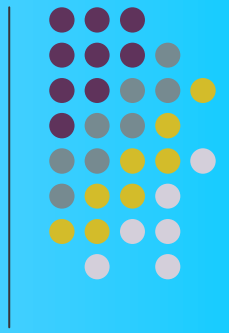
The Higgs Reduction Mechanism in Free Fermionic Models



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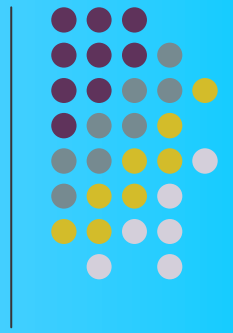
Outline



- *Motivations*
- *Free Fermionic Models (FFM)*
- *Yukawa selection mechanism*
- *Higgs doublet-triplet splitting*
- *Model with reduced Higgs spectrum*
- *Conclusions*

Motivations

In the free fermionic formulation we have *realistic models*

- Existence of **3 chiral generations**
- Observable gauge group : **SU(3)xSU(2)xU(1)^n**
- **N=1** Supersymmetry
- Standard **SO(10) embedding** for the weak hypercharge
- **Stability of the proton**
- …

Heterotic string vacua with solely MSSM states are derived.

The Free Fermionic Models

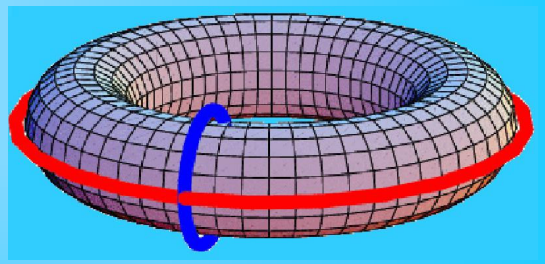
- Field content (light-cone gauge)

$$\{\ \psi^{\mu}_{12}\ \chi^{1,..6}\ y^{1,..6}\ \omega^{1,..6}\ |\ \bar{y}^{1,..6}\ \varpi^{1,..6}\ \bar{\Psi}^{1,..5}\ \bar{\eta}^{1,2,3}\ \bar{\phi}^{1,..8}\ \}$$

left sector (susy) *right sector*

- A model is constructed by specifying the *phases picked up* by the WS fermions *along non-contractible loops*

$$f \rightarrow e^{-i\alpha(f)\pi} f$$



- The phases are consistent with *modular invariance*

- The phases are given in terms of *basis vectors*

$$\vec{b} = \{\alpha\,(\psi^{\mu}{}_{12}),\ \alpha\,(\chi^{1}),\ \alpha\,(\chi^{2}),..\}$$

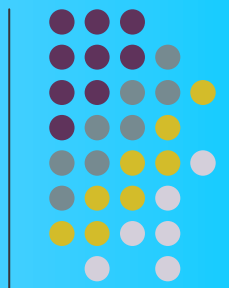
- For a given basis $B = \{\vec{b}_1,..\vec{b}_n\}$

the Hilbert space $\Xi = \sum m_i \vec{b}_i$, $m_i = 1,..N_{bi} - 1$
is obtained by acting on the vacuum with bosonic and fermionic operators

- The physical spectrum is obtained by applying the *GSO projections*

- If $B = \{\mathbf{1,S,b_1,b_2,b_3}\}$ + opportune choice of α, β, γ b.c. basis vectors we have **4D** models with **N=1 Susy** + **3 chiral generations**, one from each b_i, i=1,2,3.

Yukawa selection mechanism



The Yukawa selection mechanism is given by the vector γ responsible of the breaking

SO(10) → SU(5) x U(1)

The b.c. basis vectors in γ fix the Yukawa couplings

$Qu\bar{h}$, $LN\bar{h}$
Qdh , Leh

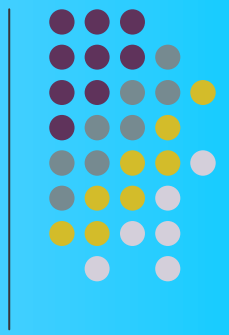
Each sector b_i gives rise to an *up-like* or *down-like* cubic level Yukawa coupl.

$$\Delta_i = | \gamma_L - \gamma_R | = 0,1$$

down-quark type Yukawa coupl.

up-quark type Yukawa coupl.

Higgs doublet-triplet splitting



The *NS* sector gives *3 multiplets* of Higgs states in the **10** of **SO(10)** each of them associated with *one of the twisted sectors* b_i.

