Highlights on Non-Supersymmetric Strings

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A recent review: *E. Dudas, J. Mourad, AS, 2511.04367 (Physics Reports), and refs. therein*

+

J. Mourad and AS, 2606.04542 (JHEP)

SCUOLA NORMALE SUPERIORE

INFN Istituto Nazionale di Fisica Nucleare

Corfu 2026 Workshop on Quantum Gravity and Strings
(September 6-13, 2026)

10D Tachyon-Free Models

The (SUSY) 10D-11D Hexagon

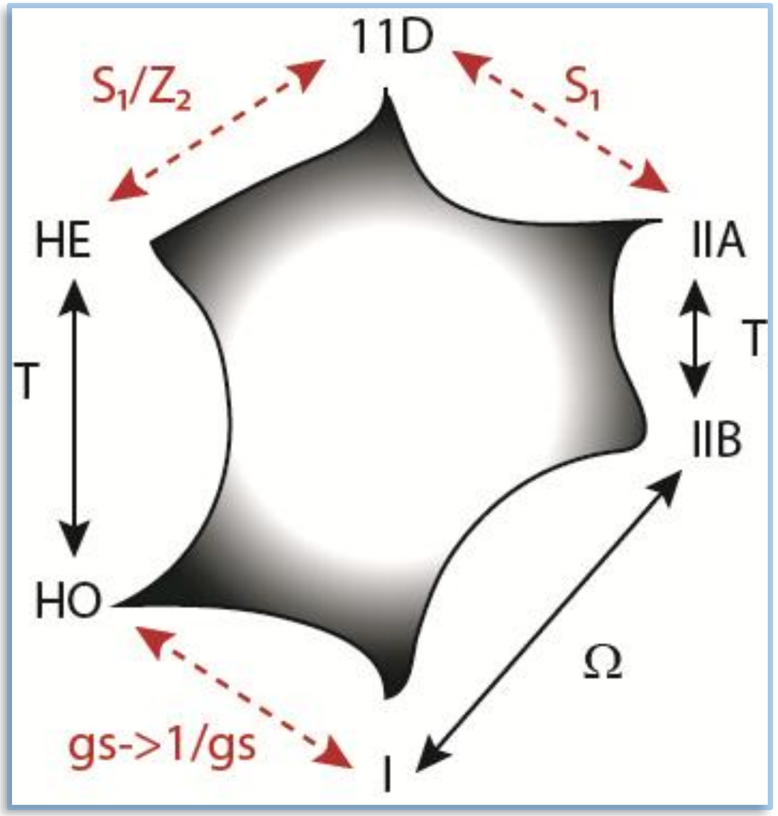
- Perturbative → **Solid arrows**
- [10&11D supergravity → **Dashed arrows**]
- **Highest point** of (SUSY) String Theory

BUT:

- Exhibits **dramatically our limitations**

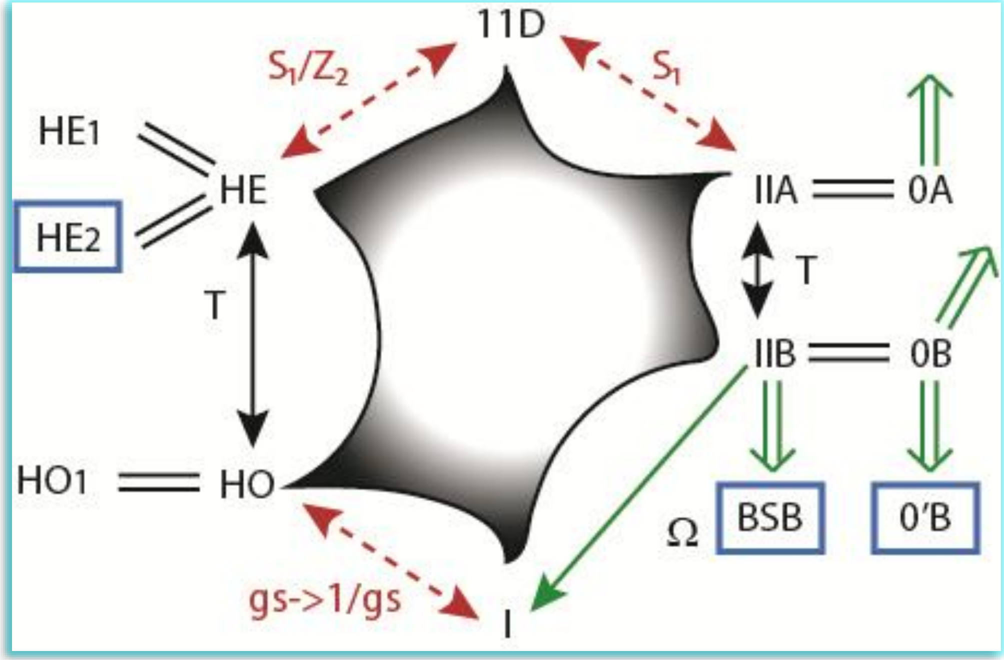
(Witten, 1995)

- **SUSY**: **stabilizes** the 10D Minkowski vacua



BROKEN SUSY ?

The 10D-11D Zoo



- Non-SUSY closed & orientifolds

(Seiberg, Witten, 1986)
(Dixon, Harvey, 1986)
(Bianchi, AS, 1990)

∃ 3 non-SUSY non-tachyonic strings

- SO(16)xSO(16) — *(Dixon, Harvey, 1986)* *(Alvarez-Gaumé, Ginsparg, Moore, Vafa, 1987)*
- 0'B U(32) — *(AS, 1995,1997)*
- [BSB: Usp(32)] — *(Sugimoto, 1999)*

- **NO SUPERSYMMETRY → TACHYONS (typically) : We are still UNABLE to cope with them**

❖ **RECENTLY: geometric links to 11D**

(Baykara, Dudas, Vafa, 2026)
(Altavista, Anastasi, Raucci, Uranga, Wang, 2026)

- **10D theories WITHOUT SUPERSYMMETRY but NO TACHYONS: a good starting point**

Non-Tachyonic 10D String Models

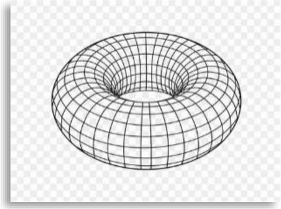
1. SO(16)xSO(16) : ORBIFOLD of the HE ($E_8 x E_8$) heterotic by $(-1)^{FL+F1+F2}$

