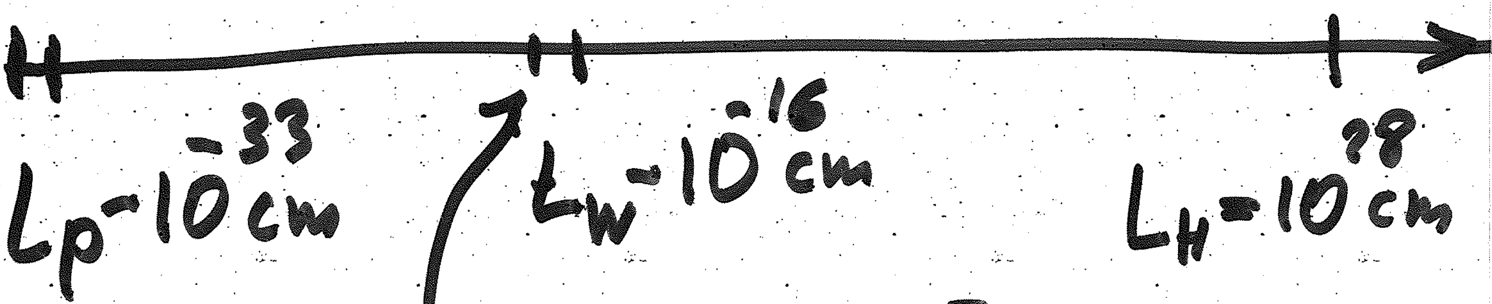
BSM



$L_{LHC} \sim 10^{-17}\,\mathrm{cm}$

$\rightarrow \sim \mathrm{TeV}$

SM + GR

$$SU(3)_C \times SU(2)_W \times U(1)_Y$$

$$8 = g_\mu \qquad W^\pm_\mu, Z_\mu, A_\mu$$

$$Q_L \equiv \begin{pmatrix} u \\ d \end{pmatrix}_L \qquad q_R \equiv u_R, d_R$$

$$L \equiv \begin{pmatrix} e \\ \nu \end{pmatrix}_L \qquad e_R, \; \nu_R$$

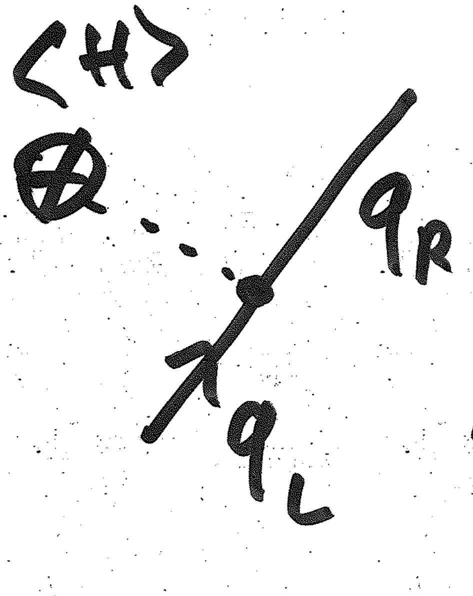
$$H \equiv \begin{pmatrix} H^0 \\ H^- \end{pmatrix}$$

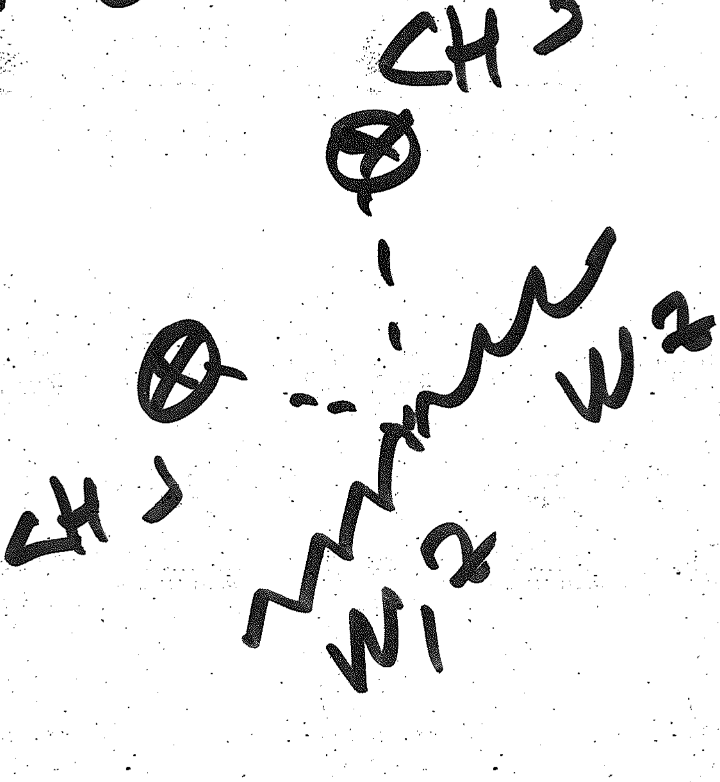
$$g_u H Q_L u_R + g_d H^* Q_L d_R$$

$$+ g_e H^* L e_R + g_\nu H L \nu_R$$

$$g_{u,d,e,\nu}$$

$$\langle H \rangle \neq 0$$





$L_W \lessapprox r. \Leftarrow SM$

GR:

$10^{-2}cm \gtrapprox r \gtrapprox 10^{28} cm$

$\uparrow$

WHY BSM?

SM:

$\boxed{\text{① Hierarchy Problem.}}$

② Strong CP

③ Fermion masses

GR:

① Dark Matter

② Singularities:
BH, Cosmological . . .

