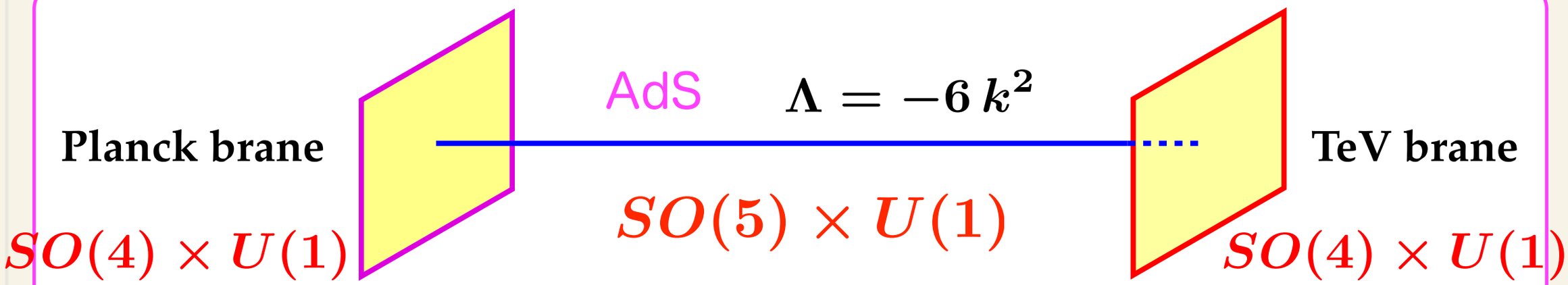
H Parity & Stable Higgs

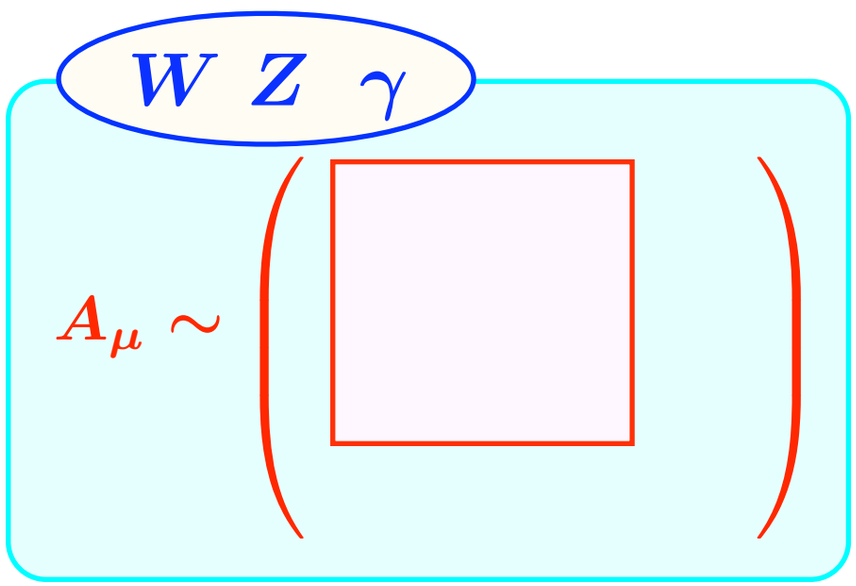
Yutaka Hosotani, Osaka University

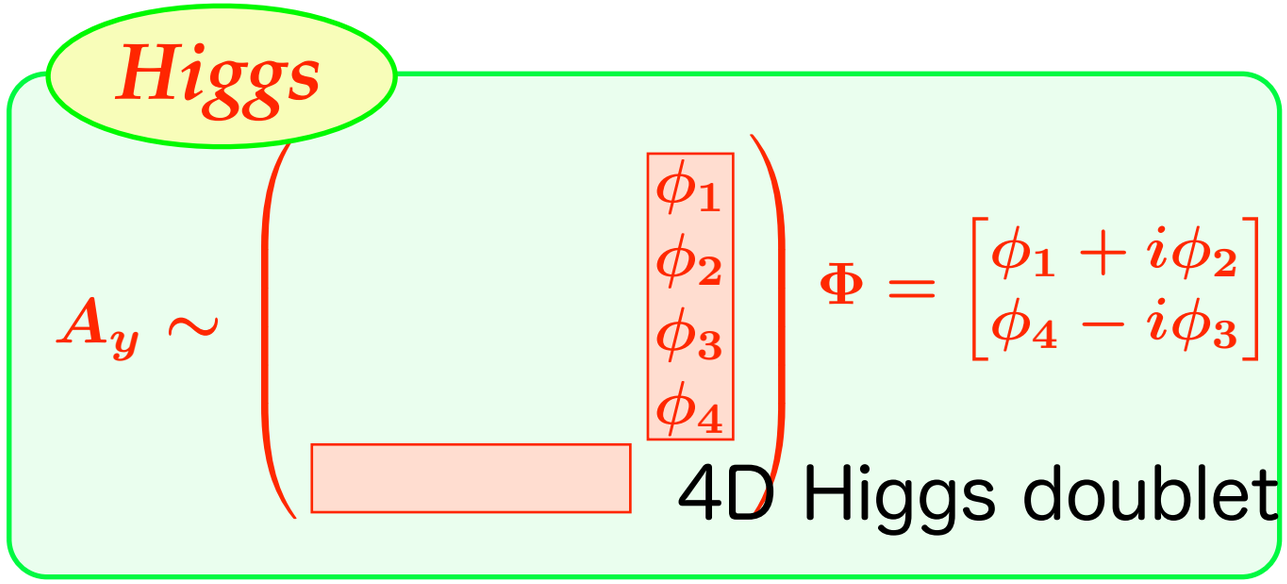
余剰次元物理2011（at 大阪大） 24 January 2011

$SO(5) \times U(1)$ gauge-Higgs unification in Randall-Sundrum warped space

Agashe, Contino, Pomarol 2005
Hosotani, Sakamura 2006
Medina, Shah, Wagner 2007







Matter content

YH, Noda, Uekusa, 0912.1173
(YH, Oda, Ohnuma, Sakamura 2008)

Planck brane

$SO(5) \times U(1)$

TeV brane

$SO(4) \times U(1)$

$\langle \hat{\Phi} \rangle \neq 0$
$(0, \frac{1}{2})$

$\begin{pmatrix} \hat{T}_R \\ \hat{B}_R \end{pmatrix}$
$\begin{pmatrix} \hat{U}_R \\ \hat{D}_R \end{pmatrix}$
$\begin{pmatrix} \hat{X}_R \\ \hat{Y}_R \end{pmatrix}$
$(\frac{1}{2}, 0)$

$\begin{pmatrix} T_L \\ B_L \\ t_L \\ b_L \\ t'_R \end{pmatrix}_{\frac{2}{3}}$

