in realistic models

$$\{ 1 , S , \xi_1 , \xi_2 \} \oplus \{ b_1 , b_2 \} \oplus \{ \alpha , \beta , \gamma \}$$

$N = 4$ $N = 1$

$E_8 \times E_8$ $Z_2 \times Z_2$

new feature Asymmetric orbifold

the key focus: boundary conditions of the internal fermions

$$\{ y , \omega \mid \bar{y} , \omega \}$$

WS fermions that have same B.C. in all basis vectors are paired

pairing of LR fermions $\rightarrow$ Ising model $\rightarrow$ symmetric real fermions

pairing of LL & RR fermions $\rightarrow$ complex fermions $\rightarrow$ asymmetric

A STRINGY DOUBLET–TRIPLET SPLITTING MECHANISM

NAHE $\rightarrow \quad \chi_j \bar{\psi}^{1,\cdots,5} \bar{\eta}_j + c.c. \rightarrow (5+\bar{5})_j = 10_j$ of $SO(10)$

$\alpha \quad \rightarrow \quad SO(10) \quad \rightarrow \quad SO(6) \times SO(4)$

$y_3\bar{y}_3$	$y_4\bar{y}_4$	$y_5\bar{y}_5$	$y_6\bar{y}_6$		$y_3 y_6$	$y_4\bar{y}_4$	$y_5\bar{y}_5$	$\bar{y}_3\bar{y}_6$
1	0	0	1		1	0	0	0

$$\Delta_j = |\alpha_L(T_2^j) - \alpha_R(T_2^j)|$$

$\Delta_j = 0 \rightarrow D_j, \bar{D}_j \qquad\qquad \Delta_j = 1 \rightarrow h_j, \bar{h}_j$

$$\Delta_{1,2,3} = 1 \Rightarrow h_j \quad \bar{h}_j \qquad j = 1, 2, 3$$

A superstring solution to the GUT hierarchy problem

Model 1

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

supplemented with adequate gauge symmetry breaking

$\rightarrow$ 3 gen $\oplus$ $SU(3) \times SU(2) \times U(1)^2$ model

symmetric $\Longrightarrow$ moduli

$y_i \omega_i \bar{y}_i \bar{\omega}_i$

are in

model 2

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

Asymmetric $BC \Rightarrow$

all untwisted moduli are projected out!

all $y_i\omega_i\bar{y}_i\bar{\omega}_i$ are disallowed

can be translated to asymmetric bosonic identifications

$$X_L + X_R \rightarrow X_L - X_R$$

moduli fixed at enhanced symmetry point

Twisted moduli

(2,2) $b_j \oplus b_j + \xi_2 \quad \rightarrow \quad (16 \oplus 10 + 1) + 1 = 27 + 1 \Rightarrow$ twisted moduli

(2,0) $b_j \, + \, b_j + 2\gamma \quad \rightarrow 16_{SO(10)} + 16_{SO(16)}$

all twisted moduli are projected out

Conclusions

Consistent quasi-realistic string vacua in which all untwisted (geometrical) & twisted moduli are projected out

Moduli are fixed

Extra dimensions are fictitious in these models

this may imply that extra dimensions are fictitious in the phenomenologically relevant string vacua

organizing principle but not real physical significance in the effective low energy field theory

similar to $SO(10) \rightarrow SU(3) \times SU(2) \times U(1)^2$ by Wilson lines