THE LHC AND HIERARCHIES IN STRING/M THEORY

B. ACHARYA
A.S.I.C.T.P.

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- INTERFACE BETWEEN LHC AND STRING THEORY

- M THEORY VACUA WITH A STABLE HIERARCHY

- WARPED HIERARCHIES IN STRING THEORY

Why String Theory?

Because a simple question:

What do 4d Heterotic Vacua Look Like?

Has a very compelling answer.....

Non-Abelian Gauge Group

Chiral fermions

Hierarchical Yukawas

Dynamical susy Breaking

⋮

Grand Unification

2-3 splitting

etc

LHC

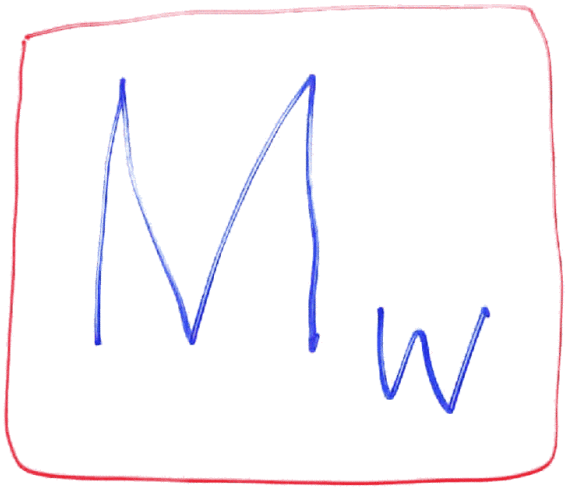
Sta

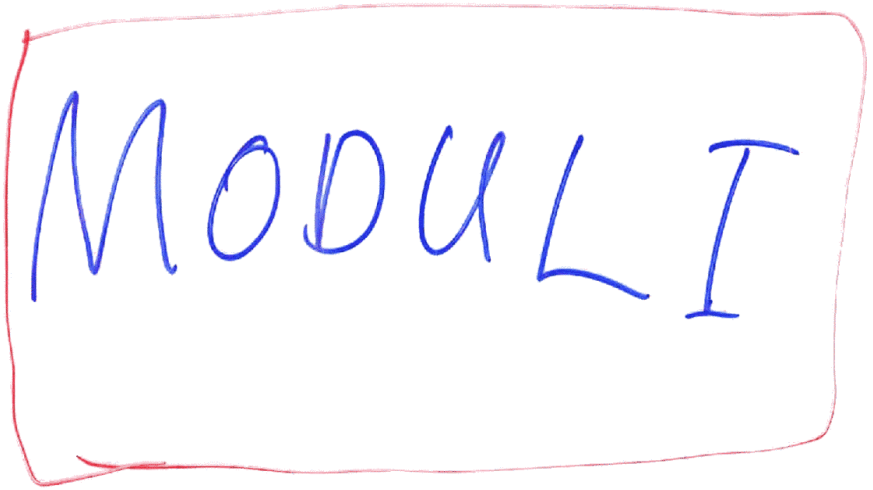
Arrivando

SO, LETS CONFRONT THESE VACUA WITH THE LHC DATA

After all, a given vacuum either IS or IS NOT consistent with the signal.

Whats the catch?





MODULI: A LOT OF RECENT PROGRESS

HIERARCHY: TWO BASIC IDEAS

1) $\Lambda \sim M_p e^{-\frac{2\pi}{\alpha_H b_0}}$

2) $\Lambda \sim M_p \underbrace{e^{-2\pi R_0 M_p}}_{\text{WARP FACTOR}}$

In IIB vacua, can generate hierarchy by warping or fine tuning by fluxes.

In M theory, IIA, heterotic fluxes give a large mass to scalars (via a large W)

$\Rightarrow$ $M_W = 0$ or M_{GUT}

HIERARCHY IN M THEORY

w/ Konstantin Bobkov
Gordon Kane
Piyush Kumar
Diana Vaman

hepth/0608262
+ to appear

M THEORY VACUA

- G_2 HOL EXTRA DIM's X_7
- Gauge Symmetry from orbifold sing. along $Q_3 \subset X$ (BSA)
- Chiral fermions are localized at the tips of conical singularities (BSA + WITTEN)
- Hierarchical Yukawas
  2-3 splitting
  Grand Unification

Since Q_3's dont intersect generically in X_7

SUSY BREAKING IS GRAVITY MEDIATED

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All the moduli

$z_i = t_i + i s_i$

t_i: axions

s_i: geometric moduli

enjoy axionic shift symmetry

(Not true in heterotic or IIB theory)

W is purely non-perturbative.

