Non-linear left-right dynamical Higgs effects

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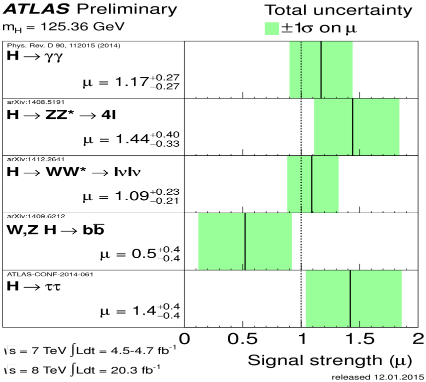
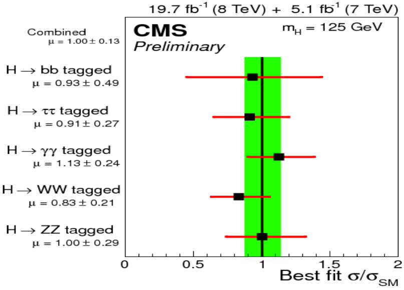
JY, arXiv:1507.03974.

R. Kunming, J. Shu and JY arXiv:1507.04745.





SCALAR RESONANCE FOUND !

Higgs particle @ LHC

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Hierarchy problem

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NP @ TeV

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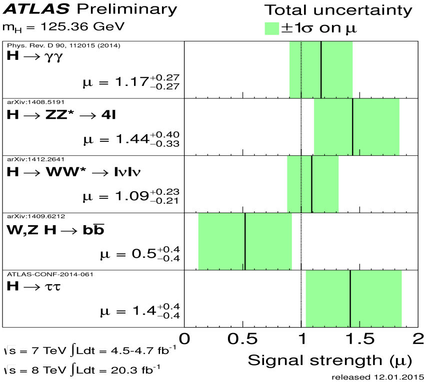
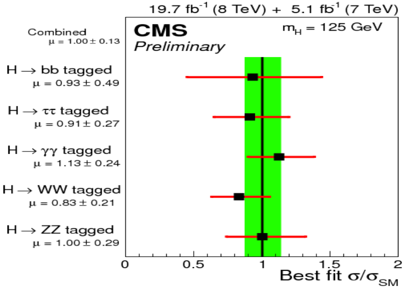
* Perturbative regimes
  - MSSM
  - SUSY particles
  - Heavy fermion resonances





SCALAR RESONANCE FOUND !

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Hierarchy problem

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NP @ TeV

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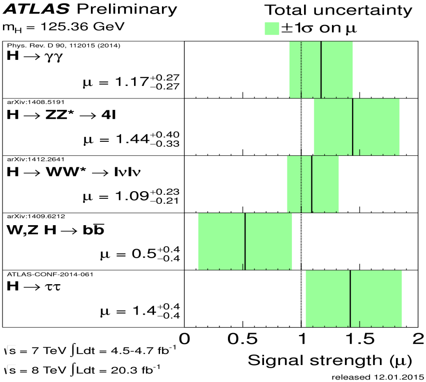
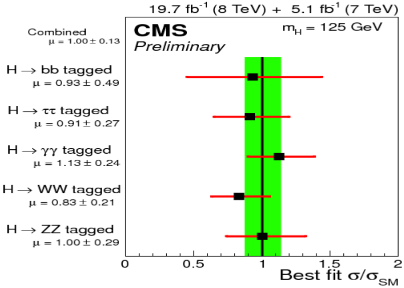
* Non-perturbative regime strong dynamics @ $\Lambda_s \sim$ TeV
  - Technicolor $\Rightarrow$ 3 GB encoded but no light Higgs h
  - Composite Higgs $\Rightarrow$ SM light Higgs as a composite PGB from a strongly coupled theory (similar to pions in QCD).





SCALAR RESONANCE FOUND !

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Hierarchy problem

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NP @ TeV

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* Non-perturbative regime
strong dynamics @ $\Lambda_s \sim$ TeV

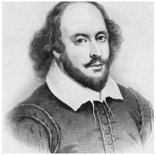
MODEL INDEPENDENT

Effective approach philosophy

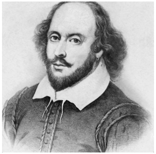
To cope possible BSM signals through effective gauge invariant operators

Effective approach philosophy

To cope possible BSM signals through effective gauge invariant operators

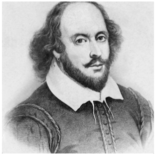


Φ or not to Φ

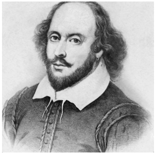


Effective approach philosophy

To cope possible BSM signals through effective gauge invariant operators



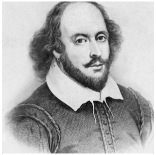
Φ or not to Φ



Linear expansion vs Non-linear expansion

Effective approach philosophy

To cope possible BSM signals through effective gauge invariant operators



Φ or not to Φ

Linear expansion vs Non-linear expansion

Espinosa's talk

Linear expansion

* SM EW doublet Φ in $\mathcal{O}_i$
* n-dimensional operators $\mathcal{O}_i^{(n)}$ suppressed by powers of Λ^{n-4}
* Lagrangian expansion $\mathscr{L}_{eff} = \mathscr{L}_{SM} + \sum_i \frac{c_i}{\Lambda^2} \mathcal{O}_i^{(6)} + \text{h.c.} + \dots$
* CP-conserving gauge-Higgs couplings: HISZ basis

$$\mathcal{O}_{GG} = -\frac{g_s^2}{4}\Phi^\dagger\Phi\, G^a_{\mu\nu}G^{a\mu\nu} \qquad \mathcal{O}_{WW} = -\frac{g^2}{4}\Phi^\dagger W_{\mu\nu}W^{\mu\nu}\Phi$$

$$\mathcal{O}_{BB} = -\frac{g'^2}{4}\Phi^\dagger B_{\mu\nu}B^{\mu\nu}\Phi \qquad \mathcal{O}_{BW} = -\frac{g\,g'}{4}\Phi^\dagger B_{\mu\nu}W^{\mu\nu}\Phi$$

$$\mathcal{O}_{W} = \frac{i\,g}{2}(D_\mu\Phi)^\dagger W^{\mu\nu}(D_\nu\Phi) \qquad \mathcal{O}_{B} = \frac{i\,g'}{4}(D_\mu\Phi)^\dagger B^{\mu\nu}(D_\nu\Phi)$$

$$\mathcal{O}_{\Phi,1} = (D_\mu\Phi)^\dagger\,\Phi\ \Phi^\dagger\,(D^\mu\Phi) \qquad \mathcal{O}_{\Phi,2} = \frac{1}{2}\partial^\mu\left(\Phi^\dagger\Phi\right)\partial_\mu\left(\Phi^\dagger\Phi\right)$$

