The Non-Linear Realization for a Composite Higgs

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work in collaboration with I. Brivio, M.B. Gavela, L. Merlo and S. Rigolin

Nature-approved QFT principles
or:
Where do (light) bosons come from?

I Gauge Principle

Photon, Gluons (massless vector bosons)

II Nambu-Goldstone Theorem

Pions, Kaons (massless* scalars)

Nature-approved QFT principles
or:
Where do (light) bosons come from?

I Gauge Principle

Photon, Gluons (massless vector bosons)

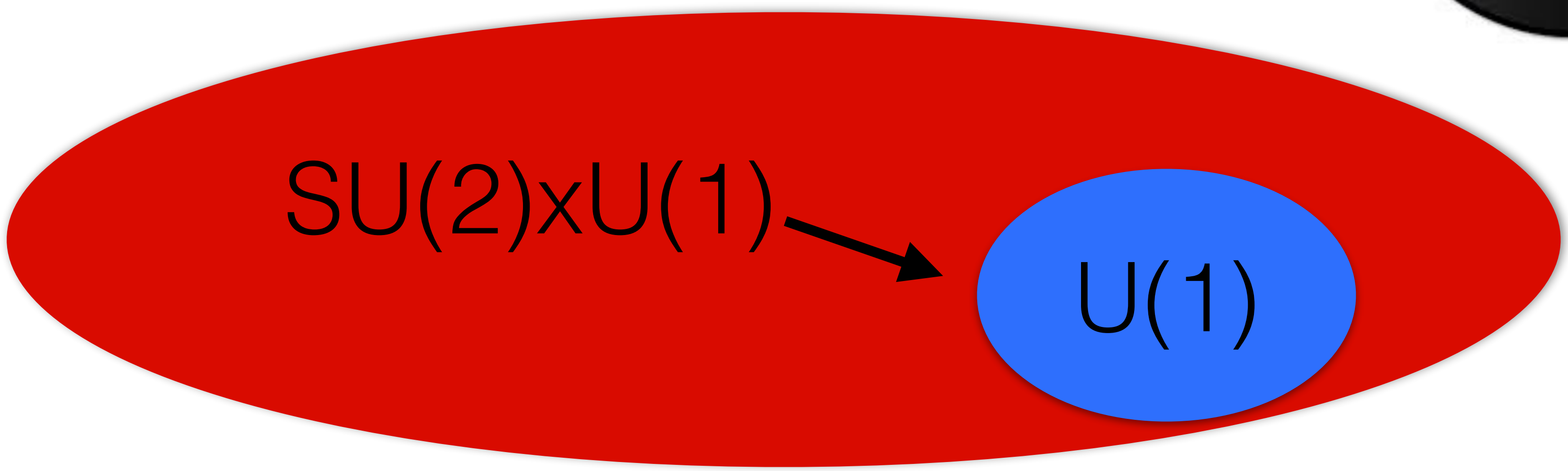
II Nambu-Goldstone Theorem

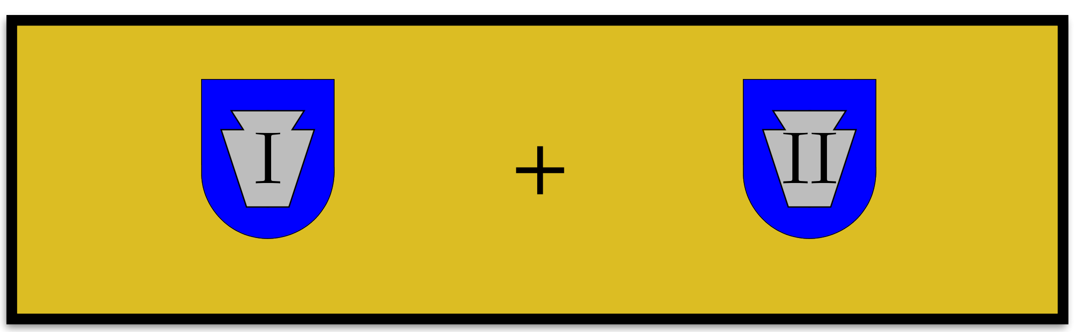
we´ll stay lorentz invariant
(see Murayama´s talk otherwise)

Pions, Kaons (massless* scalars)

Real life example:

Electroweak Gauge Group





Massless + Massless = Massive

3 Goldstone Bosons Eaten by W,Z

Building Lagrangians for Golstones

[à la Callan, Coleman, Wess & Zumino]

$$\boxed{\mathcal{G} \to \mathcal{H}}$$

$$\mathcal{G} = \mathcal{H} \oplus \mathcal{G}/\mathcal{H}$$

Generators: $\{T\}\,,\ \{X\}$

NG Bosons live in the broken group $\mathcal{G}/\mathcal{H}$:

$$\Omega(x) = e^{i\,\Xi(x)^a X_a/f}$$

and transform according to the group composition law

general element of the whole group

$$\Omega \to \mathfrak{g}\,\Omega = \mathfrak{b}\,\mathfrak{h}\,\Omega\,\mathfrak{h}^{-1}\,\mathfrak{h} \equiv \Omega'\,\mathfrak{h}'$$

transformation in the broken piece

transformation in the unbroken subgroup

$$\Omega'(x) = \mathfrak{g}\,\Omega(x)\,\mathfrak{h}^{-1}$$

Building Lagrangians for Golstones

If, on top, the coset is symmetric, i.e.

