On electromagnetic duality and the vacua of $\mathcal{N} = 8$ supergravity

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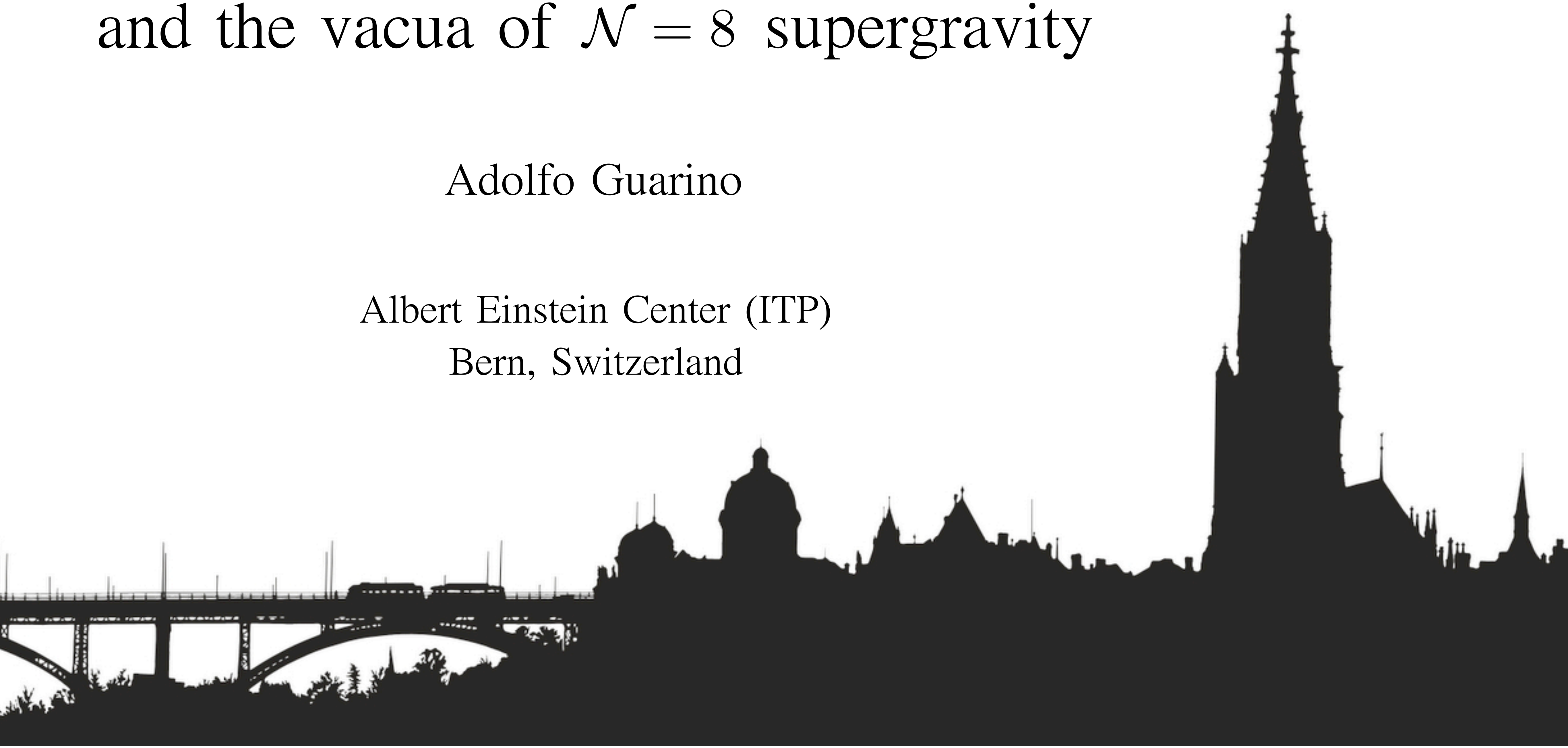

StringPheno 2013
17th July, Hamburg

Work in collaboration with A. Borghese & D. Roest

This is a talk about the consequences of a U(1) rotation...