$\begin{pmatrix} U_L \\ D_L \\ X_L \\ Y_L \\ b'_R \end{pmatrix}_{-\frac{1}{3}}$

vector rep

$(\frac{1}{2}, \frac{1}{2}) \oplus (0, 0)$

$\begin{pmatrix} \hat{L}_{2XR} \\ \hat{L}_{2YR} \end{pmatrix}$
$\begin{pmatrix} \hat{L}_{3XR} \\ \hat{L}_{3YR} \end{pmatrix}$
$\begin{pmatrix} \hat{L}_{1XR} \\ \hat{L}_{1YR} \end{pmatrix}$

$\begin{pmatrix} \nu_{\tau L} \\ \tau_L \\ L_{1XL} \\ L_{1YL} \\ \tau'_R \end{pmatrix}_{-1}$

$\begin{pmatrix} L_{2XL} \\ L_{2YL} \\ L_{3XL} \\ L_{3YL} \\ \nu'_{\tau R} \end{pmatrix}_0$

SM spectrum

Anomaly cancellation

Effective interactions

AB phase $\hat{\theta}_H = \theta_H + \dfrac{H}{f_H} \sim \hat{\theta}_H + 2\pi$ $\quad f_H = \dfrac{2}{\sqrt{kL}} \dfrac{m_{KK}}{\pi g}$

$$\mathcal{L}_{\rm eff} \sim -V_{\rm eff}(\hat{\theta}_H) - m_f(\hat{\theta}_H)\,\overline{\psi}_f \psi_f$$

