

Lecture II

A Composite Higgs

Suppose the Higgs is composite, we will discuss two logical possibilities:

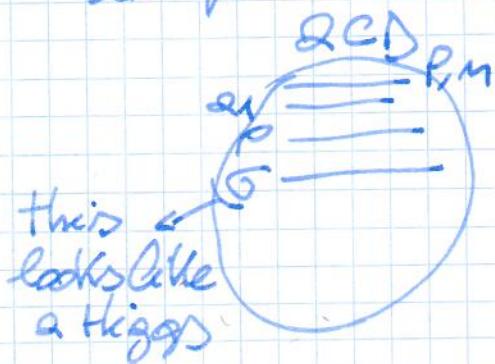
I Generic Composite Higgs

- full of problems

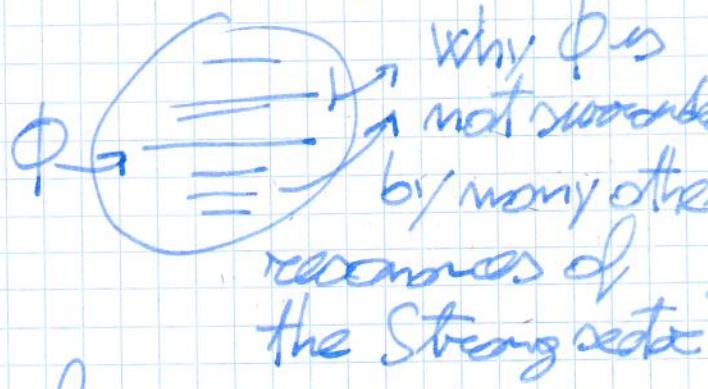
II pNGB Composite Higgs

- more reasonable
- includes Little Higgs

Case I is in trouble already by one simple observation:



New Strong sector



The naive expectation for a generic composite is:

$$M_H^2 = -\frac{3Y_t^2}{2\pi^2} M_*^2 + \underline{M_*^2} + \text{"small from UV"}$$

The "threshold correction" dominates:

$$M_H \sim M_*$$

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A generic strong sector has a single scale, like QCD. This scale sets the mass of all the composite resonances.

We know that $m_s > m_H$. A generic bound from EWPT on vector resonances is:

$$m_s \gtrsim 2 \text{ TeV}$$

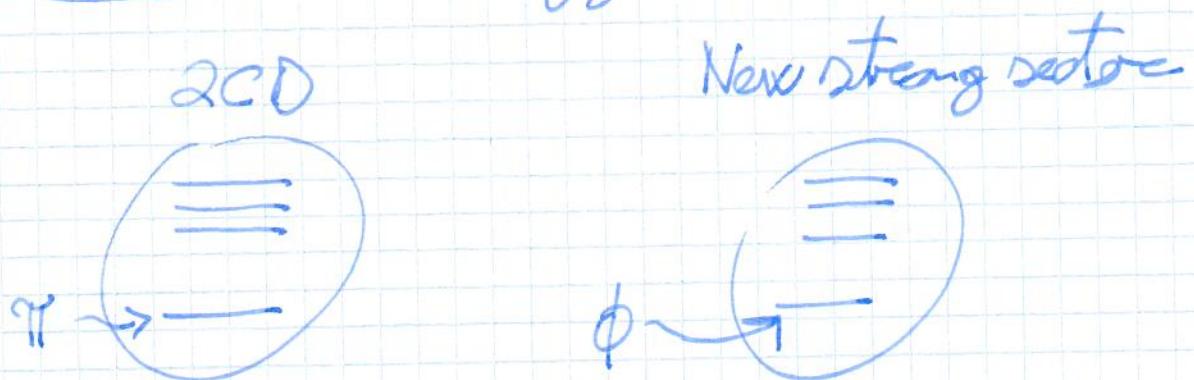
$$\Rightarrow \frac{m_H^2}{m_s^2} \lesssim 10^{-2}/10^{-3} \rightarrow \text{why so?}$$

$\underbrace{}_{m_s^2}$

Badly tuned situation, $\Delta \approx 1000$!