Grading: $\mathcal{R}: \begin{cases} T_a \to +T_a \\ X_{\hat{a}} \to -X_{\hat{a}} \end{cases}$

$$\mathbf{\Sigma}(x) \equiv \Omega(x)^2 \,,$$

trade omega for sigma

$$\mathbf{\Sigma}'(x) = \mathfrak{g}\,\mathbf{\Sigma}(x)\,\mathfrak{g}_{\mathcal{R}}^{-1}$$

Lagrangian:

$$\mathcal{L} = \frac{f^2}{4}\mathrm{Tr}\left(D_\mu \mathbf{\Sigma}\, D^\mu \mathbf{\Sigma}^\dagger\right) + \mathcal{L}^{(p^4)} + \ldots$$

The expansion is in momentum!

$$\frac{E}{f}$$

Electroweak NG bosons

$$\mathcal{G} = SU(2)_L \times U(1)_Y \quad \mathcal{H} = U(1)_{em}$$

$$\mathbf{U}(x) = e^{i\pi^a(x)\sigma_a/v}$$

$$\mathbf{U}(x) \to L\,\mathbf{U}(x)R^\dagger\,,$$ custodial SU(2)xSU(2)

$$D_\mu \mathbf{U} \equiv \partial_\mu \mathbf{U} + \frac{ig}{2} W_\mu^a\,\sigma_a \mathbf{U} - \frac{ig'}{2} B_\mu(x)\mathbf{U}\sigma_3\,,$$

$$\mathbf{T}(x) \equiv \mathbf{U}(x)\sigma_3\mathbf{U}^\dagger(x)\,,$$ Singlets U(1)**!!**

$$\mathbf{V}_\mu(x) \equiv (\mathbf{D}_\mu \mathbf{U}(x))\,\mathbf{U}^\dagger(x)\,,$$ Triplets SU(2)

Electroweak NG bosons

$$\mathcal{G} = SU(2)_L \times U(1)_Y \quad \mathcal{H} = U(1)_{em}$$

Lagrangian:

$$\mathcal{L} = -\frac{v^2}{4}\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{V}^\mu\right) + c_T \frac{v^2}{4}\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{T}\right)\mathrm{Tr}\left(\mathbf{V}^\mu \mathbf{T}\right) + \mathcal{L}^{(p^4)} + \cdots$$

$$= \frac{g^2 v^2}{4}\left(W^+_\mu W^\mu_- + \left(\frac{1}{2c_W^2} - \frac{c_T}{c_W^2}\right) Z^\mu Z_\mu\right) + \ldots$$

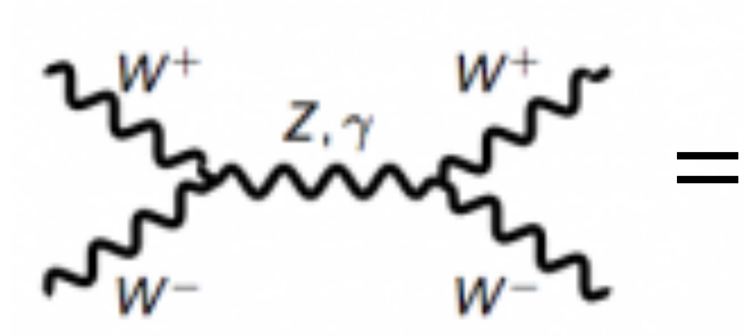
$$\mathcal{L}^{(p^4)} \longrightarrow$$

Appelquist Longhitano Feruglio Basis

$$(\mathrm{Tr}(\mathbf{V}_\mu \mathbf{V}_\nu))^2 \;,\; (\mathrm{Tr}(\mathbf{V}_\mu \mathbf{V}^\mu))^2 \;\ldots$$

…One Serius Problem

Exploding cross sections



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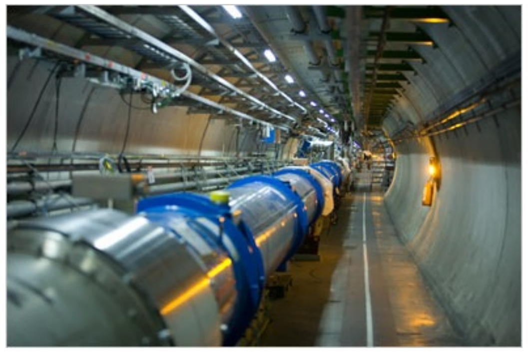
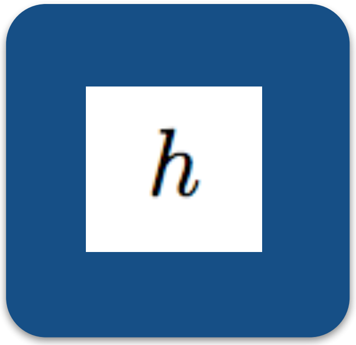
Add some particle to paliate non-unitarity



→ maybe scalar singlet?



Chiral Higgs Lagrangian:

$$\mathcal{L} = \frac{1}{2}\partial_\mu h \partial^\mu h - \frac{v^2}{4}\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{V}^\mu\right)\mathcal{F}\left(\frac{h}{v}\right) + \cdots$$

Chiral Higgs Lagrangian:

O(p^4): Gauge-Scalar Basis

{R.A., Gavela, Merlo, Rigolin, Yepes}

$$\mathcal{P}_W = -\frac{1}{2}\mathrm{Tr}(\mathbf{W}_{\mu\nu}\mathbf{W}^{\mu\nu})\,\mathcal{F}_W(h) \qquad \mathcal{P}_B = -\frac{1}{4}B_{\mu\nu}B^{\mu\nu}\,\mathcal{F}_B(h)$$

$$\mathcal{P}_1 = gg' B_{\mu\nu}\mathrm{Tr}(\mathbf{T}\mathbf{W}^{\mu\nu}) \qquad \mathcal{P}_{14} = g\epsilon_{\mu\nu\rho\lambda}\mathrm{Tr}(\mathbf{T}\mathbf{V}^\mu)\mathrm{Tr}(\mathbf{V}^\nu\mathbf{W}^{\rho\lambda})$$