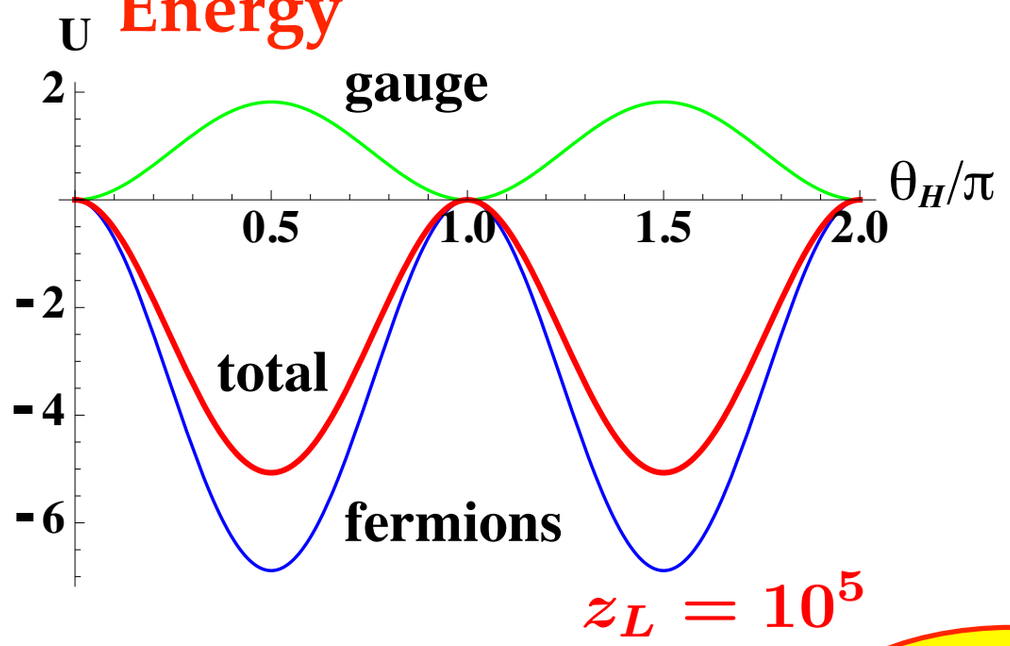
$$-m_W(\hat{\theta}_H)^2 W_\mu^\dagger W^\mu - \frac{1}{2} m_Z(\hat{\theta}_H)^2 Z_\mu Z^\mu$$

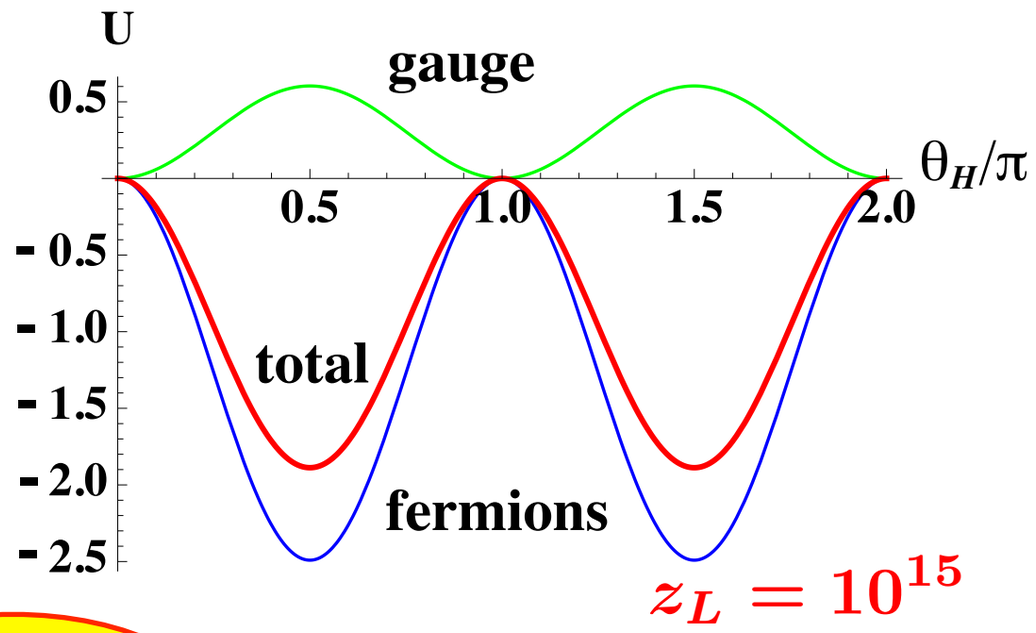
	Gauge-Higgs		**SM**
$m_W(\hat{\theta}_H) \sim$	$\frac{1}{2} g f_H \sin\hat{\theta}_H$	*periodic nonlinear*	$\frac{1}{2} g (v + H)$
$m_f(\hat{\theta}_H) \sim$	$y_f f_H \sin\hat{\theta}_H$		$y_f (v + H)$