Higgs mass is just the first issue, other issues will come from couplings

Case II: the Higgs is a pNGB



$m_H = 0$ if Goldstone symmetry is unbroken
 small m_H naturally accommodated by ~~an~~ explicit
 breaking with a tiny perturbation.

Ingredients :

G : global group of Strong Sector
 gauging:
 $\xrightarrow{\text{W.J.}} \text{G} \rightarrow H$
 H : Strong sector breaks spontaneously
 $G \rightarrow H$

Couplings to other : break G explicitly,
~~SM~~ ~~WIMPs~~ portals : discussed later

H must be large enough to contain GSM

$$\text{Lie}[G] = \{T^A\} = \{T^1, T^2, T^3\}$$

unbroken generators broken generators

$\in \text{Lie}[H]$

Representative vacuum configuration (or order parameter) :

$$\vec{F}, |\vec{F}| = f$$

$$T^2 \vec{F} = 0, T^3 \vec{F} \neq 0$$

Notice that the all vacua obtained from \vec{F} by G , $\vec{f} \rightarrow g \vec{f}$, are completely equivalent

Picking one \vec{F} or the other (i.e., selecting T^2, T^3 in G) is merely a conventional choice.
 \vec{F} will not be the true vacuum after G breaking will select one.

Convenient choice:

$G_{SM} \subseteq H \rightarrow$ namely gauge couplings will be: \vec{Q}, \vec{Y} not to $\{W_n, B_n\}, J^a, \overset{\rightarrow}{\hat{Q}}$

Massless modes are scalar fields ~~with~~ defined by the ansatz:

$$\overset{\rightarrow}{\Phi}(x) = e^{\delta_Q(x)} T^{\hat{Q}} \cdot \vec{F}$$

Indeed, all fields of the strong sector

For $\delta_Q = \text{constant}$, $E[\overset{\rightarrow}{\Phi}] = E[\vec{F}] = E_{vac}$

Therefore $\delta_Q(x)$ have no potential energy, are massless.

Fluctuations along the $T^{\hat{Q}}$ just drop, can be omitted.

The strong sector alone gives no potential and no mass:

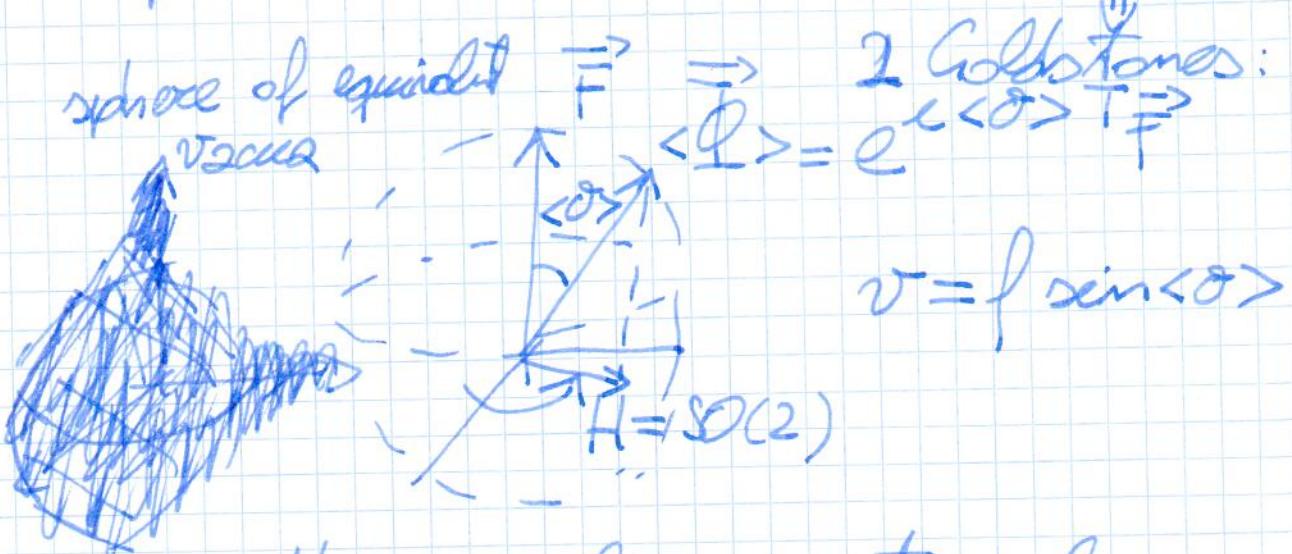
$$V(\delta) = 0 \Rightarrow M_\delta = 0$$