Higgs electroweak doublets	$h_i, \overline{h_i}$	$\chi^{i,i+1}(\overline{\Psi}^{4,5})^*\overline{\eta}^{\,i}$
Higgs colour triplets	$D_i, \overline{D_i}$	$\chi^{i,i+1}(\Psi^{4,5})^*\overline{\eta}^{\,i}$

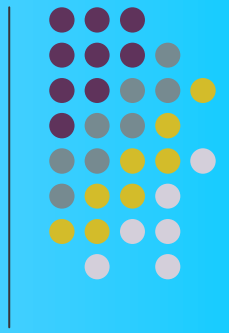
The doublet-triplet splitting mechanism results from the b. c. in α which break

SO(10) → SO(6) x SO(4)

$$\Delta_i = |\alpha_L - \alpha_R| = 0,1$$

h_i projected out *h_i remains in the spectrum*

We look for models such that…



- *No Higgs triplets ; one Higgs doublet*

$$\Delta_3(\beta) = 1$$

- *Up-quark type Yukawa couplings* selected

$$\Delta_3(\gamma) = 1$$

- *No chiral fractionally charged exotics*

Model with reduced Higgs spectrum

SO(10) breaking

Hidden gauge group breaking

	ψ^μ	χ^{12}	χ^{34}	χ^{56}	$\bar{\psi}^{1,\dots,5}$					η^1	η^2	η^3	$\bar{\phi}^{1,\dots,8}$							
b_4	1	1	0	0	1	1	1	1	1	0	1	0	1	1	1	1	0	0	0	0
β	1	0	1	0	1	1	1	0	0	1	1	1	0	0	0	0	1	1	0	0
γ	1	0	0	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	0	0	$\frac{1}{2}$	$\frac{1}{2}$	0	0	$\frac{1}{2}$	$\frac{1}{2}$

	y^3y^6	y^4y^4	y^5y^5	y^3y^6	$y^1\omega^6$	y^2y^2	$\omega^5\bar{\omega}^5$	$y^1\bar{\omega}^6$	$\omega^1\omega^3$	$\omega^2\bar{\omega}^2$	$\omega^4\bar{\omega}^4$	$\bar{\omega}^1\bar{\omega}^3$
b_4	1	0	0	0	0	0	1	1	0	0	1	0
β	0	0	1	1	1	0	0	1	0	1	0	1
γ	0	1	0	1	0	0	0	1	1	1	0	0

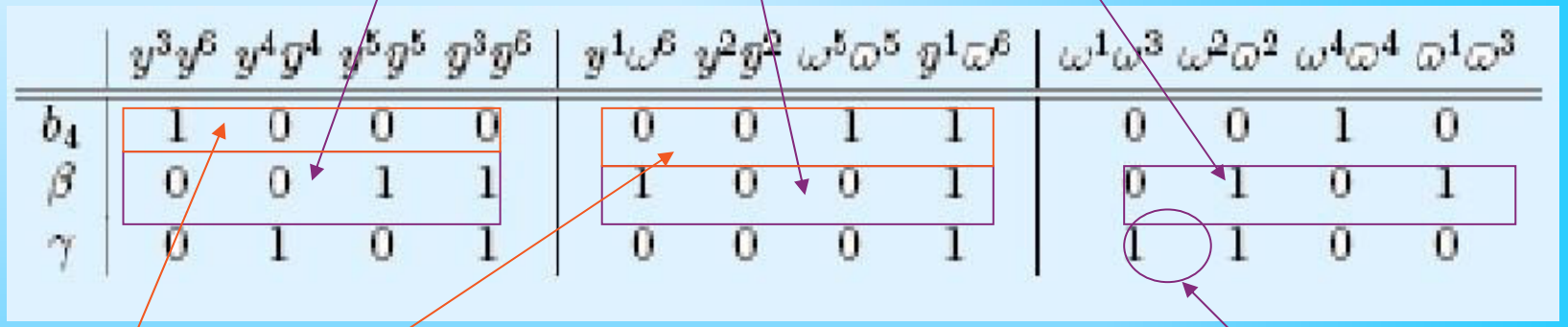
b_1 sector

b_2 sector

b_3 sector

Model with reduced Higgs spectrum

keep h_1 keep D_2 keep h_3

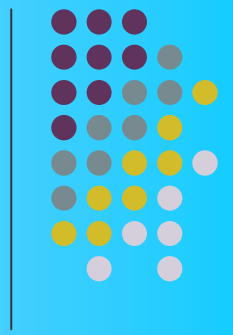


	y^3y^6	y^4y^4	y^5y^5	y^3y^6	$y^1\omega^6$	y^2y^2	$\omega^5\varpi^5$	$y^1\varpi^6$	$\omega^1\omega^3$	$\omega^2\varpi^2$	$\omega^4\varpi^4$	$\varpi^1\varpi^3$
b_4	1	0	0	0	0	0	1	1	0	0	1	0
β	0	0	1	1	1	0	0	1	0	1	0	1
γ	0	1	0	1	0	0	0	1	1	1	0	0

Project out the untwisted vectorial repr. $\Delta_\gamma = 1$

(up-quark type Yukawa coupling is selected)

Conclusions



- *Free Fermionic Models* produce some of the *most realistic string models* to date.

  The presence of 3 pairs of Higgs doublets is generally reduced by the analysis of *supersymmetric flat directions.*

- An alternative option for the *reduction of the Higgs states* is given by an opportune *choice of free fermion boundary conditions* at the string scale.

- The previous mechanism also provides a *reduction of the moduli space.*