(Dixon, Harvey, 1987)
(Alvarez-Gaumé, Ginsparg, Moore, Vafa, 1987)

$$\text{HE Massless Modes}: g_{\mu\nu}, B_{\mu\nu}, \phi, \psi_{\mu\, L}, \lambda_R + (A_\mu, \chi_L)^{(248,1)+(1,248)}$$

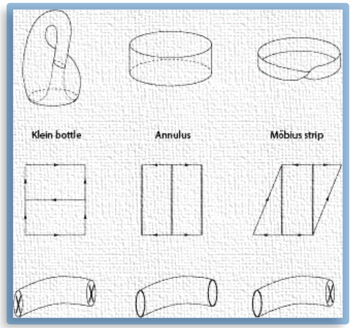
$$\Downarrow$$

$$\text{Massless Modes}: g_{\mu\nu},\ B_{\mu\nu},\ \phi,\ A_\mu^{(120,1)+(1,120)},\ \chi_L^{(128,1)+(1,128)},\ \chi_R^{(16,16)}$$



2. (S)U(32) : ORIENTIFOLD of the (tachyonic) 0B

(AS, 1995, 1997)



$$g_{\mu\nu},\ B_{\mu\nu,C},\ \phi,\ a_S, A^+_{\mu\nu\rho\sigma,S},\quad T,\ B_{\mu\nu,V},\ B_{\mu\nu,S},\ a_C, A^-_{\mu\nu\rho\sigma,C}$$

+ (open) $A_\mu^{32\times 32},\ \lambda^{496+496}$

simplest occurrence of generalized GS

3. USp(32) : ORIENTIFOLD of IIB (variant of type I)

(Sugimoto, 1999)

$$\text{Massless Modes}: \underbrace{g_{\mu\nu},\ B_{\mu\nu},\ \phi\ , \psi_{\mu L},\ \lambda_R}_{\text{SUSY}}$$

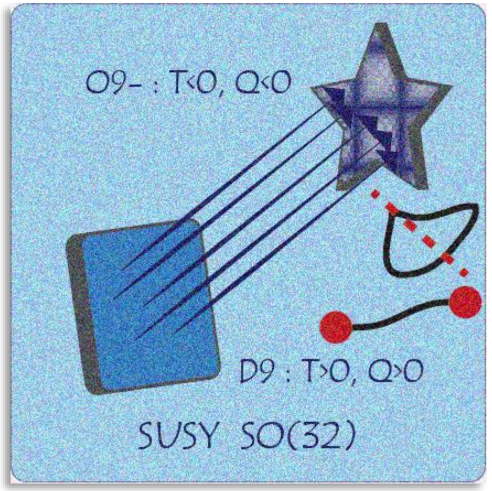
+ (open) $A_\mu^{528} + \chi_L^{(495)+\underbrace{(1)}_{\text{goldstino}}}$ $\Rightarrow$ **Brane SUSY Breaking**

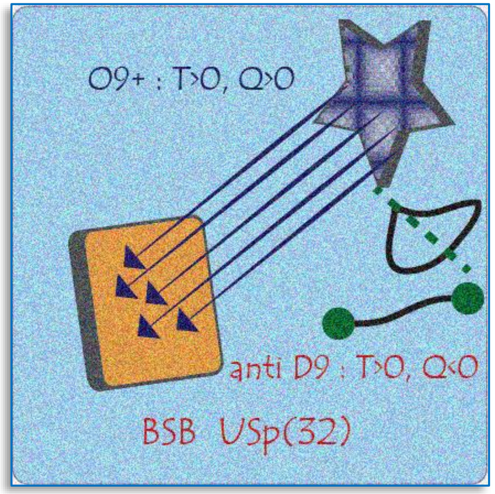
Brane SUSY Breaking (BSB)

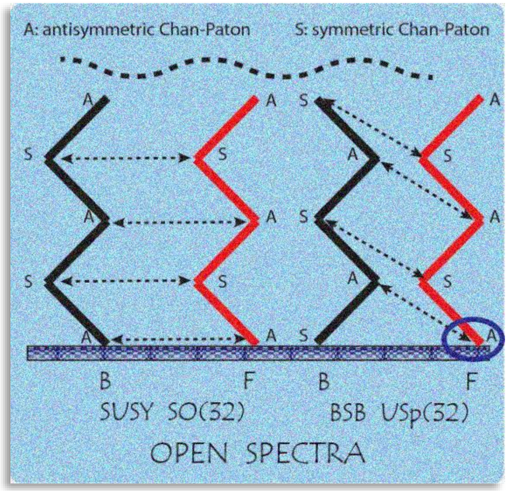
(Antoniadis, Dudas, AS, 1999)
(Angelantonj, 1999)
(Aldazabal, Uranga, 1999)

- **NO TACHYONS**
- **Non-linear SUSY: ∃ goldstino!**

(Dudas, Mourad, 2000)
(Pradisi, Riccioni, 2001)







NON-LINEAR REALIZATIONS: USUALLY limits of linear ones. "HIGGS" MODES ?

In lower dimensions **BSB CAN BE INEVITABLE** with special Klein-bottle projections

SUSY IN CLOSED SPECTRUM, NOT IN OPEN: noted in Rome in the early '90's (see hep-th/9302099),

with **M. Bianchi and G. Pradisi** **[See Angelantonj, Condeescu, Dudas, Leone, 2403.02392 [hep-th] for some recent developments]**

NO SUSY → Back-Reaction on the Vacuum

- **DUAL ROLE** of **Vacuum amplitudes** in **String Theory:**
  - a. **Consistency conditions**
  - b. [**Backreaction on vacuum**]

- **AT BEST: Double expansion** in powers of $\boxed{\alpha' R}$ and $\boxed{g_s = e^{\phi}}$

- **VERY DIFFICULT: one can at least EXPLORE the dominant terms … AND YET …**

1. SO(16) x SO(16) [STRING FRAME] :

$$\mathcal{S} = \frac{1}{2\,k_{10}^2} \int d^{10}x\,\sqrt{-G}\left\{e^{-2\phi}\left[-R + 4(\partial\phi)^2 - \frac{1}{12}\,\mathcal{H}_3^2 - \frac{1}{4}\,\mathrm{tr}\,\mathcal{F}^2\right] - T + \ldots\right\}$$

2. 0’B, USp(32) [STRING FRAME] :

$$\mathcal{S} = \frac{1}{2\,k_{10}^2} \int d^{10}x\,\sqrt{-G}\left\{e^{-2\phi}\left[-R + 4(\partial\phi)^2\right] - \frac{1}{12}\,\mathcal{H}_3^2 - \frac{1}{4}\,e^{-\phi}\,\mathrm{tr}\,\mathcal{F}^2 - T\,e^{-\phi} + \ldots\right\}$$