The $\langle \delta \rangle$ is arbitrary and has no physical effect, it is just some equivalent vacuum

By G explicit breaking

$$\nabla^H(\delta) \neq 0 \rightarrow \begin{cases} M_H \neq 0 \\ \langle \delta \rangle \text{ is now determine and observable} \end{cases}$$

Example: $SO(3) \rightarrow SO(2)$: 2 broken generator



$\langle \delta \rangle$ is the misalignment angle.

H-breaking is controlled by the projection of \vec{F} on the H plane:

In the SM, $v = 246 \text{ GeV} = E_{\text{SB}}/\sqrt{s_{\text{scale}}}$

$$\mathfrak{f} = \frac{v^2}{p^2} = \sin^2 \langle \delta \rangle$$

- \mathfrak{f} plays a crucial role in CH:

If $\mathfrak{f} \approx 1$, H, and G_{SM} , are broken as much as the other G/H generators. No progress is made with respect to Technicolor. We could have equally well started from a smaller G.

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and break G_{SM} with the Strong Sector condensate.

If $\mathcal{G} \ll 1$: a gap is generated among v and f . The strong sector ideally can be decoupled by sending $f \rightarrow \infty$

In practice, we hope $\mathcal{G} \lesssim 0.1$ could be enough. A moderate accidental tuning is expected in the potential.

~~This~~ \mathcal{G} controls Higgs coupling deviations, a single tunable parameter allows us to recover systematically the SM.

Crucial advantage compared with the case of a Generic Composite Higgs.

Example I: The Abelian Composite Higgs

Our "Strong Sector" is just a scalar theory:

$$\mathcal{L}_S = \frac{1}{2} \partial_\mu \vec{\Phi}^\dagger \partial^\mu \vec{\Phi} - \frac{g_*^2}{8} (\vec{\Phi}^\dagger \vec{\Phi} - f^2)^2$$

$$\vec{\Phi} = 3 \text{ of } SO(3), \quad \vec{\Phi} \rightarrow e^{i \omega_A T^A} \vec{\Phi}$$

$$\text{Manifold of equivalent vacua: } \langle \vec{\Phi}^\dagger \vec{\Phi} \rangle = f^2$$

$$\text{Representative vacuum: } \vec{F} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

P+

Generators: $T^A = \left\{ I, \frac{\vec{\sigma}}{l} \right\}$

$SU(2) \leftarrow \rightarrow SU(2)$ 2-blatt

$$T = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 & -l & 0 \\ l & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}; \quad \frac{T^A}{l} = \left\{ \frac{1}{\sqrt{2}} \begin{pmatrix} 0 & 0 & -l \\ 0 & 0 & 0 \\ l & 0 & 0 \end{pmatrix}, \frac{1}{\sqrt{2}} \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & l \\ 0 & -l & 0 \end{pmatrix} \right\}$$

Non-linear basis:

$$\vec{\phi} = e^{i \frac{\sqrt{2}}{l} \vec{\sigma} \cdot \vec{\Pi}(x)} \frac{\vec{\sigma}}{l} \begin{pmatrix} 0 \\ 0 \\ l + \sigma(x) \end{pmatrix} \xrightarrow{\text{normalization}} \sigma \text{"resonance"}$$

$$[U[\vec{\Pi}]] = e^{i \frac{\sqrt{2}}{l} \vec{\sigma} \cdot \vec{\Pi}(x)} \frac{\vec{\sigma}}{l} = \begin{pmatrix} 1 - (1 - \cos \vec{\Pi}) & \vec{\Pi} \vec{\Pi}^t & \sin \frac{\vec{\Pi}}{l} \\ -\sin \frac{\vec{\Pi}}{l} & \vec{\Pi}^t & \cos \frac{\vec{\Pi}}{l} \end{pmatrix}$$

\hookrightarrow Goldstone excuse!: check!

