NIC : EMERGENCE OF EW SCALE THROUGH D PORTAL 4 FEB

USE DIM TRANSM. TO GEN. SCALE IN SCALE-INVT THY

COLEMAN-WEINBERG

Classically scale inv't thy $V_{cl.} = \frac{\lambda}{4!}|\phi|^4$

PICK REGULATOR, REN SCHEME

↳ IF REGULATOR HAS SCALE, THEN YOU GET $\sim \Lambda^2 |\phi|^2$
(eg HARD CUTOFF) → BREAK SCALE INVARIANCE BADLY

~~STILL NEED A~~

DIM REG: STILL USE REN SCALE, BUT ONLY LOG.

↳ $V \sim \cancel{\log \Lambda}\ 0 \cdot |\phi|^2$

can't get $(\text{mass})^2$

$$\left.\frac{d^4 V}{d^4\phi}\right|_{\phi=M} = \lambda$$

U(1) CHARGE

$$V^{1\text{-loop}} = \frac{\lambda}{4!}|\phi|^4 + \left(\underbrace{\frac{5\lambda^2}{1152\pi^2}} + \frac{3e^4}{64\pi^2}\right)|\phi|^4\left(\log\left(\frac{|\phi|^2}{M^2}\right) - \frac{25}{6}\right)$$

btw, reasonable to assume $\lambda \sim e^4$
eg λ generated by γ loop

BETTER: RG FLOWS TO THIS BALLPARK

then $\lambda^2 \ll e^4$ term (squiggle term → 0)

MINIMIZING IN THIS LIMIT,

$$v = M \exp\left(\frac{11}{6} - \frac{4\pi^2}{9} \cdot \frac{\lambda}{e^4}\right)$$

invert to get $\lambda(v)$

$$V = \frac{3e^4}{64\pi^2} |\phi|^4 \left[\underline{\underline{\log\left(\frac{|\phi|^2}{v^2}\right)}} - \frac{1}{2}\right] + \mathcal{O}(e^8)$$

of λ^2

$\Rightarrow$ Dimensional transmutation

RADIATIVE EFFECTS: 2 DIM PARAM $\mapsto$ 1 DIMLESS + 1 DIMFUL

e, λ $\qquad$ e $\qquad$ v

WE GENERATED A SCALE $\langle|\phi|\rangle$

ONLY VALID PERTURBATIVELY

$\hookrightarrow$ but use RGE to start the @ $M = \Lambda_{UV}$

UV SCALE (not cutoff)

v

$$\boxed{\langle|\phi|\rangle = \Lambda_{UV} \exp\left(\frac{11}{6} - \frac{4\pi^2}{9} \cdot \frac{\lambda}{e^4}(\Lambda_{UV})\right)}$$

exp. suppression of vev.

but we're neglecting $\mathcal{O}(\lambda^2)$ terms even though λ/e^4 not nec. small

is this valid?

point: for reasonable λ/e^4, get exp suppressed v.

thus we avoid $\mu^2|H|^2$ renormalization in SM, no fine tuning required.

PROBLEM : PHENOMENOLOGICALLY, THIS IS RULED OUT.

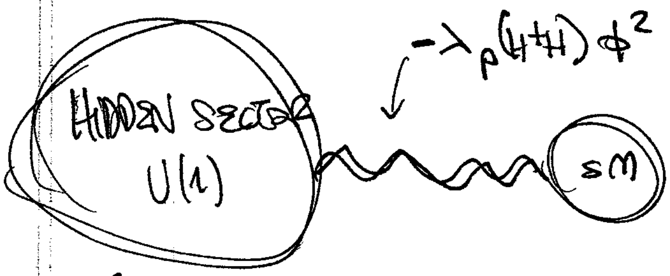
$$m_h^2 = \frac{3e^2}{8\pi^2} m_X^2 \ll m_X^2$$

not like SM!

