



Fayet-Iliopoulos D-term in Non-Susy Heterotic String Orbifolds

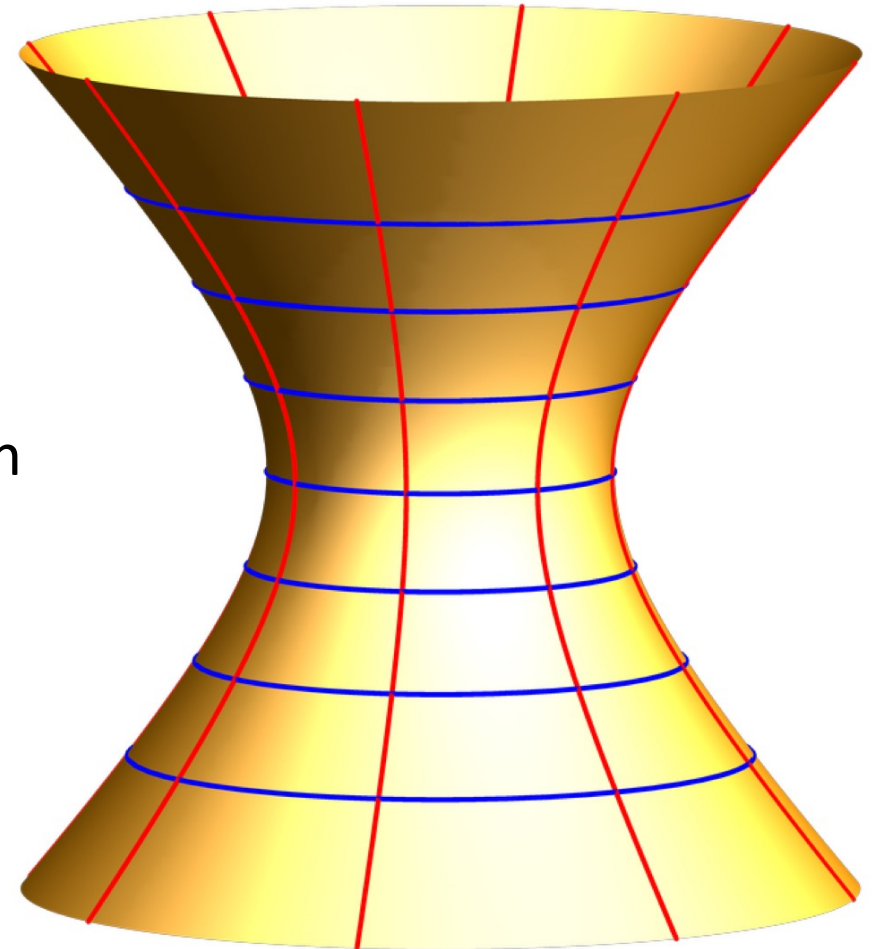
Alonzo R. Diaz Avalos

Based on 2302.10075, 2306.16878
with Alon Faraggi, Viktor Matyas, Ben Percival

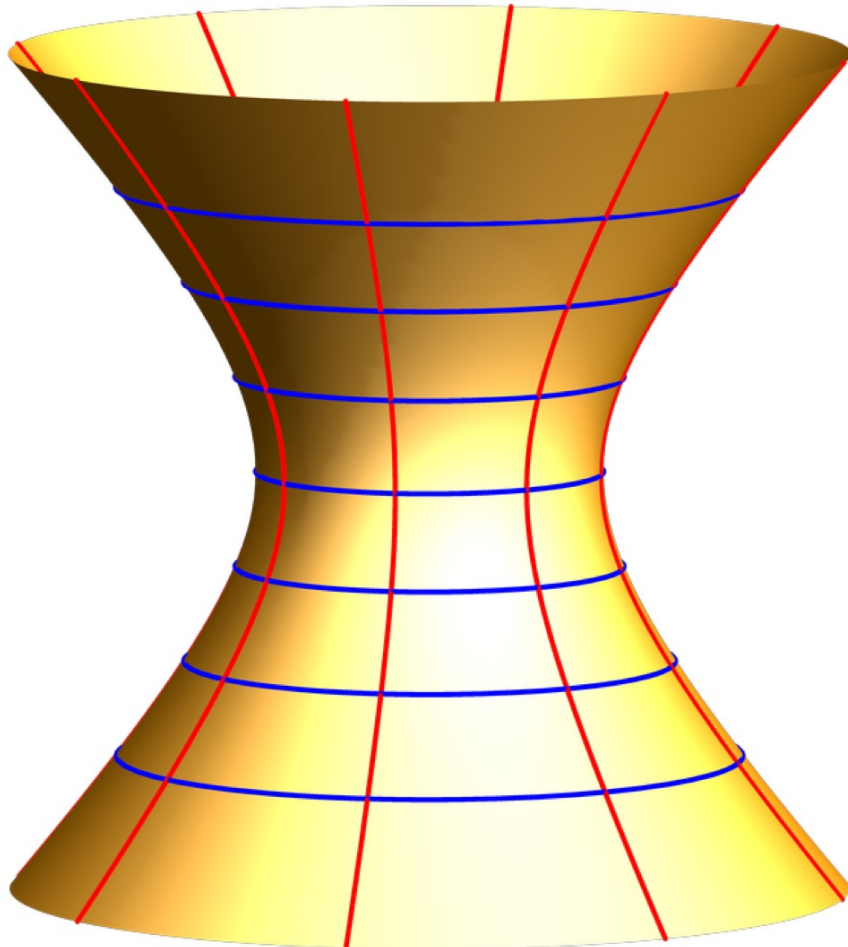
De Sitter Vacua ?



