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.

λ : δ 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^*], S Singlet in [1,24]
- Q,L,U^*, D^*, E^* in [1,$5^* \otimes 10$]
- $W = g_S\, S\, P_i^A\, (P^*)^j_A\, Y^i_j + g_\mu\, S H_u\, H_d + g_T\, S^3 + W_{std}$
- ([Y,SU(1,2,3)] = 0 = Tr Y)
- $\delta W = m_{ISS}\, P_i^A\, (P^*)^i_A + W_0$

(I)ntriligator (S)eiberg (S)hih

- m_{lSS} Induces Meta-stable State With $F \sim m_{lSS} \Lambda_5$
- $\langle P^5 \rangle = \langle (P^*)^5 \rangle^* \sim \Lambda_5{}^5 e^{i (b/\Lambda_5)}$
- 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 ~ 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:

$$m_{ISS} \sim \lambda^{1/4} M_P / \Lambda_5$$

- Bounds From RH Selectron Mass
- m_{e_R} ~ (1/250) (4) F/Λ_5
- m_{ISS} ~ 6.25 TeV
- Roughly Consistent With CSB (F ~ 10 TeV^2) and ISS for e.g. Λ_5 ~ 1.5 TeV
- ISS: Probably Meta-stable State Disappears for $m_{ISS}/\Lambda_5 \gg 1$

- SU(2) × U(1) Breaking Scale ~ $g_S \Lambda_5$ ($W \sim g_S S P Y P_* + g_\mu S H_u H_d + g_T S^3$)
- 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 $m_{pb} \sim 1$ eV (asymmetry???)

The Dark Matter to Baryon Ratio

- Asymmetry ε 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 $l^+ l^-$ + missing energy
- Other SUSY decay cascades give $l^+ l^-$ + X + missing energy
- X might be e.g. $l^+ l^-$ if mass ordering is Bino > RH slepton > goldstino.
- PGB Dark Matter Candidate Should Be Visible – Dominantly emitted in charge changing weak decays BR ~ $\alpha_3^4 (m_q / M?)^2$
- Gravitino has mass ~ 5×10^{-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 ~ 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?