$$WWH \\ ZZH \\ Yukawa = SM \times \cos\theta_H$$

Effective potential

Energy





$$\theta_H = \frac{\pi}{2}$$

EW symmetry breaking by Hosotani mechanism

WWH, ZZH, Yukawa = 0

H parity

H : —

other SM particles :

+

Proof (1) **YH, Ko, Tanaka, 0908.0212**

Mirror reflection symmetry: $y \to -y$

Enhanced periodicity: $\theta_H \simeq \theta_H + \pi$

Proof (2)

YH, Tanaka, Uekusa, 1010.6135

$$SO(5): \quad SO(4) \simeq SU(2)_L \times SU(2)_R \qquad SO(5)/SO(4)$$

$$\{ T^\alpha \} = \quad \{ T^{a_L}, T^{a_R}, \quad T^{\hat{a}}, T^{\hat{4}} \}$$

Algebra is invariant under

$$\Rightarrow \{ T'^\alpha \} = \quad \{ T^{a_R}, T^{a_L}, \quad T^{\hat{a}}, -T^{\hat{4}} \}$$

$$T'^\alpha = \Omega_H T^\alpha \Omega_H^{-1} \qquad \Omega_H = \begin{pmatrix} 1 & & & \\ & 1 & & \\ & & -1 & \\ & & & 1 \end{pmatrix}$$

$$P_H: \quad \begin{array}{c} SU(2)_L \leftrightarrow SU(2)_R \\ T^{\hat{4}} \rightarrow -T^{\hat{4}} \end{array}$$

$\Longleftrightarrow$

Agashe, Contino, Da Rold, Pomarol 2006

Suppress corrections to

$$T, \quad Zb\bar{b}$$

$$\text{At } \theta_H = \frac{\pi}{2}$$

bulk action　　invariant under $A_M \to \Omega_H A_M \Omega^{-1}$

⇨ P_H **-inv**

brane interactions　P_H odd fields do not couple.

⇨ Theory is H parity invariant.

$$P_H = \begin{cases} + & \boldsymbol{W^{(n)}, Z^{(n)}, \gamma^{(n)}, gluon^{(n)}, q^{(n)}, \ell^{(n)}, \cdots} \\ - & \boldsymbol{H^{(n)}, W'^{(n)}, Z'^{(n)}, q'^{(n)}, \ell'^{(n)}, \cdots} \end{cases}$$

Higgs field : the lightest P_H-odd field.