Tadpole potential

Lessons from the Low-Energy EFT

1. Cosmology & the Climbing Scalar

$V = e^{\gamma\phi}$: Climbing & Descending Scalars

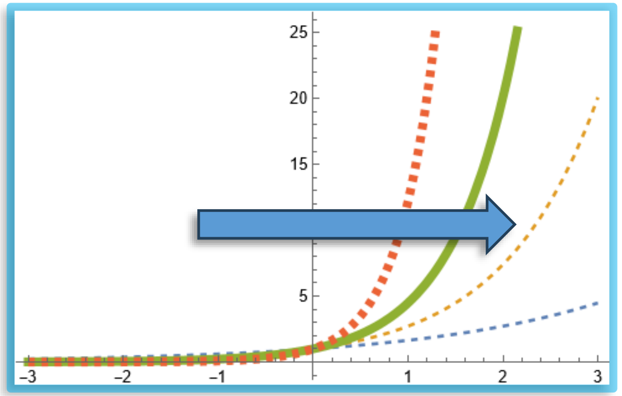
Follow solutions BACK TO INITIAL SINGULARITY:

(Halliwell, 1987;..., Dudas and Mourad, 2000; Russo, 2004)
(Dudas, Kitazawa, AS, 2010)

- **$\gamma < \gamma_c$? Both signs of INITIAL speed allowed**

a. **"Climbing" solution** (ϕ climbs, then descends):

b. **"Descending" solution** (ϕ only descends):



$\gamma < \gamma_c$: $\exists$ LM attractor (BUT disappears for $\gamma \geq \gamma_c$)

(Lucchin and Matarrese, 1985)

$$V_E \sim e^{\gamma\phi}$$

"D – dim stringy canonical" ϕ :

$$\gamma_c = 4\,\frac{\sqrt{D-1}}{D-2}$$

$$\gamma_c = \frac{3}{2} \text{ in D} = 10$$

"4D QFT canonical" : $\gamma_c = \sqrt{6}$

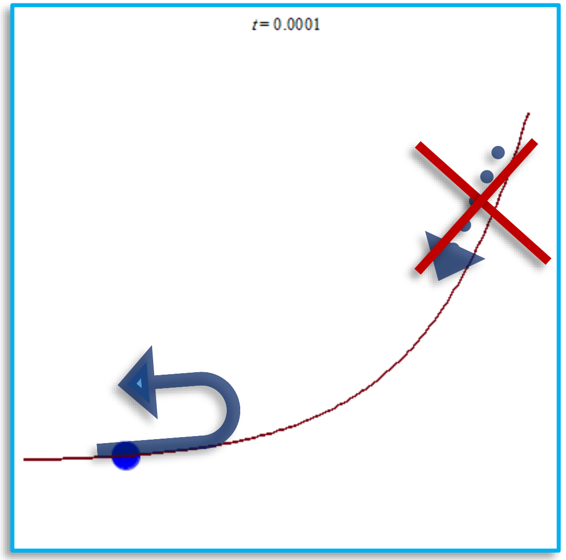
$$V_S \sim e^{-\phi}$$

$$V_E = e^{\frac{3}{2}\phi}$$

$$\ddot{\varphi} + \dot{\varphi}\sqrt{1+\dot{\varphi}^2} + \gamma\left(1+\dot{\varphi}^2\right) = 0$$

$$\ddot{\varphi} + \dot{\varphi}\,|\dot{\varphi}| + \gamma\,\dot{\varphi}^2 \simeq 0 \longrightarrow \boxed{\dot{\varphi} = \frac{C}{t}}$$

$$\boxed{|C| = \frac{1}{1+\epsilon\gamma}\,, \quad \epsilon = \pm 1} \qquad \boxed{V = T e^{2\gamma\varphi}}$$



WITH "MILD" ADDITIONAL v(ϕ): FAST-to-SLOW ROLL at WEAK COUPLING!

[INSTABILITY OF ISOTROPY: dynamical origin of COMPACTIFICATION?]

(Basile, Mourad, AS, 2018)

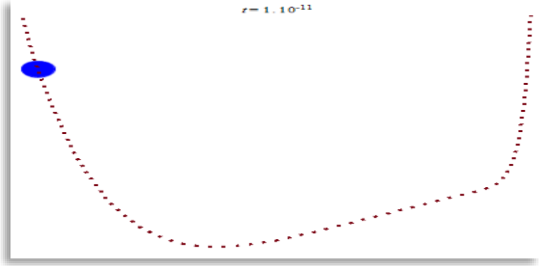
Resonates with: **(Kim, Nishimura and Tsuchiya, *2012*; Anagnostopoulos, Azuma, Ito, Nishimura and Papadoudis, 2018)**

Climbing Scalar as Trigger of Inflation? (2-point function)

CLIMBING & SLOW-ROLL ? With (super)critical Exponential (*e.g.* + Starobinsky) → **FIXED INITIAL CONDITIONS**

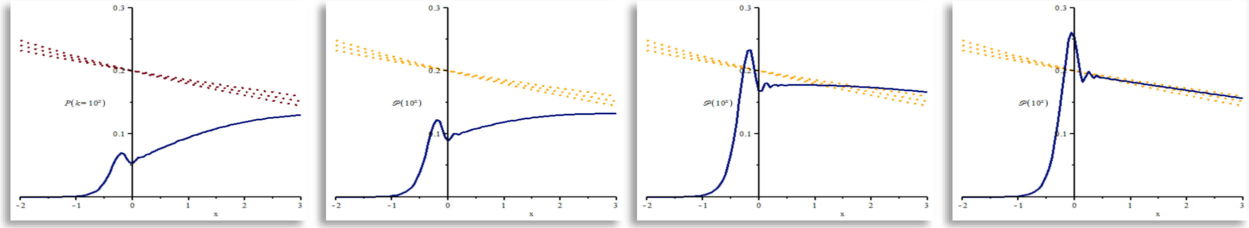
$$V(\phi) = T\, e^{2\varphi} + v(\phi)$$

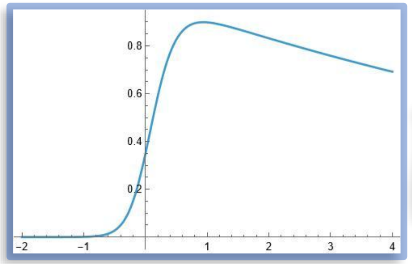
$$e.g. \;\; v(\phi) = v_0 \left(1 - e^{-\frac{2}{3}\varphi}\right)^2$$



(Dudas, Kitazawa, Patil, AS, 2013)
(Kitazawa, AS, 2014)

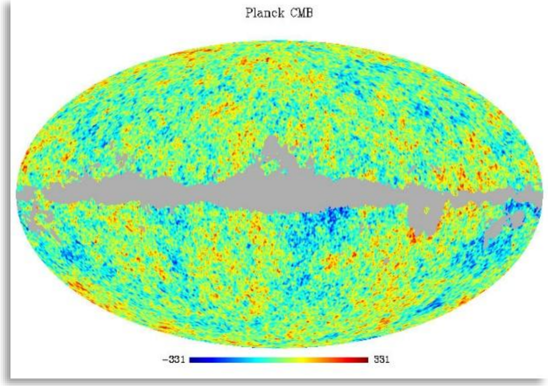
CUTS LOW END of primordial power spectrum → **POSSIBLE POSTDICTION** of damping of first CMB multipoles ?