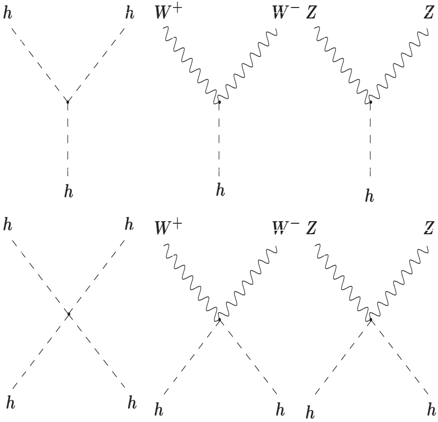
$$\mathcal{O}_{\Phi,4} = (D_\mu\Phi)^\dagger(D^\mu\Phi)\left(\Phi^\dagger\Phi\right) \qquad \mathcal{O}_{\Box\Phi} = (D_\mu D^\mu\Phi)^\dagger(D_\nu D^\nu\Phi)$$

Büchmuller and Wyler, 1986
Hagiwara, Ishihara, Szalapski, and Zeppenfeld, 1993
Grzadkowski, Iskrzynski, Misiak, and Rosiek, 2010

Espinosa's talk

Linear expansion

$$\mathcal{O}_{\Phi,4} = (D_\mu\Phi)^\dagger (D^\mu\Phi)\left(\Phi^\dagger\Phi\right)$$
$$= \frac{1}{2}e^2 (v+h)^4 \left[W_\mu^- \, W_\mu^+ \csc^2\theta_W + 2\csc^2(2\theta_W)\; Z_\mu^2\right] + (v+h)^2\;(\partial_\mu h)^2$$



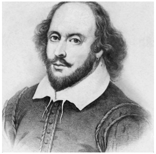
$\mathcal{O}_{\Phi,4}$ induces

* Λ^{-2} suppressed W & Z masses corrections
* Purely cubic and quartic h interactions
* Cubic and quartic gauge-h interactions

Effective approach philosophy

To cope possible BSM signals through effective gauge invariant operators

Φ or **not to Φ**



Linear expansion vs **Non-linear expansion**

NON-LINEAR EXPANSION GUIDELINE

Inspired by Strong dynamics regimes @ $\Lambda_s \sim$ TeV

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Non-linear left–right σ-model coupled to a light Higgs h

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STRATEGY

$\overbrace{\hspace{10cm}}$

Effective non-linear σ-model $+$ $SU(2)_R$ extension $+$ Light Higgs h

Effective non-linear σ-model

* GB d.o.f now encoded as

$$\mathbf{U}_{L(R)}(x) = e^{i\,\tau_a\,\pi^a_{L(R)}(x)/f_{L(R)}}\,, \qquad f_{L(R)} - \text{GB scales}$$

* Larger $\mathcal{G} = SU(2)_L \otimes SU(2)_R \otimes U(1)_{B-L}$, with local rotations

$$\mathbf{L}(x) \equiv e^{\frac{i}{2}\tau^a\alpha^a_L(x)}, \qquad \mathbf{R}(x) \equiv e^{\frac{i}{2}\tau^a\alpha^a_R(x)}, \qquad \mathbf{U_Y}(x) \equiv e^{\frac{i}{2}\tau^3\alpha^0(x)}$$

$$\mathbf{U}_L \to \mathbf{L}\,\mathbf{U}_L\,\mathbf{U}^\dagger_Y\,, \qquad \mathbf{U}_R \to \mathbf{R}\,\mathbf{U}_R\,\mathbf{U}^\dagger_Y$$

* $D^\mu\mathbf{U}_\chi \equiv \partial^\mu\mathbf{U}_\chi + \frac{i}{2}\,g_\chi\,W^{\mu,a}_\chi\,\tau^a\,\mathbf{U}_\chi - \frac{i}{2}\,g'\,B^\mu\,\mathbf{U}_\chi\,\tau^3, \qquad \chi = L,\ R$

* Covariant vectorial & scalar objects

$$\mathbf{V}^\mu_\chi \equiv (D^\mu\mathbf{U}_\chi)\,\mathbf{U}^\dagger_\chi\,, \qquad \mathbf{T}_\chi \equiv \mathbf{U}_\chi\,\tau_3\,\mathbf{U}^\dagger_\chi$$

$SU(2)_L - SU(2)_R$ interplay

* Left–right mixing operators

$$\mathrm{Tr}\left(\mathcal{O}_L^i\,\mathcal{O}_R^j\right) \quad \Longrightarrow \quad \mathrm{Tr}\left(\mathbf{U}_L^\dagger\,\mathcal{O}_L^i\,\mathbf{U}_L\,\mathbf{U}_R^\dagger\,\mathcal{O}_R^j\,\mathbf{U}_R\right)$$

Introduction of $\Longrightarrow$ $\widetilde{\mathcal{O}}_\chi^i \equiv \mathbf{U}_\chi^\dagger\,\mathcal{O}_\chi^i\,\mathbf{U}_\chi\,, \qquad \chi = L,\ R$

*

$$\widetilde{\mathbf{V}}_\chi^\mu \equiv \mathbf{U}_\chi^\dagger\,\mathbf{V}_\chi^\mu\,\mathbf{U}_\chi \qquad \& \qquad \widetilde{\mathbf{T}}_\chi \equiv \mathbf{U}_\chi^\dagger\,\mathbf{T}_\chi\,\mathbf{U}_\chi = \tau_3$$

*

$$\widetilde{W}_\chi^{\mu\nu} \equiv \mathbf{U}_\chi^\dagger\,W_\chi^{\mu\nu}\,\mathbf{U}_\chi$$

Light Higgs h

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Introduced through

Linear SM & BSM vs Non linear BSM

Powers of $(v+h)^n$

$$\left(\Phi^\dagger \Phi\right)^n \sim (v+h)^n$$
$$\left(\Phi^\dagger D_\mu \Phi\right)^n \sim (v+h)^n (\partial_\mu h)^n$$

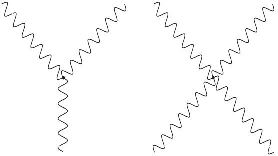
Generic polynomial Higgs-dependence

$$\mathcal{F}(h) = \sum_{n=0} \left(\frac{v}{f}\right)^n g_n(h,v)$$

EFT non-linear σ-model $\quad + \quad$ Light Higgs h

Pure gauge
non-linear operators

$\mathcal{F}(h)$, $\partial_\mu \mathcal{F}(h)$, $\partial_\mu \partial^\mu \mathcal{F}(h)$



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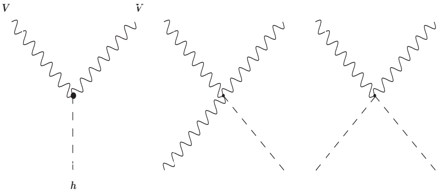

More operators!

