New Models

SUSY, SUSY Breaking, Electroweak Symmetry Breaking, Dark Matter,...

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Pre-LHC

*LHC is about to turn on!*

*A good understanding of as many models as possible will help us find and interpret new physics at the LHC.*

*Allot of our time (but not all!) is devoted to models and signals with LHC consequences.*

Here’s a sample.
I’ll divide the into 3 categories.
1. “Natural”:
Meta-Stable SUSY

* The leading avenue for natural BSM physics has bean Supersymmetry.

* **How is SUSY broken?**

* Constructing models of SUSY has bean challenging.

* ISS have pointed out a simple possibility:


\[ V = \begin{cases} V_{\text{peak}} & \Phi = \Phi_{\text{peak}} \\ V_+ & \text{otherwise} \end{cases} \]

**SQCD**

+ mass term
mu Problem

* MSSM: why is the supersymmetric Higgs mass of the same size as SUSY?
* Kitano: if the Higgs is a composite of the ISS sector

This is actually the old Guidice-Massiero mechanism for the mu problem, but it is now applicable outside of gravity mediation!
Reheating ISS

* Which vacuum are we likely to land in?
* A careful and systematic analysis of the cosmological history is needed.

* CFW: First order phase transition

\[
T_c \sim \frac{\mu}{(N_F + N)^{1/4}}
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* CFW:

\[ (\mu^2 \Lambda^a)^{\frac{1}{2+a}} \]

1: \( q \neq 0, M = 0 \)
2: \( q = 0, M \neq 0 \)

Second order phase transition, \( T_c \sim \mu \)
First order phase transition, \( T_c \sim \mu \) lifetime controlled by \( \frac{\Lambda}{\mu} \)

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CFW:
2. Un-Natural:
6-Higgs Doublet Model

- A minimal way to extend the SM to get Unification and Dark matter:
  
  \[
  \text{SM + one 5-plet of Higgs doublets.}
  \]

  1. Extra doublets change running: couplings unify
6-Higgs Doublet Model

- A minimal way to extend the SM to get Unification and Dark matter:

$$\text{SM} + \text{one 5-plet of Higgs doublets}.$$  

the hierarchy problem  

one more fine tuning

Good value:  

“Two for the price of one”
6-Higgs Doublet Model

Collider signals are hard.
But direct detection has good prospects:

![Graph showing cross section per nucleon vs. WIMP mass (GeV)]

- CDMS II 2007
- SuperCDMS

Cross section per nucleon (cm²)

WIMP mass (GeV)
3. Natural, but not what you’d naively expect:
**Uncolored Partners**

* Naturalness implies the existence of a top partner, that's related to the top by symmetry.

![Diagram](image)

squarks are colored!

Great news for LHC!!!
Uncolored Partners

* Naturalness implies the existence of a top partner, that's related to the top by symmetry.

squarks are colored!
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But, do squarks really have to be colored?!
Folded Supersymmetry

* The divergence may be canceled by “discrete” partners:

Inspired by large-N orbifold correspondence

Squarks are charged under QCD’, but also under our EW group.
Folded Supersymmetry

* The divergence may be canceled by “discrete” partners:

$$\begin{align*}
  t & \leftrightarrow Z_2 & t' \\
  \tilde{t} & \leftrightarrow Z_2 & \tilde{t}'
\end{align*}$$

Squarks are charged under QCD’, but also under our EW group.
New Signals

* The dynamics of QCD’ is very different: squarks are produced but remain bound!

quirks (or squirks, rather) - Luty et al, Strassler and Zurek.

In progress: Burdman, Chacko, Goh, RH; Wizansky, RH.
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Soft radiation down to the ground state.

Annihilation to SM particles.
And so on........

Matching MadEvent to Pythia

W’s at LHC

LHC$^{-1}$=ILC

Light Gluinos

QCD on $R_3 \times S_1$

Event generation with twistors

Atom interferometry

Techniques for high order QCD

the “Entropic Principle”
In Conclusion

LHC is Coming!
We’re excited and exploring possibilities!