$$\mathcal{P}_2 = ig' B_{\mu\nu}\mathrm{Tr}(\mathbf{T}[\mathbf{V}^\mu,\mathbf{V}^\nu]) \qquad \mathcal{P}_{15} = \mathrm{Tr}(\mathbf{T}\mathcal{D}_\mu\mathbf{V}^\mu)\mathrm{Tr}(\mathbf{T}\mathcal{D}_\nu\mathbf{V}^\nu)$$

$$\mathcal{P}_3 = ig\mathrm{Tr}(\mathbf{W}_{\mu\nu}[\mathbf{V}^\mu,\mathbf{V}^\nu]) \qquad \mathcal{P}_{16} = \mathrm{Tr}([\mathbf{T},\mathbf{V}_\nu]\mathcal{D}_\mu\mathbf{V}^\mu)\mathrm{Tr}(\mathbf{T}\mathbf{V}^\nu)$$

$$\mathcal{P}_4 = ig' B_{\mu\nu}\mathrm{Tr}(\mathbf{T}\mathbf{V}^\mu)\partial^\nu(h/v) \qquad \mathcal{P}_{17} = ig\mathrm{Tr}(\mathbf{T}\mathbf{W}_{\mu\nu})\mathrm{Tr}(\mathbf{T}\mathbf{V}^\mu)\partial^\nu(h/v)$$

$$\vdots \qquad \vdots$$

$$\ldots \quad \mathcal{P}_{26} = (\mathrm{Tr}(\mathbf{T}\mathbf{V}_\mu)\mathrm{Tr}(\mathbf{T}\mathbf{V}_\nu))^2\,.$$

O(p^4): Higgs-Derivatives Basis

$$\mathcal{P}_{\Box H} = \frac{1}{v^2}(\partial_\mu\partial^\mu h)^2\,, \qquad \mathcal{P}_{\Delta H} = \frac{1}{v^3}(\partial_\mu h)^2\,\Box h\,,$$

$$\mathcal{P}_{DH} = \frac{1}{v^4}((\partial_\mu h)(\partial^\mu h))^2\,.$$

Total of 31

Note the minimal # of assumptions

Chiral Higgs Lagrangian:

O(p^4): Gauge-Scalar Basis

$$\mathcal{P}_W = -\frac{1}{2}\mathrm{Tr}(\mathbf{W}_{\mu\nu}\mathbf{W}^{\mu\nu})\,\mathcal{F}_W(h) \qquad \mathcal{P}_B = -\frac{1}{4}B_{\mu\nu}B^{\mu\nu}\,\mathcal{F}_B(h)$$

$$\mathcal{P}_1 = gg' B_{\mu\nu}\mathrm{Tr}(\mathbf{T}\mathbf{W}^{\mu\nu}) \qquad \mathcal{P}_{14} = g\epsilon_{\mu\nu\rho\lambda}\mathrm{Tr}(\mathbf{T}\mathbf{V}^{\mu})\mathrm{Tr}(\mathbf{V}^{\nu}\mathbf{W}^{\rho\lambda})$$

$\mathcal{P}_2 = ig'B_{\mu\nu}$ … $\mathbf{V}^{\nu})$

$\mathcal{P}_3 = ig\mathrm{Tr}($ … $(\mathbf{T}\mathbf{V}^{\nu})$

$\mathcal{P}_4 = ig'B_{\mu\nu}$ …

… $))^2\,.$

For the pheno see Brivio´s talk

{Brivio, Corbett, Éboli, Gavela, Gonzalez-Fraile, Gonzalez-Garcia, Merlo, Rigolin,}

CP odd operators

{Gavela, Gonzalez-Fraile, Gonzalez-Garcia, Merlo, Rigolin, Yepes}

Completeness check 1 loop

{Gavela, Kanshin, Machado, Saa}

NLO estimate and fermions

{Buchalla, Cata, Krause}

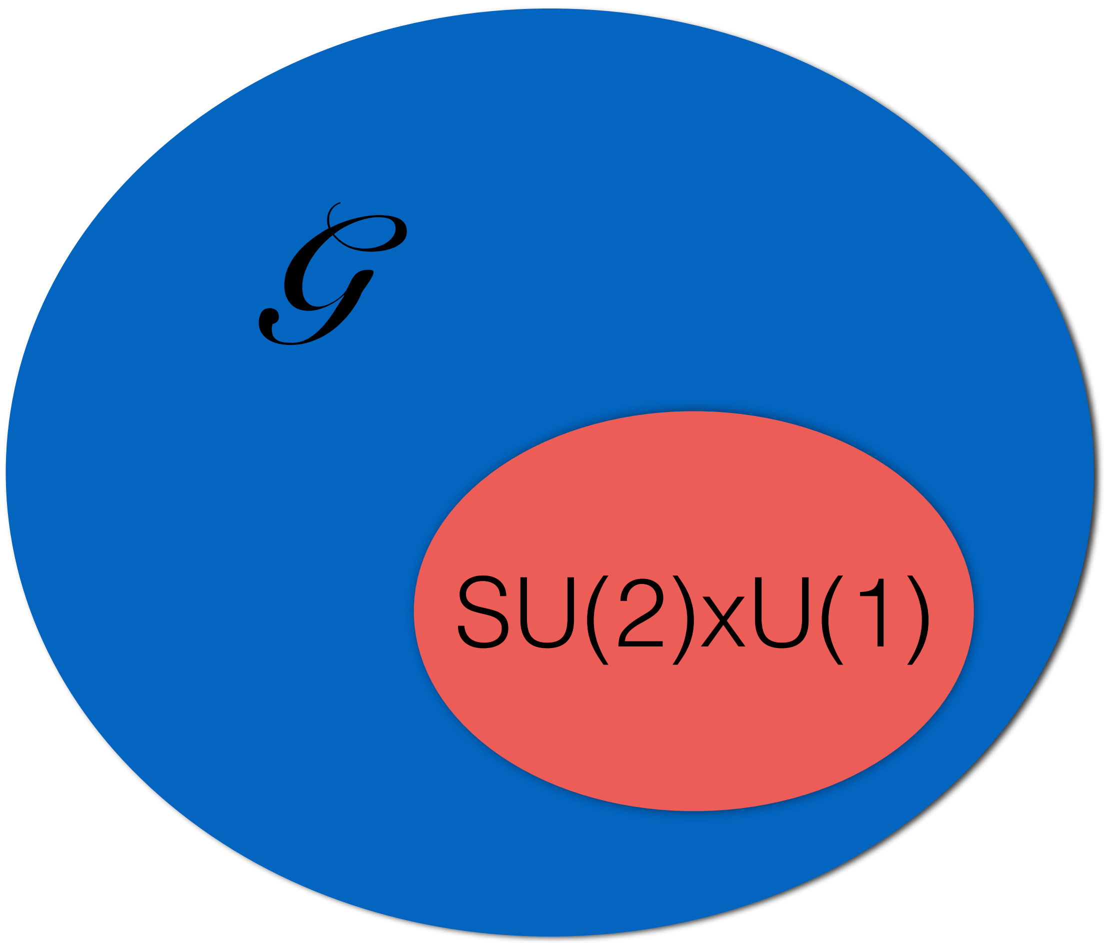
$$\mathcal{P}_{\Box H} = \frac{1}{v^2}(\partial_\mu\partial^\mu h)^2\,, \qquad \mathcal{P}_{\Delta H} = \frac{1}{v^3}(\partial_\mu h)^2\,\Box h\,,$$

