


POWER COUNTING DIPOLE OPS IN SD

ANCIENT SCIENCE :

SUPER-NAIVE DIM ANALYSIS

4D:  $\sim \int d^4k \frac{1}{k} \frac{1}{k} \frac{1}{k^2} \sim \log \Lambda$

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

WHY: ① GAUGE INVARIANCE

\rightarrow forces " $M^\mu \propto (P+P)^\mu$ "

$\leftrightarrow g \cdot M = 0$ } why: $M^\mu \sim \bar{u}_p [(P+P)^\mu - (m_p + m_e) \gamma^\mu] u_p$
 USING EOM
 \leftrightarrow this is the thing which can be massaged into a dipole operator

② LORENTZ INVARIANCE

SD: same, expect $M \sim 1/M$

\hookrightarrow eg uncompact x^D (orig carries over) \rightarrow = UV of compact y^D

trickier to show for compact x^D w/ branes
 \hookrightarrow go to flat case, can see cancellations

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

I didn't investigate bulk.

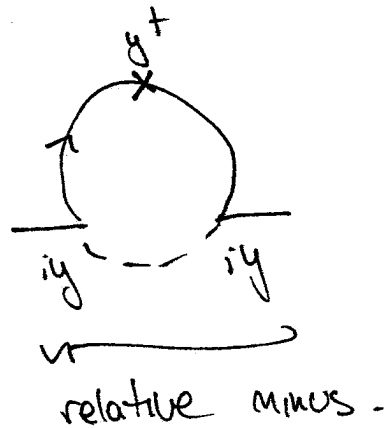
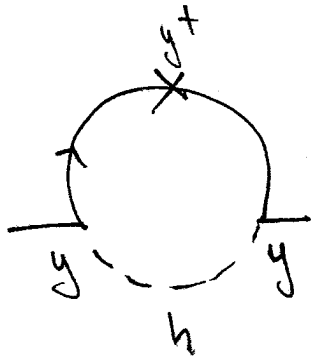
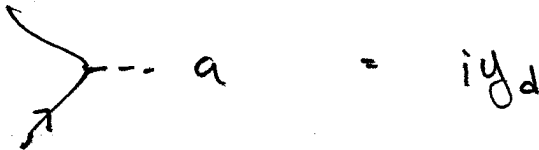
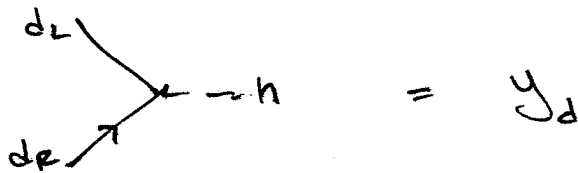
① HIGGS-GOLDSTONE CANCELLATION

② CHARGED SCALAR MASS

two ways to see this

① CANCELLATION IN FEYNMAN GAUGE

$$\hookrightarrow M_{\text{GOLDSTONE}}^2 = M_{\text{GAUGE BOSON}}^2$$



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

ⓑ A nicer way to see this

$$\mathcal{L} = H \cdot \bar{Q} y_d d_R + (H^\dagger i\sigma^2) \cdot \bar{Q} y_u u_R$$

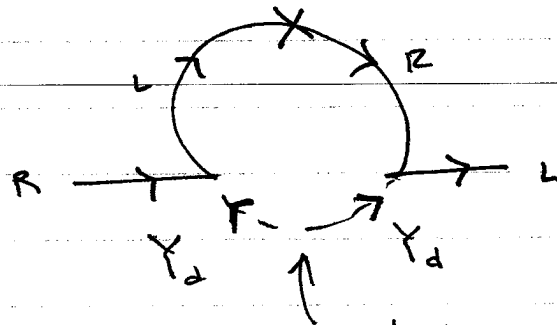
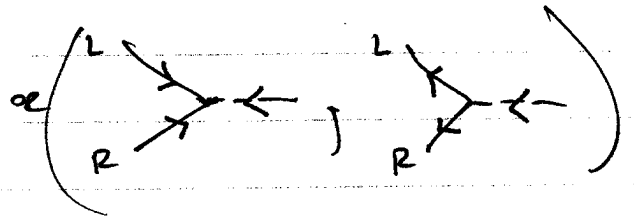
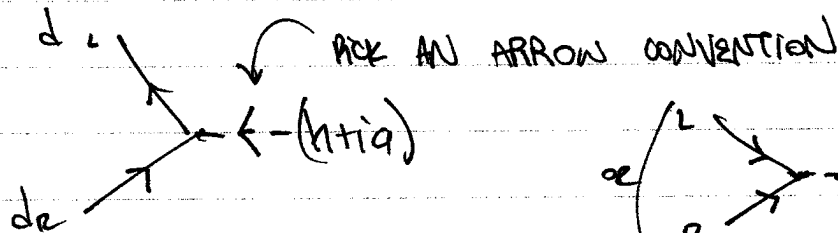
↑