$\vec{\Pi} = \vec{\Pi} \vec{\Pi}^t$. General formula for $SU(N) \rightarrow SU(N-1)$

The Lagrangian becomes:

$$\begin{aligned} \mathcal{L}_S = & \frac{1}{2} \partial_\mu \sigma \partial^\mu \sigma - \frac{(g_s l)^2}{2} \sigma^2 - \frac{\partial_\mu^2 l}{2} \sigma^3 - \frac{g_s^2}{8} \sigma^4 \\ & + \frac{1}{2} \left(1 + \frac{\sigma}{l} \right)^2 \left[\frac{l^2}{\eta^2} \sin^2 \frac{\vec{\Pi}}{l} \vec{\Pi}^t \vec{\Pi} + \right. \\ & \left. + \frac{l^2}{4 \eta^4} \left(\frac{\eta^2}{l^2} - \sin^2 \frac{\vec{\Pi}}{l} \right) \partial^\mu (\eta^2) \partial^\nu (\eta^2) \right] \end{aligned}$$

$\sigma: m_\sigma = g_* f = m_*$ = "Massive Resonance"

$\eta^L: m_\eta = 0$ = "Mossler Goldstones"
(1 complex NGB Higgs doublet)

Strong sector analogy:

$$\begin{aligned} m_* &\longleftrightarrow \text{confirat} \\ g_* &\longleftrightarrow \text{"effective syding"} = \begin{cases} 4\pi & \text{large} \\ 4\pi \sim N_c & \text{Nc colors} \end{cases} \end{aligned}$$

Observation: L_S obey a Power-Counting rule:

$$L_S = \frac{m_*^4}{g_*^2} \hat{L} \left(\frac{g_* \pi}{m_*}, \frac{g_* \sigma}{m_*}, \frac{\sigma}{m_*} \right)$$

→ polynomials with $\alpha(1)$ coefficients

Extremely fancy, but useful, way to re-state the result: k -dimensionality

We sometimes reintroduce k in our calculations:

$$\int D\phi e^{-S_L} \xrightarrow{k \text{ dimensions}} \int D\phi e^{-S_L} \quad \boxed{\begin{array}{l} k \text{ is marginal} \\ \text{in } L \text{ and} \\ \text{effectively set to } k=1 \end{array}}$$

⇒ L has effectively "-1" k dimensions:

$$\begin{aligned} [L]_k &= -1 && \text{fixed energy} \\ [L]_E &= +4 && \text{dimensions} \end{aligned}$$

$$\Rightarrow [\cancel{\phi^2}]_k = -1 \Rightarrow [\phi]_k = -1/2$$

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Remember the usual trick $\phi \rightarrow \sqrt{k} \phi'$

$$[(\cancel{\phi})^2]_k = -1 \Rightarrow [\cancel{\phi}]_k = 0$$

• By inspecting \mathcal{L}_S power-counting

$$[g_s]_k = +1/2 \rightarrow \text{"Coupling"}$$

$$[m_s]_k = 0 \quad [g_s]_0 = 0$$

$$[m_s]_k = 0 \rightarrow \text{"mass scale"}$$

$$[m_s]_0 = +1$$

\mathcal{L}_S is a single-coupling (g_s) and single scale (m_s) theory.

Power-counting formula could have been derived purely on the basis of this generalized dimensional analysis.

