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GOAL: SUMMARY of DOMINANT & NEXT-TO-DOMINANT DIAGRAMS CONTRIBUTING TO THE C_7 & C_8 OPERATORS IN RS.

C_7^a DOMINANT

$\swarrow$ anarchic

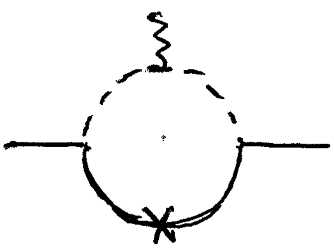
1MIH$^\pm$
w/ γ off quark

THIS DIAGRAM DOES NOT EXIST IN $\mu \to e\gamma$; GRAPH IS SIMILAR TO 1MIH^0, EXCEPT THERE IS NO GOLDSTONE CANCELLATION.

INTEGRAL IS NASTY, GIVES ≈ 0.5 [see v.1 of $\mu\to e\gamma$!]

$$\approx \underset{\substack{\uparrow \\ \text{mass ins.}}}{(10^{-1})}\ \underset{2/3}{Q_u}\ (0.5)$$

C_7^a SUBDOMINANT (refer to $\mu \to e\gamma$)

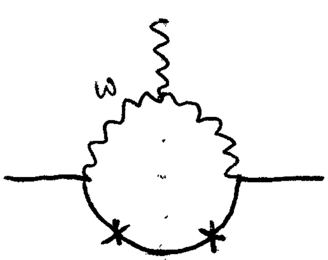


1MIH$^\pm$
w/ γ off H$^\pm$

THIS IS SUPPRESSED BY AN ALGEBRAIC CANCELLATION FOR THE BRANE-LOCALIZED H. ONE ENDS UP W/ A FACTOR of $(M_W R')^2$

[see latest $\mu \to e\gamma$ paper]

$$\approx (10^{-1})\underbrace{(M_W R')^2}_{10^{-2}}(0.65) \sim 6.5\times 10^{-4}$$



2MIW
or: (2+1)MIW
$\uparrow$ external

THIS IS THE DOM. CONTR TO a IN $\mu \to e\gamma$

$$\approx \underset{\uparrow}{(10^{-1})^3}\ \underbrace{g_{5W4}^2 \ln R'/R}_{\approx 7.3}\ (-0.31)$$

$\uparrow$ includes 3/2 in expression

note: ext mass ins. $\approx$ int mass ins. b/c. intermediate state is a KK mode; no $(m_{SM} R') \ll 10^{-1}$ SUPPRESSION

REMARKS: the gauge couplings are enhanced by $g_{SM}^2 \to g_{SM}^2 \underbrace{\log R'/R}_{\sim 35}$

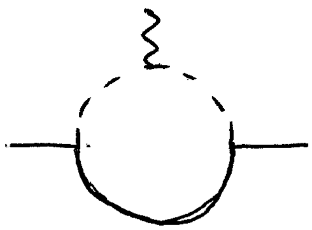
SOME SM COUPLINGS:

$$g_{Zu_Lu_L} = \frac{g}{c_W}\left(\frac{1}{2} - \frac{2}{3}s_W^2\right) = .26 \qquad g_{Zu_Ru_R} = \frac{g}{s_W}\left(-\frac{2}{3}s_W^2\right) = -.11$$

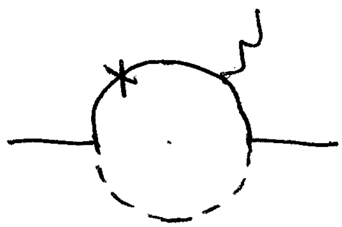
$$g_{Zd_Ld_L} = \frac{g}{c_W}\left(-\frac{1}{2} + \frac{1}{3}s_W^2\right) = -.315 \qquad g_{Zd_Rd_R} = \frac{g}{c_W}\frac{1}{3}s_W^2 = .057$$

USE: $G_F = \frac{\sqrt{2}}{8}\frac{g^2}{M_W^2} = 1.166\times 10^{-5}/\mathrm{GeV}^2 \Rightarrow g \approx .65$