R-symmetry : U(1) yes or no?

- Dimensional reduction of 10D SYM produces N=4 SYM

[Brink, Scherk & Schwarz '76]

$$L_{10\mathrm{D}} = -\frac{1}{2}F^2 + \frac{i}{2}\,\bar{\lambda}\,\not{D}\lambda$$

$i = 1, .., 4$ ⇒

$$\begin{aligned} L_{4\mathrm{D}} \;\; = \;\; & -\frac{1}{2}F^2 + i\,\bar{\lambda}_i\,\not{D}\lambda^i + \frac{1}{2}(D\phi_{ij})^2 \\ & -\frac{i}{2}g\,(f\,\phi^{ij}\bar{\lambda}_i\lambda_j + c.c) \\ & -\frac{1}{4}g^2\,(f\,\phi_{ij}\phi_{kl})^2 \end{aligned}$$

reduction = fermi masses + scalar potential

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R-symmetry group is SU(4) and not U(4) !!

[Cremmer & Julia '78, '79]

- Analogous results for N=8 gauged SUGRAs from M/Type II reductions with fluxes

$[f \leftrightarrow H_3, F_p, \omega, \ldots]$

> Reality condition on the 70 scalars :

$$\phi^*_{IJKL} = \phi^{IJKL} = \tfrac{1}{24}\,\epsilon^{IJKLMNPQ}\phi_{MNPQ}$$

$I = 1, \ldots, 8$

R-symmetry group is SU(8) and not U(8) !!

An extra U(1) in N=8 gauged supergravity

[... see Dall'Agata's & Inverso's talks]

- The theory contains 56 = 28 (electric) + 28 (magnetic) vectors spanning a 28-dimensional gauge symmetry group $G \subset E_7$

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[Dall' Agata, Inverso & Trigiante '12]

- Recently, an extra U(1) rotation outside the R-symmetry group SU(8) has been identified and used to orientate G inside the electromagnetic space Sp(56)

$$D_\mu \phi = \partial_\mu \phi + \left(\cos\omega \, A_\mu^{(\text{electric})} + \sin\omega \, A_\mu^{(\text{magnetic})} \right) \phi$$

> Therefore : $\omega = 0$ (electric) , $\omega = \frac{\pi}{2}$ (magnetic) and $0 < \omega < \frac{\pi}{2}$ (dyonic)

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GOALS :

1) Using the embedding-tensor, compute the ω-dependent scalar potential and analyse its critical points

2) Compute fermi masses and relate them to Type IIB generalised flux backgrounds via the embedding-tensor/flux dictionary

[de Wit, Samtleben & Trigiante '04]
[Aldazabal, Cámara, (Rosabal) & Andrés, Graña '08, '10]
[Dibitetto, A.G & Roest '11]

Example 1 : G_2-invariant sector of G = SO(8)