$$\mathcal{P}_{DH} = \frac{1}{v^4}((\partial_\mu h)(\partial^\mu h))^2\,.$$

Total of 31

But where does the Higgs singlet come from?

Use Goldstone theorem again



and assume the 4 scalar d.o.f. come in a ***SU(2)-doublet***

this scenario decouples $\quad \xi = \frac{v^2}{f^2}$

We already know how to build the Lagrangian for these models...

dim $\mathcal{G}/\mathcal{H}$ be at least 4

$$\mathbf{\Sigma}(x) \equiv \Omega(x)^2 \,,$$

$$\widetilde{\mathbf{V}}_\mu = (\partial_\mu \mathbf{\Sigma})\, \mathbf{\Sigma}^{-1} \,,$$

in $\mathcal{L}^{(p^2)}$ only one term

$$-\frac{f^2}{4} \mathrm{Tr}\left(\widetilde{\mathbf{V}}_\mu \widetilde{\mathbf{V}}^\mu\right) \,,$$

in $\mathcal{L}^{(p^4)}$ ten...

$$\widetilde{\mathcal{A}}_{B\Sigma} = g'^2 \mathrm{Tr}\left(\mathbf{\Sigma}\widetilde{\mathbf{B}}_{\mu\nu}\mathbf{\Sigma}^{-1}\widetilde{\mathbf{B}}^{\mu\nu}\right) ,$$
$$\widetilde{\mathcal{A}}_{W\Sigma} = g^2 \mathrm{Tr}\left(\mathbf{\Sigma}\widetilde{\mathbf{W}}_{\mu\nu}\mathbf{\Sigma}^{-1}\widetilde{\mathbf{W}}^{\mu\nu}\right) ,$$
$$\widetilde{\mathcal{A}}_1 = g\, g'\, \mathrm{Tr}\left(\mathbf{\Sigma}\widetilde{\mathbf{B}}_{\mu\nu}\mathbf{\Sigma}^{-1}\widetilde{\mathbf{W}}^{\mu\nu}\right) ,$$
$$\widetilde{\mathcal{A}}_2 = i\, g'\, \mathrm{Tr}\left(\widetilde{\mathbf{B}}_{\mu\nu}\left[\widetilde{\mathbf{V}}^{\mu}, \widetilde{\mathbf{V}}^{\nu}\right]\right) ,$$

$$\widetilde{\mathcal{A}}_3 = i\, g\, \mathrm{Tr}\left(\widetilde{\mathbf{W}}_{\mu\nu}\left[\widetilde{\mathbf{V}}^{\mu}, \widetilde{\mathbf{V}}^{\nu}\right]\right) ,$$
$$\widetilde{\mathcal{A}}_4 = \mathrm{Tr}\left(\widetilde{\mathbf{V}}_{\mu}\widetilde{\mathbf{V}}^{\mu}\right)\mathrm{Tr}\left(\widetilde{\mathbf{V}}_{\mu}\widetilde{\mathbf{V}}^{\mu}\right) ,$$
$$\widetilde{\mathcal{A}}_5 = \mathrm{Tr}\left(\widetilde{\mathbf{V}}_{\mu}\widetilde{\mathbf{V}}_{\nu}\right)\mathrm{Tr}\left(\widetilde{\mathbf{V}}^{\mu}\widetilde{\mathbf{V}}^{\nu}\right) ,$$
$$\widetilde{\mathcal{A}}_6 = \mathrm{Tr}\left((\mathcal{D}_{\mu}\widetilde{\mathbf{V}}^{\mu})^2\right) ,$$
$$\widetilde{\mathcal{A}}_7 = \mathrm{Tr}\left(\widetilde{\mathbf{V}}_{\mu}\widetilde{\mathbf{V}}^{\mu}\widetilde{\mathbf{V}}_{\nu}\widetilde{\mathbf{V}}^{\nu}\right) ,$$
$$\widetilde{\mathcal{A}}_8 = \mathrm{Tr}\left(\widetilde{\mathbf{V}}_{\mu}\widetilde{\mathbf{V}}_{\nu}\widetilde{\mathbf{V}}^{\mu}\widetilde{\mathbf{V}}^{\nu}\right) ,$$

but the matter content is the same in the LE and HE bases:
we can write thia Lagrangian in terms of the Chiral Lag.