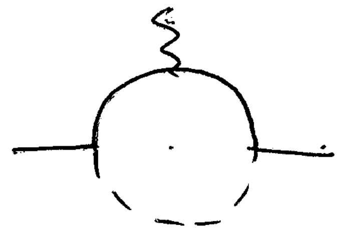
$g_W = \frac{1}{\sqrt{2}}g = .46$



0MIH±



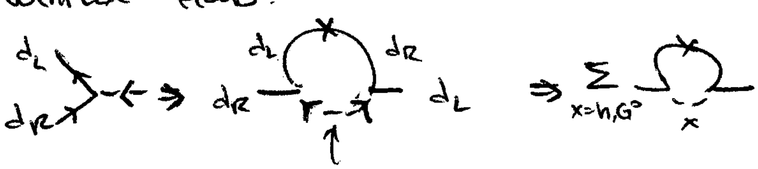
1MIH



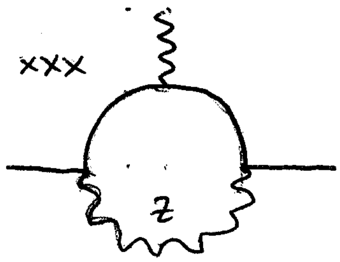
0MIH

THESE ARE ALL NEGLIGIBLE. 0MIH± & 0MIH MUST HAVE AN EXTERNAL MASS INSERTION. HOWEVER, BECAUSE THE INTERMEDIATE STATE IS BRANE-TO-BRANE, IT MUST BE A ZERO MODE (by boundary conditions), THUS INSTEAD OF A 10^{-1} SUPPRESSION, THESE GET A 10^{-3} SUPPRESSION.

THE 1MIH DIAGRAM IS TINY B/C of A CANCELLATION BETWEEN THE PHYSICAL HIGGS & THE NEUTRAL GOLDSTONE. THE EASIEST WAY TO SEE THIS IS TO PROMOTE THE (higgs + Goldstone) TO A COMPLEX FIELD:



$\propto (m_h^2 - m_Z^2)(R')^2 \sim 10^{-4}$



Z DIAGRAMS W/ 3 MASS INSERTIONS
AT LEAST 1 INTERNAL SINCE CONSECUTIVE EXTERNAL MASS INSERTIONS → ZERO MODE

SO: 3MIZ, (2+1)MIZ, (1+2)MIZ } $Z \to Z^5$

$$3MIZ \approx (10^{-1})^3 \underbrace{g_{Zd_Ld_L} g_{Zd_Rd_R} \ln R'/R}_{-.63} \underbrace{(-.1)}_{\mu \to e\gamma \text{ value}}$$

$$(2+1)MIZ \approx (10^{-1})^3 \underbrace{g^2_{Zd_Ld_L} \ln R'/R}_{3.5} \underbrace{(.2)}_{\mu \to e\gamma \text{ value}}$$

$$(1+2)MIZ \approx (10^{-1})^3 \underbrace{g_{Zd_Ld_L} g_{Zd_Rd_R} \ln R'/R}_{-.63} \underbrace{(.13)}_{\mu \to e\gamma}$$

$$3MIZ_5 \approx (10^{-1})^3 \underbrace{g_{Zd_Ld_L} g_{Zd_Rd_R} \ln R'/R}_{-.63} \underbrace{(-0.07)}_{\mu \to e\gamma}$$

$$(2+1)MIZ_5 \approx (10^{-1})^3 \underbrace{g^2_{Zd_Ld_L} \ln R'/R}_{3.5} \underbrace{(-0.0036)}_{\mu \to e\gamma}$$ why so small?

$$(1+2)MIZ_5 \approx (10^{-1})^3 \underbrace{g_{Zd_Ld_L} g_{Zd_Rd_R} \ln R'/R}_{-.63} \underbrace{(0.0275)}_{\mu \to e\gamma}$$?

