SO(5)xU(1) gauge-Higgs unification

Yutaka Hosotani



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Higgs boson at 125-126 GeV

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Unification vs Symmetry breaking Hosotani mechanism on the lattice

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Gauge-Higgs unification



Gauge-Higgs unification

gauge theroy A_M in 5 dim.

Physics



















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

Physics













 $V_{ ext{eff}}(heta_H)$ & m_H parameters input $m_Z,\ g_w,\ \sin^2 heta_W$ $k,\; z_L=e^{kL},\; g_A,\; g_B$ $c_t,~ ilde{\mu}/\mu_2$ m_t, m_b c_F, n_F m_H



$$V_{eff}(\theta_H) \& m_H$$

$$Parameters$$

$$k, z_L = e^{kL}, g_A, g_B$$

$$c_t, \tilde{\mu}/\mu_2$$

$$c_F, n_F$$

$$V_{eff}$$

$$\theta_H : \frac{dV_{eff}}{d\theta_H} = 0$$

$$m_H^2 = \frac{1}{f_H^2} \frac{d^2V_{eff}}{d\theta_H^2}\Big|_{min}$$

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$$Parameters$$

$$k, z_{L} = e^{kL}, g_{A}, g_{B}$$

$$c_{t}, \tilde{\mu}/\mu_{2}$$

$$c_{F}, n_{F}$$

$$W_{eff}$$

$$H_{H} : \frac{dV_{eff}}{d\theta_{H}} = 0$$

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$$m_{H} = 126 \text{ GeV}$$

$$\theta_{H}(z_{L}, n_{F})$$

$$\theta$$

$$V_{
m eff} = \left(rac{m_{
m KK}}{2\pi}
ight)^4 U$$

 $z_L = 10^7 \ , \ n_F = 3$ $c_t = 0.330 \ , \ c_F = 0.353$





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$heta_H(z_L,n_F)$ & $m_{ ext{KK}}(z_L,n_F)$ $m_{Z^{(1)}}(z_L,n_F)$





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Higgs boson: Production and decay rates















11



 $egin{aligned} \Gamma(H o \gamma \gamma) &= rac{lpha^2 g_w^2}{1024 \pi^3} rac{m_H^3}{m_W^2} \left| \mathcal{F}_{ ext{total}}
ight|^2 \ \mathcal{F}_{ ext{total}} &= \mathcal{F}_W + rac{4}{3} \mathcal{F}_t + rac{1}{2} n_F \mathcal{F}_F \end{aligned}$ H



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H

$ heta_{H}$	0.117	0.360
$\mathcal{F}_{W^{(0)}}$	8.330	7.873
$\mathcal{F}_W/\mathcal{F}_{W^{(0)}}$	0.9996	0.998
$\mathcal{F}_{t^{(0)}}$	-1.372	-1.305
$\mathcal{F}_t/\mathcal{F}_{t^{(0)}}$	0.998	0.990
$({\cal F}_F/{\cal F}_{t^{(0)}})$	-0.0034	-0.033
$\mathcal{F}_{ ext{total}}$	6.508	6.199
$\mathcal{F}_{ ext{total}}/(\mathcal{F}_{W^{(0)}}+\mathcal{F}_{t^{(0)}})$	(1.001)	(1.011)
Physics		

Corrections due to KK W and top : 0.1 % - 1 % for θ_H = 0.1 - 0.3.



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Branching fraction $B(H \rightarrow j) \sim B^{\rm SM}(H \rightarrow j)$



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 $\begin{array}{l} \textbf{Branching fraction} \ B(H \to j) \sim B^{\rm SM}(H \to j) \\ \sigma^{\rm prod}(H) \cdot B(H \to \gamma \gamma) \sim ({\rm SM}) \times \cos^2 \theta_H \\ 0.99 \sim 0.91 \end{array}$



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S parameter Tree unitarity $\theta_H < 0.3$ Z' search



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> Low energy physics : close to SM

















Hosotani mechanism on the lattice

Polyakov loops and the Hosotani mechanism on the lattice Cossu, Hatanaka, YH, Noaki, 1309.xxxx [hep-lat]



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SU(3) gauge theory on $\mathbb{R}^3 \times \mathbb{S}^1$ with adjoint/fund. fermions

$$P \exp\left\{ig \int_{S^1} dy A_y
ight\} \sim \left\{e^{i heta_1}, e^{i heta_2}, e^{i heta_3}
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gauge fields $(m_A^{(n)})_{jk}^2 = \frac{1}{R^2} \left(n + \frac{\theta_j - \theta_k}{2\pi}\right)^2$

Physics

 $\theta_j \neq \theta_k$ SU(3) sym. breaking



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mR: varied





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	$(heta_1, heta_2, heta_3)$	Р	symmetry, phase
X	large fluctuations	0	SU(3) confined
$A_1 A_{2,3}$	$(0,0,0),(\pm rac{2}{3}\pi,\pm rac{2}{3}\pi,\pm rac{2}{3}\pi)$	$1, e^{\pm i 2 \pi/3}$	SU(3) deconfined
$B_1 B_{2,3}$	$(\pi,\pi,0)(\pmrac{1}{3}\pi,\pmrac{1}{3}\pi,\mprac{2}{3}\pi)$	$-rac{1}{3} \ rac{1}{3} e^{\pm i\pi/3}$	SU(2) imes U(1) split
С	$(0,rac{2}{3}\pi,-rac{2}{3}\pi)$	0	U(1) imes U(1) reconfined
Physics			

Lattice simulations

 $egin{aligned} 16^3 imes 4 ext{ lattice} & eta = rac{6}{g_0^2}: ext{ varied} \ (N_{ ext{ad}}, N_{ ext{fd}}) = (2, 0) & ma = 0.10 \end{aligned}$





= 6.50

1 -1

-0.5

0.5

 $\boldsymbol{\beta}$

-0.5



-0.5

B

-0.5

= 5.95

1 -1

-0.5

0.5



Normalized Density Plots



Normalized Density Plots



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promising!





Hosotani mechanism established on the lattice