

A discrete life in the swampland



Angel M. Uranga
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E. Gonzalo, L. Ibáñez, A.U, arXiv:1812.06520 [hep-th]

G. Buratti, J. Calderón, A.U, arXiv:1812.05016 [hep-th]

A. Mininno, E. García-Valdecasas, to appear

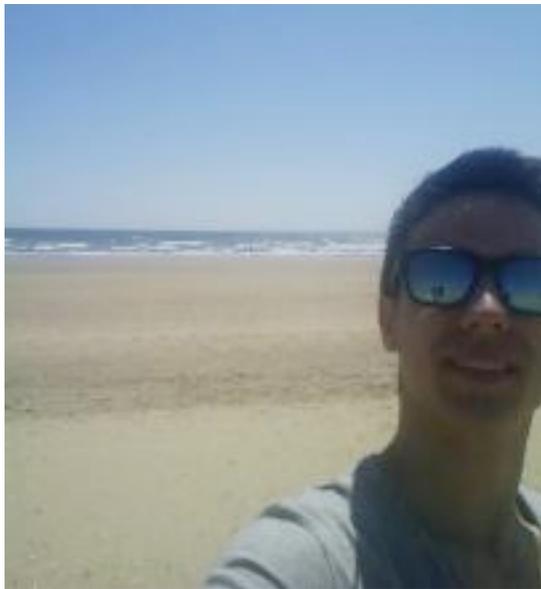
String Pheno '19



Eduardo García-Valdecasas



Ginevra Buratti



José Calderón



Alessandro Mininno

Motivation

INSTITUTO DE FÍSICA TEÓRICA UAM-CSIC PRESENTS:

Navigating the Swampland

MADRID, 25-27 SEPTEMBER 2019



SWAMP GONDOLIERS

L. E. Ibáñez
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Instituto de
Física
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Discuss interplay with discreteness

 Periodicities

 Dualities

 Monodromies

 Symmetries...

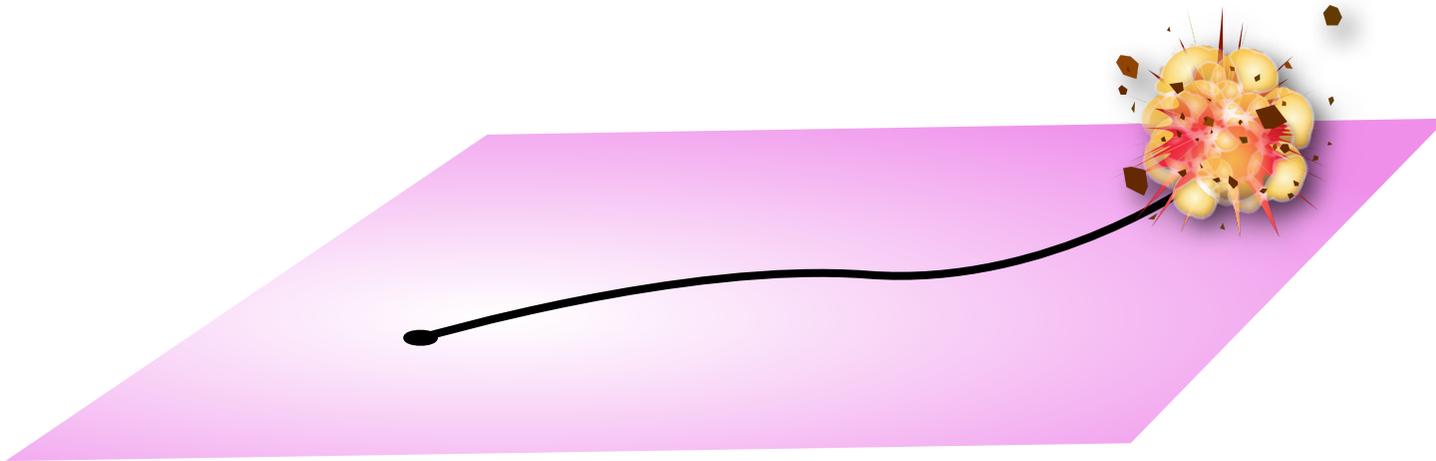
Swampland distance conjecture

📌 Slogan: “Transplanckian trips in field space not allowed”

📌 More precise

[Ooguri, Vafa; Palti;...]