[Dall' Agata, Inverso & Trigiante '12]
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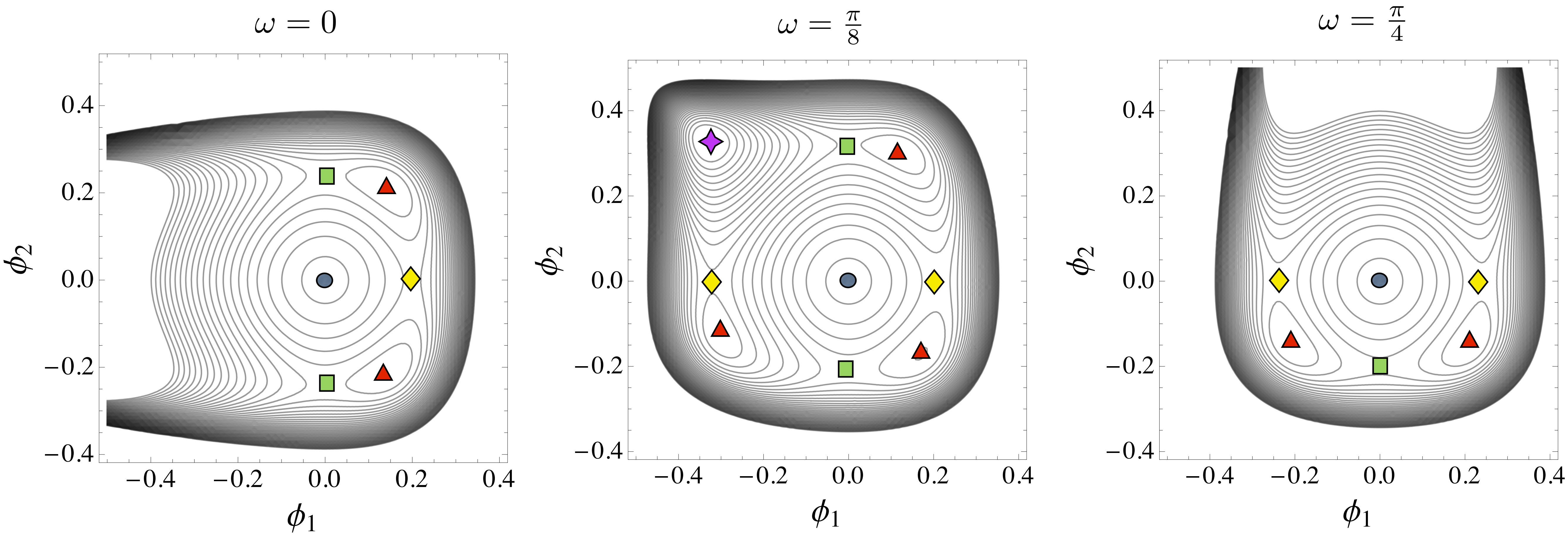

critical point	residual sym G_0	SUSY	Stability
●	$SO(8)$	$\mathcal{N}=8$	✓
■	$SO(7)_-$	$\mathcal{N}=0$	×
◆	$SO(7)_+$	$\mathcal{N}=0$	×
▲	G_2	$\mathcal{N}=1$	✓
✦	G_2	$\mathcal{N}=0$	✓

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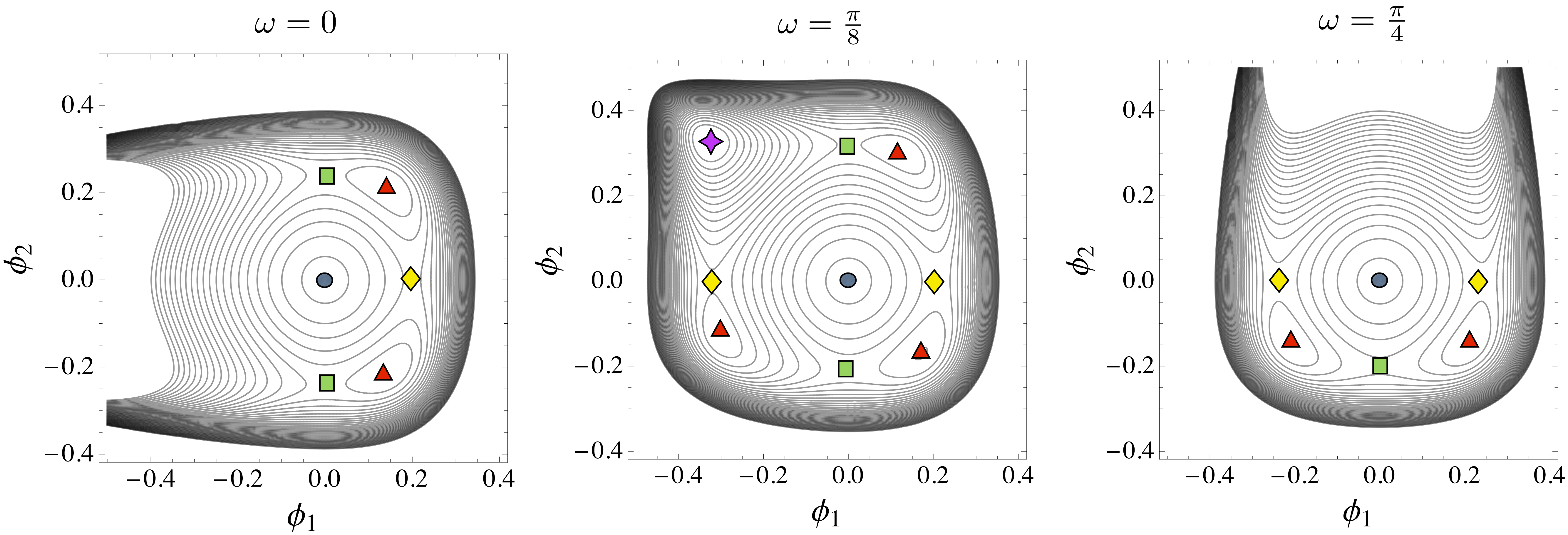

