Remodeling the Pentagon After The Events of 2/23/06

Basic Idea of C(osmological) S(USY) B(reaking):

C.C. $\lambda = 0$ : SUSIC, R-Symmetric Theory.

$\lambda : \delta L$, Breaks R, Tune $W_0$: $\lambda \sim \lambda$, $m_{3/2}$

$\sim \lambda^{1/4}$: $F = \gamma M_P \lambda^{1/4}$
Remodeled Pentagon

- SU(5) × SU(1,2,3) SUSY Gauge Theory
- P in [5,5] (Second Refers To SU(5) GUT)
- P* in [5*, 5*, 5*], S Singlet in [1,24]
- Q,L,U*, D*, E* in [1,5* ⊗ 10]
- \[ W = g_S S P_i^A (P^*)^j_A Y^i_j + g_μ S H_u H_d + g_T S^3 \]
  + \[ W_{\text{std}} \]
- \[ ([Y,SU(1,2,3)] = 0 = \text{Tr } Y) \]
- \[ δ W = m_{\text{ISS}} P_i^A (P^*)^i_A + W_0 \]
m_{ISS} Induces Meta-stable State With F \sim m_{ISS} \Lambda_5

\langle P^5 \rangle = \langle (P^*)^5 \rangle^* \sim \Lambda_5^5 e^{i(b/\Lambda_5)}

Residual Z_5 R Symmetry Broken By g_{S,T}

SUSY Limit Two Vacua H_u = H_d = 0 \neq S, H_u = H_d = g_S \Lambda_5, S=0 But No Symm. When S = 0 in Second. Hypothesize Non-zero in SUSY Violating State.

Gives Std. Model Gaugino Masses \sim 16.5 (F / \Lambda_5) g_S q
SU(1,2,3) Std. Model Gauge Group
Embedded in SU(5) Flavor Group of the Pentagon Model:

Gauge Mediated SUSY Breaking
(Dine-Nelson) + Higgs F Terms $\propto <S>$
Pentagon Model (Maybe) Avoids Most Problems With Precision Electroweak.

Fundamental Origin of SUSY Breaking:

$$m_{\text{ISS}} \sim \lambda^{1/4} M_P / \Lambda_5$$
• Bounds From RH Selectron Mass
• \( m_{e_R} \sim \frac{1}{250} (4) \frac{F}{\Lambda_5} \)
• \( m_{\text{ISS}} \sim 6.25 \text{ TeV} \)
• Roughly Consistent With CSB (\( F \sim 10 \text{ TeV}^2 \)) and ISS for e.g. \( \Lambda_5 \sim 1.5 \text{ TeV} \)
• ISS: Probably Meta-stable State Disappears for \( m_{\text{ISS}} / \Lambda_5 \gg 1 \)
SU(2) × U(1) Breaking Scale ~ g_S \Lambda_5 (W ~ g_S S P Y P * + g_\mu S H_u H_d + g_T S^3)

Tan \beta \sim 1

No Problems With FCNC

Two Problematic (?) CP Phases

Natural Proton Stability

Dark Matter: Probably Pseudo-Goldstone boson of spontaneously broken penta-baryon number m_{pb} \sim 1 \text{ eV (asymmetry???)}}
The Dark Matter to Baryon Ratio

- Asymmetry $\varepsilon$ in Penta-baryon number fixed by requiring PGB to be dark matter.
- Coupling $J_{PB}^{\mu} J_{B\mu} \alpha_3^2 : J_{PB}^0 \sim \varepsilon g T^3$
- Spontaneous Baryogenesis (Cohen & Kaplan)
- Chemical Potential for B biases EW
- Baryon Violation
- Gives Too Large a Baryon Asymmetry
Alternative Solutions

1. Introduce PB Breaking With Scale $10^6 - 10^8$ GeV. Need Symmetries To Preserve Ordinary Baryon Number – In Progress

- Give Up Penton Dark Matter. Alternative Could Be QCD Axion, Which We Need To Solve Strong CP Anyway
Experimental Signatures

- The Pentagon Model Has Clear Exptl. Signatures at Least Some of Which Can be seen at LHC
- Slepton pair decays into $l^+ l^- + \text{missing energy}$
- Other SUSY decay cascades give $l^+ l^- + X + \text{missing energy}$
- $X$ might be e.g. $l^+ l^-$ if mass ordering is Bino $> \text{RH slepton} > \text{goldstino}$.
- PGB Dark Matter Candidate Should Be Visible – Dominantly emitted in charge changing weak decays BR $\sim \alpha_3^4 \left( m_q / M? \right)^2$
- Gravitino has mass $\sim 5 \times 10^{-3}$ eV – No Cosmological Influence – Lab?
Outlook and Challenges

- Can we show $\langle S \rangle \neq 0$?
- Do we need fine tuning to get EWSB $\sim 250$ GeV, $m_h < 180$ GeV?
- Better Solution of Strong Penta-Dynamics
- Can We Fix Penton Model of Dark Matter?
- Large $g_{S,T,\mu} \rightarrow$ Landau Poles?
- How Does the Pentagon Fit Into a High Energy Theory?