Intersecting Brane Models and Cosmology

Jason Kumar
Texas A&M University
w/ B. Dutta and L. Leblond
(hep-th/0608188,0703278)
String goal→find models which match observation

• problem→many models arise from different background choices
  – compactification manifold \((10D \rightarrow 4D)\)
  – branes, fluxes
  – “landscape” of vacua
• not known how to construct a working model which gets everything right
• there are known ways to construct very large classes of models which get big pieces right
  – could contain examples which get the rest right
• our aim:
  – study general properties of a large class, not just one model
  – find features interesting for phenomenology/cosmology
  – we look at intersecting brane models (IBM’s)
IBM setup

• compactify IIA/B on orientifolded CY 3-fold
  – 10D → 4D, N=8 → N=1
• bgd. has space-filling charge → must cancel
  – add D6-branes (generic)
• open strings give gauge theory, matter
  – visible, (pseudo-)hidden sector
• general features
  – extra gauge groups (many)
  – generic bifundamental matter

• $l_{ab}$ counts bifund. matter
  – generically nonzero, since 3-cycles intersect
D-term inflation from open strings in IBM hidden sector

• with N brane stacks
  – N U(1)’s
  – O(N^2) bifundamental scalars
  – many flat directions for \( V_D \)
• what we want
  – split off one of the N D-terms
    • \( V_D = V_{\text{inf}} + V_{\text{rest}} \)
  – go out on \( V_{\text{rest}} \) flat direction
    • Yukawa couplings then lift waterfall directions
    • \( V_{\text{inf}} \) inflates
  – Coleman-Weinberg pot. \( \rightarrow \) flat dir. rolls back until tachyon forms, ending inflation
  – additional \( V_F \) terms suppressed by large gauge invariance in hidden sector

\[
V_{\text{inf}} \approx g^2 \left( |\phi_+|^2 - |\phi_-|^2 - \xi \right)^2
\]

\[
W = \lambda S \phi_+ \phi_- \quad V_F = \lambda^2 S^2 \phi_+^2 + \ldots
\]

\[
V_{\text{CW}} = \frac{V_0 g^2}{8 \pi^2} \log \left( \frac{\lambda^2 S^2}{\Lambda^2} \right)
\]
\[ V_{\text{inf}} = V_c = g^2 (|\phi_+|^2 - |\phi_-|^2 - \xi)^2 \]

- flat direction \( \rightarrow \) fields at corners of “square”
  - gauge inv. \( \rightarrow \) turning fields in “polygons” can leave \( V_{\text{rest}} \) invariant
  - for square, only non-vanishing Yukawa coupling is suppressed

\[ W = \frac{\lambda'}{M_{\text{pl}}} \phi_1 \phi_2 \phi_3 \phi_4 \]

- if \( V_F \ll V_D \) \( \rightarrow \) \( \eta \) problem suppressed as in standard D-term inflation
Need to match cosology data

- constraints
  - at least 60 e-folds
  - $P_R \sim 10^{-9}$
  - $n \leq 1$
  - low cosmic string tension

- assume $M_{\text{inf.}} < M_{\text{string,mod.}} < M_{\text{pl}}$ for control

- $\xi \sim 10^{-5} M_{\text{pl}}^2$

- $U(2), I_{ab} > 1 \rightarrow$ cosmic string unstable

- Get $n \approx 0.98$ (2σ away from WMAP)

- for “square” $g^2 \lambda^2 < 10^{-13}$
  - $\lambda$ exponentially suppressed at large volume
  - less tuning for bigger polygon
  - fine-tuning is only sign of intersection #, not coupling
Baryogenesis from mixed anomaly

- chiral bifund. matter → **mixed anomalies**
  - appearance is *generic*
  - can involve **hidden** and **SM sector**
  - $U(1)_bG^2$ mixed anomaly
- **sphaleron** in **hidden** sector violates $B$
  - hidden sector baryogenesis
- **two scenarios**
  - ordinary **1st order PT**
  - **our inflation scenario**
    - when waterfall tachyon condenses, dumps energy (**tachyon preheating**) in $G$ (Felder, Kofman, Linde; Tranberg and Smit)
  - Both scenarios increase baryogenesis possibilities via anomaly beyond EW group

\[ \partial_\mu J_B^\mu \propto \text{Tr}[F_G \wedge F_G] \]
Conclusion

• there is a lot to learn about the general properties of intersecting brane models

• we could have done this in EFT, but what’s the motivation?
  – interesting features which don’t seem favored from an EFT point of view might appear common in stringy completions

• data here/coming from cosmology and particle physics → let’s see if stringy scenarios can help patch them together