STRATEGY

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Effective non-linear σ-model $+$ $SU(2)_R$ extension $+$ Light Higgs h

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Constructed by

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Building blocks

$$\widetilde{\mathbf{T}}_\chi, \quad \widetilde{\mathbf{V}}^\mu_\chi, \quad \mathcal{F}(h), \quad \partial_\mu \mathcal{F}(h), \quad \partial_\mu \partial^\mu \mathcal{F}(h)$$

EFT $\Rightarrow$

NON LINEAR LEFT-RIGHT DYNAMICAL HIGGS

EFT Lagrangian

$$\mathscr{L}_{\text{chiral}} = \mathscr{L}_0 + \mathscr{L}_{0,R} + \mathscr{L}_{0,LR} + \Delta\mathscr{L}_{\text{CP}} + \Delta\mathscr{L}_{\text{CP},LR}$$

* $\mathscr{L}_0$: LO SM Lagrangian
* $\mathscr{L}_{0,R} \supset$ up to p^2–right handed ops.
* $\mathscr{L}_{0,LR} \supset$ up to p^2 left–right mixing ops.
* $\Delta\mathscr{L}_{\text{CP}} \supset$ up to p^4 left & right ops.
* $\Delta\mathscr{L}_{\text{CP},LR} \supset$ up to p^4 left–right mixing ops.

$\mathscr{L}_0$ & $\mathscr{L}_{0,R}$ & $\mathscr{L}_{0,LR}$

$$\mathscr{L}_0 = -\frac{1}{4} B_{\mu\nu} B^{\mu\nu} - \frac{1}{4} W^a_{\mu\nu,\,L} W^{\mu\nu,\,a}_L - \frac{1}{4} G^a_{\mu\nu} G^{\mu\nu,\,a} +$$

$$+ \frac{1}{2}(\partial_\mu h)(\partial^\mu h) - V(h) - \frac{f_L^2}{4}\mathrm{Tr}\left(\mathbf{V}_L^\mu \mathbf{V}_{\mu,\,L}\right)\left(1 + \frac{h}{f_L}\right)^2$$

$$\mathscr{L}_{0,R} = -\frac{1}{4} W^a_{\mu\nu,\,R} W^{\mu\nu,\,a}_R - \frac{f_R^2}{4}\mathrm{Tr}\left(\mathbf{V}_R^\mu \mathbf{V}_{\mu,\,R}\right)\left(1 + \frac{h}{f_L}\right)^2 ,$$

$$\mathscr{L}_{0,LR} = -\frac{1}{2}\mathrm{Tr}\left(\widetilde{W}_L^{\mu\nu} \widetilde{W}_{\mu\nu,\,R}\right) - \frac{f_L f_R}{2}\mathrm{Tr}\left(\widetilde{\mathbf{V}}_L^\mu \widetilde{\mathbf{V}}_{\mu,\,R}\right)\left(1 + \frac{h}{f_L}\right)^2 ,$$

- Mixing effects sourced by $\mathscr{L}_{0,LR}$
- $V_\chi V_\chi h$, $V_\chi V_\chi hh$, $V_L V_R h$, $V_L V_R hh$ couplings

CP-conserving part: $\Delta\mathscr{L}_{\rm CP} = \Delta\mathscr{L}_{{\rm CP},L} + \Delta\mathscr{L}_{{\rm CP},R}$

$$\Delta\mathscr{L}_{{\rm CP},L} = c_G\mathcal{P}_G(h) + c_B\mathcal{P}_B(h) + \sum_{i=\{W,C,T\}} c_{i,L}\mathcal{P}_{i,L}(h) + \sum_{i=1}^{26} c_{i,L}\mathcal{P}_{i,L}(h) + \ldots$$

$$\Delta\mathscr{L}_{{\rm CP},R} = \sum_{i=\{W,C,T\}} c_{i,R}\mathcal{P}_{i,R}(h) + \sum_{i=1}^{26} c_{i,R}\mathcal{P}_{i,R}(h)$$

$$\mathcal{P}_G = -\frac{g_s^2}{4}\, G^a_{\mu\nu}\, G^{\mu\nu}_a\, \mathcal{F}_G$$

$$\mathcal{P}_B = -\frac{g'^2}{4}\, B_{\mu\nu}\, B^{\mu\nu}\, \mathcal{F}_B$$

$$\mathcal{P}_{W,\chi} = -\frac{g_\chi^2}{4}\, W^a_{\mu\nu,\chi}\, W^{\mu\nu,a}_\chi\, \mathcal{F}_{W,\chi}$$

$$\mathcal{P}_{C,\chi} = -\frac{f_\chi^2}{4}\,\mathrm{Tr}\left(\mathbf{V}^\mu_\chi\,\mathbf{V}_{\mu,\chi}\right)\mathcal{F}_{C,\chi}$$

$$\mathcal{P}_{T,\chi} = \frac{f_\chi^2}{4}\left(\mathrm{Tr}\left(\mathbf{T}_\chi\,\mathbf{V}^\mu_\chi\right)\right)^2\mathcal{F}_{T,\chi}$$

* $\mathcal{F}_i(h) \equiv 1 + 2\,a_i\,\frac{h}{f_L} + b_i\,\frac{h^2}{f_L^2} + \ldots$

* $\mathcal{P}_{i,L}(h)$:
  Alonso, Gavela, Merlo, Rigolin & JY, PLB **722** (2013) 330

* $\mathcal{P}_{i,R}(h)$ from $\mathcal{P}_{i,L}(h)$

COMPLETE CP-PRESERVING BASIS $\mathcal{P}_{i,\,\chi}(h)$

$$\mathcal{P}_{1,\,\chi} = g_\chi\, g'\, B_{\mu\nu}\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, W_\chi^{\mu\nu}\Big)\, \mathcal{F}_{1,\,\chi}\,,$$

$$\mathcal{P}_{2,\,\chi} = i\, g'\, B_{\mu\nu}\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, \big[\mathbf{V}_\chi^\mu, \mathbf{V}_\chi^\nu\big]\Big)\, \mathcal{F}_{2,\,\chi}\,,$$

$$\mathcal{P}_{3,\,\chi} = i\, g_\chi\, \mathrm{Tr}\Big(W_\chi^{\mu\nu}\, \big[\mathbf{V}_{\mu,\,\chi}, \mathbf{V}_{\nu,\,\chi}\big]\Big)\, \mathcal{F}_{3,\,\chi}\,,$$

$$\mathcal{P}_{4} = i\, g'\, B_{\mu\nu}\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathbf{V}_\chi^\mu\Big)\, \partial^\nu \mathcal{F}_{4}\,,$$