- Universe is expanding with positive acceleration
- A positive cosmological constant Λ is the oldest and simplest solution to this \rightarrow de Sitter Spacetime.
- However de Sitter space in conflict with QFT formulation (and string theory)



De Sitter Vacua ?



Possible Solutions:

- KKLT
 - Landscape – Swampland
 - Quintessence
 - Is there a way to uplift the Vacuum through an exact string theory computation ?
- } Low-Energy



Free-Fermionic Construction:

→ Symmetric $\mathbb{Z}_2 \times \mathbb{Z}_2$ orbifold with $\mathcal{N} = 1$ Susy

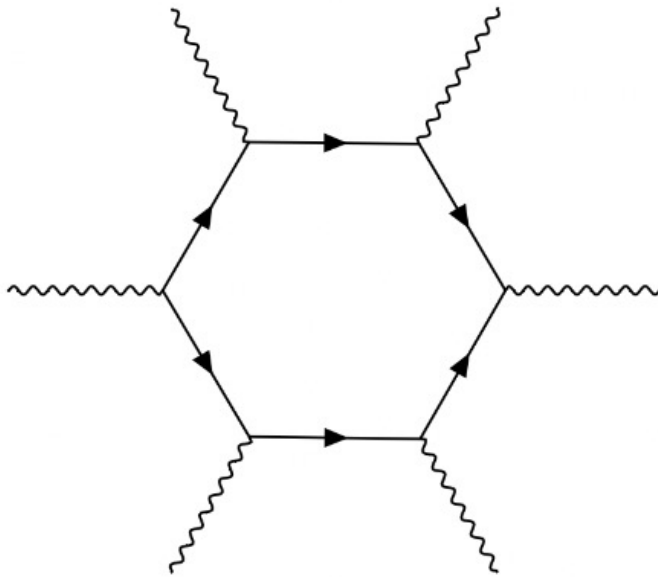
with Gauge group $SO(10) \times \underbrace{U(1)_1 \times U(1)_2 \times U(1)_3}_{\text{}} \times SO(8)^2$

Fayet-Iliopoulos term

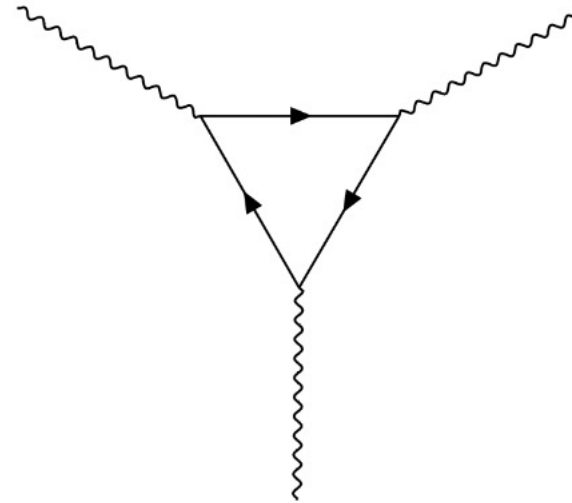


Anomalies: Lagrangian $\mathcal{L} \rightarrow$ local transformation $\rightarrow \mathcal{L}$ not Invariant

10D



4D



Fayet-Iliopoulos term



Green-Schwarz Mechanism $\mathcal{N} = 1$:

Anomaly cancelled by the ‘anomalous’ variation of some other field(s)

$$\mathcal{L} \xrightarrow{U(1)} A_\mu \rightarrow A_\mu + \partial_\mu \Lambda \quad \rightarrow \quad \delta\mathcal{L} \sim \xi \Lambda F^2 \quad \xi \sim \text{Tr } Q$$

$$\mathcal{L} + aF^2 \xrightarrow{U(1)} a \rightarrow a - \xi \Lambda \quad \rightarrow \quad \delta\mathcal{L} = 0$$