Counting parameters **10 vs 31**

an example: SU(3)

$$\mathcal{G} = SU(3) \quad \mathcal{H} = SU(2)_L \times U(1)_Y$$

$$\Xi^a(x) X_a = \begin{pmatrix} 0 & 0 & \varphi_1(x) \\ 0 & 0 & \varphi_2(x) \\ \varphi_1^*(x) & \varphi_2^*(x) & 0 \end{pmatrix} = \varphi(x) \underbrace{\begin{pmatrix} 0 & \mathbf{U}(x) e_2 \\ (\mathbf{U}(x) e_2)^\dagger & 0 \end{pmatrix}}_{\mathcal{X}(x)}$$

$$\mathbf{\Sigma} = e^{i\Xi^a X_a / f} = \mathbb{1} + i \sin\left(\frac{\varphi}{f}\right) \mathcal{X} + \left(\cos\left(\frac{\varphi}{f}\right) - 1\right) \mathcal{X}^2 .$$

generic for a symmetric coset? $[T, X] \propto X\,,$ $[X, X] \propto T\,,$

an example: SU(3)

$$\mathcal{G} = SU(3) \quad \mathcal{H} = SU(2)_L \times U(1)_Y$$

$$\begin{aligned}
\mathcal{L} &= \frac{f^2}{4}\mathrm{Tr}\left(D_\mu \boldsymbol{\Sigma}\, D^\mu \boldsymbol{\Sigma}^\dagger\right) + \mathcal{L}^{(p^4)} + \ldots \\
&= \frac{1}{2}\partial_\mu h \partial^\mu h - f^2 \sin^2\left(\frac{\varphi}{2f}\right)\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{V}^\mu\right) \\
&\quad + \frac{f^2}{2}\sin^4\left(\frac{\varphi}{2f}\right)\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{T}\right)\mathrm{Tr}\left(\mathbf{V}^\mu \mathbf{T}\right) + \mathcal{L}^{(p^4)} + \ldots
\end{aligned}$$

$$\frac{v^2}{4} = f^2 \sin^2\left(\frac{\langle\varphi\rangle}{2f}\right)$$

Trade v for $\langle\varphi\rangle$

an example: SU(3)

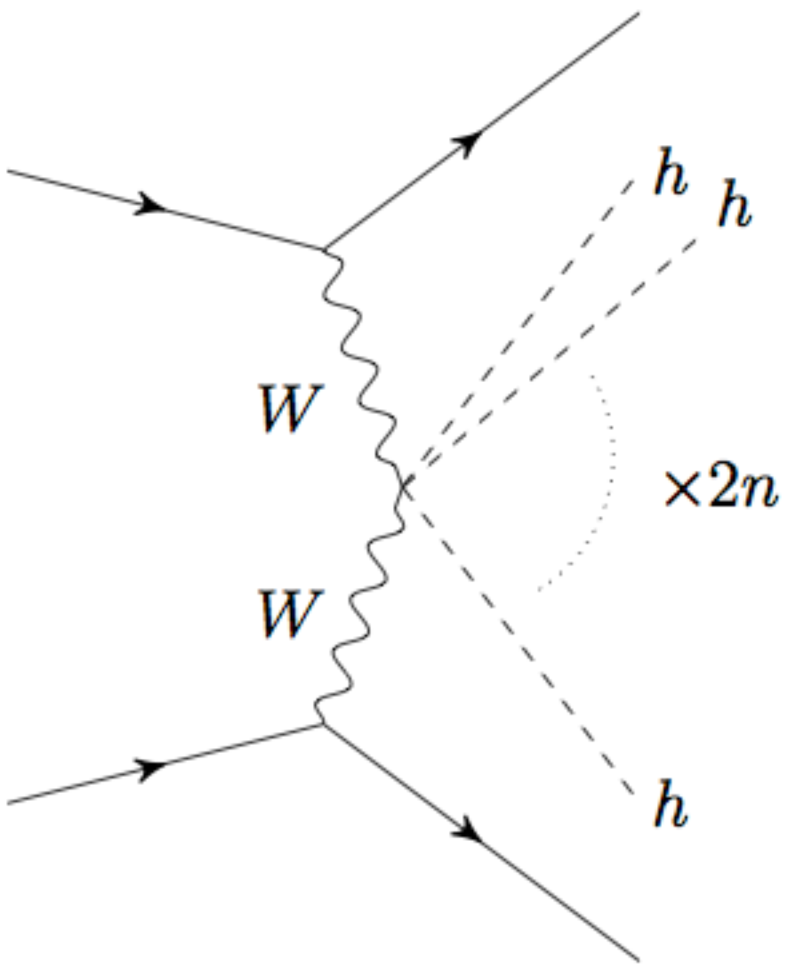
$$\mathcal{G} = SU(3) \quad \mathcal{H} = SU(2)_L \times U(1)_Y$$

$$\begin{aligned}\mathcal{L} &= \frac{f^2}{4}\mathrm{Tr}\left(D_\mu \mathbf{\Sigma}\, D^\mu \mathbf{\Sigma}^\dagger\right) + \mathcal{L}^{(p^4)} + \ldots \\ &= \frac{1}{2}\partial_\mu h \partial^\mu h - f^2 \sin^2\left(\frac{\varphi}{2f}\right)\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{V}^\mu\right) \\ &\quad + \frac{f^2}{2}\sin^4\left(\frac{\varphi}{2f}\right)\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{T}\right)\mathrm{Tr}\left(\mathbf{V}^\mu \mathbf{T}\right) + \mathcal{L}^{(p^4)} + \ldots\end{aligned}$$

