DOE Site Visit

John Terning
Outline

- Higgsless Models
- Multithroat Backgrounds
- Accelerated Cosmic Expansion
Hierarchy Problem

- SUSY
- Technicolor

Little Higgs
Hierarchy Problem

SUSY

Extra Dimensions

curved

flat

RS bulk fermions small large

little Higgs discrete
EWSB by Boundary Conditions

• is $WW$ scattering unitary?
• why is $M_W = \cos \theta_W M_Z$?
• how do we pass precision tests?

Csáki, Cacciapaglia, Marandella, JT with

Grojean, Hubisz, Murayama, Pilo, Reece, Shirman

hep-ph/0401160, hep-ph/0409126,
Scattering Amplitude

\[ A = A^{(4)} \frac{E^4}{M_n^4} + A^{(2)} \frac{E^2}{M_n^2} + A^{(0)} + \ldots \]
WW Scattering via KK bosons

contact interaction

s channel exchange

t channel exchange

u channel exchange
Cancellation

\[ E^4 \text{ term: } g_{nnnn}^2 - \sum_k g_{nnk}^2 \]

\[ \int_0^L dy \ f_n^4(y) = \sum_k \int_0^L dy \int_0^{\pi R} dz \ f_n^2(y) f_k^2(z) f_k(y) f_k(z) \]

completeness of hermitian operator:

\[ \sum_k f_k(y) f_k(z) = \delta(y - z) \]

\[ E^2 \text{ term: } 4g_{nnnn}^2 M_n^2 - 3 \sum_k g_{nnk}^2 M_k^2 \]

\[ \sum_k M_k^2 \left( \int dy f_n^2(y) f_k(y) \right)^2 = \frac{4}{3} M_n^2 \int dy f_n^4(y) - \frac{2}{3} [f_n^3 f'_n] + 2 \sum_k [f_n f'_n f_k] \int dy f_n^2(y) f_k(y) - \sum_k [f_k^2 f'_k] \int dy f_n^2(y) f_k(y) \]

for Dirichlet or Neumann BC’s the \( E^2 \) terms cancel
Finite VEV

at \( z = R' \): \( \partial_z \psi = -\frac{g_5^2 v^2}{2} \psi \)

for small \( v \): \( M_W^2 = \frac{g^2 v^2}{4} \frac{R^2}{R'^2} \)

for \( R' = 2 \cdot 10^{-3} \text{ GeV}^{-1}, R = 10^{-19} \text{ GeV}^{-1} \)

Lattice: Bhattacharya, Csaki, Martin, Shirman JT hep-lat/0503011
Decoupling the Higgs for $v = 1$ TeV

$\psi_W(z)$

Higgs decouples from scattering as $v \to \infty$
Towards a Realistic Model

\[ ds^2 = \left( \frac{R}{z} \right)^2 \left( \eta_{\mu\nu}dx^\mu dx^\nu - dz^2 \right) \]

gauge symmetry \( SU(2)_L \times SU(2)_R \times U(1) \)

AdS/CFT correspondence

 guarantees a custodial symmetry that protects \( T \)
Precision Constraints

Log$_{10}$ $R$ [GeV$^{-1}$]

Log$_{10}$ $R$ [GeV$^{-1}$]

$T$

$S$

$-1.0$

$-0.5$

$0.5$

$1.0$

$1.5$

$2.0$

$2.5$

$3.0$

$3.5$

$4.0$

$4.5$

$5.0$

$5.5$

$6.0$

$6.5$

$7.0$

$7.5$

$8.0$

$8.5$

$9.0$

$9.5$

$10.0$
LHC Signal

Luminosity: 300 fb$^{-1}$

- $E_j > 300$ GeV
- $p_{T,j} > 30$ GeV
- $2.0 < |\eta_j| < 4.5$
- $|\eta_1| < 2.5$

Birkedal, Matchev, Perelstein, hep-ph/0308038
Multithroat Backgrounds

Cacciapaglia, Csáki, Grojean, JT hep-ph/0604218
Multithroat Backgrounds
Accelerated Acceleration

\[ \Delta m \]

Rolling up linear phantom \( z_* = 1 \)

Csáki, Kaloper, JT astro-ph/0507148
Quintessence
Conclusion

- Cosmological data and the promise of the LHC data has sparked many new theoretical ideas