MSSM Compactifications from Intersecting Branes

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String Model building approach

$\Longrightarrow$

- Instead of trying to fix the moduli we are trying to build a realistic model (spectrum) in a Botton-up approach
- Embed local anomaly free SM (MSSM) configurations to a string compactification

Basic goals $\Longrightarrow$

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- This is an exact string description - No fluxes present
  $\longrightarrow$
  could get implemented ? fixing all moduli ?

Intersecting brane Model building in 2 directions

N=0 SM Toroidal Vacua :

- *G.Altazabal, S.Franco, L.Ibanez, R.Rabadan, A.Uranga, hep-th/0011073*

D6 N=0 SM Toroidal Orientifold Vacua :

- *R.Blumenhagen, B.Kors, D.Lust. T.Ott, hep-th/0107138; L.Ibanez, F.Marchesano, R.Rabadan, hep-th/0105155; C.K, hep-th/0205147,-th/0203187; D.Cremades, L.Ibanez, F.Marchesano, hep-th/0201205; D.Bailin, G.Kraniotis, A.Love, hep-th/0212012; · · ·*

D6 N=0 SM Orbifold Orientifold Vacua

- *R. Blumenhagen, B. Körs, D. Lüst and T. Ott,* $\underbrace{hep-th/0107138}_{Z_3}$; *C.K,* $\underbrace{hep-th/0412035, hep-th/0406258}_{Z_3 \times Z_3}$

D5 N=0 SM Orbifold Orientifold Vacua - $T^4 \times C/Z_N$

- *D.Cremades, L.Ibanez, F.Marchesano, hep-th/0205074; C.K, hep-th/0207234*
  $\longrightarrow$ First SM realization of extra dimension scenario

D6 N=1 SM Orbifold Orientifold Vacua

- *M.Cvetic,G. Shiu, A.Uranga,* $\underbrace{hep-th/0107166}_{Z_2 \times Z_2}$*; R. Blumenhagen, L. Görlich, T. Ott,* $\underbrace{hep-th/0210059}_{Z_4}$*; G.Honecker, T.Ott,* $\underbrace{hep-th/0404055}_{Z_4}$*; M. Cvetic, T. Li, T. Liu, hep-th/0403061;* $\cdots$

and also Yukawa properties, soft-terms,..

- *S.Abel, A.Owen, hep-th/0310257;-th/0303224; M.Cvetic, I.Papadimtriou, hep-th/0303083; G. L. Kane, P. Kumar, J. D. Lykken, T. T. Wang, hep-ph/0411125 . . .*

$IIA/T^6/\Omega R$ Model Building with Intersecting Branes - Why ?

R.Blumenhagen, L.Gorlish. B.Kors, D.Lust, hep-th/0007024

Toroidal models provide a better understanding of :

- *Proton stability* $\longrightarrow$ *BARYON* number is a gauged symmetry *and also*
- *LEPTON* number *CAN BE* a gauged symmetry [NEUTRINOS GET DIRAC

MASSES] in models where the gauge group structure at the string scale is $\longrightarrow$ $U(3) \times U(2) \times U(1)^n \Longrightarrow$ ONLY THE SM AT LOW ENERGY $\longrightarrow$

L.Ibanez, F.Marchesano, R.Rabadan, $\underbrace{hep-th/0105155}_{4-STACK}$;

C. K, $\underbrace{hep-th/0205147}_{5-STACK}$, $\underbrace{hep-th/0206108}_{6-STACK}$, $\underbrace{hep-th/0410034}_{5-6-STACKS}$

- *LEPTON* number *IS NOT* a gauged symmetry [NEUTRINOS GET ALSO

MAJORANA MASSES] $\longrightarrow$ Pati-Salam GUTS $\longrightarrow$

C.K, hep-th/0203187, hep-th/0209202, hep-th/0210200

$IIA/T^6/\Omega R$ - Intersesting model properties

- *Chirality $\Longrightarrow$ 3 generations + υ_R's*
- *smallness of neutrino masses*
- *No tachyons*
- *A cosmological constant; NSNS tadpole ? cosmology*
- Extra exotics may get massive from existing couplings only for Pati-Salam GUTS in $N = 0$ SMs $\longrightarrow$ C.K, hep-th/0203187,209202,210200
- Explain Doublet-Triplet Splitting $\longrightarrow$ flipped SU(5) $\longrightarrow$ M.Axenides, E.Floratos, C.K, hep-th/0307255

$\frac{T^6}{\Omega R}$ - *The* MSSM build within a Non-SUSY model

N_i	$(n_i^1,\ m_i^1)$	$(n_i^2,\ m_i^2)$	$(n_i^3,\ m_i^3)$
$N_a = 3$	$(1,\ 0)$	$(1/\rho,\ 3\rho\epsilon\beta_1)$	$(1/\rho,\ -3\rho\tilde{\epsilon}\beta_2)$
$N_b = 1$	$(0,\ \epsilon\tilde{\epsilon})$	$(1/\beta_1,\ 0)$	$(0,\ -\tilde{\epsilon})$
$N_c = 1$	$(0,\ \epsilon)$	$(0,\ -\epsilon)$	$(\tilde{\epsilon}/\beta_2,\ 0)$
$N_d = 1$	$(1,\ 0)$	$(1/\rho,\ 3\rho\epsilon\beta_1)$	$(1/\rho,\ -3\rho\tilde{\epsilon}\beta_2)$

Table 1: Intersection numbers that localize the MSSM spectrum.

- $\epsilon = \tilde{\epsilon} = \beta_1 = \beta_2 = 1 \rightarrow$ D.Cremades, L.Ibanez, F.Marchesano, hep-th/0212064, hep-th/0302105
- $\epsilon,\ \tilde{\epsilon},\ \beta_1,\ \beta_2 \neq 1 \rightarrow$ C.K, hep-th/0309070

Gauge Groups

Not Only $U(3) \times Sp(2)_b \times Sp(2)_c \times U(1)_d \longrightarrow$

$U(3) \times Sp(2)_b \times SU(2)_c \times U(1)_d \, ; U(3) \times Sp(2)_b \times U(1)_c \times U(1)_d$