\varphi W} + g_Y^2 C_{\varphi B} + g_L g_Y C_{\varphi WB}}{(g_L^2 + g_Y^2)^2}\right), \\
v^{-2}c_{z\gamma} &= 4\left(\frac{C_{\varphi W} - C_{\varphi B} - \frac{g_L^2 - g_Y^2}{2g_L g_Y}C_{\varphi WB}}{g_L^2 + g_Y^2}\right), \\
v^{-2}\tilde{c}_{gg} &= \frac{4}{g_s^2}C_{\varphi\tilde{G}}, \\
v^{-2}\tilde{c}_{\gamma\gamma} &= 4\left(\frac{1}{g_L^2}C_{\varphi\tilde{W}} + \frac{1}{g_Y^2}C_{\varphi\tilde{B}} - \frac{1}{g_L g_Y}C_{\varphi W\tilde{B}}\right), \\
v^{-2}\tilde{c}_{zz} &= 4\left(\frac{g_L^2 C_{\varphi\tilde{W}} + g_Y^2 C_{\varphi\tilde{B}} + g_L g_Y C_{\varphi W\tilde{B}}}{(g_L^2 + g_Y^2)^2}\right), \\
v^{-2}\tilde{c}_{z\gamma} &= 4\left(\frac{C_{\varphi\tilde{W}} - C_{\varphi\tilde{B}} - \frac{g_L^2 - g_Y^2}{2g_L g_Y}C_{\varphi W\tilde{B}}}{g_L^2 + g_Y^2}\right), \\
v^{-2}\delta\lambda_3 &= -\frac{1}{\lambda}C_\varphi + 3C_{\varphi\Box} - \frac{3}{4}C_{\varphi D} - \frac{1}{2}\Delta_{G_F}, \\
v^{-2}[\delta y_f]_{JK} &= -\frac{v}{\sqrt{2m_{f_J}m_{f_K}}}[C^\dagger_{f\varphi}]_{JK} + \delta_{JK}\left(c_{\varphi\Box} - \frac{1}{4}C_{\varphi D} - \frac{1}{2}\Delta_{G_F}\right)
\end{aligned}$$

Higgs Basis - interpretation part 1

First group of Wilson coefficients corresponds has a simple interpretation of certain Higgs couplings

$$
\begin{aligned}
\mathcal{L} \supset \; & \frac{h}{v}\Big[(1+\delta c_w)\frac{g_L^2 v^2}{2} W_\mu^+ W_\mu^- + (1+\underline{\delta c_z})\frac{(g_L^2+g_Y^2)v^2}{4} Z_\mu Z_\mu \\
& - \sum_{f\in u,d,e}\sum_{IJ}\sqrt{m_{f_I} m_{f_J}}\left[(\delta_{IJ} + \underline{[\delta y_f]}_{IJ})\,\bar{f}_L f_R + \mathrm{h.c.}\right] \\
& + c_{ww}\frac{g_L^2}{2} W_{\mu\nu}^+ W_{\mu\nu}^- + \tilde{c}_{ww}\frac{g_L^2}{2} W_{\mu\nu}^+ \tilde{W}_{\mu\nu}^- + c_{w\Box} g_L^2 \left(W_\mu^- \partial_\nu W_{\mu\nu}^+ + \mathrm{h.c.}\right) \\
& + \underline{c_{gg}}\frac{g_s^2}{4} G_{\mu\nu}^a G_{\mu\nu}^a + \underline{c_{\gamma\gamma}}\frac{g_L^2 g_Y^2}{4(g_L^2+g_Y^2)} A_{\mu\nu} A_{\mu\nu} + \underline{c_{z\gamma}}\frac{g_L g_Y}{2} Z_{\mu\nu} A_{\mu\nu} + \underline{c_{zz}}\frac{g_L^2+g_Y^2}{4} Z_{\mu\nu} Z_{\mu\nu} \\
& + \underline{c_{z\Box}} g_L^2 Z_\mu \partial_\nu Z_{\mu\nu} + c_{\gamma\Box} g_L g_Y Z_\mu \partial_\nu A_{\mu\nu} \\
& + \underline{\tilde{c}_{gg}}\frac{g_s^2}{4} G_{\mu\nu}^a \tilde{G}_{\mu\nu}^a + \underline{\tilde{c}_{\gamma\gamma}}\frac{g_L^2 g_Y^2}{4(g_L^2+g_Y^2)} A_{\mu\nu} \tilde{A}_{\mu\nu} + \underline{\tilde{c}_{z\gamma}}\frac{g_L g_Y}{2} Z_{\mu\nu} \tilde{A}_{\mu\nu} + \underline{\tilde{c}_{zz}}\frac{g_L^2+g_Y^2}{4} Z_{\mu\nu} \tilde{Z}_{\mu\nu}\Big]
\end{aligned}
$$

