

$$\underline{\langle H \rangle \rightarrow 0}$$

$$W_{\mu}^{\pm}, Z_{\mu}$$

$$(H^{\dagger} H)_a$$

$$H = \rho \begin{pmatrix} \omega_0 e^{i\varphi} \\ \chi_0 e^{i\varphi} \end{pmatrix}$$

$$W_{\mu} = \tilde{W}_{\mu} + Z_{\mu} \phi$$

$$\begin{pmatrix} u \\ d \end{pmatrix}_L$$

$$u_R, d_R$$

$$\underline{\underline{SU(3)_c}}$$

$$SU(2)_w$$

$$\langle \bar{q}_L q_R \rangle \neq 0$$

$$M_{W,2} \rightarrow \infty$$

$$\Sigma U(2)_L \otimes U(2)_R$$

$$\pi^\pm, \pi^0$$

$$\Lambda_{\text{QCD}} \sim 1 \text{ GeV} \ll M_{W,2}$$

Assumptions

① New QCD-type Force.

$$\Lambda_T \sim 100 \text{ GeV}$$

② New "quarks".

$$Q_L = \begin{pmatrix} U \\ D \end{pmatrix}_L \quad U_R, D_R$$

$$SU(N)_T \otimes \underline{SU(2)_W \otimes U(1)_Y}$$

$$\underline{\langle \bar{Q}_L Q_R \rangle \neq 0.}$$

$$Q_L^i \quad Q_R^i \quad i=1 \dots N$$

$$\underline{\pi^\pm, \pi^0}$$



$$\boxed{H \bar{Q}_L Q_R}$$

$$H \longrightarrow \bar{Q}_L Q_R$$

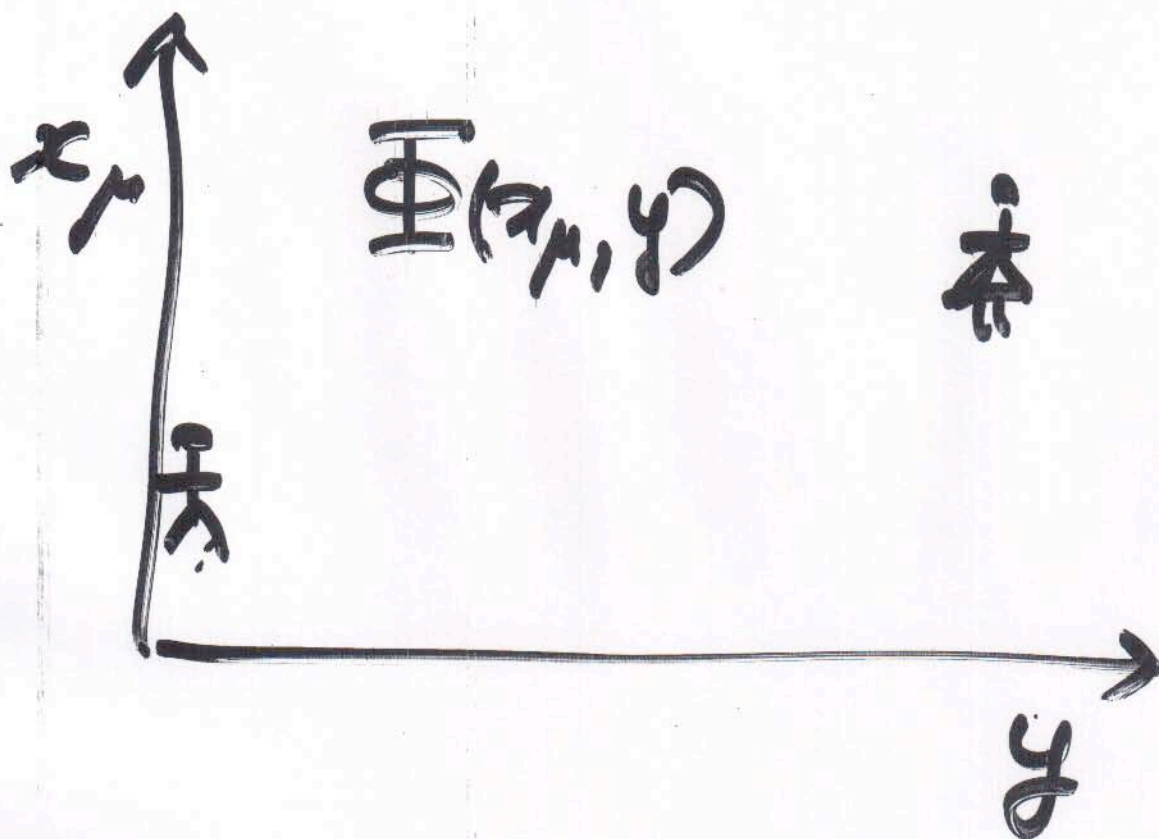
$$\frac{\bar{Q}_L Q_R \bar{q}_L q_R}{\Lambda^2}$$



AT ← Tower.

