FLIP

NOTES FOR DISCUSSION W/ CSI-
2 MAY 2012

POWER COUNTING DIPOLE OPS IN 5D

ANCIENT STUFF :

SUPER-NAIVE DIM ANALYSIS

4D:

$$\sim \int d^4k \, \frac{1}{\not k} \frac{1}{\not k} \frac{1}{k^2} \sim \log \Lambda$$

BUT: ACTUAL DIPOLE GOES LIKE $1/M^2$

WHY: ① GAUGE INVARIANCE

$\Rightarrow$ forces "$\mathcal{M}^\mu \propto (p+p')^\mu$"

$\leftrightarrow q \cdot M = 0$ why: $\mathcal{M}^\mu \sim \bar{u}_{p'} \left[(p+p')^\mu - (m_\mu + m_e)\gamma^\mu \right] u_p$

USING EOM

$\leftrightarrow$ this is the thing which ~~can be massaged into~~ a dipole operator

② LORENTZ INVARIANCE

5D: same, expect $\mathcal{M} \sim 1/M$

$\hookrightarrow$ eg noncompact XD (arg carries over) $\rightarrow$ = UV of compact thy

trickier to show for compact XD w/ branes

$\hookrightarrow$ go to flat case, can see cancellation

But on top of this there are additional effects, esp in the case of a brane Higgs.

I didn't investigate bulk.

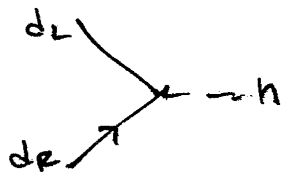
① HIGGS-GOLDSTONE CANCELATION

② CHARGED SCALAR MASS

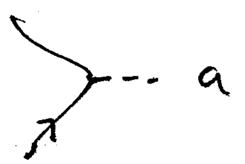
two ways to see this

Ⓐ CANCELATION IN FEYNMAN GAUGE

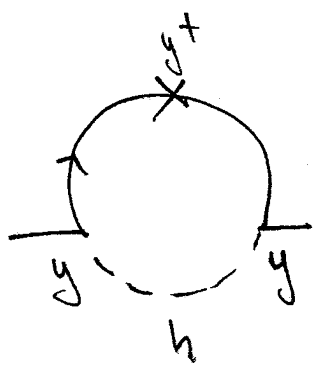
↳ $M^2_{\text{GOLDSTONE}} = M^2_{\text{GAUGE BOSON}}$

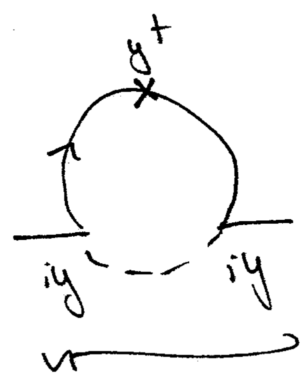


$= y_d$



$= i y_d$





relative minus.

$\Rightarrow \Sigma(\text{diag}) \sim (M_h^2 - M_Z^2)$

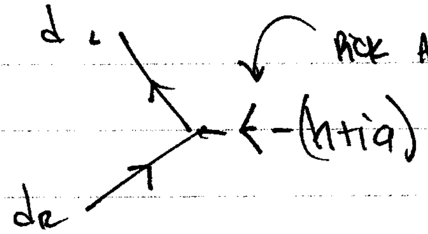
(B) A nicer way to see this

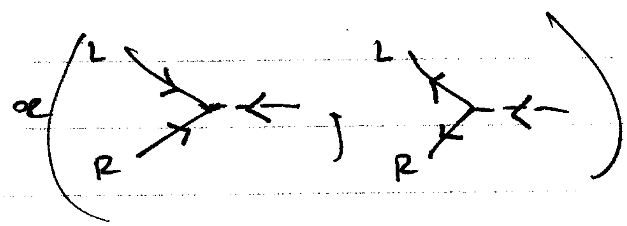
$$\mathcal{L} = H\cdot\bar{Q}\, y_d\, d_R + \underbrace{(H^* i\sigma^2)\cdot\bar{Q}\, y_u\, u_R}_{\text{for charged Higgs (later)}}$$