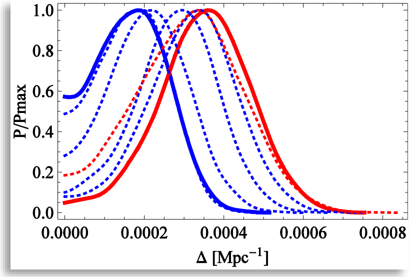




$$P(k) \sim k^{3-2\nu} \longrightarrow P(k) \sim \frac{k^3}{[k^2 + \Delta^2]^{\nu}}$$

[Extends Chibisov-Mukhanov tilt by Δ]





$$\Delta = (0.351 \pm 0.114) \times 10^{-3}\ \mathrm{Mpc}^{-1}$$

$$\Delta_{\rm infl} \sim 10^{12} e^{N-60}\ \mathrm{GeV}$$

[+30 degrees extended mask]

(Gruppuso, Mandolesi, Natoli, Kitazawa, AS, 2015)
(+ Lattanzi, 2017)

Climbing Scalar as Trigger of Inflation? (3-point function)

(Meo, AS, 2025)
(Meo, 2026)

$$\int_{-\infty}^{0} d\eta\, f(\eta) \Big[G_1(k_1,\eta)\, G_2(k_2,\eta)\, G_3(k_3,\eta) \;-\; \mathrm{c.c.} \Big]$$

$$G \;: \qquad v_k''(\eta) \;+\; \left[k^2 \;-\; W(\eta)\right] v_k(\eta) \;=\; 0$$

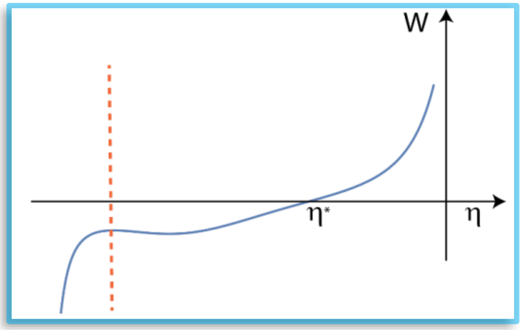
- **2-point: SENSITIVE TO BEHAVIOR CLOSE TO $\eta \to 0^-$**
- **3-point: SENSITIVE TO ALL EARLIER HISTORY → INITIAL SINGULARITY ??**

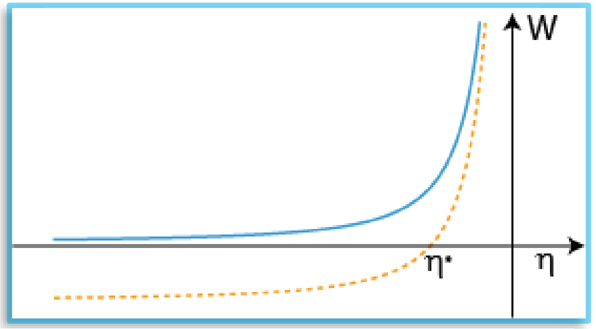
G: from v, which solves the Mukhanov-Sasaki equation

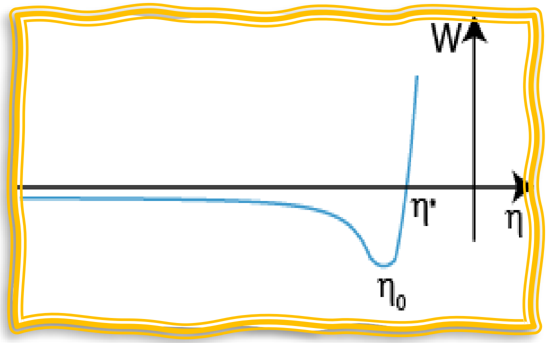
NEED String Theory as regulator of initial Singularity, BUT HOW? WHAT W ?

- **INITIAL SINGULARITY: can be dealt with by a "smoothing hypothesis" (BOUNCE)** (Gasperini, Veneziano, 1993)

❖ **G is SINGULAR at the TURNING POINT: DISTINCT SIGNATURE !**

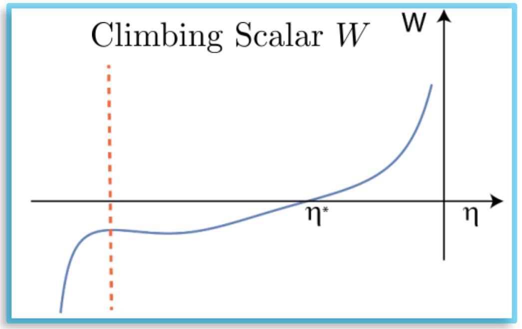






Climbing Scalar as Trigger of Inflation? (3-point function)

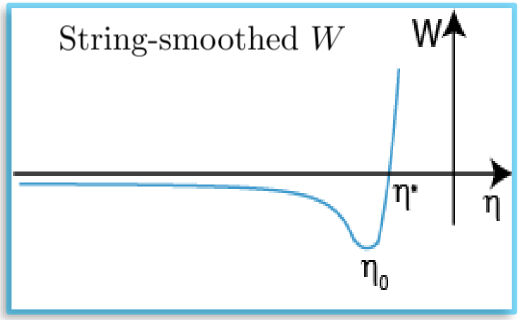
(Meo, AS, 2025)
(Meo, 2026)