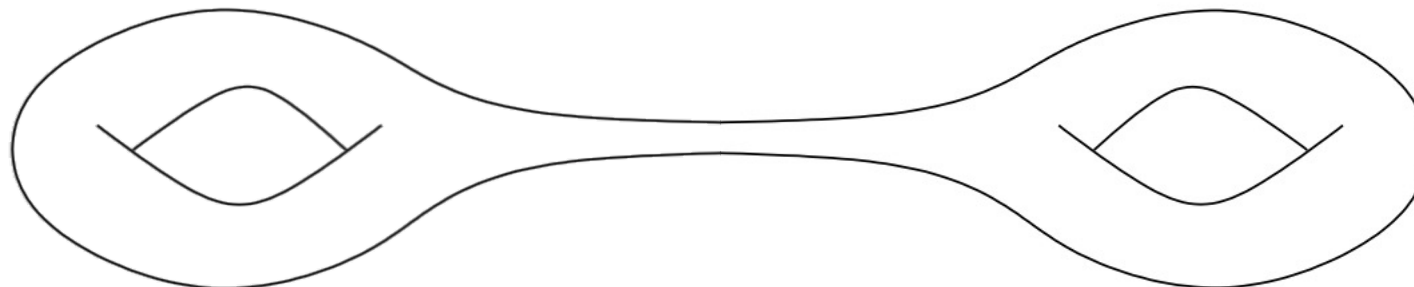
Fayet-Iliopoulos term



Imposing Gauge Invariance

$$V_D = \frac{1}{2} g_s^{-2} D^2 = \dots + \frac{1}{2} g_s^2 \xi^2 \quad \xi \sim \text{Tr} Q$$

- Additional contribution in N=1 when non-zero TrQ
 - Destabilizes the vacua



Fayet-Iliopoulos term



Imposing Gauge Invariance

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- Additional contribution in N=1 when non-zero TrQ
- “When N=1 \rightarrow N=0 remains there”



Susy breaking

- Explicit Breaking: gravitino projected out of the spectrum

$$\mathbb{Z}_2: \quad \psi_I \rightarrow -\psi_I$$

- Spontaneous Breaking:

$$\mathbb{Z}_2 + X \rightarrow X + \pi: \quad \psi_I \rightarrow \psi_I \quad \text{invariant but massive } m \sim \frac{1}{R}$$

Fayet-Iliopoulos term



Imposing Gauge Invariance

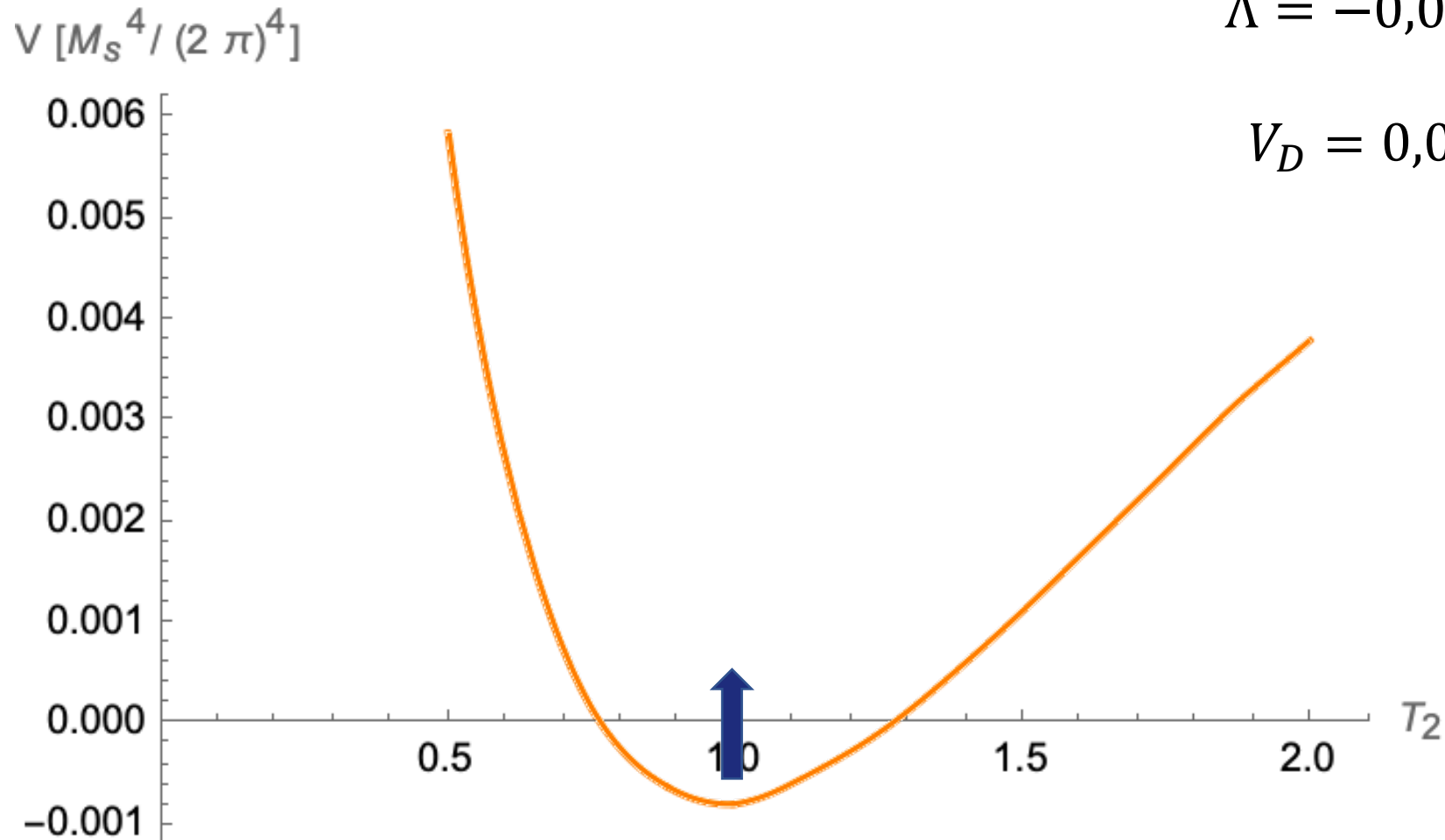
$$V_D = \frac{1}{2} g_s^{-2} D^2 = \dots + \frac{1}{2} g_s^2 \xi^2 \quad \xi \sim \text{Tr } Q$$