↘

for charged Higgs (later)

$$\begin{pmatrix} h_1 + ih_2 \\ h + ia \end{pmatrix} \cdot \begin{pmatrix} \bar{u}_L \\ \bar{d}_L \end{pmatrix}$$

↑ treat this like a \mathbb{C} scalar

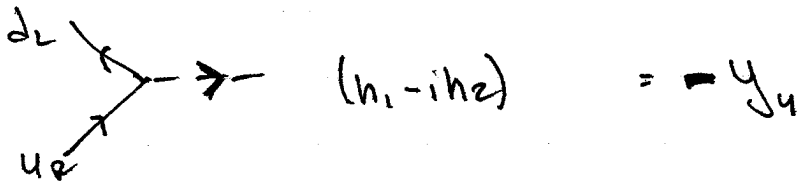
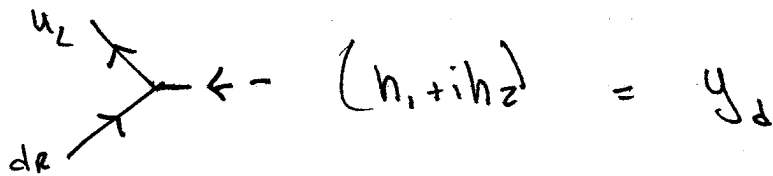


must have mass insertion $\propto M^2$ ✓

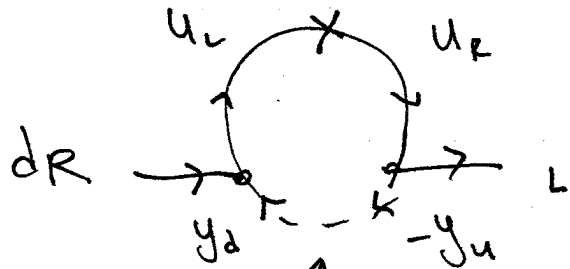
What about charged Higgs?

- ① Goldstone cancellation doesn't work
- ② M_W^2 in $t \rightarrow e \gamma$, not $b \rightarrow s \gamma$ (2PM?)

try to use stick @ field rotation

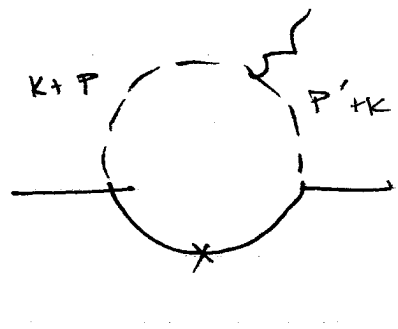


$$\text{From: } (H^+ i\sigma^2 \cdot \bar{2}) y_u u_R = \begin{pmatrix} h - ia \\ -h_1 + ih_2 \end{pmatrix} \begin{pmatrix} \bar{u}_L \\ \bar{d}_L \end{pmatrix} y_u u_R$$



no mass insertion required.

But: in $t \rightarrow e\gamma$ we do find $(N_{WR})^2$ expression
 ↪ seems to be algebraic coincidence?



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

↙ deriv. coupling

Algebra: req: 4D HIGES, γ from HIGES -

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

Why didn't this show up in arrow-analysis?
 it has to do w/ photon emission, which doesn't affect arrows: $\rightarrow \underbrace{\gamma}_{\downarrow} \rightarrow -$

NOTE: this works for NEUTRAL internal fermion.
 No, ^{APPARENT} similar algebraic trick for photon emission off internal up-quark.

↪ trickier: SD propagators