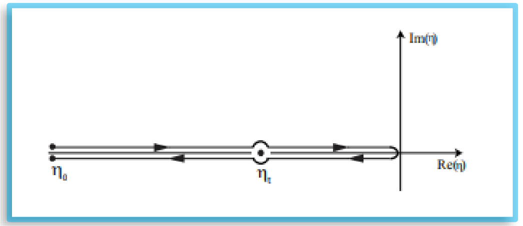


$$\int_{-\infty}^{0} d\eta\, f(\eta)\left[G_1(k_1,\eta)\, G_2(k_2,\eta)\, G_3(k_3,\eta)\ -\ \text{c.c.}\right]$$

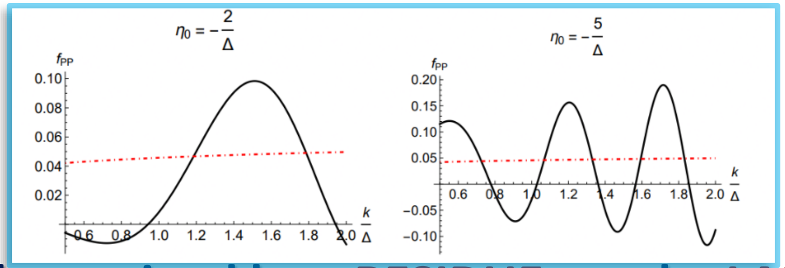
$$f_{NL}(k)\ =\ 40\,\frac{\gamma^4\, M_p^4\, \Delta^6}{\mathcal{H}^4}\left[\left(\frac{k}{\Delta}\right)^2+1\right]^{2\nu}\ \langle\zeta(k)\zeta(k)\zeta(k)\rangle$$

$$f_{NL}(k)\ =\ f_{PP}(k)\ +\ f_t(k)$$

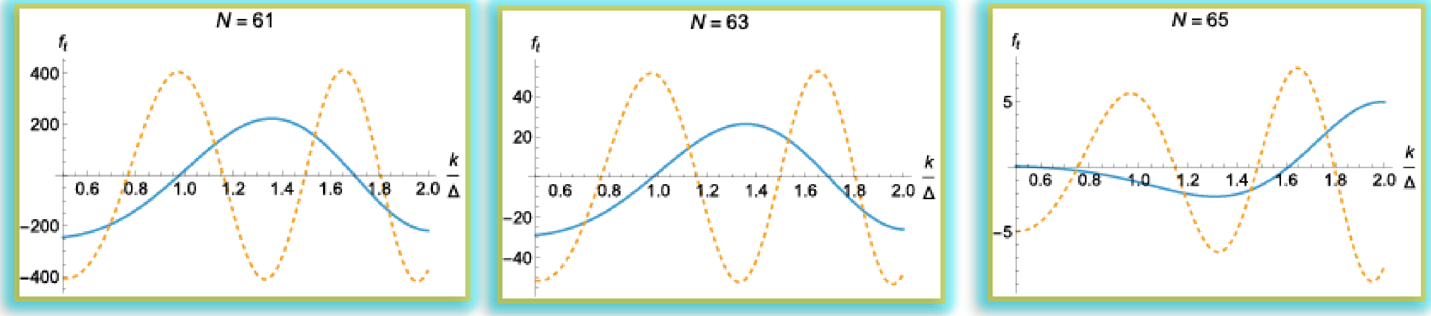




1) f_{PP} (from WHOLE DYNAMICS): NO new prospects for detection (frequency determined by $\eta_0 \sim -1/\Delta$)



2) f_t (from TURNING POINT): determined by a RESIDUE, can be LARGE (~ 100 times f_{PP})!
Reasonable size (within PLANCK limits ONLY for 62<N<66) (frequency determined by $\eta_t \sim -1/\Delta$)



Lessons from the Low-Energy EFT

2. Dudas-Mourad Vacua & Generalizations

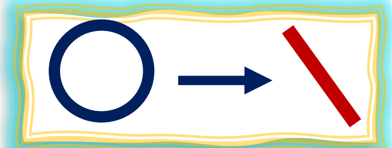
9D Dudas-Mourad Vacua

(Dudas, and Mourad, 2000, 2001)

$$S = \frac{1}{2\,k_{10}^2} \int d^{10}x \sqrt{-G} \left\{ e^{-2\phi}\left[-R + 4(\partial\phi)^2\right] - \frac{1}{12}\,\mathcal{H}_3^2 - \frac{1}{4}\, e^{-\phi}\,\mathrm{tr}\,\mathcal{F}^2 - T\, e^{-\phi} + \ldots \right\}$$

9D solutions → T : DRIVES compactification (KK CIRCLE → INTERVAL)

[HERE for Usp(32) and U(32) orientifolds]



- **SPONTANEOUS COMPACTIFICATIONS: INTERVALS of FINITE length ~ $\frac{1}{\sqrt{T}}$**
- **FINITE 9D Planck mass & gauge coupling**
- **At ends: g_s→ (0,∞) & curvature diverges**
- **ASYMPTOTICS: Kasner-like (FREE!)**

$$e^{\phi} = e^{u+\phi_0}\, u^{\frac{1}{3}}$$
$$ds^2 = e^{-\frac{u}{6}}\, u^{\frac{1}{18}}\, dx^2 + \frac{2}{3\,T\,u^{\frac{3}{2}}}\, e^{-\frac{3}{2}(u+\phi_0)}\, du^2$$

$$u \to 0 \;:\; ds^2 \sim (\mu_0\,\xi)^{\frac{2}{9}}\, dx^2 + d\xi^2\,, \quad e^{\phi} \sim (\mu_0\,\xi)^{\frac{4}{3}}$$
$$u \to \infty \;:\; ds^2 \sim [\mu_0\,(\xi_m - \xi)]^{\frac{2}{9}}\, dx^2 + d\xi^2\,, \quad e^{\phi} \sim [\mu_0\,(\xi_m - \xi)]^{-\frac{4}{3}}$$

- **EXTENSION:** $V_E = T\, e^{\frac{3}{2}\phi} \longrightarrow V = T\, e^{\gamma\,\phi}$ **[needed for SO(16)xSO(16)]**

  - **Large values of Curvature & g_s : INEVITABLE in these NON-SUSY compactifications?**
  - **STABILITY ?**

Dudas-Mourad Vacua : Stability , I

(Basile Mourad, AS, 2018)

❖ **Dudas-Mourad: ∃ STRONG COUPLING END, BUT STABLE VACUUM !**

- **SETUP : Scalar perturbations:**

$$ds^2 \;=\; e^{2\Omega(z)}\left[(1+A)\,dx^\mu\,dx_\mu \;+\;(1-7A)\,dz^2\right] \;,$$