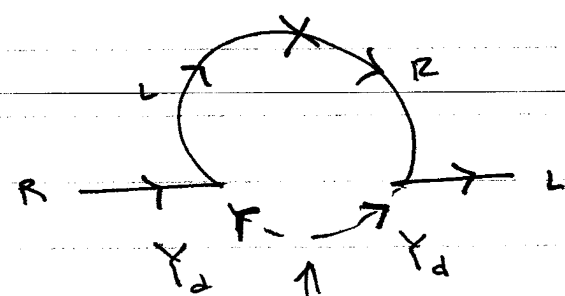
$$H \uparrow \quad \begin{pmatrix} h_1 + i h_2 \\ h + i a \end{pmatrix}\cdot\begin{pmatrix} \bar{u}_L \\ \bar{d}_L \end{pmatrix}$$

treat this like a $\mathbb{C}$ scalar

PICK AN ARROW CONVENTION





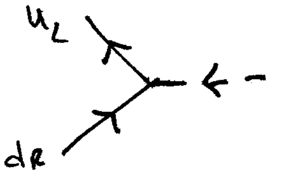


must have mass insertion $\boxed{\propto M^2}$

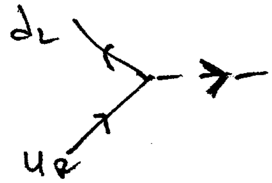
What about charged Higgs?

① Goldstone cancellation doesn't work
② M_W^2 in $\mu \to e\gamma$, not $b \to s\gamma$ (EDM?)

try to use slick ① field rotation

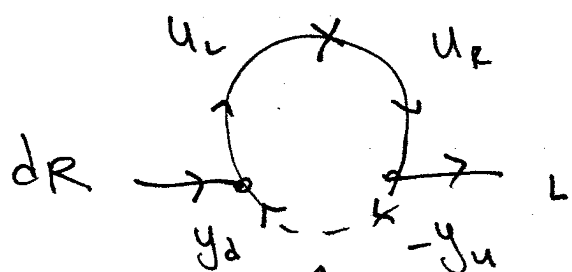


$(h_1 + i h_2) \quad = \quad y_d$



$(h_1 - i h_2) \quad = \quad -y_u$

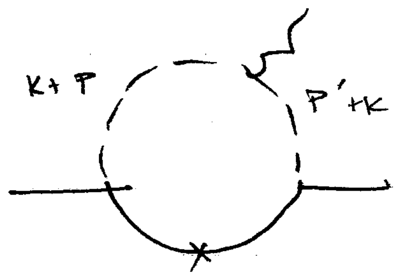
from: $\left(H^\dagger i\sigma^2 \cdot \bar{Q}\right) y_u u_R = \begin{pmatrix} h - ia \\ -h_1 + i h_2 \end{pmatrix} \cdot \begin{pmatrix} \bar{u}_L \\ \bar{d}_L \end{pmatrix} y_u u_R$



no mass insertion required.

But: in $\mu \to e\gamma$ we do find $(M_W R')^2$ suppression

↳ seems to be algebraic coincidence?



deriv. coupling

$$\sim \int d^4k \, \Delta_F \Delta_F \underbrace{\frac{(2k-p-p')^\mu}{[(p+k)^2-M_W^2][(p'+k)^2-M_W^2]}}_{\star}$$

<u>Algebra</u>: REQ: 4D HIGGS, γ from HIGGS.

$$\star = \frac{(p+p')^\mu}{(k^2-M_W^2)^2}\left[\frac{k^2}{k^2-M_W^2}-1\right] = \frac{M_W^2(p+p')^\mu}{(k^2-M_W^2)^3}$$

[why didn't this show up in arrow-analysis?
it has to do w/ photon emission, which doesn't affect arrows:]

<u>NOTE</u>: this works for NEUTRAL internal fermion.
no APPARENT similar algebraic trick for photon emission off internal up-quark.

↳ trickier: 5D propagators