In general depends on ALL moduli.

Expect STABILISATION AND HIERARCHY

$$W = \Lambda_1^3 + \Lambda_2^3 + \ldots$$

$$\sim A_1 e^{\frac{\sum_i N_i z_i}{p}} + A_2 e^{\frac{\sum_i \tilde{N}_i z_i}{q}}$$

constants $O(1)$

rank $\sim 5-10$

INTEGERS OF ORDER 1

$$K = -3 \ln \prod_i S_i^{q_i} \quad \left(\sum q_i = \frac{7}{3}\right)$$

First minimised $V(s_i)$ numerically (semi-analytically)

This showed that there are meta-stable vacua with all moduli fixed

Later, found an analytical solution!

$$s_i \sim \frac{3}{N_i 4\pi} \frac{PQ}{P-Q} \ln \frac{A_2 P}{A_1 Q} + O\left(\frac{P-Q}{\ln\left(\frac{A_2 P}{A_1 Q}\right)}\right) + \ldots$$

$$m_{3/2} \sim 2.97\, m_p \times 10^3 A_2 P \left(\frac{P-Q}{PQ}\right)^{+9/2} \times \left(\frac{A_2 P}{A_1 Q}\right)^{\frac{-P}{P-Q}} \left(\ln\left(\frac{A_2 P}{A_1 Q}\right)\right)^{-7/2}$$

eg if $A_1 = 0.12$ $A_2 = 2$ $P = 8$ $Q = 7$

$M_{3/2} \sim 2061$ GeV

$M_0^2 \sim M_{3/2}^2$ (reasonably universally)

$M_{1/2} \sim 0.22 \left| \frac{q}{q \mp 1.25} \right| M_{3/2}$

$|q|<1$ generically suppressed (95%)

(cf $\frac{M_{3/2}}{\ln(M_{3/2})}$ Conlon/Quevedo)

$\Delta M_{1/2}$ (ANOMALY MEDIATION) COMPARABLE

$M_{1/2} + \Delta M_{1/2} \sim$ few 100 GeV.

$\mu \sim M_{3/2}$ (we think)

so LSP Bino.

More detailed study of the full pattern of Tevatron/LHC signal is underway

(w/ J. Shao + ...)

see Piyush kumars talk.

LHC STA ARRIVANDO

TEVATRON GIA ARRIVATO!

(Grazie JL!)

1) SIGNAL FOR TEVATRON/LHC WILL CLEARLY BE VISIBLE (as gluinos are light)

2) Can probably distinguish these vacua from IIB KKLT / Large Volume

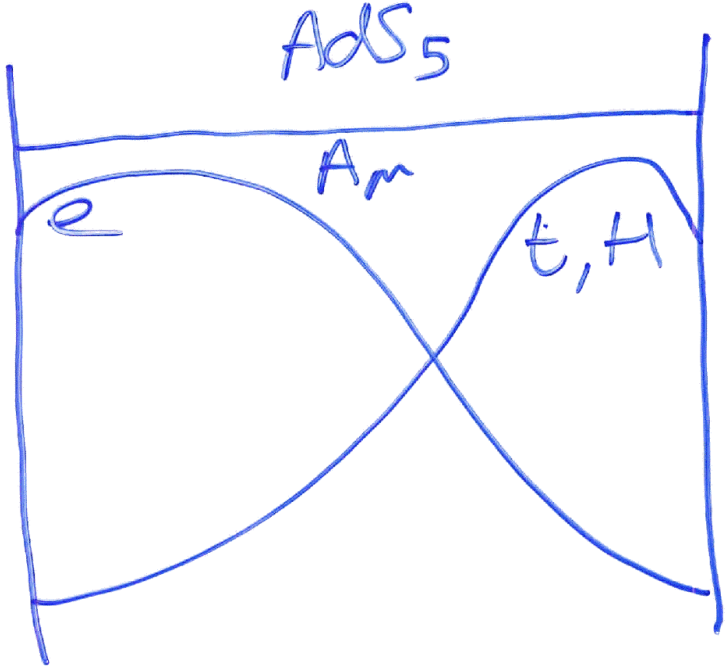
WARPED STANDARD MODEL IN STRING THEORY

w/ R. VALANDRO + F. BENINI

to Appear

(see Roberto's talk on Thursday)

