Current Projects

Zhenyu Han

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- Mass determination with missing particles at the LHC (with Witek Skiba).
- Gauge-Higgs unification without tadpoles (with Yang Bai).
Mass determination with missing particles

• Missing particles bring difficulties in event reconstruction and mass determination.

• Example: $t'$ pair production, assuming $t' \rightarrow t + A'$. $A'$ : neutral missing particle.
Finding the proper variables

- Variables sensitive to the mass difference $M_{t'} - M_{A'}$, but not the absolute scale of the masses: average values of missing transverse momentum, total transverse momentum, etc. (Cheng, Low & Wang; Meade & Reece)

Figure 1: Contour plots for $\langle P_t \rangle$ and $\langle H_t \rangle$
• If found a variable with a different dependence on $M_{t'}$ and $M_{A'} \implies$ masses determined.

Figure 2: Contour plot for $\langle p_t \rangle$, and the correlation between $\langle p_t \rangle$ and $\langle H_t \rangle$. 
Goals and Methods

- Generate events: signal+SM background, **PYTHIA+ATLFAST**
- Optimize the cuts to keep signal events and reduce background events.
- Looking for the best variable: stable and yields significant difference to raise the degeneracy.
- Estimate how well we could measure the masses at LHC.
Gauge-Higgs unification

- An alternative solution to the hierarchy problem – gauge symmetry in extra-dimensions protects the Higgs mass.
- Gauge components in extra-dimensions $A_5, A_6$ behave as scalar fields in 4-dimensions–candidates for the Higgs.
- Orbifold symmetry breaking–larger group broken to $SU(2) \times U(1)$ by boundary conditions and yields Higgs doublets
  
  e.x. $SU(3) \rightarrow SU(2) \times U(1) : 8 \rightarrow 3 + 2 + 2 + 1$.

- Higgs mass proportional to the symmetry breaking scale ($M_h^2 \sim \frac{1}{16\pi^2 R^2}$), protected by gauge symmetry beyond that.
Tadpole problem in 6-dimensions

- There exist fixed points with symmetry broken to the SM $SU(2) \times U(1)$.
- In $SU(3)$ theory, $F_{yz}^8$ is gauge invariant on the fixed points and contains a Higgs mass term.

\[ \Rightarrow M_h^2 \sim \Lambda^2 / 16\pi^2. \quad \Lambda : \text{cutoff} \]

Reintroduce the hierarchy problem.

- The tadpole problem is generic in gauge-Higgs unification in 6 dimensions, if the unbroken gauge symmetry contains a $U(1)$ factor.
The solution–collective symmetry breaking

- E.x. $G_2 \rightarrow SU(3)$ on one fixed points, $G_2 \rightarrow SU(2) \times SU(2)$ on another fixed points. The common subgroup of $SU(3)$ and $SU(2) \times SU(2)$ is $SU(2) \times U(1)$.

- The symmetry is broken to $SU(2) \times U(1)$ globally, but at each fixed points, the symmetry is larger than $SU(2) \times U(1)$.

  $\implies$ No tadpoles can be added.

- The goal: construct a realistic model– choices of orbifold, gauge group, fermion representations, Yukawa interactions...
Summary

Get ready for LHC: models and tools.
...but keep others in mind...