Example of applications :

$$[\cancel{\lambda}]_{\text{tree-}k} = +1 \sim \cancel{\ell}, \cancel{g_s^2}, \frac{1}{\cancel{m_p^2}}, \cancel{\chi^3}$$

e.m. \cancel{c}
 \cancel{ec} \cancel{grav}

Higgs quartic, $\leftarrow (\lambda)$

$$\underline{[\lambda]_k = +1}$$

$$[\cancel{\lambda}]_{\text{1-loop-}k} = +2 \sim \frac{g^4}{16\pi^2}, \frac{dg^2}{16\pi^2}, \dots \text{etc}$$

At each loop order, \hbar ~~lower~~ dimensional analysis can be used to check our results. (10)

Notice : $[f]_E = 1$; $[f]_h = [m_s/g_s] = -\frac{1}{2}$

$\frac{1}{f}$ is called a "Dimensionfull coupling"

• Back to our Lagrangian, let us discuss symmetries

It has just been rewritten. It must have the full $SU(3)$ symmetry group:

Linearly realized $SU(2) = U(1)$:

$$\vec{\Pi} \rightarrow e^{i\delta_2} \vec{\Pi} \quad \vec{\Phi} \rightarrow e^{i\Omega_2 T} \vec{\Phi}$$

\longleftrightarrow
in original
field basis

\hookrightarrow unbroken
symmetry
transformation

Non-linearly realized T^a :

$$\vec{\Pi} \rightarrow \vec{\Pi} + \frac{\vec{\Pi}}{\tan \Omega_p} \vec{\Pi} + \left(\frac{1}{\vec{\Pi}} - \frac{1}{\tan \Omega_p} \right) (\vec{\omega} \vec{\Pi}) \frac{\vec{\Pi}}{\vec{\Pi}}$$

\downarrow
 \sim exercise: check!

$$\vec{\Phi} \rightarrow \vec{\Phi} + e \lambda_e T^a \vec{\Phi}$$

complicated, but still a symmetry.

Not just "non-linear", also "non-homogeneous".
Therefore:

$$V[\Pi] = 0$$

$$\langle \Pi \rangle \neq 0 \iff \langle \Pi \rangle = 0$$

↪ unobservable.

- Abelian Complex Higgs scalar

$$H = \frac{\Pi_1 - e\Pi_2}{\sqrt{2}}$$

- Last ingredient is a U(1) gauge field A_μ :

$$\vec{\partial}_\mu \vec{\Phi} \rightarrow \vec{\partial}_\mu \vec{\Phi} = (\vec{\partial} - i\sqrt{2}e A_\mu \vec{T}) \vec{\Phi}$$

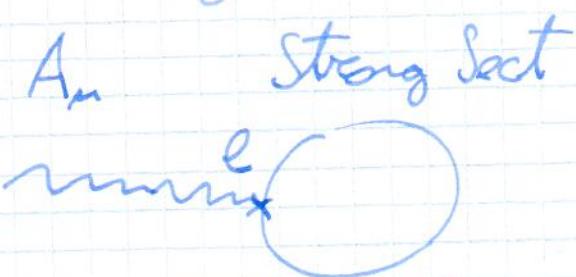
we gauged T , but any other direction would have been equivalent by an $SO(3)$ transformation (check!).

- We see that $[e]_h = +1/2$, power-counting gets modified:

$$L_S = \frac{m_*^4}{g_*^2} \hat{L} \left(\frac{g_* \vec{T}}{m_*}, \frac{g_* \vec{G}}{m_*}, \frac{\vec{J}}{m_*}, \frac{e \vec{A}}{m_*} \right)$$

Composite Fields interactions
weight the same

We regard A_μ as a field which is extended to the Strong Sector:



its coupling strength is ~~as~~ a completely free parameter. This is why it has a different power-counting rule.

Notice that now counting controls the elementary/composite interactions, purely elementary terms arise from the elementary sector ad hoc free. For instance the kinetic term of A_μ violates power counting.