③ Quantum gravity

$\underline{\underline{h_{\mu\nu}}}$ $\underline{\text{spin-}2}$ $\underline{\underline{M=0}}$

$$\int \frac{h_{\mu\nu}}{M_P}\tau^{\mu\nu}$$

$$\hbar = c = \underline{1}$$

$$[L] = [M]^{-1}$$

$$T^{\mu\nu} = \begin{pmatrix} M & & & \\ & 0 & & \\ & & 0 & \\ & & & 0 \end{pmatrix} \delta(\vec{x})$$

$$\tau^{\mu\nu} = \begin{pmatrix} m & & & \\ & 0 & & \\ & & 0 & \\ & & & 0 \end{pmatrix} \delta(\vec{x} - \vec{r})$$

$$V(r) = -G_N \frac{M m}{r}$$

$$V(r)\big|_{EM} = \frac{e_1 e_2}{r}$$

$$G_N = \frac{1}{M_P^2}$$

$$V(r)_{gr} \propto \left(\frac{M}{M_p}\right)\left(\frac{m}{M_p}\right)\frac{1}{r}$$

$$V(r)_{EM} \propto e_1 \, e_2 \, \frac{1}{r}$$

$$e \longleftrightarrow \frac{m}{M_p}$$

$$M_p \sim 10^{19}\,\mathrm{GeV} \sim 10^{-4}\,g.$$

$$\left(\frac{E}{M_p}\right)$$

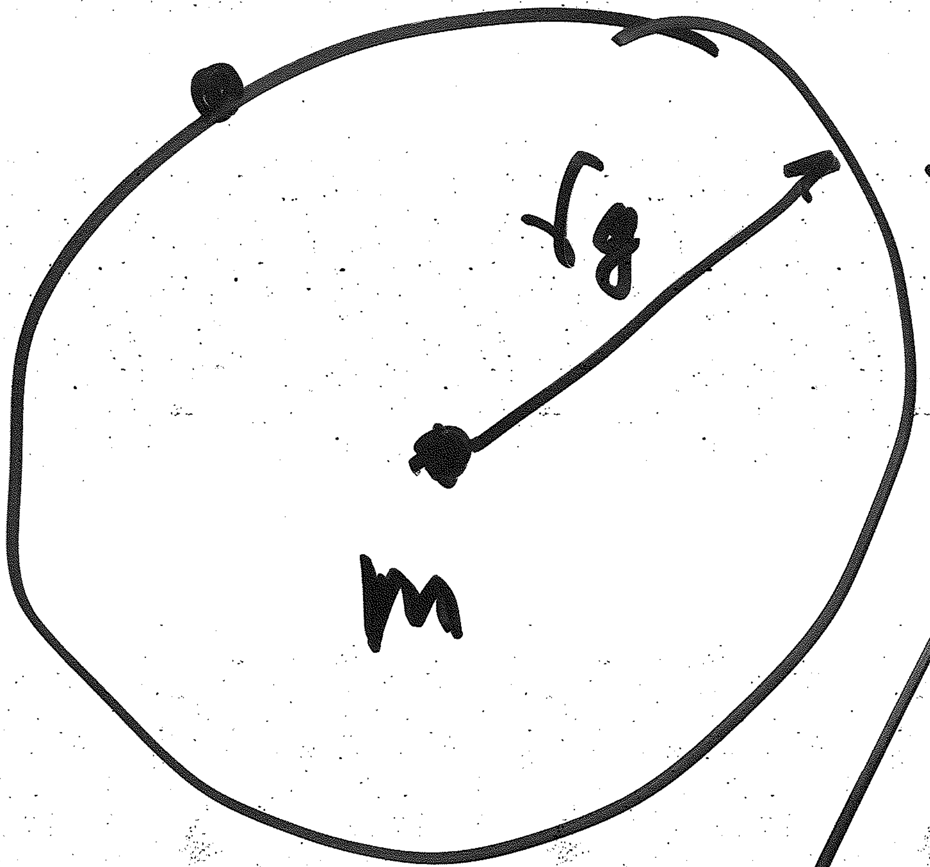
$$L_p \gg r$$

$$E \gg M_p$$

L $\quad$ $E \sim \frac{1}{L}$

$m \ll M_P$

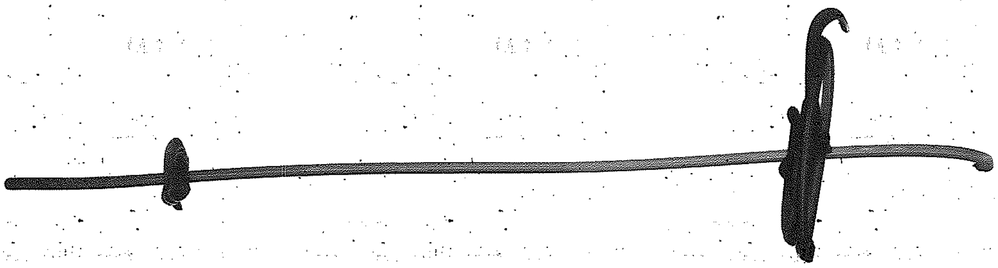
$m \gg M_P$



$r_g \equiv 2 G_N m$

m'

$$G_N \frac{m m'}{r} = \frac{m' v^2}{2}$$



r_g

$h_{\mu\nu} \gtrsim M_p$

$$g_{\mu\nu} = \eta_{\mu\nu} + \frac{h_{\mu\nu}}{M_p}$$

$h_{\mu\nu} \ll M_p$.