- Additional contribution in N=1 when non-zero TrQ
- “When N=1 \rightarrow N=0 remains there”
- $[\xi^2] = M^4$ as CC \rightarrow additional POSITIVE contribution to CC



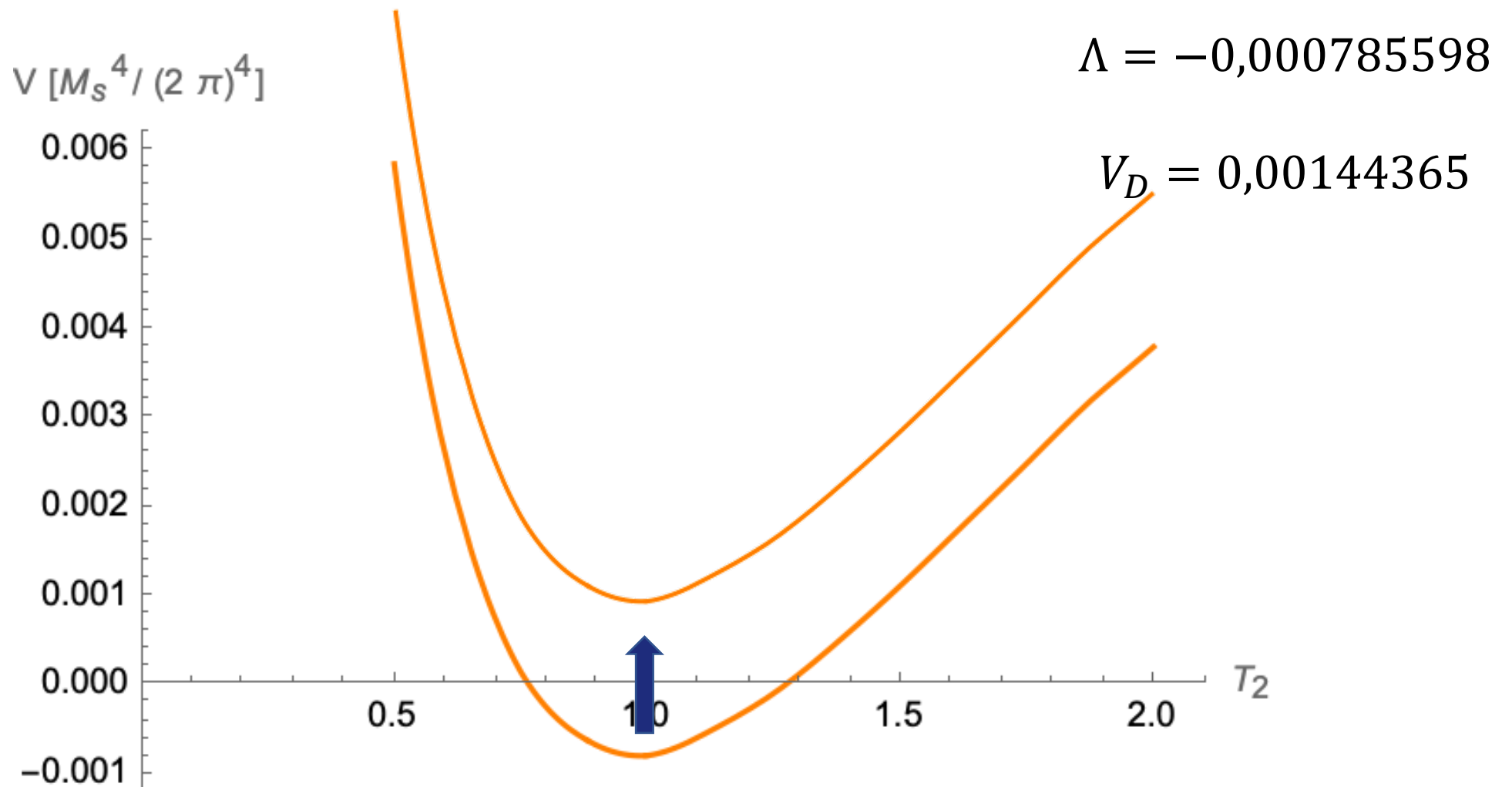
Does this really work ?

