Intersecting Brane Models and Cosmology

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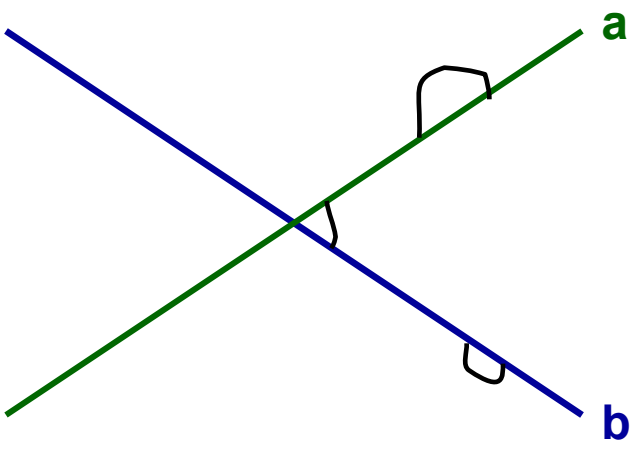
String goal→find models which match observation

- problem→ many models arise from different background choices
  - compactification manifold (10D → 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

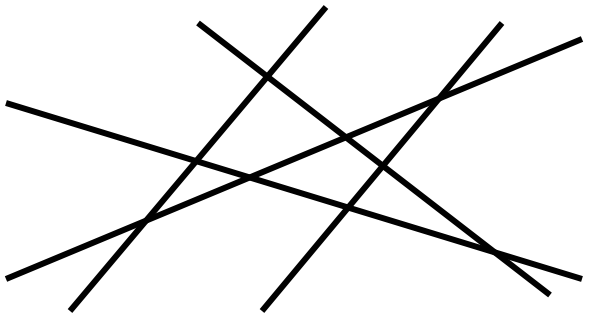
- compactify IIA/B on orientifolded CY 3-fold
  - 10D → 4D, N=8 → N=1
- bgd. has space-filling charge → must cancel
  - add D6-branes (generic)
- open strings give gauge theory, matter
  - visible, (psuedo-)hidden sector
- general features
  - extra gauge groups (many)
  - generic bifundamental matter

- I_{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
    - $V_D = V_{inf} + V_{rest}$
  - go out on V_{rest} flat direction
    - Yukawa couplings then lift waterfall directions
    - V_{inf} inflates
  - Coleman-Weinberg pot.→ flat dir. rolls back until tachyon forms, ending inflation
  - additional V_F terms suppressed by large gauge invariance in hidden sector



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

$$W = \lambda S \phi_+ \phi_- \qquad V_F = \lambda^2 S^2 \phi_+^2 + \ldots$$

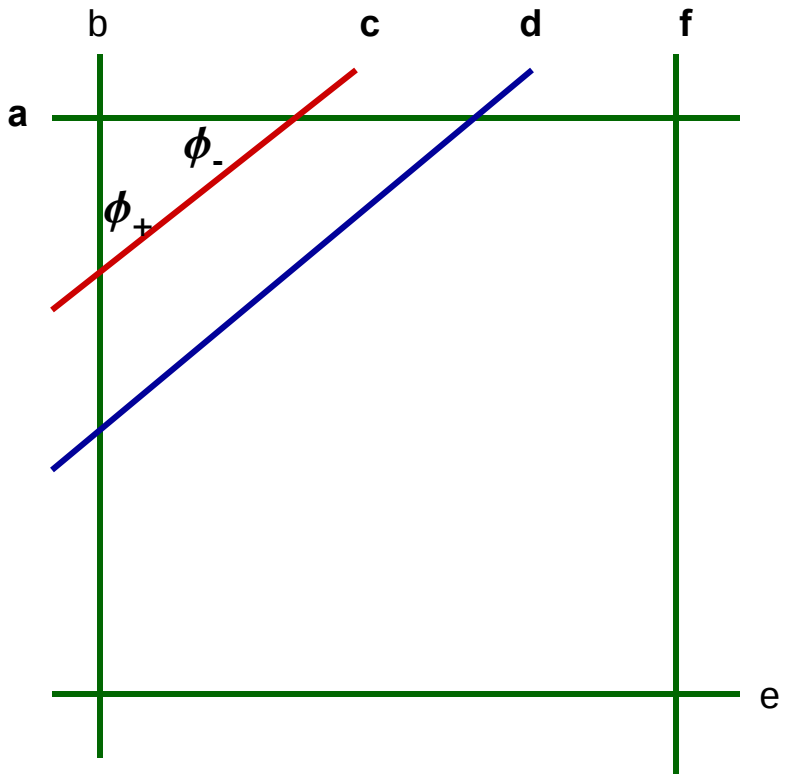
$$V_{CW} = \frac{V_0 g^2}{8\pi^2} \log\left(\frac{\lambda^2 S^2}{\Lambda^2}\right)$$

$V_{inf} = V_c = g^2 (|\phi_+|^2 - |\phi_-|^2 - \xi)^2$

- flat direction → fields at corners of "square"
  - gauge inv. → turning fields in "polygons" can leave V_{rest} invariant
  - for square, only non-vanishing Yukawa coupling is suppressed

$$W = \frac{\lambda'}{M_{pl}} \phi_1 \phi_2 \phi_3 \phi_4$$

  - if $V_F \ll V_D$ → η problem suppressed as in standard D-term inflation

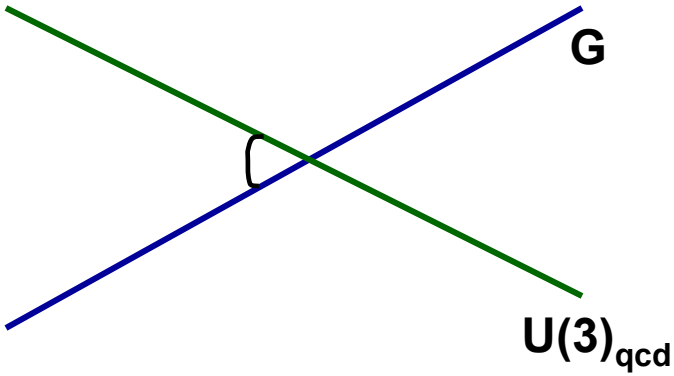


Need to match cosmology data

- **constraints**
  - at least 60 efolds
  - $P_R \sim 10^{-9}$
  - $n \leq 1$
  - low cosmic string tension
- assume $M_{inf.} < M_{string}, M_{mod.} < M_{pl}$ for control
- $\xi \sim 10^{-5} M_{pl}^2$
- U(2), $I_{ab} > 1 \rightarrow$ cosmic string unstable
- Get $n \approx 0.98$ (2σ away from WMAP)
- for "square" $g^2\lambda^2 < 10^{-13}$
  - λ 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
  - $U(1)_b G^2$ 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)



$$\partial_\mu J^\mu_B \propto \mathrm{Tr}\left[F_G \wedge F_G\right]$$

- Both scenarios increase baryogenesis possibilities via anomaly beyond EW group

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