Adiabatic motion in moduli space over transplanckian (geodesic) distances leads to breakdown of effective field theory



- Appearance of infinite tower of light modes

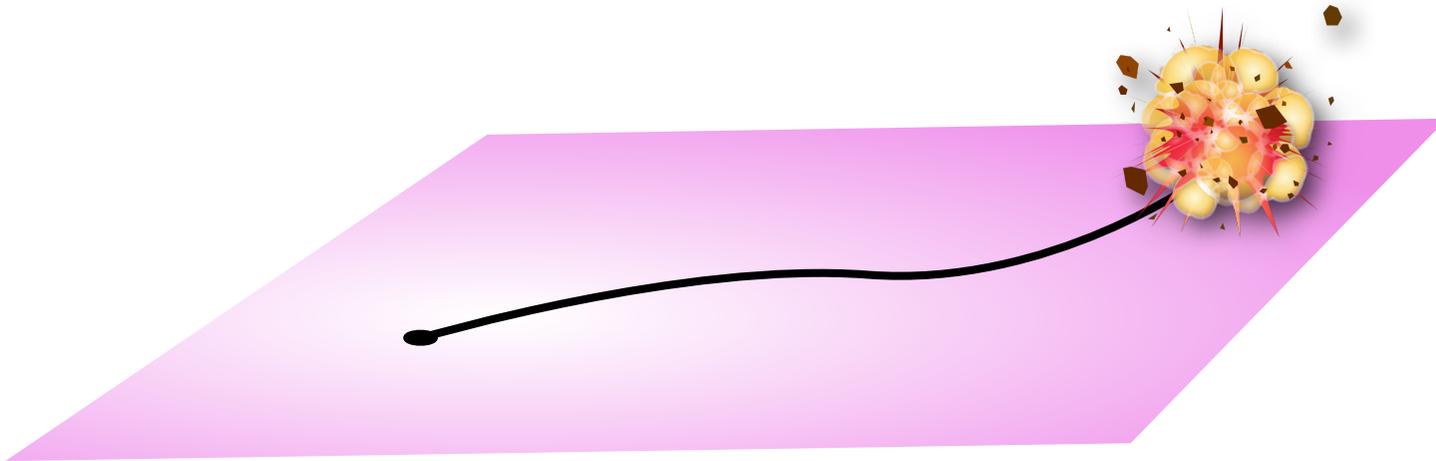
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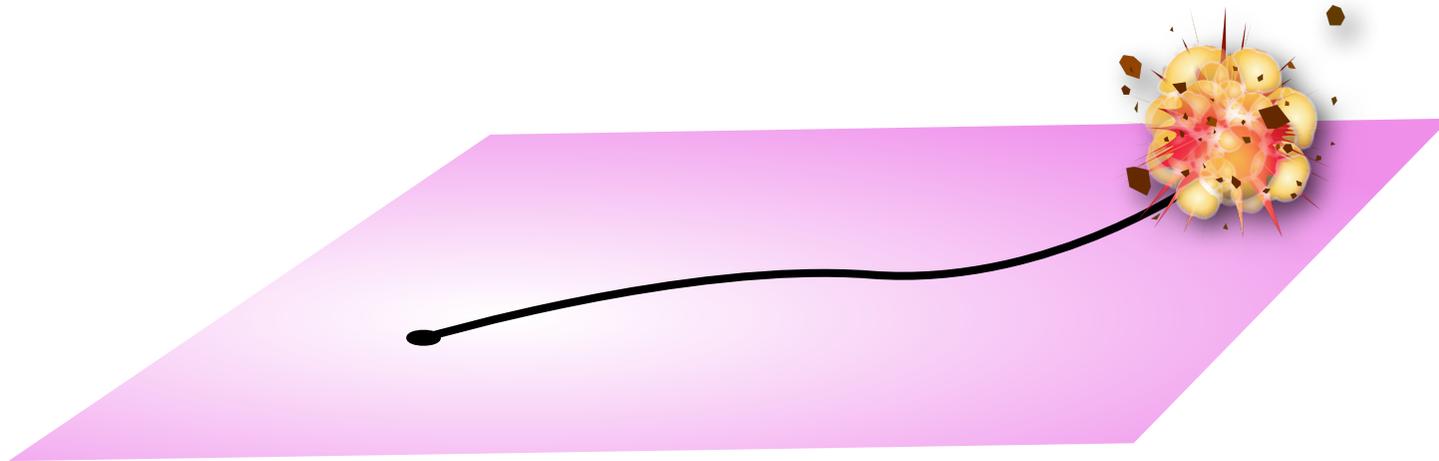
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- What if non-adiabatic?