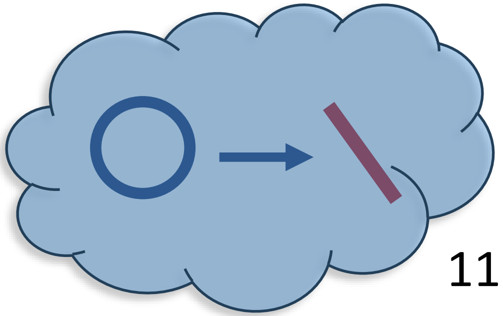
$$A'' + A'\left(24\,\Omega' \;-\; \frac{2}{\phi'}\,e^{2\Omega}\,V_\phi\right) \;+\; A\left(m^2 \;-\; \frac{7}{4}\,e^{2\Omega}\,V \;-\; 14\,e^{2\Omega}\,\Omega'\,\frac{V_\phi}{\phi'}\right) \;=\; 0$$

❖ **Schrödinger-like form:**

$$\left(e^{2\Omega(z)} \;=\; |\alpha_0\,y|^{\frac{1}{9}}\;\; e^{-\,\alpha_0\,y^2}\right)$$

$$\begin{aligned} m^2\,\Psi \;&=\; \left(b \;+\; \mathcal{A}^\dagger\,\mathcal{A}\right)\Psi \\ \mathcal{A} \;&=\; \frac{d}{dr} \;-\; \alpha(r)\;, \qquad \mathcal{A}^\dagger \;=\; -\,\frac{d}{dr} \;-\; \alpha(r)\;, \qquad b \;=\; \frac{7}{2}\,e^{2\Omega}\,V\,\frac{1}{1\;+\;\frac{9}{4}\,\alpha_O\,y^2} \;>\; 0 \end{aligned}$$

BUT: Boundary Conditions !



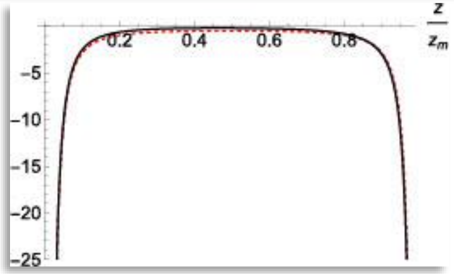
Dudas-Mourad Vacua : Stability , II

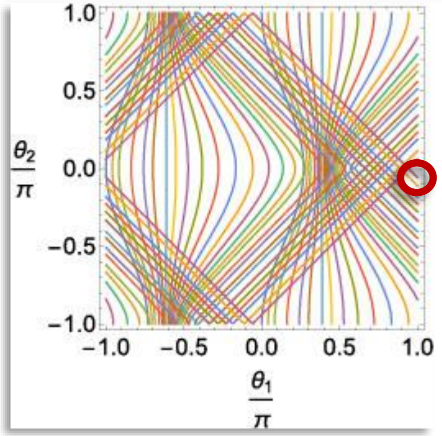
(Mourad, AS, 2023)

- (SINGULAR) potentials CLOSELY APPROXIMATED by Legendre ones
- EXACT eigenvalue equations
- VERTICAL ADJUSTMENTS: compare with exact zero modes

$$V_\pm \;=\; \left(\frac{\pi}{z_m}\right)^2 \left[\frac{\left(\mu^2 \;-\; \frac{1}{4}\right)}{\sin^2\left(\frac{\pi\, z}{z_m}\right)} \;-\; \left(\frac{1}{2} \pm \mu\right)^2\right]$$

Tensor Modes (μ=0) :



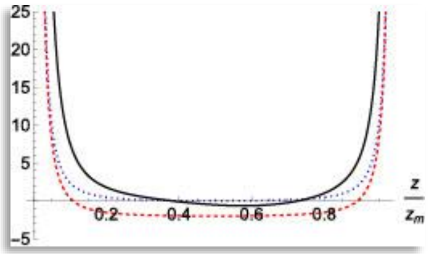


Contour lines of fixed tachyon mass

$$m^2 \;\simeq\; \left(\frac{\pi}{z_m}\right)^2 \; n\,(n\,+\,1)\;\;,\;\; n = 0, 1, 2, \ldots$$

UNIQUE STABLE b.c. (π,0)
(massless 9D graviton !)

Scalar Modes (μ=1)



UNIQUE b.c.
[up to vertical adjustment]
(massive scalar !)

$$m^2 \;\simeq\; \left(\frac{\pi}{z_m}\right)^2 \left[n(n+1) - \frac{7}{8}\right]\;,\;\; n = 1, 2, \ldots$$

More on Dudas-Mourad Vacua

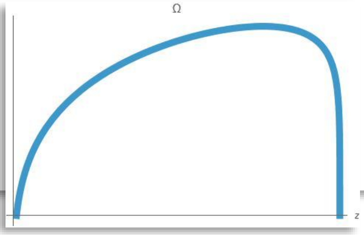
(Mourad, AS, 2021-2023)
(Raucci, Mourad, AS, 2024)

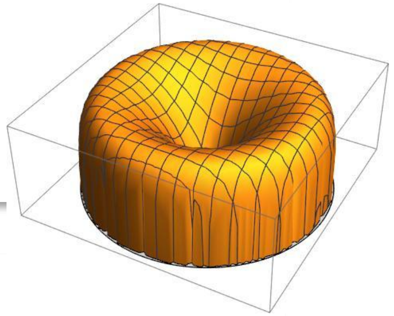
- **MORE PROGRESS: Asymptotic analysis + Numerical tests**

1. A PUZZLE :

- **WITH tadpole potential : typically, SHORT-DISTANCE COLLAPSE (around branes)** *(Antonelli, Basile, 2019)*

- **IN FACT: higher-dimensional DUDAS-MOURAD-LIKE VACUA**





2. D-BRANES in (S)U(32) and Usp(32):

- **Can be CLASSIFIED by CFT METHODS (ignoring the tadpole potential)** *(Dudas, Mourad, AS, 2001)*

- **WITH TADPOLE POTENTIAL: THEY RE-EMERGE IN THE 9D MINKOWSKI VACUUM reached after Dudas-Mourad**

  - **UNCHARGED BRANES: EXACT SOLUTIONS of the reduced equations**

  - **CHARGED BRANES: ASYMPTOTICS CONSISTENT with their RE-EMERGENCE**

Cosmologies from Tension & Curvature

(Mourad, AS, 2026)