$$\mathcal{P}_{5,\,\chi} = i\, g_\chi\, \mathrm{Tr}\Big(W_\chi^{\mu\nu}\, \mathbf{V}_{\mu,\,\chi}\Big)\, \partial_\nu \mathcal{F}_{5,\,\chi}\,,$$

$$\mathcal{P}_{6,\,\chi} = \Big(\mathrm{Tr}\Big(\mathbf{V}_{\mu,\,\chi}\, \mathbf{V}_\chi^\mu\Big)\Big)^2\, \mathcal{F}_{6,\,\chi}\,,$$

$$\mathcal{P}_{7,\,\chi} = \mathrm{Tr}\Big(\mathbf{V}_{\mu,\,\chi}\, \mathbf{V}_\chi^\mu\Big)\, \partial_\nu \partial^\nu \mathcal{F}_{7,\,\chi}\,,$$

$$\mathcal{P}_{8,\,\chi} = \mathrm{Tr}\Big(\mathbf{V}_\chi^\mu\, \mathbf{V}_\chi^\nu\Big)\, \partial_\mu \mathcal{F}_{8,\,\chi}\, \partial_\nu \mathcal{F}'_{8,\,\chi}\,,$$

$$\mathcal{P}_{9,\,\chi} = \mathrm{Tr}\Big(\big(\mathcal{D}_\mu \mathbf{V}_\chi^\mu\big)^2\Big)\, \mathcal{F}_{9,\,\chi}\,,$$

$$\mathcal{P}_{10,\,\chi} = \mathrm{Tr}\Big(\mathbf{V}_\chi^\nu\, \mathcal{D}_\mu \mathbf{V}_\chi^\mu\Big)\, \partial_\nu \mathcal{F}_{10,\,\chi}\,,$$

$$\mathcal{P}_{11,\,\chi} = \Big(\mathrm{Tr}\Big(\mathbf{V}_\chi^\mu\, \mathbf{V}_\chi^\nu\Big)\Big)^2\, \mathcal{F}_{11,\,\chi}\,,$$

$$\mathcal{P}_{12,\,\chi} = g_\chi^2\, \Big(\mathrm{Tr}\Big(\mathbf{T}_\chi\, W_\chi^{\mu\nu}\Big)\Big)^2\, \mathcal{F}_{12,\,\chi}\,,$$

$$\mathcal{P}_{13,\,\chi} = i\, g_\chi\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, W_\chi^{\mu\nu}\Big)\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, \big[\mathbf{V}_{\mu,\,\chi}, \mathbf{V}_{\nu,\,\chi}\big]\Big)\, \mathcal{F}_{13,\,\chi}\,,$$

$$\mathcal{P}_{14,\,\chi} = g_\chi\, \epsilon_{\mu\nu\rho\sigma}\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathbf{V}_\chi^\mu\Big)\, \mathrm{Tr}\Big(\mathbf{V}_\chi^\nu\, W_\chi^{\rho\sigma}\Big)\, \mathcal{F}_{14,\,\chi}\,,$$

$$\mathcal{P}_{15,\,\chi} = \Big(\mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathcal{D}_\mu \mathbf{V}_\chi^\mu\Big)\Big)^2\, \mathcal{F}_{15,\,\chi}\,,$$

$$\mathcal{P}_{16,\,\chi} = \mathrm{Tr}\Big(\big[\mathbf{T}_\chi, \mathbf{V}_{\nu,\,\chi}\big]\, \mathcal{D}_\mu \mathbf{V}_\chi^\mu\Big)\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathbf{V}_\chi^\nu\Big)\, \mathcal{F}_{16,\,\chi}\,,$$

$$\mathcal{P}_{17,\,\chi} = i\, g_\chi\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, W_\chi^{\mu\nu}\Big)\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathbf{V}_{\mu,\,\chi}\Big)\, \partial_\nu \mathcal{F}_{17,\,\chi}\,,$$

$$\mathcal{P}_{18,\,\chi} = \Big(\mathbf{T}_\chi \big[\mathbf{V}_\chi^\mu, \mathbf{V}_\chi^\nu\big]\Big)\, \Big(\mathbf{T}_\chi\, \mathbf{V}_{\mu,\,\chi}\Big)\, \partial_\nu \mathcal{F}_{18,\,\chi}\,,$$

$$\mathcal{P}_{19,\,\chi} = \mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathcal{D}_\mu \mathbf{V}_\chi^\mu\Big)\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathbf{V}_\chi^\nu\Big)\, \partial_\nu \mathcal{F}_{19,\,\chi}\,,$$

$$\mathcal{P}_{20,\,\chi} = \mathrm{Tr}\Big(\mathbf{V}_{\mu,\,\chi}\, \mathbf{V}_\chi^\mu\Big)\, \partial_\nu \mathcal{F}_{20,\,\chi}\, \partial^\nu \mathcal{F}'_{20,\,\chi}\,,$$

$$\mathcal{P}_{21,\,\chi} = \Big(\Big(\mathbf{T}_\chi\, \mathbf{V}_\chi^\mu\Big)\Big)^2\, \partial_\nu \mathcal{F}_{21,\,\chi}\, \partial^\nu \mathcal{F}'_{21}\,,$$

$$\mathcal{P}_{22,\,\chi} = \Big(\Big(\mathbf{T}_\chi\, \mathbf{V}_\chi^\mu\Big)\, \partial_\mu \mathcal{F}_{22,\,\chi}\Big)^2\,,$$

$$\mathcal{P}_{23,\,\chi} = \mathrm{Tr}\Big(\mathbf{V}_{\mu,\,\chi}\, \mathbf{V}_\chi^\mu\Big)\, \Big(\Big(\mathbf{T}_\chi \mathbf{V}_\chi^\nu\Big)\Big)^2\, \mathcal{F}_{23,\,\chi}\,,$$

$$\mathcal{P}_{24,\,\chi} = \mathrm{Tr}\Big(\mathbf{V}_\chi^\mu\, \mathbf{V}_\chi^\nu\Big)\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathbf{V}_{\mu,\,\chi}\Big)\, \Big(\mathbf{T}_\chi\, \mathbf{V}_{\nu,\,\chi}\Big)\, \mathcal{F}_{24,\,\chi}$$

$$\mathcal{P}_{25,\,\chi} = \Big(\Big(\mathbf{T}_\chi\, \mathbf{V}_\chi^\mu\Big)\Big)^2\, \partial_\nu \partial^\nu \mathcal{F}_{25,\,\chi}\,,$$

$$\mathcal{P}_{26,\,\chi} = \Big(\mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathbf{V}_\chi^\mu\Big)\, \mathrm{Tr}\Big(\mathbf{T}_\chi\, \mathbf{V}_\chi^\nu\Big)\Big)^2\, \mathcal{F}_{26,\,\chi}\,,$$