Axions

-  Need scalars with sub-Planckian potential through possibly super-Planckian field range
-  Suppression of corrections in non-susy models motivates use of fields with additional symmetry

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Axions: Periodic scalars with (perturbative) shift symmetry

$$\phi \rightarrow \phi + \lambda$$

broken to discrete periodicity by:

- Non-perturbative effects \Rightarrow natural inflation
- Monodromic effects \Rightarrow axion monodromy

Natural inflation

- 📌 Single axion with 1-instanton generated potential
Freese, Frieman, Olinto

$$V(\phi) = \Lambda^4 [1 - \cos(\phi/f)]$$

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- $f \gg M_p$ problematic
edge of controllable regimes
Banks, Dine, Fox, Gorbatov

- In deep trouble with WGC swampland constraints
 - Single field
Arkani-Hamed, Motl, Nicolis, Vafa
 - Multifield
Rudelius; Montero, AU, Valenzuela; ...
 - Work & proposals go on, but...

Natural inflation

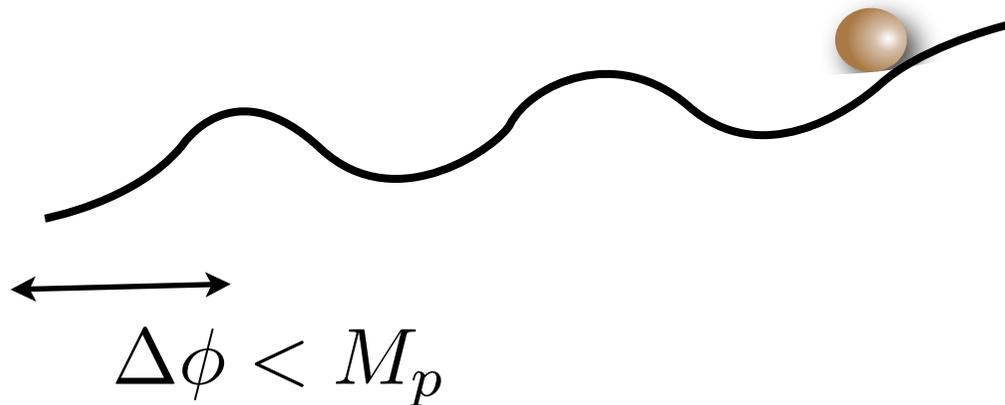
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\Rightarrow higher harmonics reduce the rolling range $< M_p$



From periodicity to duality

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-  Ubiquitous complexification of the axion
 - $SL(2, \mathbb{R})/SL(2, \mathbb{Z})$ moduli space
 - Point at infinite distance: infinite tower of particles

