

Singularities for Cosmology in String Theory

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Something about myself



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- I love eating, cooking, and doing almost all kinds of sports, specially football. Anybody in for a match?
- PhD at Institute for Theoretical Physics, Madrid, with *Angel Uranga*.
- Just got to Hamburg (~ 2h ago)! Fellow at DESY until *October 2018*.

Moving to physics...

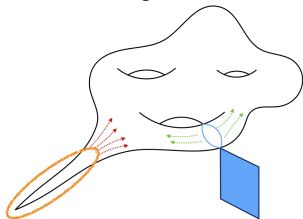
A more concrete title for the talk would be

Applications of **Toric Calabi-Yau Singularities**
to **Cosmological model building in String Theory**

I am also interested in Inflation in general, other aspects of String Phenomenology and other String Theory related topics which do not necessarily have a phenomenological application.

Toric Calabi-Yau Singularities - Generalities I

- They are local cone-like CY geometries



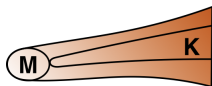
- With appropriate fluxes, they give rise to warp factors that enable a ST generalization of *Randall-Sundrum*: *Warped throats*

$$ds^2 = e^{2A(r)} \eta_{\mu\nu} dx^\mu dx^\nu + e^{-2A(r)} \left(dr^2 + r^2 d\Omega_{X_5}^2 \right) \quad \text{with}$$

$$\star_6(F_3 - \tau H_3) = i(F_3 - \tau H_3) \quad ; \quad F_5 = 4e^{4A(r)} \frac{dA}{dr} (1 + \star_{10}) dr \wedge dx^0 \wedge dx^1 \wedge dx^2 \wedge dx^3$$

- Very useful description in terms of a holographic dual gauge theory. Dimer diagrams and Toric Diagrams.

Toric Calabi-Yau Singularities - Generalities II



The typical example: Klebanov-Strassler throat

- Based on the conifold: a cone over $X_5 \sim S^2 \times S^3$.
- Without fluxes holographic dual is a $\mathcal{N} = 1$ SCFT

$$SU(N) \times SU(N) \quad \text{with } A_1, A_2 \text{ in } (\square, \bar{\square}) \text{ \& } B_1, B_2 \text{ in } (\bar{\square}, \square)$$

$$W = A_1 B_1 A_2 B_2 - A_1 B_2 A_2 B_1$$

- With fluxes: finite-size S^3 on the bottom and

$$\int_{S^3} F_3 \sim M \quad ; \quad \int_{S^2 \times \mathbb{R}^+} H_3 \sim K(r) \quad ; \quad N(r) \sim \int_{X_5} F_5 \sim M^2 \log(r/\epsilon)$$

$$e^{-4A(r)} \sim \alpha'^2 g_s^2 M^2 \frac{4 \log(r/\epsilon) + 1}{r^4}$$

- Gauge dual is no longer conformal. Gauge theory phenomena related to geometry: duality cascades, confinement...
- Other singularities \Rightarrow Other gauge duals.

Toric Calabi-Yau Singularities - Generalities III

Why **toric** singularities?

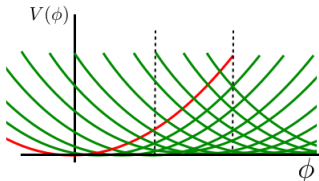
- We describe them using a Gauged Linear Sigma Model (GLSM) giving the toric action. The GLSM easily encoded into toric/web diagrams, which are very useful to know which cycles you can have for a given singularity.
- Unlike for more general singularities, the mirror and gauge dual are known explicitly. Gauge theory can be easily described in terms of dimer diagrams, allowing for a systematic description of the several phenomena one may find on the gauge theory.

Cosmological model building in ST - Generalities

ST, as a theory of everything, should be able to describe our Universe. In particular, it should be able to embed *Inflation* and *positive CC*.

These issues have turned out not to be very simple, we are still working on them!

- Inflation: large field inflation requires control over EFT. This requires embedding the EFT on a UV theory: ST best theory.
- For slow roll inflation, best inflaton candidates are *axions*.
- But in QG $f_\phi < M_p$, so extra structure required: Monodromy



Cosmological model building in ST - Generalities II

The inflaton (axion) potential comes from Non-Perturbative effects. First proposals: 5-brane axion monodromy. Then F-term axion monodromy...

- Recent developments on the Weak Gravity Conjecture (WGC) attacked other (aligned inflation, N-flation...) axion inflation proposals. We don't know what the fate of the axion monodromy inflation idea is...

Cosmological model building in ST - Generalities III

More trouble: $\Lambda > 0$ is rather non-natural in ST compactifications.

- Among many ideas, KKLT is the scenario that most people like: an anti-D3-brane on the bottom of a warped throat (small Λ). There was a long discussion of the validity of the EFT description of this setup.
- Recent developments about the nilpotent goldstino allow for a better description of this kind of setup.
- ST embedding of nilpotent goldstino requires anti-D3-branes on a orientifold.

What I have worked on

- Building throats (using toric geometry) that allow for a description of 5-brane and F-term axion monodromy inflation.
- Finding criteria that tell which toric singularities are compatible with orientifolds and how the effect of the orientifold is on the gauge theory side.
- Using the above ideas to provide a new scenario with $\Lambda > 0$. De Sitter with Dynamical SUSY Breaking.
- Building up throats with instanton contributions involving flavour branes.

Current work...

- Trying to provide a ST embedding for a new type of mechanism giving rise to inflation without axions.
- Learning more on orientifolds of toric singularities and their applications to cosmology, mostly focusing on the conifold.

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Thank you :)