Alonso, Gavela, Merlo, Rigolin & JY, PLB **722** (2013) 330

All $\mathcal{F}_i \equiv \mathcal{F}_i(h)$

JY, arXiv:1507.03974

CP-conserving left–right mixing: $\Delta\mathscr{L}_{\mathrm{CP},LR}$

$$\Delta\mathscr{L}_{\mathrm{CP},LR} = \sum_{i=\{W,C,T\}} c_{i,LR}\mathcal{P}_{i,LR}(h) \ + \ \sum_{i=2,\, i\neq 4}^{26} c_{i(j),LR}\,\mathcal{P}_{i(j),LR}(h)$$

$$\mathcal{P}_{W,\,LR}(h) \ = -\frac{1}{2}\, g_L\, g_R\, \mathrm{Tr}\left(\widetilde{W}_L^{\mu\nu}\,\widetilde{W}_{\mu\nu,\,R}\right)\,\mathcal{F}_{W,\,LR}(h)\,,$$

$$\mathcal{P}_{C,\,LR}(h) \ = -\frac{1}{2}\, f_L\, f_R\, \mathrm{Tr}\Big(\widetilde{\mathbf{V}}_L^{\mu}\widetilde{\mathbf{V}}_{\mu,\,R}\Big)\,\mathcal{F}_{C,\,LR}(h)\,,$$

$$\mathcal{P}_{T,\,LR}(h) \ = \frac{1}{2}\, f_L\, f_R\, \mathrm{Tr}\Big(\widetilde{\mathbf{T}}_L\,\widetilde{\mathbf{V}}_L^{\mu}\Big)\,\mathrm{Tr}\Big(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_{\mu,\,R}\Big)\mathcal{F}_{T,\,LR}(h)\,,$$

* 75 $\mathcal{P}_{i(j),LR}(h)$ in total: JY, arXiv:1507.03974

* CP-violating counterpart: R. Kunming, J. Shu and JY arXiv:1507.04745

COMPLETE CP-PRESERVING BASIS $\mathcal{P}_{i(j),LR}(h)$

$$\mathcal{P}_{2(1)} = i\,g'\,B_{\mu\nu}\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\left[\widetilde{\mathbf{V}}_L^{\mu},\widetilde{\mathbf{V}}_R^{\nu}\right]\right)\,\mathcal{F}_{2(1)}\,,$$

$$\mathcal{P}_{3(1)} = i\,g_L\,\mathrm{Tr}\left(\widetilde{W}_L^{\mu\nu}\left[\widetilde{\mathbf{V}}_{\mu,\,R},\widetilde{\mathbf{V}}_{\nu,\,R}\right]\right)\,\mathcal{F}_{3(1)}\,,$$

$$\mathcal{P}_{3(2)} = i\,g_R\,\mathrm{Tr}\left(\widetilde{W}_R^{\mu\nu}\left[\widetilde{\mathbf{V}}_{\mu,\,L},\widetilde{\mathbf{V}}_{\nu,\,L}\right]\right)\,\mathcal{F}_{3(2)}\,,$$

$$\mathcal{P}_{3(3)} = i\,g_L\,\mathrm{Tr}\left(\widetilde{W}_L^{\mu\nu}\left[\widetilde{\mathbf{V}}_{\mu,\,L},\widetilde{\mathbf{V}}_{\nu,\,R}\right]\right)\,\mathcal{F}_{3(3)}\,,$$

$$\mathcal{P}_{3(4)} = i\,g_R\,\mathrm{Tr}\left(\widetilde{W}_R^{\mu\nu}\left[\widetilde{\mathbf{V}}_{\mu,\,L},\widetilde{\mathbf{V}}_{\nu,\,R}\right]\right)\,\mathcal{F}_{3(4)}\,,$$

$$\mathcal{P}_{5(1)} = i\,g_L\,\mathrm{Tr}\left(\widetilde{W}_L^{\mu\nu}\,\widetilde{\mathbf{V}}_{\mu,\,R}\right)\,\partial_\nu\mathcal{F}_{5(1)}\,,$$

$$\mathcal{P}_{5(2)} = i\,g_R\,\mathrm{Tr}\left(\widetilde{W}_R^{\mu\nu}\,\widetilde{\mathbf{V}}_{\mu,\,L}\right)\,\partial_\nu\mathcal{F}_{5(2)}\,,$$

$$\mathcal{P}_{6(1)} = \left(\mathrm{Tr}\left(\widetilde{\mathbf{V}}_L^{\mu}\,\widetilde{\mathbf{V}}_{\mu,\,R}\right)\right)^2\mathcal{F}_{6(1)}\,,$$

$$\mathcal{P}_{6(2)} = \mathrm{Tr}\left(\widetilde{\mathbf{V}}_L^{\mu}\,\widetilde{\mathbf{V}}_{\mu,\,L}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{V}}_R^{\nu}\,\widetilde{\mathbf{V}}_{\nu,\,R}\right)\,\mathcal{F}_{6(2)}\,,$$

$$\mathcal{P}_{6(3)} = \mathrm{Tr}\left(\widetilde{\mathbf{V}}_L^{\mu}\,\widetilde{\mathbf{V}}_{\mu,\,L}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{V}}_L^{\nu}\,\widetilde{\mathbf{V}}_{\nu,\,R}\right)\,\mathcal{F}_{6(3)}\,,$$

$$\mathcal{P}_{6(4)} = \mathrm{Tr}\left(\widetilde{\mathbf{V}}_R^{\mu}\,\widetilde{\mathbf{V}}_{\mu,\,R}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{V}}_L^{\nu}\,\widetilde{\mathbf{V}}_{\nu,\,R}\right)\,\mathcal{F}_{6(4)}\,,$$

$$\mathcal{P}_{7(1)} = \mathrm{Tr}\left(\widetilde{\mathbf{V}}_L^{\mu}\,\widetilde{\mathbf{V}}_{\mu,\,R}\right)\,\partial_\nu\partial^\nu\mathcal{F}_{7(1)}\,,$$