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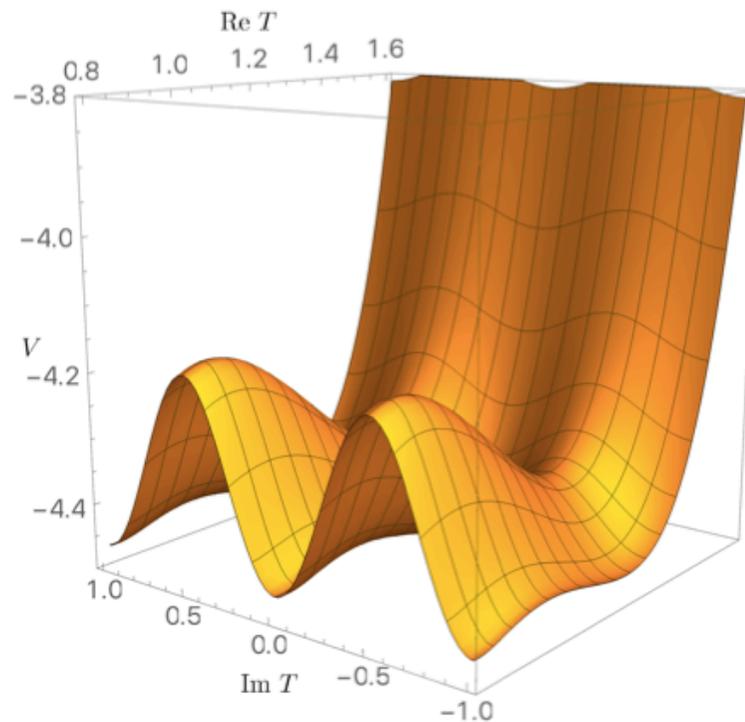
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Duality invariant scalar potentials in $N=1$ vacua

- $N=2$ threshold corrections to gauge couplings + $N=1$ gaugino condensation
- towers of (poly)instantons from dual D0s in orientifold of IIA on $K3$

cf Fernando's talk



Large distances prevented by large potential

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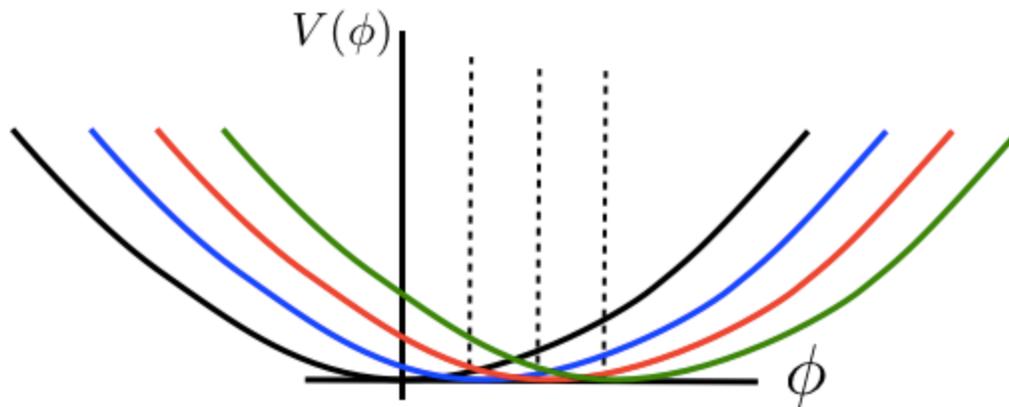
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Axion monodromy

 Alternative: Transplanckian field range with subplanckian periodicity, through multivalued potential

Silverstein, Westphal

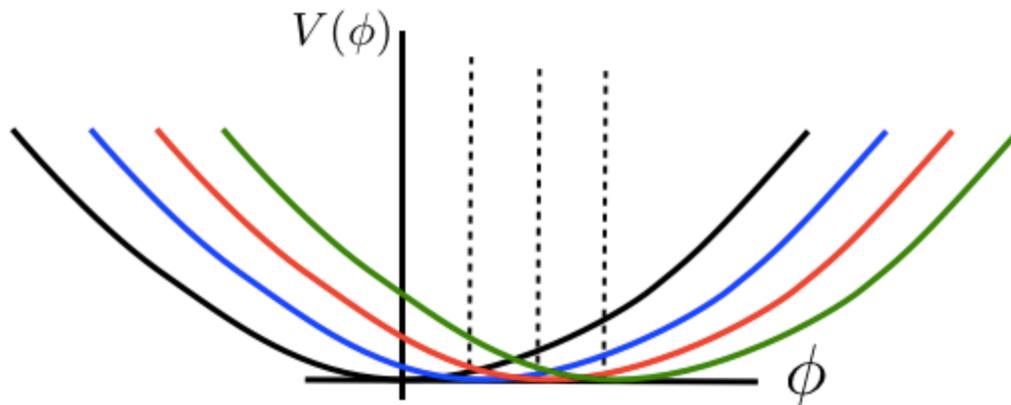


cf Witten's θ angle
in large N pure YM

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- Potential protected by dual 3-form gauge invariance