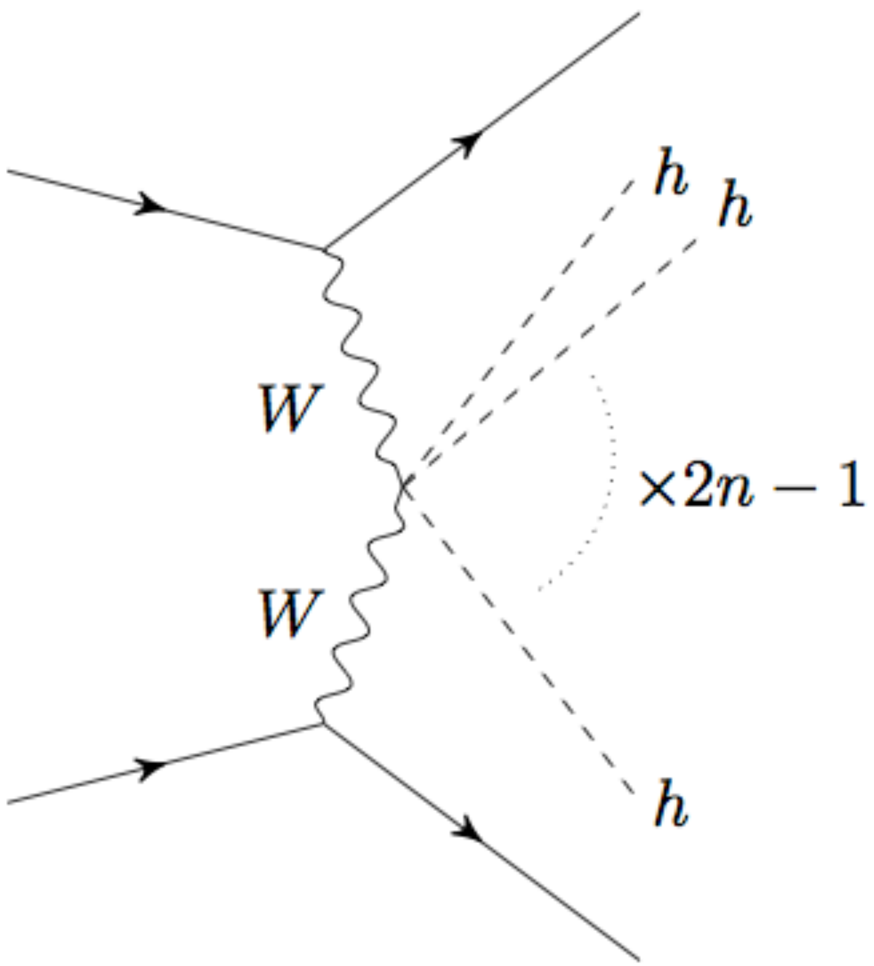
$$\sin\left(\frac{\varphi}{2f}\right) = \frac{v}{2f}\cos\left(\frac{h}{2f}\right) + \sqrt{1 - \frac{v^2}{4f^2}}\sin\left(\frac{h}{2f}\right),$$

an example: SU(3)

$$\mathcal{G} = SU(3) \quad \mathcal{H} = SU(2)_L \times U(1)_Y$$



$$\sim \frac{(-1)^n}{f^{2n}}\left(\frac{v^2}{4} - \frac{f^2}{2}\right)$$



$$\sim \frac{(-1)^{n-1}}{f^{2n-1}}\frac{v}{2}\sqrt{f^2 - \frac{v^2}{4}}$$

Unsupressed higgs emision

an example: SU(3)

$$\mathcal{G} = SU(3) \quad \mathcal{H} = SU(2)_L \times U(1)_Y$$

$$\mathcal{L} = \frac{f^2}{4}\mathrm{Tr}\left(D_\mu \mathbf{\Sigma}\, D^\mu \mathbf{\Sigma}^\dagger\right) + \mathcal{L}^{(p^4)} + \ldots$$

$$= \frac{1}{2}\partial_\mu h \partial^\mu h - f^2 \sin^2\left(\frac{\varphi}{2f}\right)\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{V}^\mu\right)$$

$$+ \frac{f^2}{2}\sin^4\left(\frac{\varphi}{2f}\right)\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{T}\right)\mathrm{Tr}\left(\mathbf{V}^\mu \mathbf{T}\right)$$

$$\left[H = U\begin{pmatrix} 0 \\ \frac{v+h}{\sqrt{2}} \end{pmatrix}\right]$$

$$f^2\left(\frac{\varphi^2}{4f^2} + \mathcal{O}\left(\frac{\varphi^2}{4f^2}\right)\right)$$

$$D^\mu H^\dagger D_\mu H$$

$\mathcal{SM}$

an example: SU(3)

$$\mathcal{G} = SU(3) \quad \mathcal{H} = SU(2)_L \times U(1)_Y$$

$$\begin{aligned}
\mathcal{L} &= \frac{f^2}{4}\mathrm{Tr}\left(D_\mu \boldsymbol{\Sigma}\, D^\mu \boldsymbol{\Sigma}^\dagger\right) + \mathcal{L}^{(p^4)} + \ldots \\
&= \frac{1}{2}\partial_\mu h \partial^\mu h - f^2 \sin^2\left(\frac{\varphi}{2f}\right)\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{V}^\mu\right) \\
&\quad + \frac{f^2}{2}\sin^4\left(\frac{\varphi}{2f}\right)\mathrm{Tr}\left(\mathbf{V}_\mu \mathbf{T}\right)\mathrm{Tr}\left(\mathbf{V}^\mu \mathbf{T}\right)
\end{aligned}$$

rho parameter

$$\alpha_{\rm em}\Delta T = \frac{\xi}{4} \qquad \Longrightarrow \qquad f \gtrsim 2\ \mathrm{TeV}\,.$$

Other (Custodial-preserving) models

Georgi Kaplan
Little Higgs

$$\mathcal{G} = SU(5) \quad \mathcal{H} = SO(5)$$

(Get rid of 10 NGB)