- Some quantitative result:

$$\mathcal{L}_{H+A} = \frac{1}{2} \left[\frac{\ell^2}{|H|^2} \sin^2 \frac{\sqrt{2} H}{\ell} D_\mu H^+ D^\mu H + \right. \\ \left. + \frac{\ell^2}{4|H|^4} \left(2 \frac{|H|^2}{\ell^2} - \sin^2 \frac{\sqrt{2} H}{\ell} \right) (\Box |H|^2) \right]$$

usual $D_\mu H = \partial_\mu H - e A_\mu H$

$$\mathcal{L}_{H+A} = \frac{1}{2} |D_\mu H|^2 + \cancel{\frac{e^2}{\ell^2} A_\mu A^\mu} + J \left(\frac{H^+}{\ell^2} \right)^2$$

$$\frac{1}{\ell^2} = \frac{m_s^4}{g_s^2} g_s^4 m_s^4 \cdot \frac{1}{M_s^2} \rightarrow \text{from general power counting}$$

as anticipated, all effects of compositeness disappear for $f \rightarrow \infty$.

Why so? Power-counting formula tell us that non-linearities drop. The only $d=4$ theory with gauge symmetry is the ordinary Abelian Higgs. This is the only theory we might have ended up with.

Notice that for $f \rightarrow \infty$, $m_* \rightarrow \infty$ and the effect of physical new resonances decouples.

The Lagrangian becomes very simple in the unitary gauge:

$$H = \frac{V + h(x)}{\sqrt{2}}$$

$$\mathcal{L} = \frac{1}{2} (\partial_\mu h)^2 + \frac{1}{2} \ell^2 f^2 \sin^2 \frac{V+h}{f} A_\mu A^\mu$$

Gauge field mass:

$$m_A^2 = \ell f \sin \frac{V}{f} \equiv \ell v$$

as anticipated, gauge symmetry breaking effects are controlled by:

$$v = f \sin \frac{V}{f}; \quad g = \frac{v^2}{\ell^2} = \sin^2 \frac{V}{f}$$

By Taylor-expanding:

$$\frac{1}{2} \ell^2 f^2 \sin^2 \frac{\sqrt{1-\ell^2} h}{\rho} A^2 = \frac{m_A^2}{2} \left(A^2 + 2 \sqrt{1-\ell^2} \frac{h}{\rho} A^2 + \right. \\ \left. + (1-2\ell^2) \frac{h^2}{\rho^2} A^2 - \frac{4}{3} \ell \sqrt{1-\ell^2} \frac{h^3}{\rho^3} A^2 + \dots \right)$$

Modified Higgs trilinear and quadrilinear couplings:

$$K_V = \frac{g_{HW}^{\text{comp}}}{g_{HW}^{\text{elm}}} = \sqrt{1-\ell^2} ; \quad \frac{g_{HHW}^{\text{comp}}}{g_{HW}^{\text{elm}}} = 1-2\ell$$

$\ell \rightarrow 0$ = "elementary Higgs"

New interactions:

~~mixing~~ of ℓ (suppressed for $\ell \rightarrow 0$)

Example II: The Minimal Composite Higgs Model

Very few changes:

$$G = SO(5), \quad H = SO(4)$$

$$T^2 = \left\{ T_L^\alpha = \begin{pmatrix} T_L^\alpha & 0 \\ 0 & 0 \end{pmatrix}, \quad T_R^\alpha = \begin{pmatrix} T_R^\alpha & 0 \\ 0 & 0 \end{pmatrix} \right\}$$

unbroken $SO(4)$ guarantees $\rho=1$

(75)

$$\hat{T}^c = \left\{ -\frac{c}{\sqrt{2}} \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}, \dots \right\}$$

4 broken generators leading to one complex Higgs doublet:

$$H = \begin{pmatrix} h_u \\ h_d \end{pmatrix} = \begin{pmatrix} \frac{\tilde{H}_2 + c \tilde{H}_1}{\sqrt{2}} \\ \frac{\tilde{H}_4 - c \tilde{H}_3}{\sqrt{2}} \end{pmatrix}$$