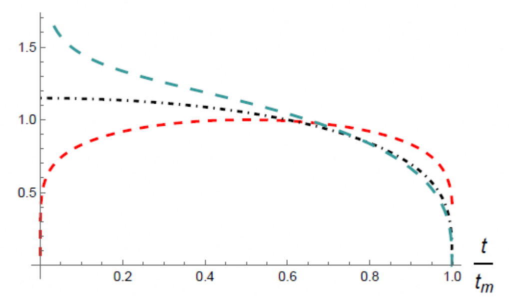
- (With some numerical help) one can examine the combined effects of
  - Tadpole potential
  - Curvature
  - Anisotropy

  →

  - NEW Attractors & Asymptotics
  - Transitions among different regimes
  - DYNAMICAL COMPACTIFICATIONS?

$$\mathcal{S}_E \;=\; \frac{1}{2\kappa_D^2}\int d^Dx\,\sqrt{-g}\left[\mathcal{R}\;-\;\frac{4}{D-2}\,(\partial\phi)^2\;-\;T\,e^{\gamma\phi}\right]$$

$$ds^2 \;=\; -\,e^{2B(\tau)}\,d\tau^2\;+\;\ell^2\left(e^{2A(\tau)}\,ds^2_{p+1,k}\;+\;e^{2C(\tau)}\,ds^2_{D-p-2,k'}\right)$$



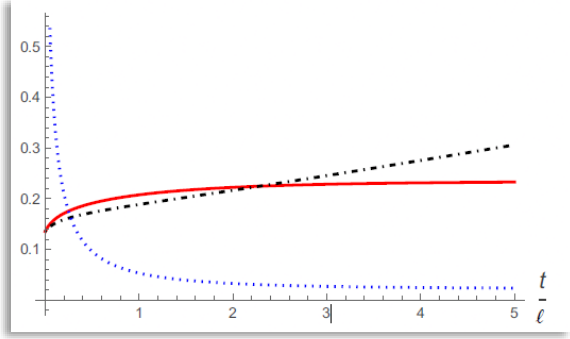
(T,k,k')=(0,0,1)

$$A''+A'\,F' \;=\; \frac{T\,e^{\gamma\phi}}{(D-2)}\,e^{2B}\;-\;\frac{k\,p}{\ell^2}\,e^{2(B-A)}$$

$$C''+C'\,F' \;=\; \frac{T\,e^{\gamma\phi}}{(D-2)}\,e^{2B}\;-\;\frac{k'(D-p-3)}{\ell^2}\,e^{2(B-C)}$$

$$\phi''+\phi'\,F' \;=\; -\,\gamma\,\frac{V'(\phi)\,(D-2)}{8}\,e^{2B}\,, \qquad [F' \;=\; (p+1)A'\;-\;B'\;+\;(D-p-2)C']$$

$$\text{Ham.Constr}:\; p(p+1)\,(A')^2\;+\;2(p+1)(D-p-2)A'C'\;+\;(D-p-2)(D-p-3)\,(C')^2\;-\;\frac{4\,(\phi')^2}{D-2}$$
$$-\;V(\phi)\,e^{2B}\;+\;\frac{k\,p(p+1)}{\ell^2}\,e^{2(B-A)}\;+\;\frac{k'(D-p-3)(D-p-2)}{\ell^2}\,e^{2(B-C)}\;=\;0$$



(T,k,k')=(0,0,-1)

- COMPLICATED DYNAMICAL SYSTEM depending on [(T,γ),k,k'] : T>0(T<0) & k<0 (k>0) favor EXPANSION (COLLAPSE)
  - EXACTLY SOLVABLE (or dominating): [(T,γ),0,0] , [(0,γ),k,0] , [(0,γ),0,k'] (& intermediate CASES, with COMPARABLE A, C, ϕ)
  - HERE: (hints on) how to tackle NON-TRIVIAL CASES : [(T,γ),0,k'] with D-p-2>1 (& FLAT spatial slices)

Cosmologies (& Vacua) from Tension & Curvature

([(T,γ),0,k'] with D-p-2>1: *asymptotics & special scaling solutions)*

(Mourad, AS, 2026)

SOLUTIONS characterized by the log-behavior which can be EXACT or ASYMPTOTIC

$$\begin{aligned} A &= \alpha_A \log(M_A t) \,, \quad C = \alpha_C \log(M_C t) \\ \phi &= \alpha_\phi \log(M_\phi t) \end{aligned}$$

$$\begin{aligned} \frac{\alpha_A}{t^2}\left[-1+(p+1)\alpha_A+(D-p-2)\alpha_C\right] &= \frac{T}{(D-2)}(Mt)^{\gamma\,\alpha_\phi} - \frac{k\,p}{\ell^2}(Mt)^{-2\alpha_A}, \\ \frac{\alpha_C}{t^2}\left[-1+(p+1)\alpha_A+(D-p-2)\alpha_C\right] &= \frac{T}{(D-2)}(Mt)^{\gamma\,\alpha_\phi} - \frac{k'(D-p-3)}{\ell^2}(Mt)^{-2\alpha_C}, \\ \frac{\alpha_\phi}{t^2}\left[-1+(p+1)\alpha_A+(D-p-2)\alpha_C\right] &= -\frac{T\,\gamma\,(D-2)}{8}(Mt)^{\gamma\,\alpha_\phi} \end{aligned}$$

TWO SPECIAL VALUES OF γ :

$$\gamma_c = 4\,\frac{\sqrt{D-1}}{D-2}\,, \qquad \gamma_0 = \frac{4}{D-2}$$

EXAMPLES:

a) KASNER BEHAVIOR (asymptotically as t->0 if $\gamma\,\alpha_\phi > -2\,, \quad \alpha_A < 1\,, \quad \alpha_C < 1$ **)**

(asymptotically as t→∞ if $\gamma\,\alpha_\phi < -2\,, \quad \alpha_A > 1\,, \quad \alpha_C > 1$ **)**

b) LUCCHIN-MATARRESE (exactly if k=k'=0,T≠0,γ≠0), with $\left(-1 + \frac{\gamma_c^2}{\gamma^2}\right) = \frac{T\,\gamma^2\,(D-2)}{16 M_\phi^2}$

$$\begin{aligned} ds^2 &= -\,dt^2 + (M_\phi\, t)^{\frac{2\gamma_0^2}{\gamma^2}}\left(d\vec{x}^2 + d\vec{y}^2\right), \\ e^\phi &= (M_\phi\, t)^{-\frac{2}{\gamma}} \end{aligned}$$

Cosmologies (& Vacua) from Tension & Curvature
([(T,γ),0,k’] with D-p-2>1: *asymptotics & special scaling solutions*)