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$$\mathcal{P}_{16(3)} = \mathrm{Tr}\left([\widetilde{\mathbf{T}}_L,\widetilde{\mathbf{V}}_L^{\nu}]\,\mathcal{D}_\mu\widetilde{\mathbf{V}}_R^{\mu}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_{\nu,\,R}\right)\,\mathcal{F}_{16(3)}\,,$$

$$\mathcal{P}_{16(4)} = \mathrm{Tr}\left([\widetilde{\mathbf{T}}_R,\widetilde{\mathbf{V}}_R^{\nu}]\,\mathcal{D}_\mu\widetilde{\mathbf{V}}_L^{\mu}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,\widetilde{\mathbf{V}}_{\nu,\,L}\right)\,\mathcal{F}_{16(4)}\,,$$

$$\mathcal{P}_{16(5)} = \mathrm{Tr}\left([\widetilde{\mathbf{T}}_R,\widetilde{\mathbf{V}}_R^{\nu}]\,\mathcal{D}_\mu\widetilde{\mathbf{V}}_L^{\mu}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_{\nu,\,R}\right)\,\mathcal{F}_{16(5)}\,,$$

$$\mathcal{P}_{16(6)} = \mathrm{Tr}\left([\widetilde{\mathbf{T}}_L,\widetilde{\mathbf{V}}_L^{\nu}]\,\mathcal{D}_\mu\widetilde{\mathbf{V}}_R^{\mu}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,\widetilde{\mathbf{V}}_{\nu,\,L}\right)\,\mathcal{F}_{16(6)}\,,$$

$$\mathcal{P}_{17(1)} = i\,g_L\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,\widetilde{W}_L^{\mu\nu}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_{\mu,\,R}\right)\,\partial_\nu\mathcal{F}_{17(1)}\,,$$

$$\mathcal{P}_{17(2)} = i\,g_R\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{W}_R^{\mu\nu}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,\widetilde{\mathbf{V}}_{\mu,\,L}\right)\,\partial_\nu\mathcal{F}_{17(2)}\,,$$

$$\mathcal{P}_{18(1)} = \mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,[\widetilde{\mathbf{V}}_L^{\mu},\widetilde{\mathbf{V}}_L^{\nu}]\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_{\mu,\,R}\right)\,\partial_\nu\mathcal{F}_{18(1)}\,,$$

$$\mathcal{P}_{18(2)} = \mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,[\widetilde{\mathbf{V}}_R^{\mu},\widetilde{\mathbf{V}}_R^{\nu}]\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,\widetilde{\mathbf{V}}_{\mu,\,L}\right)\,\partial_\nu\mathcal{F}_{18(2)}\,,$$

$$\mathcal{P}_{18(3)} = \mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,[\widetilde{\mathbf{V}}_L^{\mu},\widetilde{\mathbf{V}}_R^{\nu}]\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,\widetilde{\mathbf{V}}_{\mu,\,L}\right)\,\partial_\nu\mathcal{F}_{18(3)}\,,$$

$$\mathcal{P}_{18(4)} = \mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,[\widetilde{\mathbf{V}}_L^{\mu},\widetilde{\mathbf{V}}_R^{\nu}]\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_{\nu,\,R}\right)\,\partial_\mu\mathcal{F}_{18(4)}\,,$$

$$\mathcal{P}_{18(5)} = \mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,[\widetilde{\mathbf{V}}_L^{\mu},\widetilde{\mathbf{V}}_R^{\nu}]\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_{\mu,\,R}\right)\,\partial_\nu\mathcal{F}_{18(5)}\,,$$

$$\mathcal{P}_{18(6)} = \mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,[\widetilde{\mathbf{V}}_L^{\mu},\widetilde{\mathbf{V}}_R^{\nu}]\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,\widetilde{\mathbf{V}}_{\nu,\,L}\right)\,\partial_\mu\mathcal{F}_{18(6)}\,,$$

$$\mathcal{P}_{19(1)} = \mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,\mathcal{D}_\mu\widetilde{\mathbf{V}}_L^{\mu}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_R^{\nu}\right)\,\partial_\nu\mathcal{F}_{19(1)}\,,$$

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$$\mathcal{P}_{26(4)} = \mathrm{Tr}\left(\widetilde{\mathbf{T}}_L\,\widetilde{\mathbf{V}}_L^{\mu}\right)\,\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_{\mu,\,R}\right)\,\left(\mathrm{Tr}\left(\widetilde{\mathbf{T}}_R\,\widetilde{\mathbf{V}}_R^{\nu}\right)\right)^2\mathcal{F}_{26(4)}\,,$$

All $\mathcal{F}_i \equiv \mathcal{F}_i(h)$

JY, arXiv:1507.03974

Low energy effects: Decoupling right handed fields

via EOM $\Longrightarrow$ $\mathbf{V}^{\mu}_R \equiv -\frac{f_L}{f_R}\mathbf{V}^{\mu}_L$ @ unitary gauge as

$W^{\pm}_{\mu,\,R} \Rightarrow -\frac{g_L\, f_L}{g_R\, f_R}\, W^{\pm}_{\mu,\,L}$ & $W^3_{\mu,R} \Rightarrow \frac{g'}{g_R}\left(1+\frac{f_L}{f_R}\right) B_\mu - \frac{g_L f_L}{g_R f_R}\, W^3_{\mu,L}$

$\tilde{c}_{i,L}$	$\mathcal{P}_{i,L}$	$\mathcal{P}_{i,R}$	$\mathcal{P}_{i(j),LR}$	i
$\tilde{c}_{i,L}$	$c_{i,L}$	$c_{W,R} - 4c_{1,R} - 4c_{12,R} + \frac{f_L^2\left(c_{W,R}-4c_{12,R}\right)}{f_R^2} + \frac{f_L\left(2c_{W,R}-4c_{1,R}-8c_{12,R}\right)}{f_R}$	$-$	B
$\tilde{c}_{i,L}$	$c_{i,L}$	$\frac{f_L^2}{f_R^2}\, c_{i,R}$	$-\frac{f_L}{f_R}\, c_{i,LR}$	W
$\tilde{c}_{i,L}$	$c_{i,L}$	$c_{i,R}$	$\left\{-2\,\bar{c}_{C,LR},\, -2\,c_{T,LR}\right\}$	$\{C,\ T\}$
$\tilde{c}_{i,L}$	$c_{i,L}$	$\frac{f_L\left(-2c_{i,R}+c_{W,R}-4c_{12,R}\right)}{2f_R} + \frac{f_L^2\left(c_{W,R}-4c_{12,R}\right)}{2f_R^2}$	$\frac{f_L\left(4c_{12(1)}-c_{W,LR}\right)}{4f_R} + \frac{1}{4}\left(4c_{12(1)} - c_{W,LR}\right)$	1
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
$\tilde{c}_{i,L}$	$c_{i,L}$	$\frac{f_L^4}{f_R^4}\, c_{i,R}$	$\frac{f_L^2\left(c_{i(1)}+c_{i(2)}\right)}{f_R^2} - \frac{f_L}{f_R}\, c_{i(3)} - \frac{f_L^3}{f_R^3}\, c_{i(4)}$	6, 26

$\tilde{c}_{i,L}$ (1st column):

$c_{i,L}$ from $\mathcal{P}_{i,L}$ (2nd col) $+$ contribution from $\mathcal{P}_{i,R}$ (3rd col) $+$ combination from $\mathcal{P}_{i(j),LR}$ (4th col)

For $f_L \ll f_R \Rightarrow \{\mathcal{P}_B,\ \mathcal{P}_{C,L},\ \mathcal{P}_{T,L},\ \mathcal{P}_{1,L},\ \mathcal{P}_{2,L},\ \mathcal{P}_{4,L}\}$ sensitive to the R or the LR mixing ops.