REMARKS: FOR $\mu \to e\gamma$ WE HAD A NUMERICAL COINCIDENCE:

$$a(Y_E^3) = 2MIZ + \underbrace{3MIZ + 3MIZ^5 + (2+1)MIZ + (2+1)MIZ^5}_{\text{numerically cancel}}$$

→ BUT: this was all moot because $a(Y_E^3) \ll a(Y_N^2 Y_E)$

IN $b \to s\gamma$, SUCH A NUMERICAL COINCIDENCE DOESN'T SEEM TO HOLD SINCE THE VALUES OF THE COUPLINGS ARE DIFFERENT FOR QUARKS. BUT ANYWAY, THE COUPLINGS ARE STILL $\mathcal{O}(1)$ AND ARE SMALL COMPARED TO THE GLUON DIAGRAMS.

note: I just copied the $\mu \to e\gamma$ INTEGRAL values – $b \to s\gamma$ may differ due to the fermion localization, but don't expect a $\mathcal{O}(10)$ change. [checked numerically]

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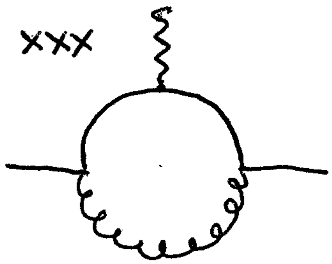


GLUON DIAGRAMS W/ 3 MASS INSERTIONS
THE GRAPHS ARE IN 1-1 CORRESPONDENCE

ACCORDING TO YUHSIN: @ 3 TeV
$\alpha_s \sim 0.1 \Rightarrow g_s^2 \sim 1.2$
$\Rightarrow g_s^2 \ln R'/R \sim 44 \gg g_z^2 \ln R'/R$

ALSO A DYNKIN FACTOR, $C_r = 4/3$ from $T^a T^a$

$$3\text{MIG} (+G^5) \sim (10^{-1})^3 \underbrace{g_s^2 \ln R'/R\, C_R}_{\sim 58} (.1) \sim .006$$

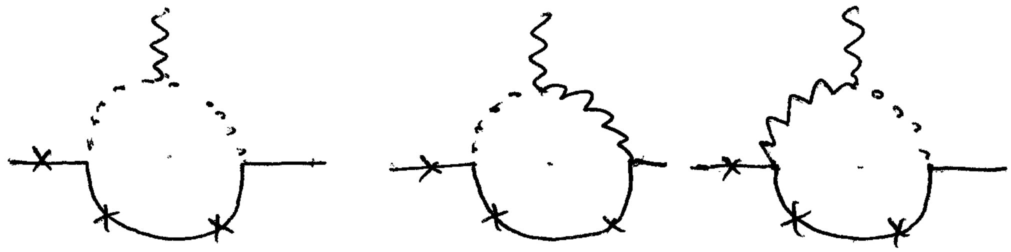
$$2\text{MIG} (+G^5) \sim (10^{-1})^3 \underbrace{g_s^2 \ln R'/R\, C_R}_{\sim 58} (.2) \sim .012$$

$$1\text{MIG} (+G^5) \sim (10^{-1})^3 \underbrace{g_s^2 \ln R'/R\, C_R}_{58} (.13) \sim .007$$

HERE WE'VE USED THE $\mu \to e\gamma$ INTEGRAL VALUES AS AN ESTIMATE. NOTE THAT THE 2MIG DIAGRAM IS ONLY A FACTOR OF FEW SMALLER THAN THE DOMINANT CHARGED HIGGS DIAGRAM.

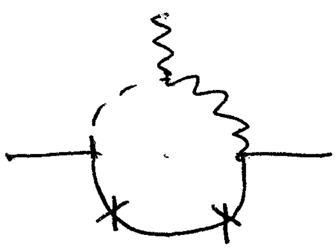
↳ need to be careful, in old notes we wrote $C_R = \frac{1}{2}$.

ZMIW/W5 DIAGRAMS



$$\sim (10^{-1})^3 \underbrace{g_w^2 \ln R'/R}_{7.4} \quad (-.05)$$

WHY IS THIS SO SMALL? DERIVATIVES ACTING ON γ PROFILE?