③ Susy

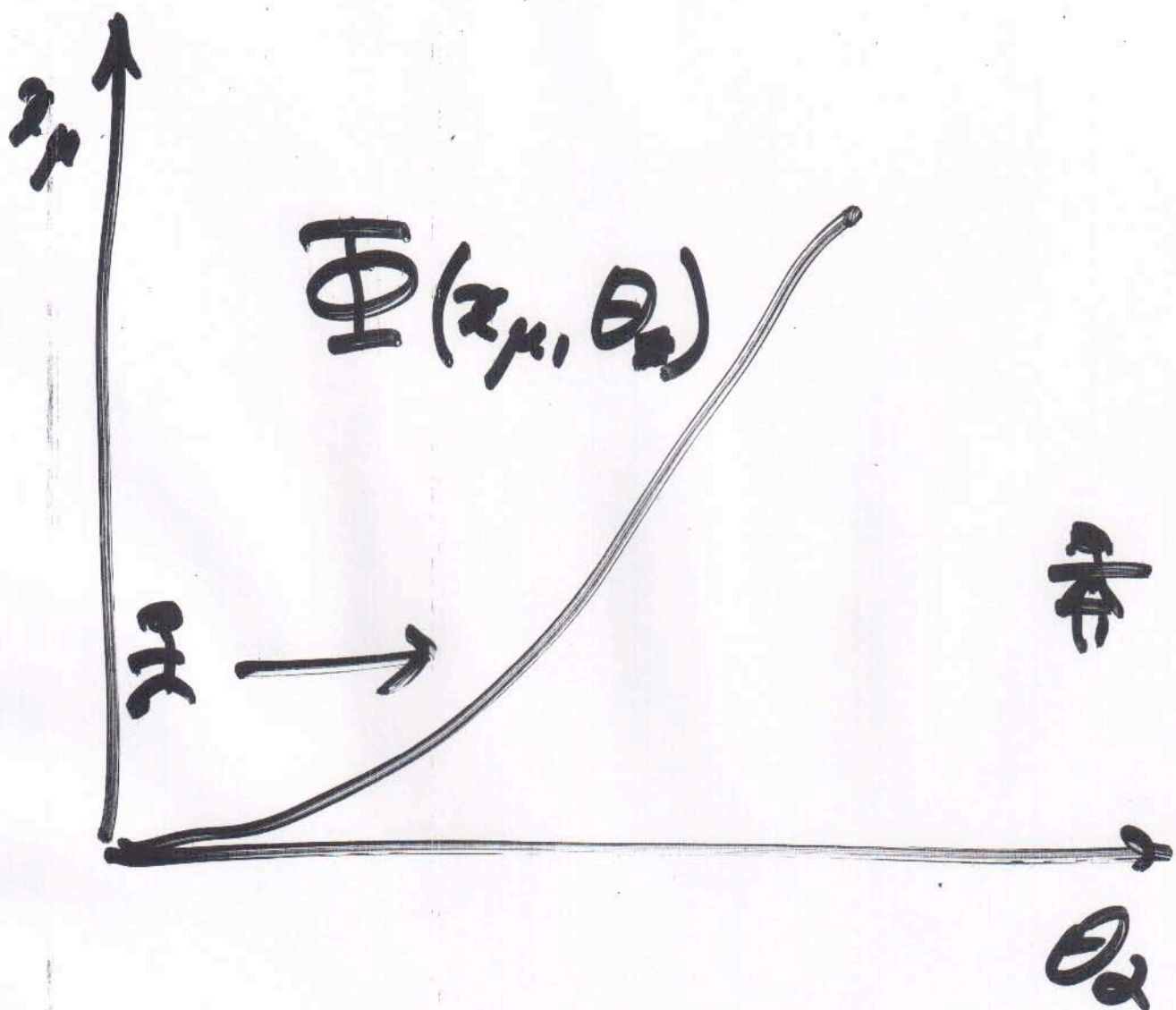
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$$\Phi(x_\mu, y) = \sum e^{i n y} \phi_{(n)}^{(m)}$$