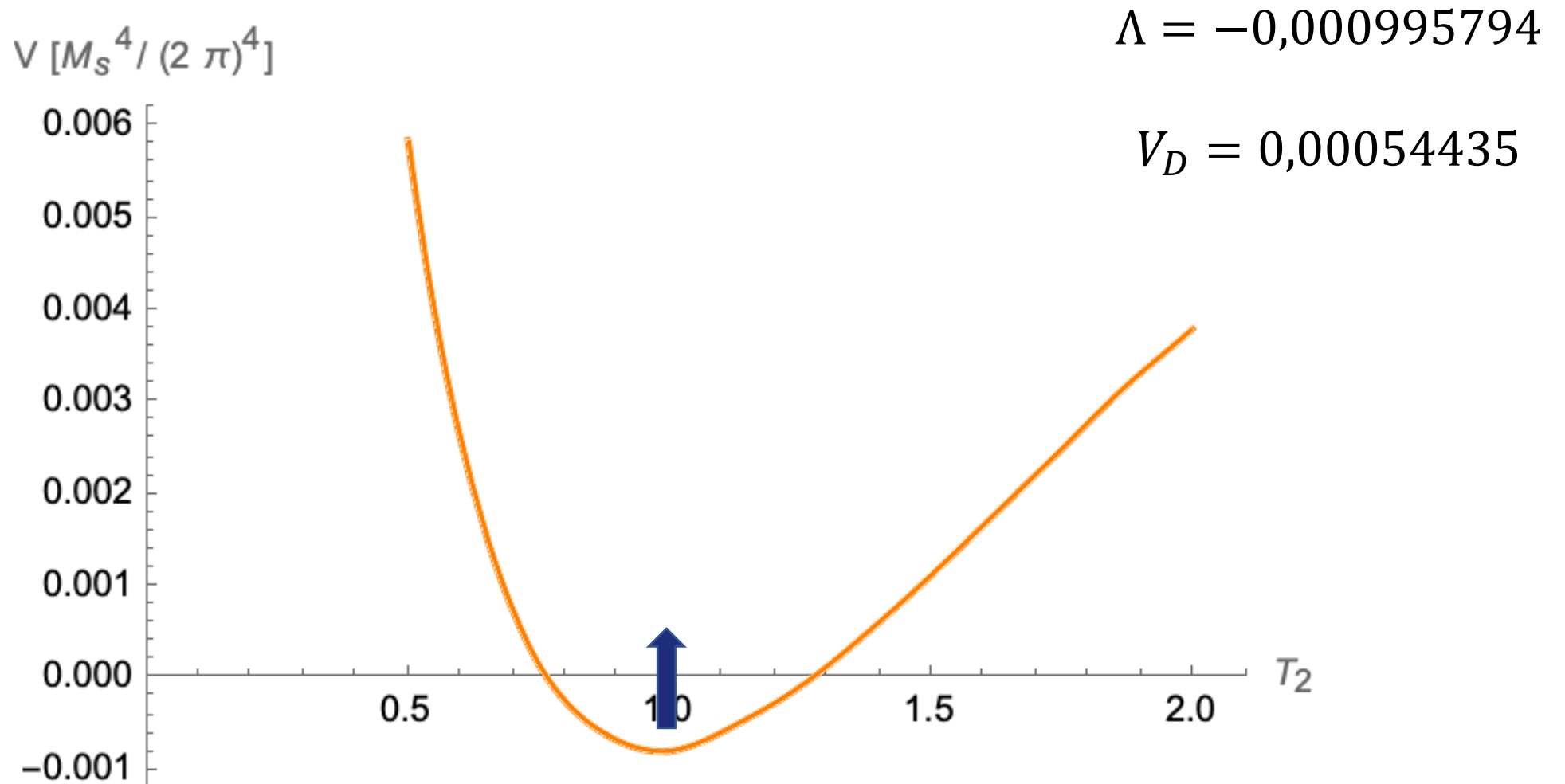
- In the PF $T^6 \sim T^2 \times T^2 \times T^2$ with $\Gamma_{2,2}(T, U) \rightarrow \Gamma_{2,2}(T_2)$, T_1^*, U_1^*, U_2^* fixed at FF point
Florakis, Rizos
- Potential computed as $V(T_2) = \int Z$ at 1-loop
- TrQ computed by analysing states charged under $U(1)_A$
- $V_D = \frac{1}{2} g_s^2 \xi^2$ fix $g_s = 1$