These Wilson coefficients at leading order are probed only by Higgs and diboson processes
They were largely unconstrained before LHC, and remain weakly constrained nowadays!

$$
\begin{aligned}
\delta c_w &= \delta c_z + 4\delta m_w, \qquad \delta m_w \equiv \frac{1}{2}\delta g_L^{We} + \frac{1}{2}\delta g_L^{W\mu} - \frac{1}{4}[c_{ll}]_{1221}, \\
c_{ww} &= c_{zz} + \frac{2g_Y^2}{g_L^2+g_Y^2} c_{z\gamma} + \frac{g_Y^4}{(g_L^2+g_Y^2)^2} c_{\gamma\gamma}, \\
\tilde{c}_{ww} &= \tilde{c}_{zz} + \frac{2g_Y^2}{g_L^2+g_Y^2} \tilde{c}_{z\gamma} + \frac{g_Y^4}{(g_L^2+g_Y^2)^2} \tilde{c}_{\gamma\gamma}, \\
c_{w\Box} &= \frac{1}{g_L^2-g_Y^2}\left[g_L^2 c_{z\Box} + g_Y^2 c_{zz} - \frac{g_Y^2(g_L^2-g_Y^2)}{g_L^2+g_Y^2} c_{z\gamma} - \frac{g_L^2 g_Y^4}{(g_L^2+g_Y^2)^2} c_{\gamma\gamma}\right], \\
c_{\gamma\Box} &= \frac{1}{g_L^2-g_Y^2}\left[2g_L^2 c_{z\Box} + (g_L^2+g_Y^2) c_{zz} - (g_L^2-g_Y^2) c_{z\gamma} - \frac{g_L^2 g_Y^2}{g_L^2+g_Y^2} c_{\gamma\gamma}\right]
\end{aligned}
$$

Higgs Basis - map part 2

Higgs basis Wilson coefficients

$$
\begin{aligned}
v^{-2}\delta g_L^{W\ell} &= C_{\varphi l}^{(3)} + f(1/2,0) - f(-1/2,-1), \\
v^{-2}\delta g_L^{Z\ell} &= -\frac{1}{2}C_{\varphi l}^{(3)} - \frac{1}{2}C_{\varphi l}^{(1)} + f(-1/2,-1), \\
v^{-2}\delta g_R^{Z\ell} &= -\frac{1}{2}C_{\varphi e}^{(1)} + f(0,-1), \\
v^{-2}\delta g_L^{Zu} &= \frac{1}{2}C_{\varphi q}^{(3)} - \frac{1}{2}C_{\varphi q}^{(1)} + f(1/2,2/3), \\
v^{-2}\delta g_L^{Zd} &= -\frac{1}{2}C_{\varphi q}^{(3)} - \frac{1}{2}C_{\varphi q}^{(1)} + f(-1/2,-1/3), \\
v^{-2}\delta g_R^{Zu} &= -\frac{1}{2}C_{\varphi u} + f(0,2/3), \\
v^{-2}\delta g_R^{Zd} &= -\frac{1}{2}C_{\varphi d} + f(0,-1/3), \\
v^{-2}\delta g_R^{Wq} &= \frac{1}{2}C_{\varphi ud},
\end{aligned}
$$

Warsaw basis Wilson coefficients

$$
f(T^3,Q) \equiv \left\{ -Q\frac{g_L g_Y}{g_L^2 - g_Y^2}C_{\varphi WB} - \left(\frac{1}{4}C_{\varphi D} + \frac{1}{2}\Delta_{G_F}\right)\left(T^3 + Q\frac{g_Y^2}{g_L^2 - g_Y^2}\right)\right\}\mathbf{1}
$$