$$y \rightarrow \theta_\alpha$$

$$\underline{d = 1, \dots, 4}$$



$$\begin{aligned} \Phi(x, \theta) = & \varphi(x) + \bar{\theta}x \\ & + \bar{\theta}\theta F + \bar{\theta}x_5\theta M + \bar{\theta}x_5x_6\theta U \\ & + \bar{\theta}\theta\theta\lambda + \bar{\theta}\theta\bar{\theta}\theta D \end{aligned}$$

$$\theta\theta\theta\theta\theta = 0$$

$$\theta_0\theta_1 = -\theta_1\theta_0$$

$$\Theta \rightarrow \Theta + \varepsilon$$

$$x_\mu \rightarrow x_\mu + c \bar{\Theta} \gamma_\mu \Theta$$

$$Z_\mu^\pm = x_\mu \pm \frac{1}{2} i \bar{\Theta} \gamma_\mu \Theta$$

$$\Theta_\pm = \frac{1 \pm i \gamma_5}{2} \Theta$$

$$Z_\mu^\pm, \Theta_\pm$$

$$\Phi(Z_\mu^\pm, \Theta_\pm) =$$

$$= \varphi + \bar{\Theta}_+ \psi + \bar{\Theta}_+ \Theta F$$

$$\Phi \rightarrow \varphi, \psi_+$$



MSSM

$Q_L, u_R, d_R, L_L, e_R$

~~W~~

$$W = H_u Q_L u + H_d Q_L d + H_d L e + [udd + \dots] + \mu H_u H_d$$

$$H Q_L u + (H^*) Q d$$

B L - violation

$Z_2$  - parity (matter, R)

$$(u, d, e, Q, L) \rightarrow -(u, d, e, Q, L)$$



$$\underline{50(10) = Z_2}$$

$$\underline{16 = (u, d, u, L, e, \nu)}$$

$$\textcircled{Z_2}$$

$Q \rightarrow \tilde{Q}$  squark

$l \rightarrow \tilde{l}$  slepton

$H \rightarrow \tilde{H}$  Higgsino

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$W_\mu \leftrightarrow \lambda$  Gaugino.

$$\Delta M^2 \sim M_{\text{susy}}^2$$

# Soft breaking

$$m_{\text{partners}}^2 \gg m_{\text{SM}}^2$$

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$$m_{ij}^2 \tilde{Q}_i^* \tilde{Q}_j + \hat{m}_{ij}^2 \tilde{L}_i^* \tilde{L}_j$$

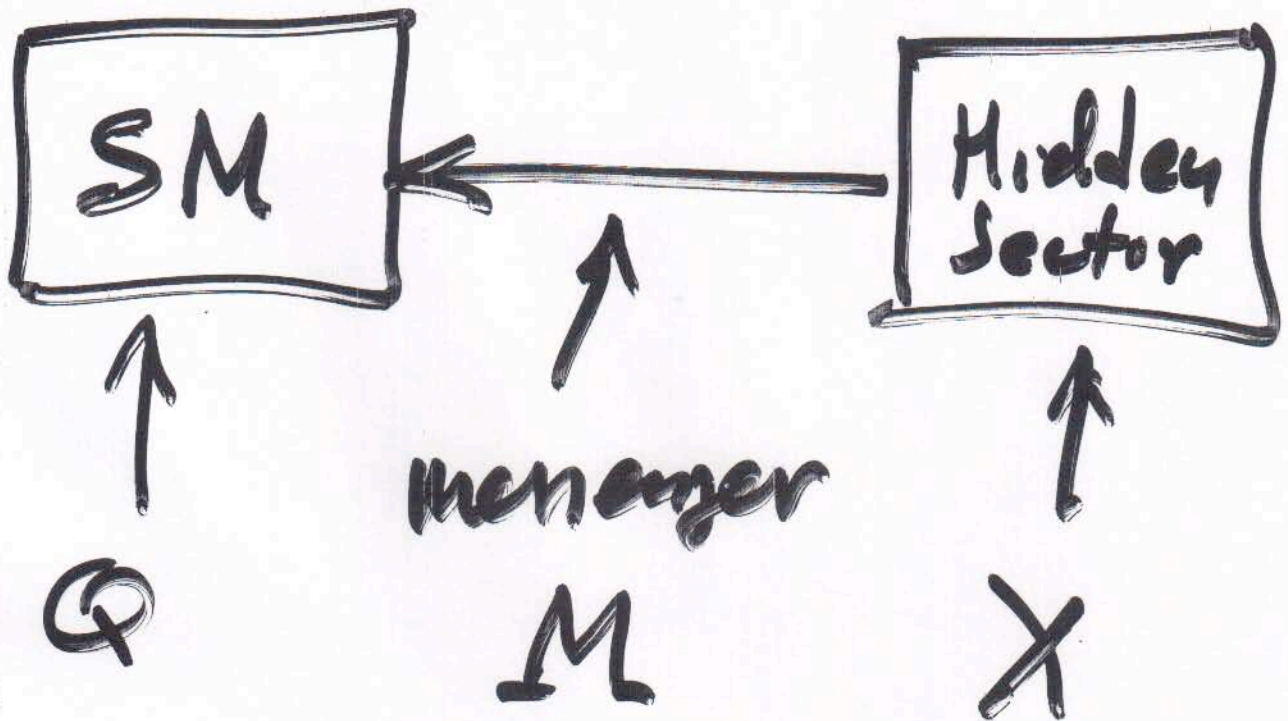
← ...