Minimal
Composite
Higgs

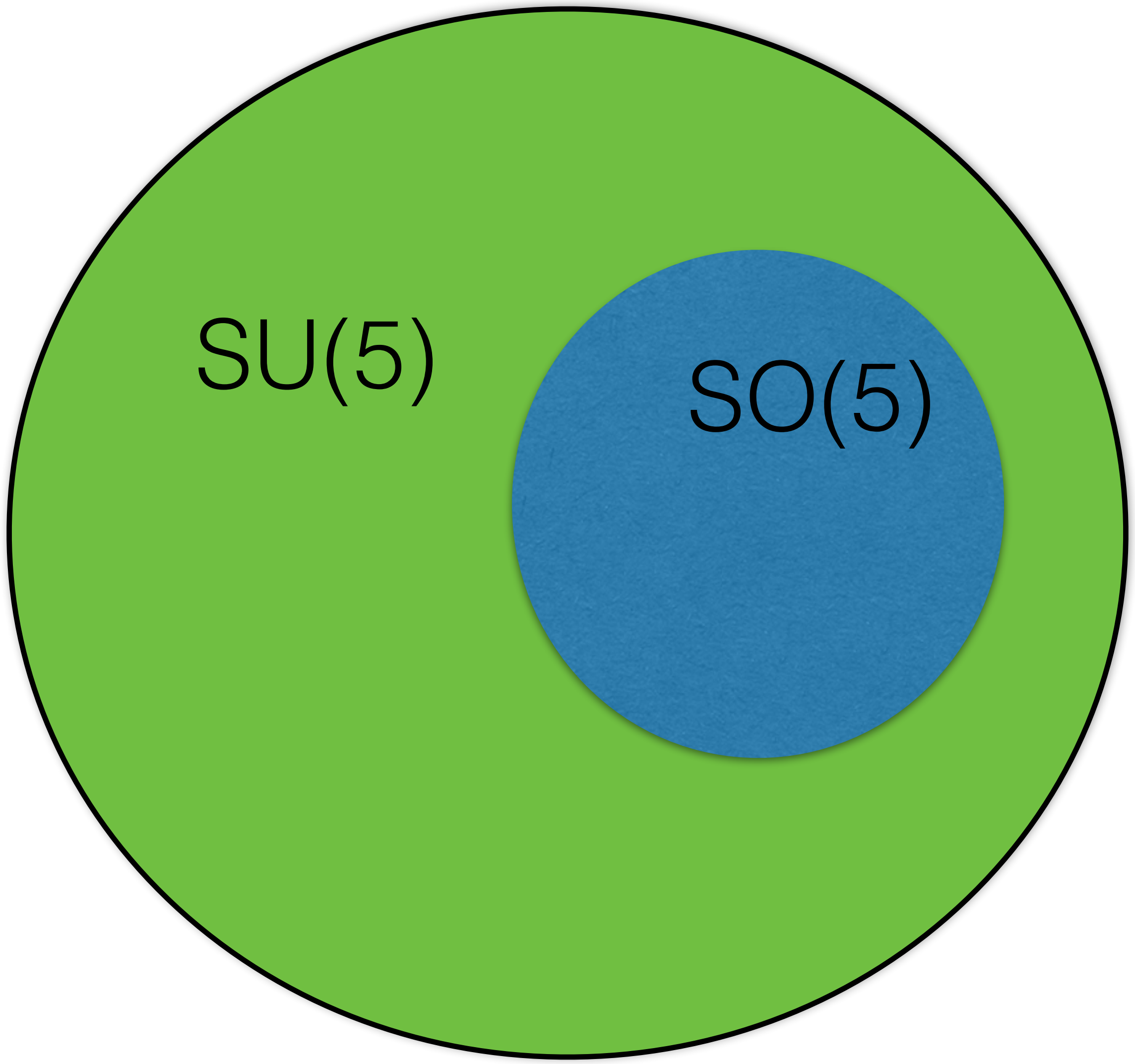
$$\mathcal{G} = SO(5) \quad \mathcal{H} = SO(4)$$