VECTOR MASS OF VEV

so: can try to salvage feature

$-\lambda_p (H^\dagger H)\phi^2$ HIGGS PORTAL



COLEMAN WEINBERG

$$V_{cl} = \frac{\lambda_H}{2}(H^\dagger H)^2 - \lambda_p (H^\dagger H)|\phi|^2 + \frac{\lambda_\phi}{4!}|\phi|^4$$

STABILITY : $\lambda_\phi \cdot \lambda_H > 12\lambda_p^2$

SIMPLIFY : $\lambda_p \ll 1$

END UP w/ $+\mu^2_{SM} = -\lambda_P \langle |\phi|^2 \rangle$

$$\Rightarrow \langle |\phi|^2 \rangle = \frac{\lambda_H}{\lambda_P} \langle |H|^2 \rangle$$

phenomenology – heuristic (TOY MODEL LIMIT)

- KINETIC MIXING OF Z, γ & γ'

  $m^2_{\gamma'} \sim e^2 \langle |\phi|^2 \rangle$

  so can be $\mathcal{O}$(10 TeV)?

  w/ 1GN MIXING-SIZED COUPLING

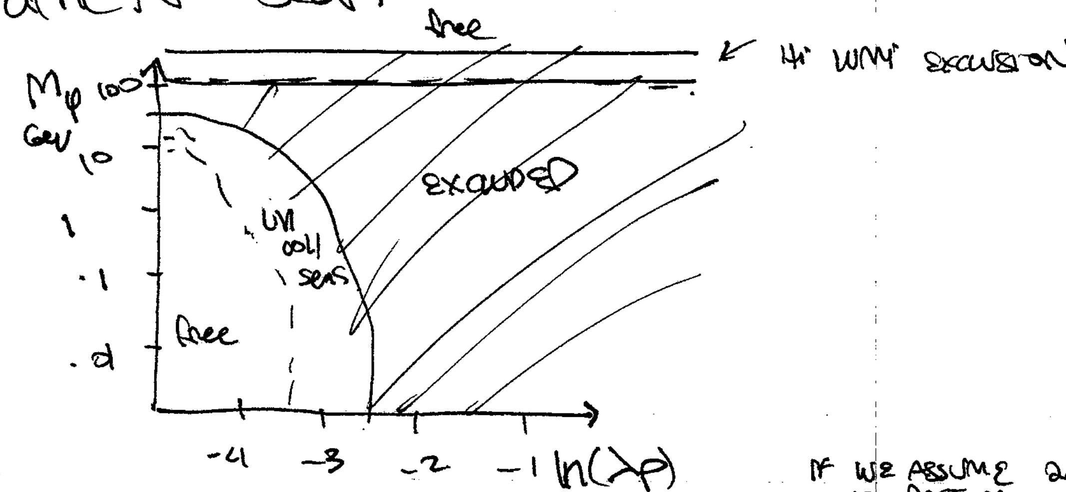
- $\underline{\varphi\, h \text{ mixing}}$: $\theta \approx \sqrt{\frac{\lambda_P}{\lambda_H}} \frac{M_h}{m^2_\rho - m_h^2} \ll 1$

effect: $\Gamma(h \to f) < \Gamma(h \to f)_{SM}$

$$\frac{\sigma\, Br_f}{(\sigma\, Br_f)_{SM}} < 1 \quad \forall \text{ final state}$$

cf $\gamma\gamma$ excess: BAD NEWS for MODEL

Parameter scan



IF WE ASSUME QFT VALID PAST M_{Pl}, reg. SCALE INV'T,

Conceptual issues

WE REQ: a) $\mu^2_{BARE}(\Lambda_{UV}) = 0$

b) DIM REG

If not, then ADDITIVE REG. TERMS!

they claim: HIERARCHY PROBLEM IN DIM REG

$$\partial_t \left(\frac{\mu^2}{M^2}\right) = (-2 + \gamma)\,\varepsilon \qquad \text{(DIM REG)}$$

stiffened if $\mu^2_{BARE}(\Lambda_{UV}) \neq 0$