In progress...

Low energy effects: S and T parameters

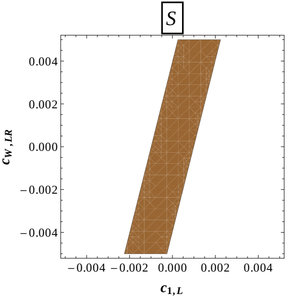
$$\Delta S = 2\, s_{2w}\, \bar{\alpha}_{WB} - 8\, e^2\, \tilde{c}_{1,L} \qquad \& \qquad \Delta T = 2\, \tilde{c}_{T,L}$$

- Effects by decoupling the right handed gauge fields
- Combined effects: non-linear operators + decoupling (via $\tilde{c}$)

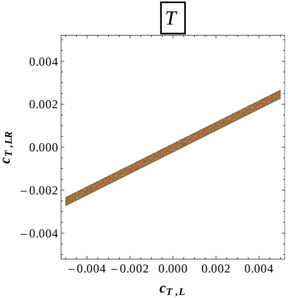
$$\Downarrow$$

$$\Delta S = -8\, e^2 \left(c_{1,L} - \frac{1}{4}\, c_{W,LR} + c_{12(1)} \right)$$

$$\Delta T = 2\, \left(c_{T,L} + c_{T,R} - 2 c_{T,LR} \right)$$



$\{c_{1,L},\ c_{W,LR},\ c_{12(1)}\} \sim 10^{-3}$



$\{c_{T,L},\ c_{T,R},\ c_{T,LR}\} \sim 10^{-3}$

In progress...

Low energy effects: TGC

$$\frac{\mathcal{L}_{\text{TGV}}}{g_{WWV}} = i\Big\{ g_1^V \left(W^+_{\mu\nu} W^{-\,\mu} V^\nu - W^+_\mu V_\nu W^{-\,\mu\nu} \right) + \kappa_V W^+_\mu W^-_\nu V^{\mu\nu} + \frac{ig}{m_W^2} \lambda_V V^{\mu\nu} W^{-\rho}_\mu W^+_{\rho\nu} +$$

$$- i g_5^V \epsilon^{\mu\nu\rho\sigma} \left(W^+_\mu \partial_\rho W^-_\nu - W^-_\nu \partial_\rho W^+_\mu \right) V_\sigma + g_6^V \left(\partial_\mu W^{+\mu} W^{-\nu} - \partial_\mu W^{-\mu} W^{+\nu} \right) V_\nu \Big\}$$

TGC	SM	Decoupling	Decoupling + Operators
g_1^Z	1	$-\frac{2s_W^4}{c_{2W}s_{2W}}\bar{\alpha}_{WB}$	$\frac{1}{2c_{2W}}\left(\tilde{c}_{T,L} - 4e^2\left(\tilde{c}_{12,L} - \frac{s_W^2\tilde{c}_{1,L}}{c_W^2}\right)\right) - \frac{4e^2\tilde{c}_{3,L}}{s_{2W}^2}$
κ_γ	1	$\frac{c_W}{s_W}\bar{\alpha}_{WB}$	$-\frac{e^2}{s_W^2}\left(2\tilde{c}_{1,L} + 2\tilde{c}_{2,L} + \tilde{c}_{3,L} + 4\tilde{c}_{12,L} + 2\tilde{c}_{13,L}\right)$
κ_Z	1	$-\frac{s_{2W}}{2c_{2W}}\bar{\alpha}_{WB}$	$\frac{1}{2}\left(2e^2\left(-\frac{\left(\frac{1}{c_{2W}}+3\right)\tilde{c}_{12,L}+\tilde{c}_{3,L}+2\tilde{c}_{13,L}}{s_W^2} + \frac{2\tilde{c}_{1,L}}{c_{2W}} + \frac{2\tilde{c}_{2,L}}{c_W^2}\right) + \frac{\tilde{c}_{T,L}}{c_{2W}}\right)$
g_5^Z	–	–	$-\frac{4e^2}{s_{2W}^2}\tilde{c}_{14,L}$
g_6^γ	–	–	$\frac{e^2}{s_W^2}\tilde{c}_{9,L}$
g_6^Z	–	–	$\frac{e^2}{c_W^2 s_W^2}\left(\tilde{c}_{16,L} - \frac{2c_W s_W^3\tilde{c}_{9,L}}{s_{2W}}\right)$

Ongoing...

Low energy effects: QGC

$$\mathscr{L}_{\rm QGV} = g^2\Big\{g^{(1)}_{WWWW}\, W^\dagger_\mu\, W^{\mu\dagger}\, W^\nu\, W_\nu \;-\; g^{(2)}_{WWWW}\,\left(W^\dagger_\mu\, W^\mu\right)^2 \;+\; g_{ZZZZ}\,\left(Z^\mu\, Z_\mu\right)^2 \;+$$

$$-\; g^{(1)}_{VVWW}\, V^\mu\, V_\mu\, W^\dagger_\nu\, W^\nu \;+\; g^{(2)}_{VVWW}\, V^\mu\, V_\nu\, W^\dagger_\mu\, W^\nu \;-\; g^{(1)}_{\gamma WWZ}\, A^\mu\, Z_\mu\, W^\dagger_\nu\, W^\nu \;+$$

$$+\;\left(g^{(2)}_{\gamma WWZ}\, A^\mu\, Z_\nu\, W^\dagger_\mu\, W^\nu \;+\; \text{h.c.}\right) \;+\; i\, g^{(3)}_{\gamma WWZ}\,{}^{\mu\nu\rho\sigma}\, W^+_\mu\, W^-_\nu\, A_\rho\, Z_\sigma\Big\}$$