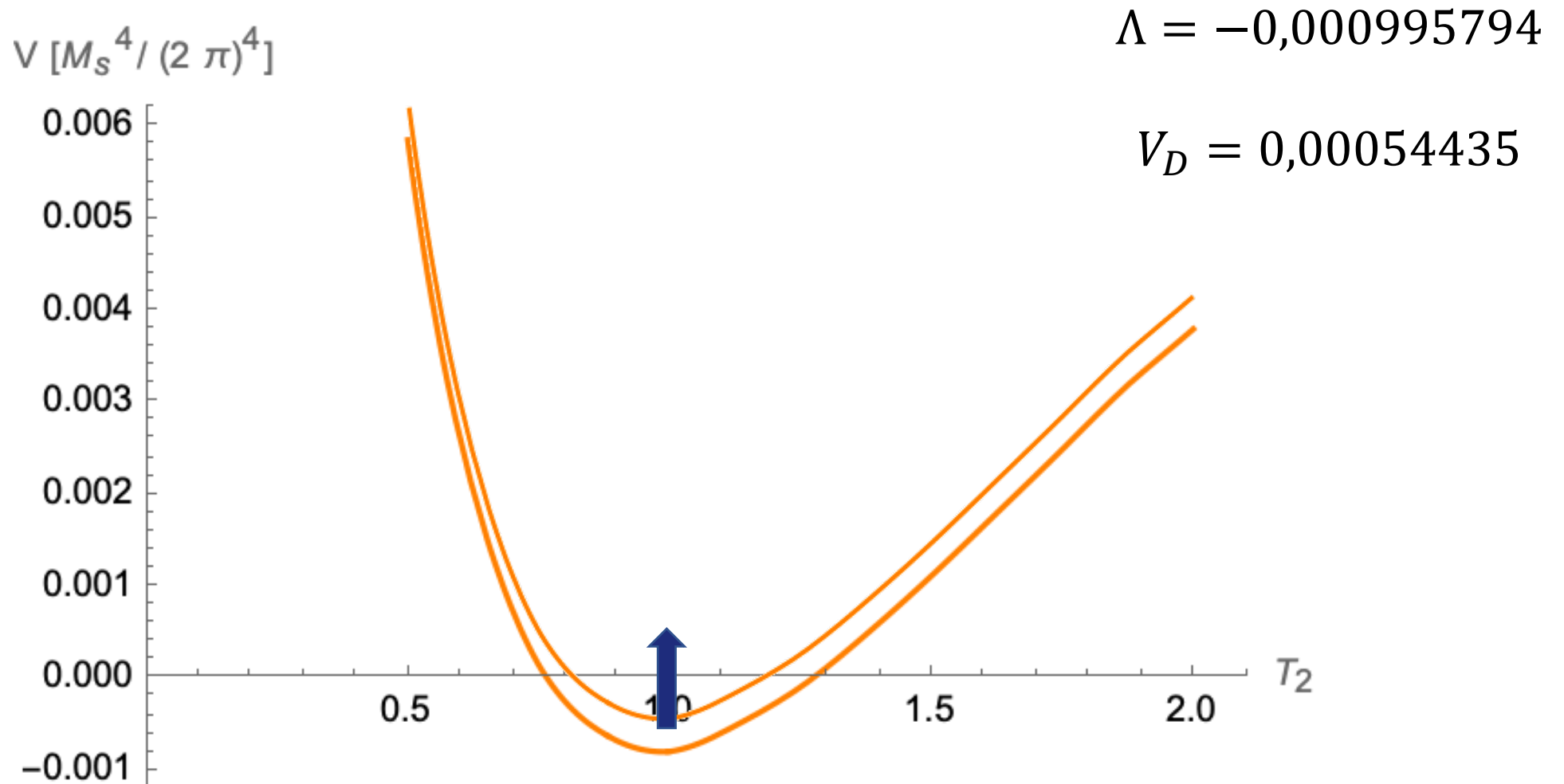


$$\Lambda = -0,000785598$$

$$V_D = 0,00144365$$