$$A_{ijk} H Q_k + \dots$$

$$\sum m_{\lambda} \bar{\lambda} \lambda$$

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Limit ( $M \rightarrow \infty$ )

$$\int d^4 Q \left( \frac{X^\dagger X Q^\dagger Q}{M^2} + \dots \right)$$

Diagram illustrating the effective Lagrangian in the limit  $M \rightarrow \infty$ , showing the integration over the messenger field  $Q$  and the resulting operator  $\frac{X^\dagger X Q^\dagger Q}{M^2}$ .

The result is identified as  $\mathcal{L}_{\text{SUSY}}^2$ .

(HP) and SUSY.

$$\mathbb{Z}_2 \psi \rightarrow e^{i\gamma_5} \psi$$

$$\phi^* \phi$$

$$\Phi \longleftrightarrow \psi \longrightarrow \text{chiral U(1)}$$

$$\mathcal{M}_\psi = \mathcal{M}_\chi$$

# Gravity-mediation

$$m_{\text{susy}}^2 \sim \frac{\langle X_F \rangle^2}{M_p^2}$$

# Gauge-mediation.

$$m_{\text{susy}}^2 \sim \frac{\langle X_F \rangle^2}{M_{\text{gauge}}^2}$$



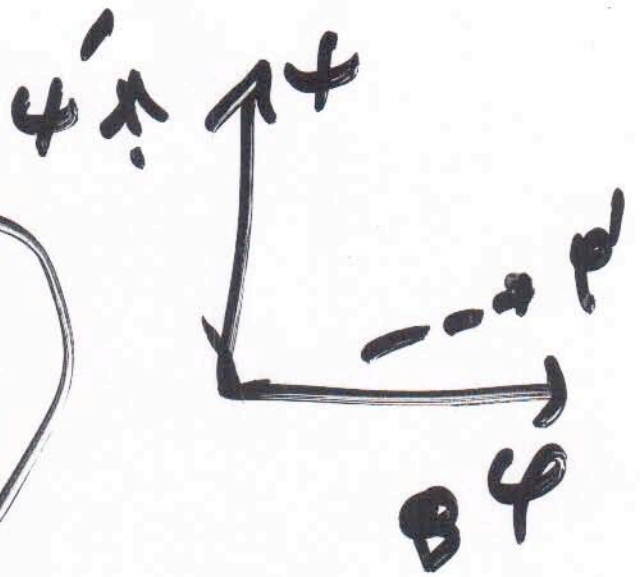
$(3 \times 3)$



$$\textcircled{G} = \frac{\langle GG \rangle}{\Lambda_{\text{QCD}}^4}$$


$\psi, \phi$

$$\begin{aligned}\delta\psi &= \epsilon\phi \\ \delta\phi &= \epsilon\psi\end{aligned}$$



$$\psi' = \psi + \delta\psi = \psi + \epsilon\phi$$

$$\phi' = \phi + \delta\phi = \phi + \epsilon\psi$$