QGC	SM	Decoupling	Decoupling + Operators
$g^{(1)}_{WWWW}$	$\frac{1}{2}$	$-\frac{c_W s_W^3}{c_{2W}}\,\bar{\alpha}_{WB}$	$\frac{4e^2\left(4s_W^4\tilde{c}_{1,L}+c_{2W}\left(\left(c_{2W}-8\right)\tilde{c}_{12,L}-2\tilde{c}_{3,L}+\tilde{c}_{11,L}-4\tilde{c}_{13,L}\right)-\tilde{c}_{12,L}\right)+s_{2W}^2\,\tilde{c}_{T,L}}{8c_{2W}s_W^2}$
$g^{(2)}_{WWWW}$	$\frac{1}{2}$	$-\frac{c_W s_W^3}{c_{2W}}\,\bar{\alpha}_{WB}$	$\frac{32e^2 s_W^4\tilde{c}_{1,L}+\left(c_{4W}-1\right)\left(4e^2\tilde{c}_{12,L}-\tilde{c}_{T,L}\right)-8e^2 c_{2W}\left(2\tilde{c}_{3,L}+2\tilde{c}_{6,L}+\tilde{c}_{11,L}+8\tilde{c}_{12,L}+4\tilde{c}_{13,L}\right)}{16c_{2W}s_W^2}$
g_{ZZZZ}	–	–	$\frac{e^2}{4c_W^4 s_W^2}\left(\tilde{c}_{6,L}+\tilde{c}_{11,L}+2\left(\tilde{c}_{23,L}+\tilde{c}_{24,L}+2\tilde{c}_{26,L}\right)\right)$
$\vdots$	$\vdots$	$\vdots$	$\vdots$
$g^{(2)}_{\gamma WWZ}$	$\frac{1}{2}s_{2W}$	$-\frac{\left(c_{4W}+3\right)s_W^2}{4c_{2W}}\,\bar{\alpha}_{WB}$	$\frac{1}{2c_{2W}}\left(e^2\left(-\frac{4c_{2W}\tilde{c}_{3,L}}{s_{2W}}-\frac{c_W\left(\left(c_{4W}+3\right)\tilde{c}_{12,L}+2\tilde{c}_{16,L}\right)}{s_W}+\right.\right.$ $\left.\left.+\frac{s_W\left(\left(c_{4W}+3\right)\tilde{c}_{1,L}+2\left(c_{2W}\tilde{c}_{9,L}+\tilde{c}_{16,L}\right)\right)}{c_W}\right)+2c_W^3 s_W\tilde{c}_{T,L}\right)$
$g^{(3)}_{\gamma WWZ}$	–	–	$-\frac{2e^2\tilde{c}_{14,L}}{s_{2W}}$

1-loop effects from $\{\mathcal{P}_{6,L},\mathcal{P}_{11,L},\mathcal{P}_{23,L},\mathcal{P}_{24,L},\mathcal{P}_{26,L}\}$ to the EWPT parameters $\Rightarrow \tilde{c}_{i,L}\sim 10^{-3}-10^{-1}$

Ongoing...

Low energy effects: Triple gauge-h couplings

$$\mathscr{L}_{hVV} = \frac{1}{v}\Big\{g^{(2)}_{hhh}\, h\,\partial_\mu h\,\partial^\mu h + g_{\gamma\gamma h} F_{\mu\nu}F^{\mu\nu} h + g^{(1)}_{hZZ} Z_{\mu\nu}Z^{\mu\nu} h + g^{(1)}_{\gamma hZ} F_{\mu\nu}Z^{\mu\nu} h + g^{(1)}_{hWW} W^\dagger_{\mu\nu}W^{\mu\nu} h +$$

$$+ g^{(2)}_{hZZ} Z_\mu\, Z^{\mu\nu}\,\partial_\nu h + g^{(2)}_{\gamma hZ} Z_\mu\, F^{\mu\nu}\,\partial_\nu h + \left(g^{(2)}_{hWW} W^\mu\, W^\dagger_{\mu\nu}\,\partial^\nu h + \mathrm{h.c.}\right) +$$

$$+ g^{(3)}_{hZZ}\,\partial^\mu Z_\mu\, Z^\nu\,\partial_\nu h + g^{(4)}_{hZZ}\,\partial^\mu Z_\mu\,\partial^\nu Z_\nu\, h + \left(g^{(3)}_{hWW}\,\partial^\mu W^\dagger_\mu\, W^\nu\,\partial_\nu h + \mathrm{h.c.}\right) + g^{(4)}_{hWW}\,\partial^\mu W^\dagger_\mu\,\partial_\nu W^\nu\, h +$$

$$+ g^{(5)}_{hWW}\, W^\dagger_\mu W^\mu h + g^{(6)}_{hWW}\, W^\dagger_\mu\, W^\mu\,\Box h + g^{(5)}_{hZZ}\, Z_\mu Z^\mu h + g^{(6)}_{hZZ}\, Z_\mu Z^\mu\,\Box h\Big\}\,.$$

TGC-h	SM	Decoupling	Decoupling + Operators
$g^{(1)}_{\gamma\gamma h}$	–	–	$-\frac{1}{2}e^2\xi\left(a_{W,L} - 4\left(a_{1,L} + a_{12,L}\right) + a_B\right)$
$g^{(1)}_{hZZ}$	–	–	$-\frac{1}{2}e^2\left(\frac{c_w^2\left(a_{W,L}-4a_{12,L}\right)}{s_w^2} + 4a_{1,L} + \frac{a_B s_w^2}{c_w^2}\right)$
⋮	⋮	⋮	⋮
$g^{(5)}_{hWW}$	$-\frac{4e^2c_w^2f_L^2\left(\bar{c}_{C,\mathrm{LR}}-1\right)}{s_{2w}^2}$	$-\frac{4e^2c_w^2f_L^2}{s_{2w}^2}\,\bar{\alpha}_W$	$-\frac{2e^2c_w^2f_L^2}{s_w^2s_{2w}^2}\left(s_w^2\left(c_H - a_{C,L}\tilde{c}_{C,L}\right) + 2e^2\tilde{c}_{W,L}\right)$
$g^{(6)}_{hZZ}$	–	–	$-\frac{4e^2}{s_{2w}^2}\left(a_{7,L} + 2a_{25,L}\right)$

Ongoing...

SUMMARY

* EW-h interactions analyzed in a LR non-linear chiral approach
* Complete linearly independent basis of effective non-linear operators has been constructed for LR symmetric models.
* Generic UV completion for the low energy non-linear treatments.
* Low energy effects from the right handed gauge field sector: EWPT parameters, TGC, QGC and gauge boson pair-Higgs couplings.

PERSPECTIVES

* 1-loop effects from $\{\mathcal{P}_{6,L}, \mathcal{P}_{11,L}, \mathcal{P}_{23,L}, \mathcal{P}_{24,L}, \mathcal{P}_{26,L}\}$ to the EWPT parameters $\Rightarrow$ $\tilde{c}_{i,L} \sim 10^{-3} - 10^{-1}$
* Bounds on $\not{CP}$ non-linear operator coefficients, mainly from anomalous triple vertices, can be established (ongoing..)
* Present and future potential of LHC to measure anomalous $\not{CP}$ TGVs will be estimated, via the dependence on kinematic variables that traces the energy behaviour produced in the cross sections by the anomalous TGVs (ongoing...)

Thanks