> Mass spectra insensitive to ω

> $\frac{\pi}{4}$-periodicity with transmutation of $SO(7)_{\pm}$

> Runaway of points at $\omega = n\,\frac{\pi}{4}$

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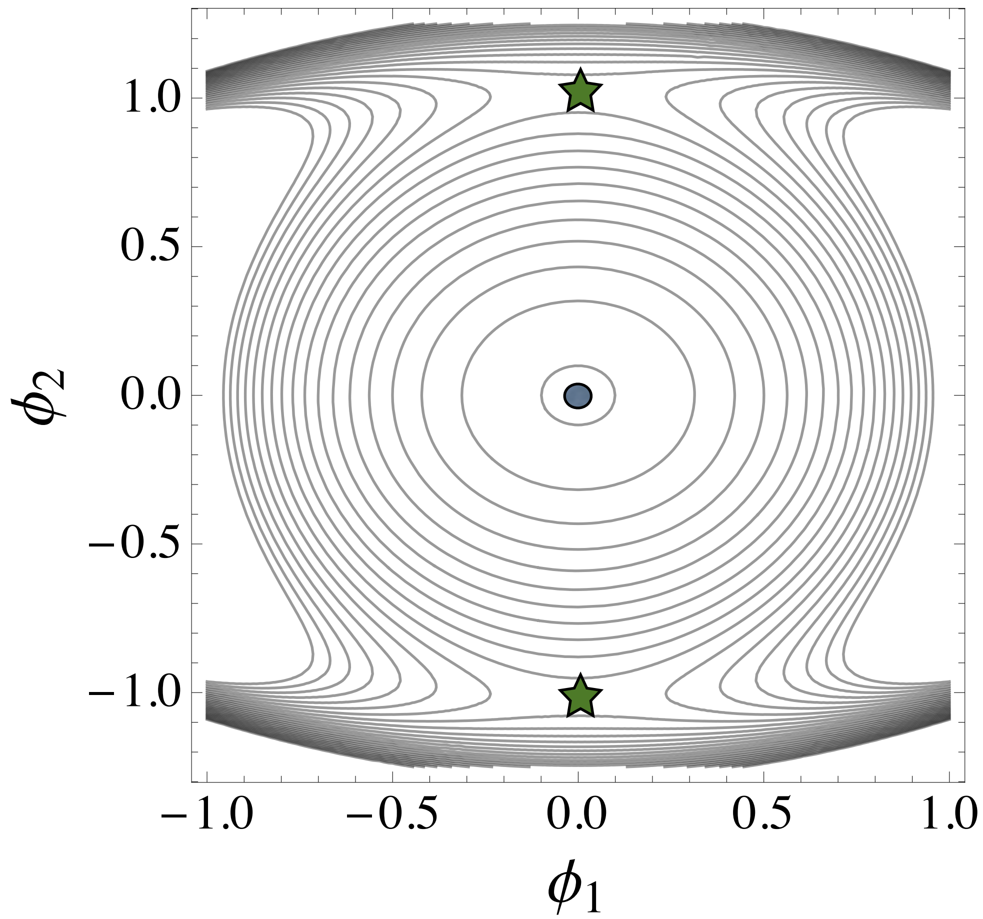
  i) the vectorial embedding : $8_v = (1,1) + (3,1) + (1,1) + (1,3)$