Marchesano, Shiu, A.U; also Dvali, Jackiw

$$|F_4|^2 + |dC_2 - nC_3|^2 \quad C_3 \rightarrow C_3 + d\Lambda_2 \quad ; \quad C_2 \rightarrow C_2 + n\Lambda_2$$

$$|F_4|^2 + n\phi F_4 + |d\phi|^2$$

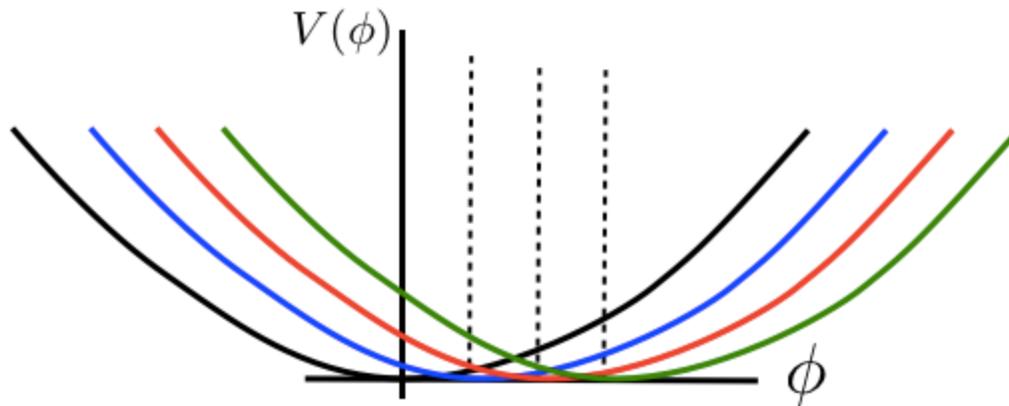
Dvali; Kaloper, Sorbo

$$|d\phi|^2 + \phi^2$$

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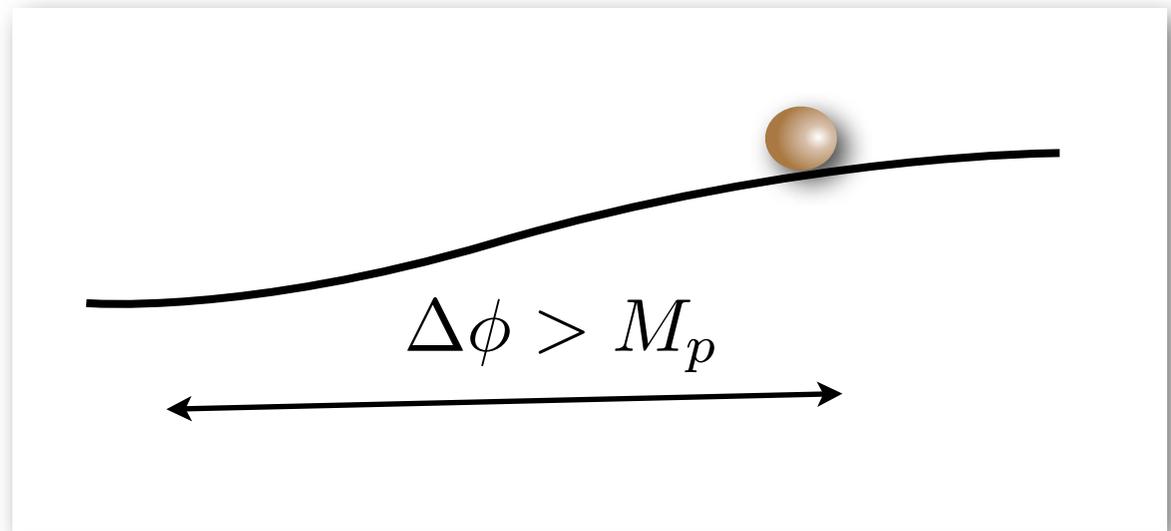
Transplanckian vs backreaction?