Same Lagrangian as in the previous example, gauging of the SM group is:

$$\vec{D}_\mu \vec{\Phi} = (\partial_\mu - e g W_\mu^\alpha T_L^\alpha - e g' B_\mu T_R^3) \vec{\Phi}$$

The result is identical to the one we had before:

$$\begin{aligned} \mathcal{L}_{A-H} &= \frac{p^2}{2|H|^2} \sin^2 \frac{\sqrt{2}|H|}{p} D_\mu H^+ D^\mu H + \\ &+ \frac{p^2}{8|H|^4} \left(2 \frac{|H|^2}{p^2} - \sin^2 \frac{\sqrt{2}|H|}{p} \right) (\partial_\mu |H|^2)^2 \end{aligned}$$

Unitary gauge: $H = \begin{pmatrix} 0 \\ V+h \end{pmatrix}$

$$\frac{1}{2} (\partial_\mu h)^2 + \frac{g^2}{4} p^2 \sin^2 \frac{V+h}{p} \left(|W|^2 + \frac{1}{2C_W^2} Z^2 \right)$$

$$W_\mu^\pm = \frac{W_\mu^1 \mp c W_\mu^2}{\sqrt{2}}$$

$$Z_\mu = c_W W_\mu - s_W B_\mu$$

$$c_W = \frac{g}{\sqrt{g^2 + g'^2}}$$

$$m_W = \frac{1}{2} g v; \quad v \approx 246 \text{ GeV} = f \sin \frac{\sqrt{f}}{f}$$

$$\beta = \frac{v^2}{f^2} = \sin^2 \frac{\sqrt{f}}{f}$$

$$m_2 = m_W / c_W \Rightarrow \text{from } P_{\text{tree}} = 1$$

Higgs coupling modifications identical to the Abelian example:

$$K_V = \frac{g_{HW}^{BH}}{g_{HW}^{SM}} = \sqrt{1-\beta}; \quad \frac{g}{g} = \dots \text{ etc.}$$

- This has been a relatively fast and ~~directly~~ ~~directly~~ heuristic way to compute CH coupling modification.

But now we should worry

1) Is the result general?

Our scalar theory is not the "true" CH model we have in mind

2) Is the result accurate?

Answer to "1)" is affirmative, but the discussion of this point needs to be postponed

Answer to "2)" can be given right now by studying the effect of the resonances on the Higgs + gauge system:

Scales

(resonances scales by $\approx 3 \text{ or } 4$ even be 4π)

$m_* \approx 2 \text{ TeV}$ \rightarrow Effects of σ described by a low-energy EFT,

$\ln 800 \text{ GeV} (\text{for } g_0 = 1)$

$\omega = 246$ # of derivatives

$$\mathcal{L}^{\text{EFT}}(H, A) = \mathcal{L}^{(2)} + \mathcal{L}^{(4)} + \mathcal{L}^{(6)} + \dots$$

previous results were derived from $\mathcal{L}^{(2)}$ alone, corrections from $\mathcal{L}^{(4)}$, etc

Integrating σ out diagrammatically means:

$$\mathcal{L}^{\text{EFT}} = \mathcal{L}^{(2)} + \text{higher order terms} + \dots$$

$\mathcal{L}^{\text{EFT}} = \mathcal{L}^{(2)} + \mathcal{L}^{(4)} + \mathcal{L}^{(6)} + \dots$

$\mathcal{L}^{(2)} \rightarrow$ only light field interaction

Diagram illustrating the integration of the σ field out:

- The first term shows the bare theory $\mathcal{L}^{(2)}$ with two external lines.
- The second term shows the full theory $\mathcal{L}^{(2)} + \mathcal{L}^{(4)}$ with four external lines, where the $\mathcal{L}^{(4)}$ part is labeled "light/heavy".
- The third term shows the full theory $\mathcal{L}^{(2)} + \mathcal{L}^{(4)} + \mathcal{L}^{(6)}$ with six external lines, where the $\mathcal{L}^{(6)}$ part is labeled "heavy/heavy".