{Pomarol, Agashe, Contino}

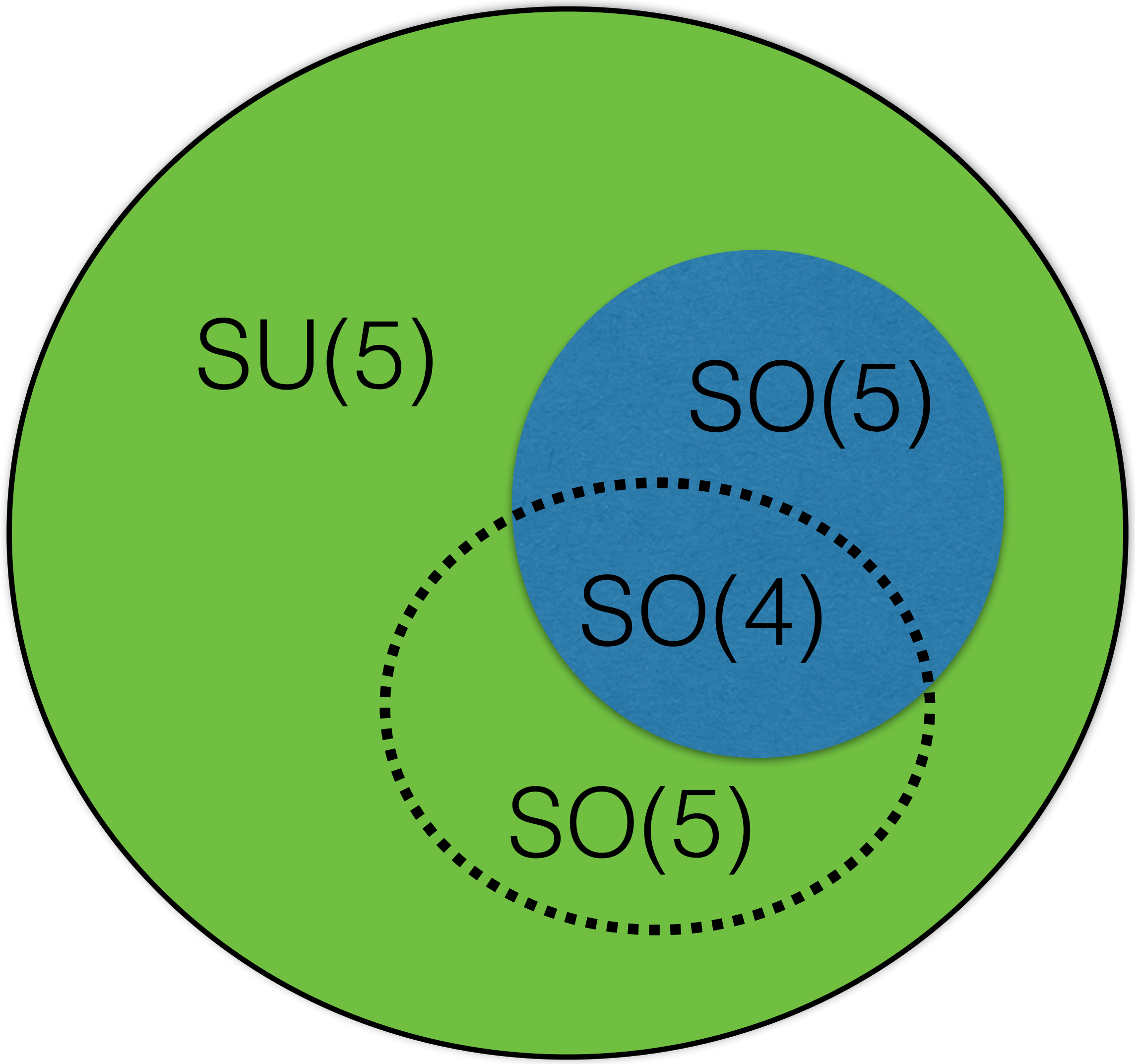
Model Table

$c_i\mathcal{F}_i(h)$	$SU(5)/SO(5)$ $SO(5)/SO(4)$	$SU(3)/SU(2)\times U(1)$
$c_1\mathcal{F}_1(h)$	$\tilde{c}_1 \sin^2\frac{\varphi}{2f}$	$\frac{\tilde{c}_1}{4}\sin^2\frac{\varphi}{f}$
$c_2\mathcal{F}_2(h)$	$\tilde{c}_2 \sin^2\frac{\varphi}{2f}$	$\frac{\tilde{c}_2}{4}\sin^2\frac{\varphi}{f}$
$c_3\mathcal{F}_3(h)$	$2\tilde{c}_3 \sin^2\frac{\varphi}{2f}$	$\frac{\tilde{c}_3}{2}\sin^2\frac{\varphi}{f}$
$c_4\mathcal{F}_4(h)$	$\tilde{c}_2\sqrt{\xi}\sin\frac{\varphi}{f}$	$\dfrac{\tilde{c}_2}{2}\sqrt{\xi}\sin\frac{2\varphi}{f}$
$c_5\mathcal{F}_5(h)$	$-2\tilde{c}_3\sqrt{\xi}\sin\frac{\varphi}{f}$	$-2\tilde{c}_3\sqrt{\xi}\sin\frac{\varphi}{f}$
$c_6\mathcal{F}_6(h)$	$16\tilde{c}_4\sin^4\frac{\varphi}{2f} - \dfrac{1}{2}\tilde{c}_6\sin^2\frac{\varphi}{f}$	$8(2\tilde{c}_4+\tilde{c}_7)\sin^4\frac{\varphi}{2f} - \dfrac{1}{2}\tilde{c}_6\sin^2\frac{\varphi}{f}$
$c_7\mathcal{F}_7(h)$	$-2\tilde{c}_6\sqrt{\xi}\sin\frac{\varphi}{f}$	$-2\tilde{c}_6\sqrt{\xi}\sin\frac{\varphi}{f}$
$\vdots$	$\vdots$	$\vdots$

"SU(5)" and "SO(5)" equivalence



"SU(5)" and "SO(5)" equivalence



Choose 4 generators in $\mathcal{G}/\mathcal{H}$, commute them and commute the conmmutators if its a doublet...

Linear

$$(\mathbf{D}_\mu\Phi)^\dagger \hat{B}^{\mu\nu}(\mathbf{D}_\nu\Phi) =$$

$$B_{\mu\nu}\mathrm{Tr}(\mathbf{T}[\mathbf{V}^\mu,\mathbf{V}^\nu])\frac{(v+h)^2}{4} + B_{\mu\nu}\mathrm{Tr}(\mathbf{T}\mathbf{V}^\mu)\partial^\nu\frac{(v+h)^2}{4}$$

or Non-Linear

$$i\,g'\,\mathrm{Tr}\left(\widetilde{\mathbf{B}}_{\mu\nu}\left[\widetilde{\mathbf{V}}^\mu,\widetilde{\mathbf{V}}^\nu\right]\right) =$$

$$B_{\mu\nu}\mathrm{Tr}(\mathbf{T}[\mathbf{V}^\mu,\mathbf{V}^\nu])\sin^2\left[\frac{\varphi}{2f}\right] + B_{\mu\nu}\mathrm{Tr}(\mathbf{T}\mathbf{V}^\mu)\partial^\nu\sin^2\left[\frac{\varphi}{2f}\right]$$

same relative factor for any number of Higgs legs

Summary

- The Higgs Chiral Lagrangian is the less prejudiced scenario (I know)
- If the Higgs Doblet is a set of pNG bosons correlations appear that tell apart this class of theories
- Do all such models have a universal functional dependence in the Higgs singlet?