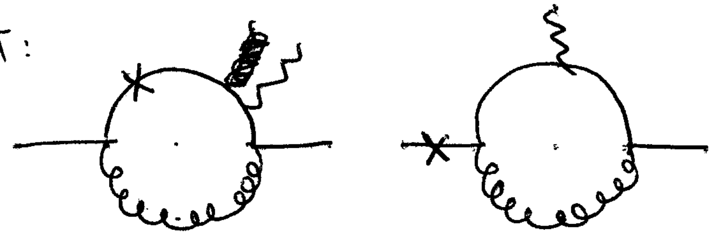


H±W MIXING

$$\sim (10^{-1})^3 \underbrace{g_w^2 \ln R'/R}_{7.4} \quad [illegible]) \; (-.23)$$

$\boxed{C_7^{\,b}}$ MIS ALIGNMENT DIAGRAMS (1 MASS INSERTION)

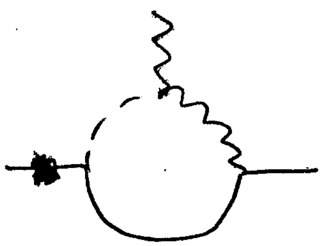
DOMINANT:
IMIG
OMIG



$$\sim (10^{-1})\ \underbrace{g_s^2 \ln R'/R}_{58}\ C_R$$

(IMIG5)
(OMIG5)
from $\mu\to e\gamma$: the analogous IMIZ5 lepton diagrams are ~50% of the IMIZ diagrams.

C_7^b SUBDOMINANT



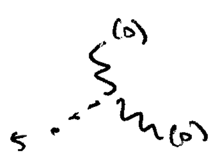
omIHW

THIS, ALONG W/ 1MIZ, WAS THE DOMINANT MISALIGNMENT CONTRIBUTION TO $\mu\to e\gamma$.

$$\sim (10^{-1})\ \underbrace{g_W^2 \ln R'/R}_{7.4}\ \underbrace{(.23)}_{\text{before align.}}$$

1MIZ(Z5) : $g_s^2 \ln R'/R \mapsto g_{Zd_Ld_L}\, g_{Zd_Rd_R} \ln R'/R$
$\qquad\qquad\qquad\qquad \mapsto g^2_{Zd_Ld_L} \ln R'/R$ } small.

OMIW5/OMIHW5 : THESE ARE ALL SMALL BECAUSE

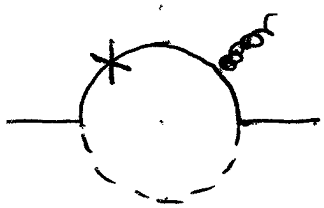


$= 0$ BY ∂_z ACTING ON FLAT PROFILES

$= 0$ BY BC @ IR BRANE

OMIW : $\sim (10^{-1})\ g_W^2 \ln R'/R\ \underbrace{(.1)}_{\text{before align}}$

$\boxed{C_8^a \text{ ANARCHIC}}$ DOMINANT

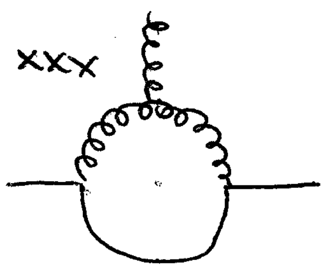


SAME AS THE ANALOGOUS γ DIAGRAM
↳ PROPORTIONAL TO $\boxed{Y_u^\dagger Y_u Y_d^\dagger}$

1MI $H^\pm$

[1,2,3] MIG w/ GLUON FROM GLUON ; $\propto \boxed{Y_d^3}$

XXX



THE DIAGRAMS WHERE THE GLUON IS EMITTED FROM THE VIRTUAL GLUON GO LIKE

$$f^{abc} t^b t^c = \frac{3}{2} i t^a$$

WHEREAS THE DIAGRAMS WHERE THE GLUON IS EMITTED FROM THE VIRTUAL QUARK GO LIKE

$$t^b t^a t^b = -1/6$$

↳ these diagrams are enhanced by $\sim \mathcal{O}(10)$

note how the dominant Higgs & gluon diagrams add:

$$a = \underbrace{I_{C_{7a}}}_{\text{1MIH}^\pm \text{ integral}} \oplus \frac{3}{2}\left(g_s^2 \ln \frac{R'}{R}\right)^2 \left(\frac{R' v}{\sqrt{2}}\right)^2 I^G_{C_{8a}}$$

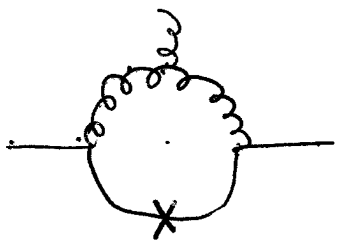
indep. flavor spurions

OTHER DIAGRAMS (C_8^a)

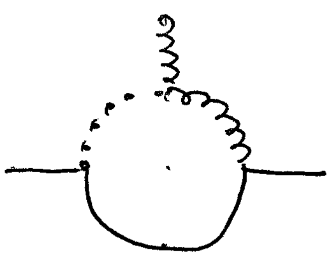
THERE ARE NO HHG COUPLINGS, SO IGNORE THOSE C_7 DIAG. THE 1MIH± GLUON DIAGRAM DOMINATES OVER THE OTHER HIGGS DIAGRAMS FOR THE SAME REASONS AS W C_7.