Stable

Stable Higgs

Higgs bosons = Dark matter

WMAP data ⇨ $m_H \sim 70\,\mathrm{GeV}$

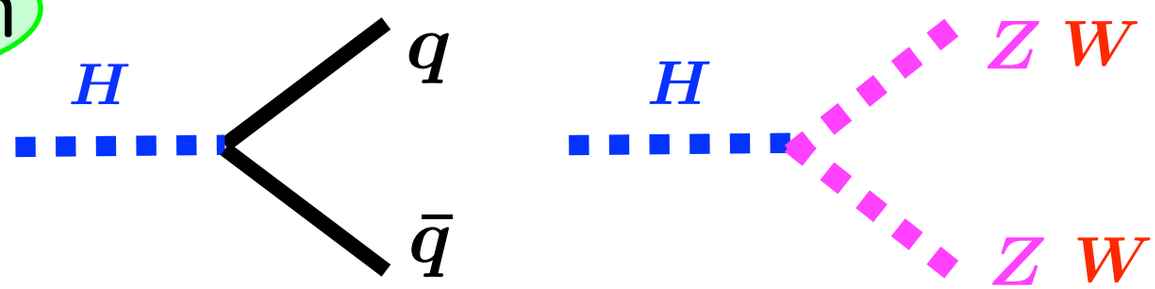
At colliders

Higgs boson

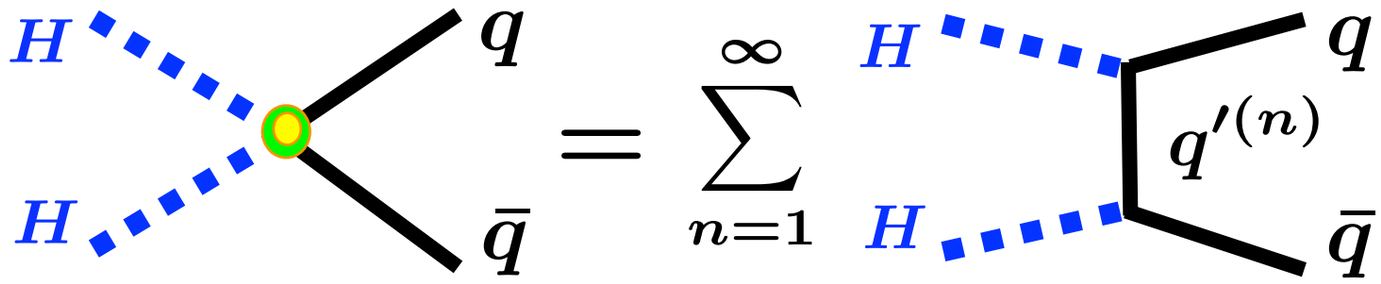
= missing energy, momentum

H parity

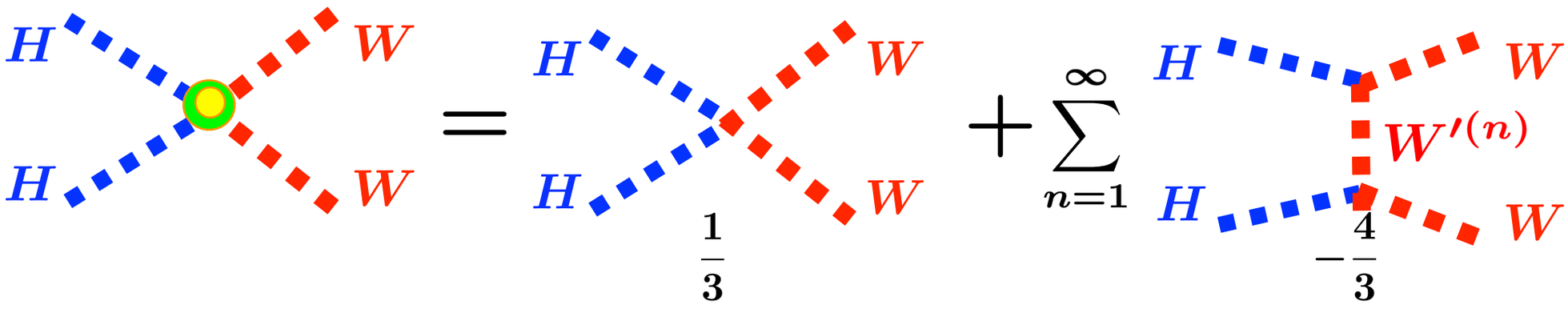
Forbidden



Allowed



$$\frac{m_q}{2f_H^2}\, H^2 \bar{q} q$$



$$\frac{g^2}{4}\, H^2 W^\dagger W$$

$SO(5) \times U(1)$ gauge-Higgs unification

Higgs = AB phase

$$\hat{\theta}_H = \theta_H + \frac{H}{f_H}$$

Dynamics → $\theta_H = \frac{\pi}{2}$

H Parity → Stable Higgs