RS



UV IR

Requires Bulk masses

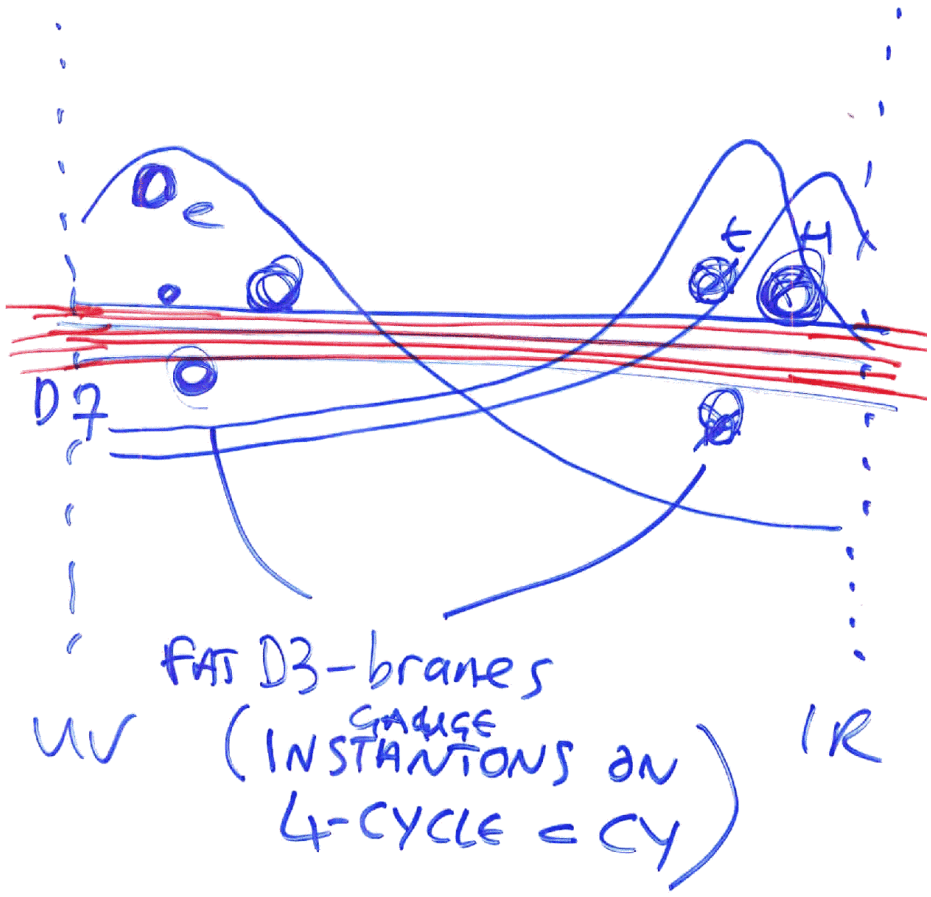
1) Need Standard Model on D7-branes to get fields in bulk

2) Bulk Masses? Three Generations?

→ Fermions localized by Instantons

AND WARP FACTOR!

→ COUPLINGS SUPPRESSED/ENHANCED BY WARPING AND INSTANTON SIZE!



CONCLUSIONS

- M and IIB vacua can have a hierarchy AND Moduli stabilised

- CAN CONFRONT LHC AND TEVATRON DATA WITH THE EXPECTED SIGNAL FROM THESE VACUA

Q:

How many other classes of vacua are there with stabilised hierarchies?

2 or 10^2 or 10^{50}?

CCP

Assume that the dual of IIB fluxes give a large enough discretuum and does not change

M_W, $\sin^2\theta_W$, λ_e ...