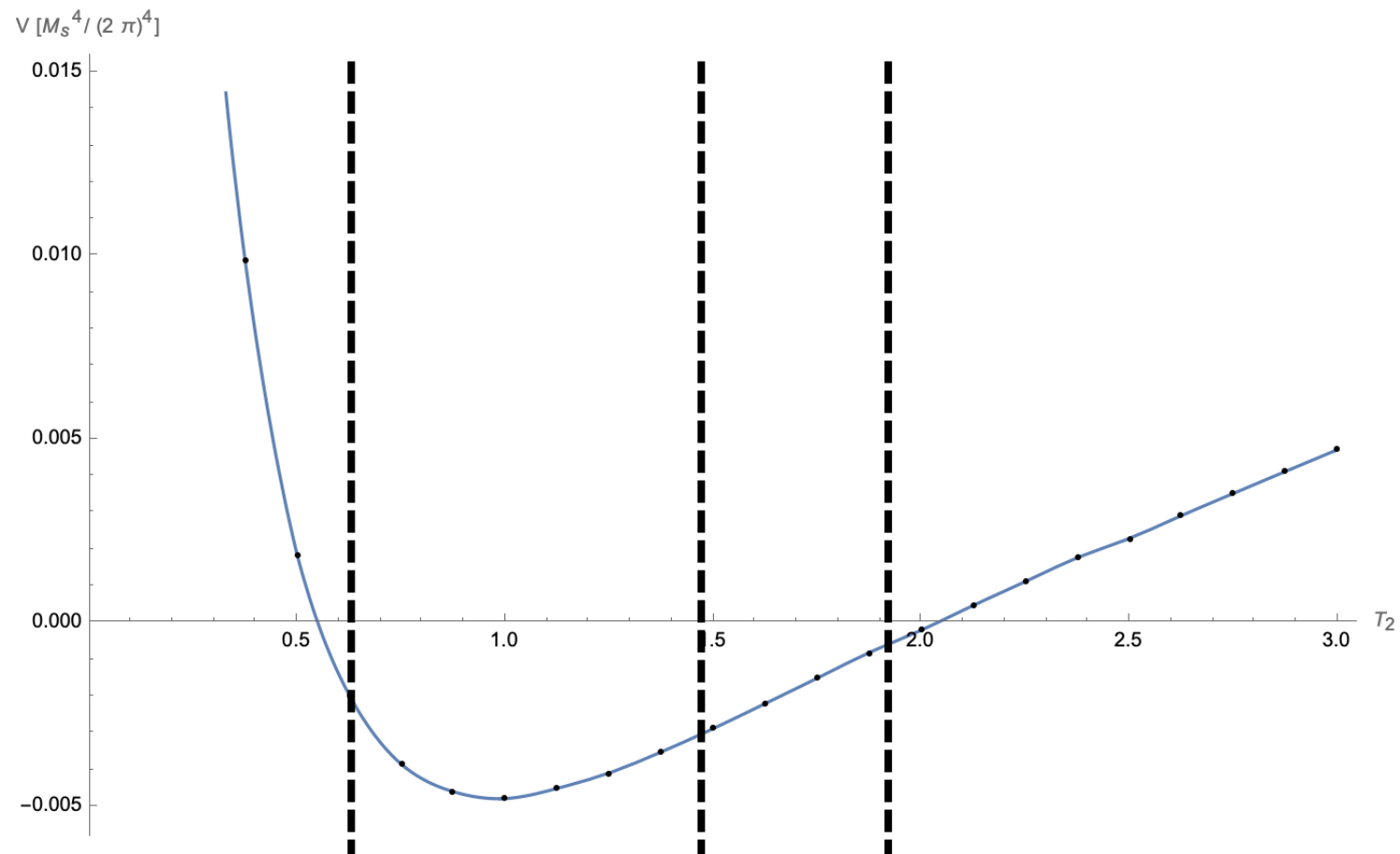








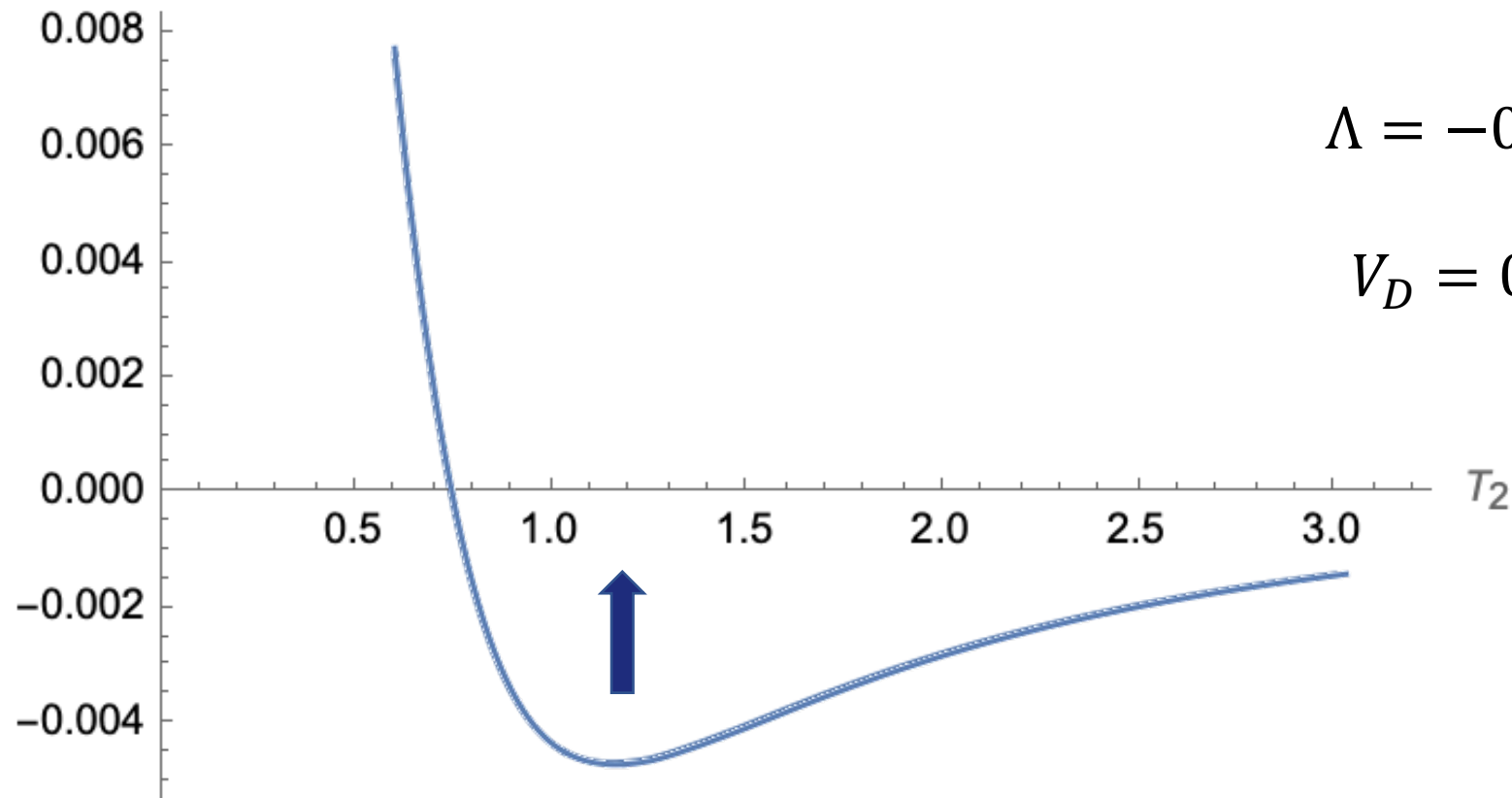
Other Models:





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$$V [M_s^4 / (2 \pi)^4]$$



$$M_\psi \sim \frac{1}{T_2}$$

$$\Lambda = -0,000215338$$

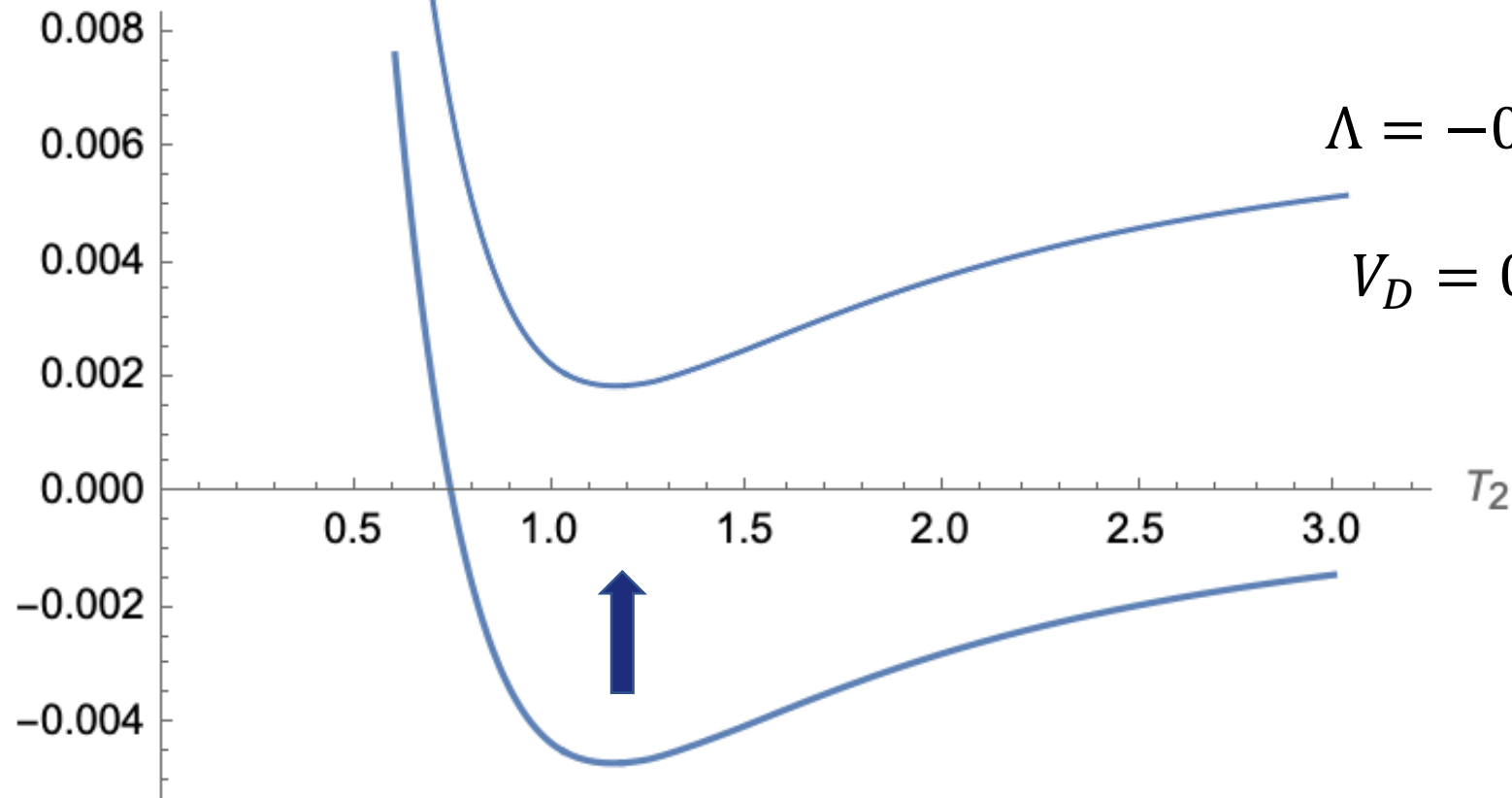
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Results



Other Models:

$$V [M_s^4 / (2 \pi)^4]$$



$$M_\psi \sim \frac{1}{T_2}$$

$$\Lambda = -0,000215338$$

$$V_D = 0,00144365$$



- $N = 1$ existence of Anomalous $U(1)$ \rightarrow additional positive contribution to CC
- Contributions remains there even with broken SUSY
- Possibility of Vacuum Uplift

Thanks for the attention !