**Phenomenology of SUSY Gauge-Higgs Unification**

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**What is Gauge-Higgs Unification?**

4D spin 1:

\[ \rightarrow (A_\mu, A_5) \rightarrow \text{Higgs} \]

(see [1])

And with SUSY?

\[(\Sigma, \Lambda_1, \Lambda_2, \Lambda_3^I) \rightarrow 4 \text{D spin 0:} \rightarrow \text{Higgs} \]

**Where SUSY GHU can appear?**

In Orbifold SUSY GUTs

Bottom-up: SUSY GUTs is motivated by couplings unification. The extra dimensions are motivated by GUT problems: doublet-triplet splitting, GUT group breaking, proton decay.

Top-down: SUSY GUT with GHU can naturally come from classes of heterotic strings model.

**Natural way to break SUSY?**

With Radion Mediated SUSY breaking (RMSB) [2]

Radion \( R \) field associated to extra dimension fluctuation.

Compactionification \( \langle F^T \rangle = R \) implies SUSY breaking:

\[ F^T \neq 0 \] (radion)

\[ F^T \neq 0 \] (chiral compensator) with \( F^T = - \frac{1}{4W(R)} \frac{\partial W}{\partial R} \)

RMSB contributions are generated at one-loop: \( \mathcal{O}(F^T / S^2) \)

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**5D complete realization : Gauge-Higgs sector**

We take the 5D SUSY GUT with SU(6) GHU of [3]. The radius \( T \) of the 5th dimension stabilized by an unknown mechanism:

\[ \langle F^T \rangle = R = M_{GUT} \]

and break the SU(6) adjoint:

\[ SU(3) \times SU(2) \times U(1) \]

\[ \rightarrow 2 \text{ Higgs doubles} \]

In odd number of dimensions, a new term (Chern-Simons) generically appears [5]. It stabilizes by an unknown mechanism:

\[ \mathcal{O}(F^T / S^2) \]

The gauge-Higgs SUSY parameters are generated [6]:

\[ \pm B_{\mu} = \mu^2 + \frac{1}{22} \mu^2 H_1^2 \]

\[ M_{1/2} = \frac{\pm B_{\mu}}{2 \cos \beta} \]

\[ \mu = F^T = \frac{- \sqrt{2}}{1 + \frac{\alpha}{2}} \]

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**5D complete realization : Matter sector**

As the gauge and Higgs fields, the matter fields are propagating in the bulk [3]. However they can have a 5D mass term which makes them confined on the branes. The usual 4D yukawas come from the overlap with the Higgs field. The more a field is confined, the less it is massive. Mixing angles appear as new parameters.

**Spectrum calculation**

How to calculate the spectrum of such model?

The pattern of inputs and constraints is different from the other models. Usually, \( \mu \) and \( B_{\mu} \) are computed from the two equation of the Higgs potential minimization:

\[ \mu^2 = \frac{1}{2} \tan 2 \beta (m_H^2 \sin^2 \beta - m_{H_u}^2 \cos^2 \beta - M_E^2) \]

\[ B_{\mu} = \frac{1}{2} \sin 2 \beta (m_H^2 \cos^2 \beta + m_{H_u}^2 \sin^2 \beta) \]

But in our model, \( \mu, B_{\mu} \) are fixed at high scale. \( M_{1/2}, \mu \) are fixed at each iteration. But a fixed point algorithm on \( \mu \) is unstable. (An alternative is to use a dichotomy algorithm).

**Scans and constraints**

In the complete realization, we scan over \( \tan \beta, M_{1/2}, \mu \), and the two mixing angles, \( \alpha, \beta \). The spectrum is constrained with theoretical consistency (EWSB, no CCB, no tachyons), and with experiment. We use the mass bounds from LEP, the constraints from B-physics (20), and verify the agreement with relic density measurement from WMAP (20). [8-11]

\[ M_{\text{1/2}}, \mu, \alpha, \beta \] constraints

**Check of assumptions**

By computing the fundamental parameters, we can check the hypothesis: the AMSB contributions are negligible, and the Chern-Simons coefficients are still non-zero, and of order one.

**Relic density**

For \( M_{1/2} = 500 \text{ GeV} \)

Too much

Not enough