Palti et al

Potentials and backreaction

- 📌 Adiabatic motion in field space with potential is “offshell”

Equations of motion
don't allow for constant vev!



- 📌 In general, hard problem

What potential? What dynamics? ...?

- 📌 Address in concrete setup: fully backreacted 10d solution

The KS warped throat

Klebanov, Tsetlyn
Klebanov, Strassler

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- 📌 Start: $AdS_5 \times S^2 \times S^3$ with N units of RR 5-form flux
Light scalar ϕ from NSNS 2-form over S^2

The KS warped throat

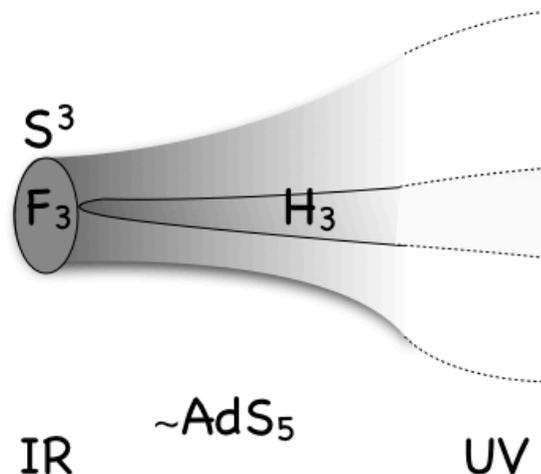
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📌 Flux compactification:

Add M units of RR 3-form flux F_3 over S^3

Locally $\text{AdS}_5 \times S^2 \times S^3$, with slow variation along r



$$\text{F5 flux} \Rightarrow N \sim N_0 + M \log r$$

$$\text{H3} \Rightarrow \phi \sim M \log r$$

$$\text{AdS5 radius } R^4 \sim M^2 \log r$$

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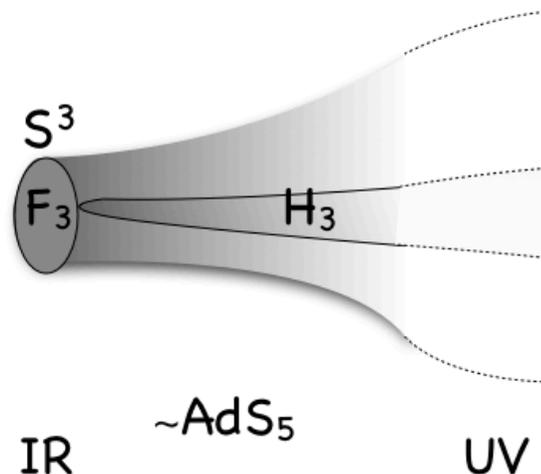
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- Full 10 supergravity solution is explicitly known

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 Reinterpret the KS solution as 5d axion monodromy

10d coupling F_3 B_2 F_5 \Rightarrow 5d coupling M ϕ F_5

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📌 “Roll” up to arbitrarily large distance in field space

$$G_{\phi\phi} \sim (N_0 + M\phi)^{-1} \quad \Delta = \int G_{\phi\phi}^{1/2} d\phi \sim \int \frac{d\phi}{\phi^{1/2}} \sim \phi^{1/2}$$

cf José Calderón’s talk

Discrete symmetries in AdS

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 $N=1$ toric theories have gravity duals with discrete symmetry groups

Good arena to explore discreteness & swampland

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 Exploit dimer technology to build infinite classes of AdS compactifications with arbitrarily large discrete gauge symmetries

Orbifolds of C^3 , conifolds, dP1... you name it

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Generically non-abelian, arising from torsion classes