THE W & Z DIAGRAMS ARE COMPLETELY SUBDOMINANT TO THE GLUON DIAGRAMS. & WE ARGUED ABOVE THAT THE GLUE-FROM-GLUE DIAGRAMS ARE ENHANCED OVER THE GLUE-FROM-QUARK DIAGRAMS.

C_8^b MISALIGNMENT



1MIG



0/1MIGS

⇒ should be small, derivative acting on zero mode gluons.

OTHER DIAGRAMS:

- GLUON DIAGRAMS BEAT ELECTROWEAK
- GLUE-FROM-GLUE BEAT GLUE-FROM-QUARK

TO CORRECT CHENG & LI APPENDIX B

$$\mathcal{L}_{\text{Neutral}} = g J^3_\mu W^\mu_3 + \frac{1}{2} g' J^Y_\mu B^\mu$$

$$\begin{aligned} Z &= c_W W^3 - s_W B \\ A &= s_W W^3 + c_W B \end{aligned} \Rightarrow \begin{aligned} W^3 &= s_W A + c_W Z \\ B &= c_W A - s_W Z \end{aligned}$$

$$g' = t_W g \qquad \frac{1}{2} J^Y = J^{EM} - J^3$$

$$\mathcal{L}_N = g J^3_\mu (s_W A^\mu + c_W Z^\mu) + t_W g \,(J^{EM} - J^3)(c_W A - s_W Z)$$

$$\supset g c_W J^3 \cdot Z + \frac{g\, s_W^2}{c_W} (J^3 - J^{EM}) \cdot Z$$

$$= \frac{g}{c_W} \Big[\underbrace{c_W^2 J^3 + s_W^2 J^3 - s_W^2 J^{EM}}_{J^3 - s_W^2 J^{EM}} \Big] \cdot Z$$

$$2 J^3 = \frac{1}{2} \bar{u} \gamma (1 - \gamma^5) u - \frac{1}{2} \bar{d} \gamma (1 - \gamma^5) d$$

$$J^{EM} = \frac{2}{3} \bar{u} \gamma u - \frac{1}{3} \bar{d} \gamma d$$

$$= \frac{g}{c_W} \Big[\frac{1}{4} \bar{u} \gamma u - \frac{1}{4} \bar{u} \gamma \gamma^5 u - \frac{1}{4} \bar{d} \gamma d + \frac{1}{4} \bar{d} \gamma \gamma^5 d - \frac{2}{3} s_W^2 \bar{u} \gamma u + \frac{1}{3} s_W^2 \bar{d} \gamma d \Big] \cdot Z$$

$$= \frac{g}{4 c_W} \Big[\left(1 - \frac{8}{3} s_W^2\right) \bar{u} \gamma u - \bar{u} \gamma \gamma^5 u - \left(1 - \frac{4}{3} s_W^2\right) \bar{d} \gamma d + \bar{d} \gamma \gamma^5 d \Big] \cdot Z$$

$$1 = P_L + P_R \,, \quad \gamma^5 = P_R - P_L \Rightarrow A + B \gamma^5 = (A - B) P_L + (A + B) P_R$$

$$g_{Zu_Lu_L} = \frac{g}{c_W} \left(\frac{1}{2} - \frac{2}{3} s_W^2 \right) \qquad g_{Zu_Ru_R} = \frac{g}{c_W} \left(-\frac{2}{3} s_W^2 \right)$$

$$g_{Zd_Ld_L} = \frac{g}{c_W} \left(-\frac{1}{2} + \frac{1}{3} s_W^2 \right) \qquad g_{Zd_Rd_R} = \frac{g}{c_W} \frac{1}{3} s_W^2$$