Higgs Basis - interpretation part 2

The Wilson coefficients δg are interpreted as vertex correction to electroweak gauge boson couplings to matter

$$
\begin{aligned}
\mathcal{L} \supset & -\frac{g_L g_Y}{\sqrt{g_L^2+g_Y^2}} A_\mu \sum_{f\in u,d,e} Q_f \bar{f}\gamma_\mu f - g_s G_\mu^a \sum_{f\in u,d} \bar{f}\gamma_\mu T^a f, \\
- & \frac{g_L}{\sqrt{2}}\left(W_\mu^+ \bar{\nu}_L \gamma_\mu (\mathbf{I} + \underline{\delta g_L^{W\ell}}) e_L + W_\mu^+ \bar{u}_L \gamma_\mu (V_{\rm CKM} + \delta g_L^{Wq}) d_L + W_\mu^+ \bar{u}_R \gamma_\mu \underline{\delta g_R^{Wq}} d_R + \mathrm{h.c.}\right) \\
- & \sqrt{g_L^2+g_Y^2} Z_\mu \left[\sum_{f\in u,d,e,\nu} \bar{f}_L \gamma_\mu (T_f^3 - s_\theta^2 Q_f + \underline{\delta g_L^{Zf}}) f_L + \sum_{f\in u,d,e} \bar{f}_R \gamma_\mu (-s_\theta^2 Q_f + \underline{\delta g_R^{Zf}}) f_R\right]
\end{aligned}
$$

These parameters are strongly constrained, in a model-independent way, by LEP-1 precision measurements

$$
\begin{aligned}
\delta g_L^{Z\nu} &= \delta g_L^{W\ell} + \delta g_L^{Ze}, \\
\delta g_L^{Wq} &= V_{\rm CKM}^\dagger \delta g_L^{Zu} V_{\rm CKM} - \delta g_L^{Zd}
\end{aligned}
$$

Given these constraints, in most cases they cannot effect LHC Higgs measurements in an observable way

Higgs Basis - map part 3

The remaining (more trivial) part of the map

$$\begin{aligned} v^{-2}\lambda_z &= \frac{3}{2} g_L C_W, \qquad v^{-2}\tilde{\lambda}_z = \frac{3}{2} g_L C_{\tilde{W}}, \\ v^{-2}\lambda_g &= \frac{C_G}{g_s^3}, \qquad v^{-2}\tilde{\lambda}_g = \frac{C_{\tilde{G}}}{g_s^3}. \end{aligned}$$

F^3

$$\begin{aligned} v^{-2} d_{Gf} &= -\frac{16}{g_s^2} C^*_{fG}, \\ v^{-2} d_{Af} &= -\frac{16}{g_L^2}\left(\eta_f C^*_{fW} + C^*_{fB}\right), \\ v^{-2} d_{Zf} &= -16\left(\eta_f \frac{1}{g_L^2 + g_Y^2} C^*_{fW} - \frac{g_Y^2}{g_L^2(g_L^2 + g_Y^2)} C^*_{fB}\right), \\ v^{-2} d_{Wf} &= -\frac{16}{g_L^2} C^*_{fW}, \end{aligned}$$

dipoles

$$v^{-2} c_i = C_i.$$

4-fermion

Higgs Basis - structure

$$\overrightarrow{c}_{HB} = \begin{pmatrix} \overrightarrow{c}_{\mathrm{Higgs}} \\ \overrightarrow{\delta g}_{\mathrm{vertex}} \\ \overrightarrow{d}_{\mathrm{dipole}} \\ \overrightarrow{c}_{F^3} \\ \overrightarrow{c}_{4fermion} \end{pmatrix}$$

At LO, probed only by Higgs and diboson processes
Most relevant for typical LHC Higgs analyses

Affecting Higgs observables, but almost all
strongly constrained by other precision measurements
Irrelevant for typical LHC Higgs analyses

Affecting Higgs observables, but most
are constrained by other precision measurements
Irrelevant for many LHC Higgs analyses

At LO, probed only by diboson processes
Most relevant for typical LHC Higgs analyses

At LO, probed e.g. by Drell-Yan processes
Irrelevant for typical LHC Higgs analyses

Higgs Basis - conclusions

For typical LHC Higgs analyses,
in the Higgs basis only a limited set of Wilson coefficients is relevant

$$\delta c_z,\ c_{z\Box},\ c_{zz},\ c_{\gamma\gamma},\ c_{z\gamma},\ c_{gg},\ \delta\lambda_3,\ \tilde{c}_{zz},\ \tilde{c}_{\gamma\gamma},\ \tilde{c}_{z\gamma},\ \tilde{c}_{gg},\ \delta y_u,\ \delta y_d,\ \delta y_e$$

(plus eventually a handful of dipole and vertex corrections)

They are interpreted as certain Higgs couplings in the SMEFT Lagrangian

Likelihood obtained for these parameters can be translated to any other SMEFT basis,
in particular to the Warsaw Basis

References

1. Yellow Report 4 [arXiv:1610.07922]

2. My HDR (available online)

3. Summary note prepared for the Offshell WG