$$\therefore \hat{Q} = \frac{m_x^4}{g_x^2} \hat{\mathcal{L}} \left[\frac{g_x H}{m_x}, \frac{eA}{m_x}, \frac{\Sigma}{m_x} \right]$$

$$\therefore \frac{1}{g_x} \hat{Q}_x = \frac{m_x^4}{g_x^2} \times \frac{g_x \hat{\mathcal{O}}}{m_x} \hat{\mathcal{J}} \left[\frac{g_x H}{m_x}, \frac{eA}{m_x}, \frac{\Sigma}{m_x} \right]$$

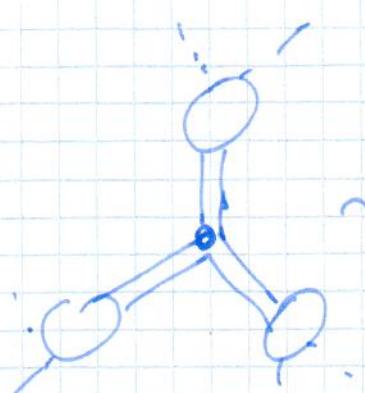
$$\therefore \hat{Q} = \frac{m_x^4}{g_x^2} \times \frac{g_x^2 \hat{\sigma}^2}{m_x^2} \cdot \hat{\mathcal{J}} \left[\frac{g_x H}{m_x}, \frac{eA}{m_x}, \frac{\Sigma}{m_x} \right]$$

$$\hat{Q}_x = \frac{m_x^4}{g_x^2} \frac{g_x^3 \hat{\sigma}^3}{m_x^3}; \quad = = = \frac{1}{\Box - m_x^2}$$

All diagrams scale the same:

$$\therefore \frac{1}{g_x} \hat{Q}_x \rightarrow \frac{1}{g_x^2} \cdot \frac{m_x^4}{m_x^2} \left(\hat{\mathcal{J}} \right)^2 \left[1 + \frac{\Box}{m_x^2} + \dots \right]$$

↓
ordinary dimensional analysis

$$\therefore \sim \frac{1}{g_x^2} m_x^4 \left(\hat{\mathcal{J}} \right)^3 \mathcal{F} \left[\frac{\Box}{m_x^2} \right]$$


$$\hat{\mathcal{L}}^{\text{EFT}} = \frac{m_x^4}{g_x^2} \hat{\mathcal{L}}^{\text{EFT}} \left[\frac{g_x H}{m_x}, \frac{eA}{m_x}, \frac{\Sigma}{m_x} \right]$$

(15)

The result might have been guessed by dimensional analysis:

$$\left[\begin{array}{c} \mathcal{L}^{\text{EFT}} \\ \mathcal{L}_{\text{tree}} \end{array} \right]_h = -1$$

$$\left[\begin{array}{c} \mathcal{L}^{\text{EFT}} \\ \mathcal{L}_{\text{tree}} \end{array} \right]_E = +4$$

→ holds for any single-mass/single-coupling theory.
Like 5d holographic models!

And what about less resonance loop corrections?

$$n \text{ loops} \rightarrow \left(\frac{\lambda}{16\pi^2} \right)^n$$

$$\mathcal{L}_{\text{Full}}^{\text{EFT}} = \frac{m_x^4}{g_x^2} \left[\mathcal{L}_{\text{tree}} + \frac{g_x^2}{16\pi^2} \mathcal{L}_{1\text{-loop}} + \dots \right]$$

Box Derivatives are weighted by $1/m_x$

Higgs interactions by $\frac{g_x}{m_x} = \frac{1}{f}$

Higher derivative corrections from 5 are small compared with $1/f^2$ operators:

$$1/f^2 \gg \frac{1}{m_x^2} \quad (\text{provided } g_x \gg 1)$$

Exercise: compute the first 4-derivative operator in the scalar theory, it should be

$$\frac{2}{f^2 m_x^2} \left(D_\mu H^+ D^\mu H \right)^2$$

dim=8
1 coupled
wants