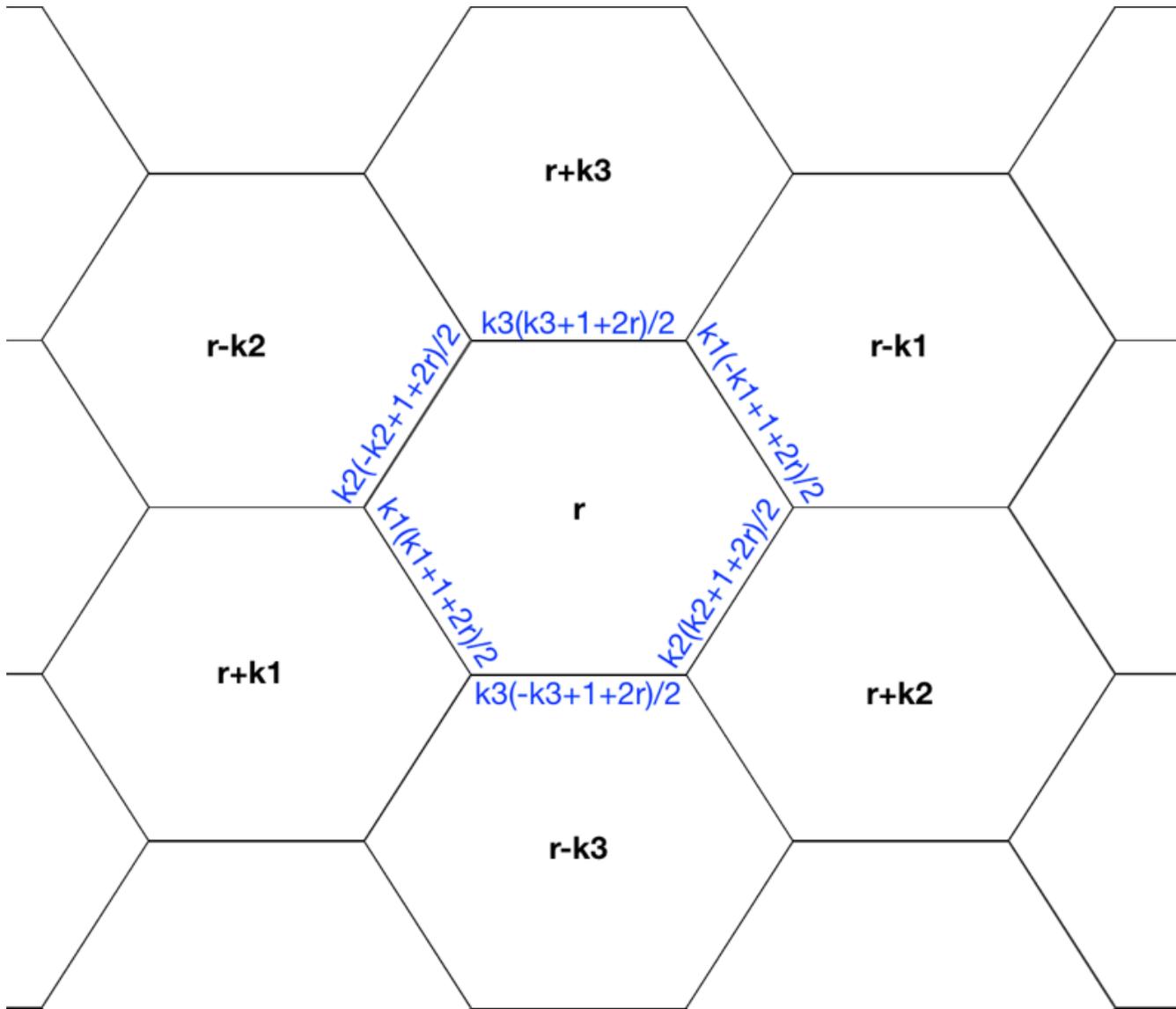
Gukov, Witten, Ranganamani, '98

Pando-Zayas et al '06

Berasaluce-González, Cámara, Marchesano, AU '12

A. Mininno, E. García-Valdecasas, AU '19

Ex: Discrete Heisenberg groups in AdS5 x S5/ZN



Conclusions

 Interplays of discreteness & swampland

Periodicities, dualities, monodromies, symmetries

 Axions as scalars with some periodicity / global identification

Important to include other dualities as identifications

 Monodromies as periodicities with fluxes / torsion ...

Important to include backreaction and non-adiabaticity

 Enhancement of monodromies/symmetries to non-abelian

Toric gauge / gravity duals as template

Thank you!