(Mourad, AS, 2026)

c) (**EXACTLY** if k=0,k’≠0,T≠0,γ≠0), with

$$\alpha_A = \frac{\gamma_0^2}{\gamma^2}\,, \qquad \alpha_C = 1$$
$$\frac{T(D-2)}{16\,M_\phi^2}\left(\gamma_0^2 - \gamma^2\right) = \frac{k'\,(D-p-3)}{(\ell\,M_A)^2}$$
$$D-p-3 + (p+1)\frac{\gamma_0^2}{\gamma^2} = \frac{T\,\gamma^2\,(D-2)}{16\,M_\phi^2}$$

$\Rightarrow$

$$\boxed{T\,k'\left(\gamma_0^2 - \gamma^2\right) > 0}$$
$$\boxed{\gamma_0 = \frac{4}{D-2}}$$

$$ds^2 = -\,dt^2 + (M_\phi\,t)^{\frac{2\gamma_0^2}{\gamma^2}}\,d\vec{x}^2 + \ell^2\,(M_C t)^2\,ds^2_{D-p-2,k'}$$
$$e^\phi = (M_\phi\,t)^{-\frac{2}{\gamma}}$$

NOTE: SPECIAL solutions with $\boxed{\gamma\,\phi + 2\,C = \text{const}}$

IN GENERAL, solutions INTERPOLATE between KASNER BEHAVIOR and OTHER EXACT ASYMPTOTICS of the previous types, where:

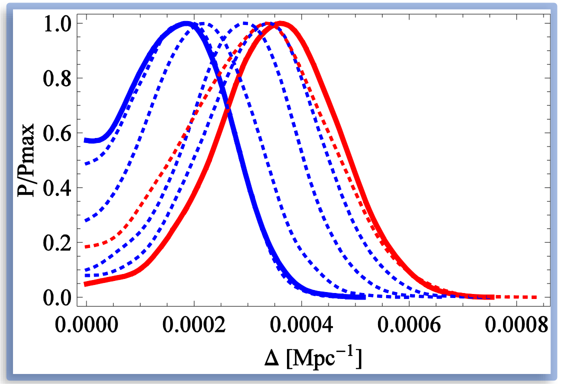
1) **one source overruns the others**
2) **two (or three) have comparable effects (SPECIAL SOLUTIONS). Play a role when STABLE under perturbations of initial conditions.**

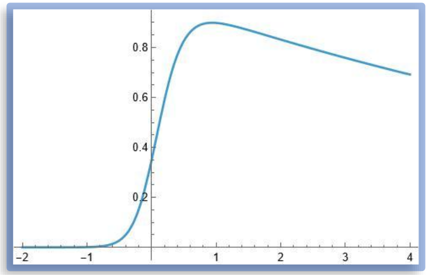
SCALING SOLUTIONS : (large or small-time) limits of more general ones.

Summarizing

➢ **TADPOLE in COSMOLOGY: climbing & inflation (with intriguing INSTABILITY of ISOTROPY)**

- **If LACK OF POWER in first multipoles were a (climbing) pre-inflationary signal:**
  - ❖ **Enhanced tensor-to-scalar ratio r at the transition**
  - **TURNING POINT: enhanced non gaussianity (by a factor O(100-1000)**
  - **[Bounce Cosmology ?]** *(Gasperini, Veneziano, 1993)*
  - ❖ **Potentially observable f_{NL} from TURNING POINT (63<N<65)**



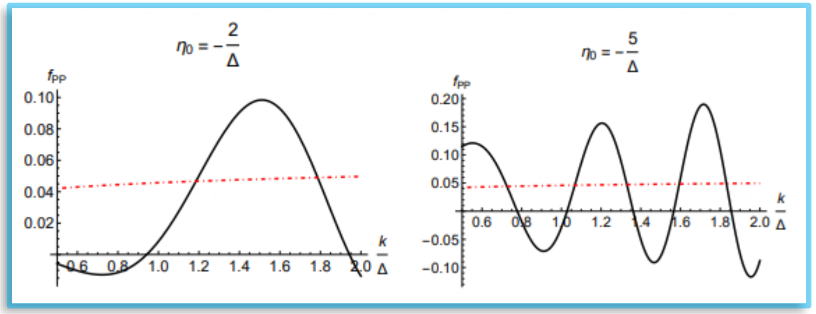


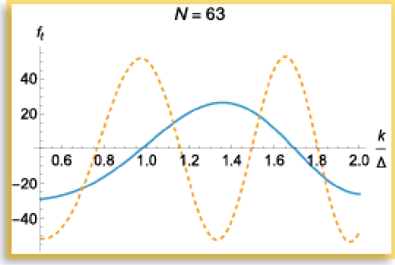
$$P(k) \sim k^{3-3\nu} \longrightarrow P(k) \sim \frac{k^3}{[k^2 + \Delta^2]^{\nu}}$$

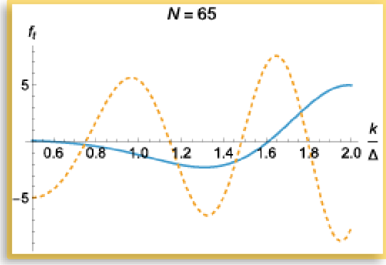
$$\Delta = (0.351 \pm 0.114) \times 10^{-3}\ \mathrm{Mpc}^{-1}$$

$$\Delta_{\mathrm{infl}} \simeq 4 \text{ x } 10^{12}\ e^{N-60}\ \mathrm{GeV}$$

RED : + 30−degree extended mask







Summarizing

- ➢ **Tadpole → DUDAS-MOURAD VACUA: BOUNDARIES play a key role !**

(Basile, Mourad, AS, 2018)
(Raucci, 2023)
(Mourad, AS, 2023)

- ✓ **STABILITY: NO tachyon modes [cfr UNSTABLE AdS x S !]**

(Gubser, Mitra, AS, 2002)
(Mourad, AS, 2018)
(Basile, Mourad, AS, 2018)

- **Confirmed by detailed analysis of self-adjoint extensions : INTERVAL vs Kaluza-Klein CIRCLE**

- **WITH k': Dynamical Compactifications**

- ❖ **BRANES & TADPOLE POTENTIALS:**
  - **Neglecting TADPOLE POTENTIALS : CFT classification** *(Dudas, Mourad, AS, 2001)*
  - **(EXACT) DEFORMED (un)charged branes in Dudas-Mourad vacua**

  - **EXPECTED ASYMPTOTICS in charged case** *(Raucci, Mourad, AS, 2024)*
  - **HIGHER-DIMENSIONAL DUDAS-MOURAD SOLUTIONS (numerically): ($S^1 \rightarrow T^n$)**

Thank You
for
Your Attention