$\omega \in [0, \frac{\pi}{4}]$



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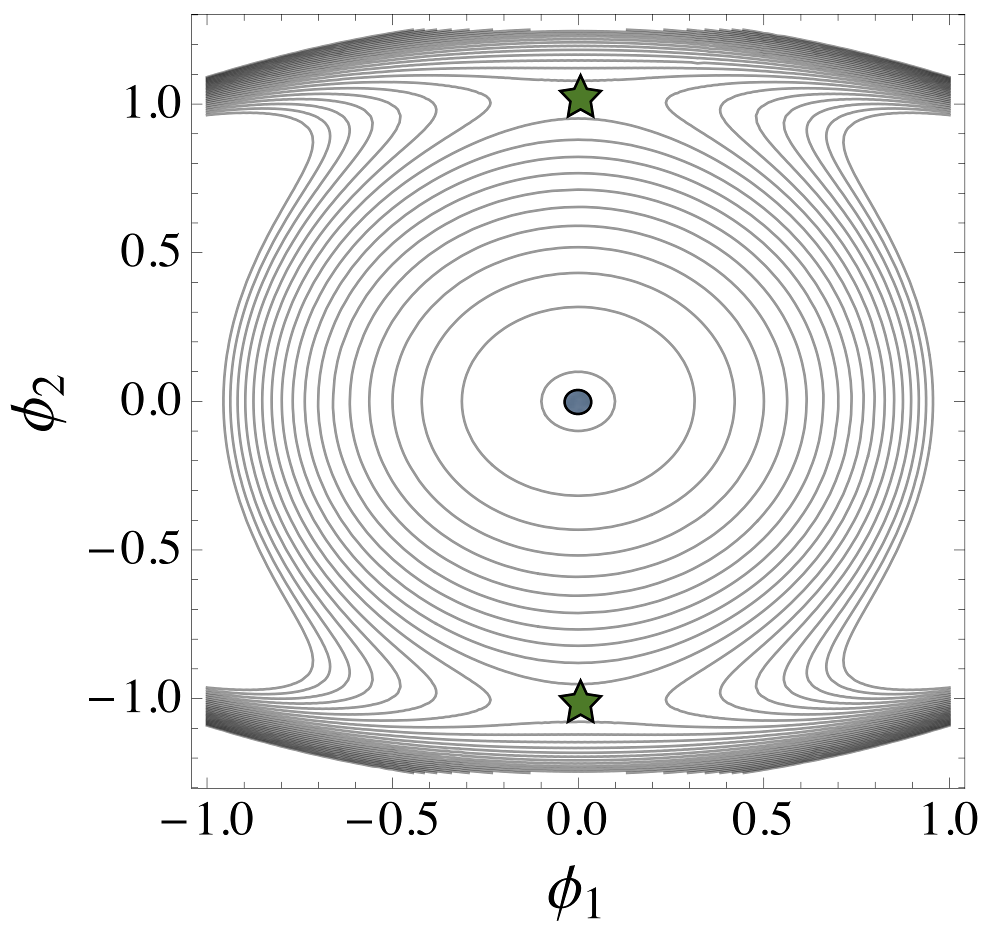

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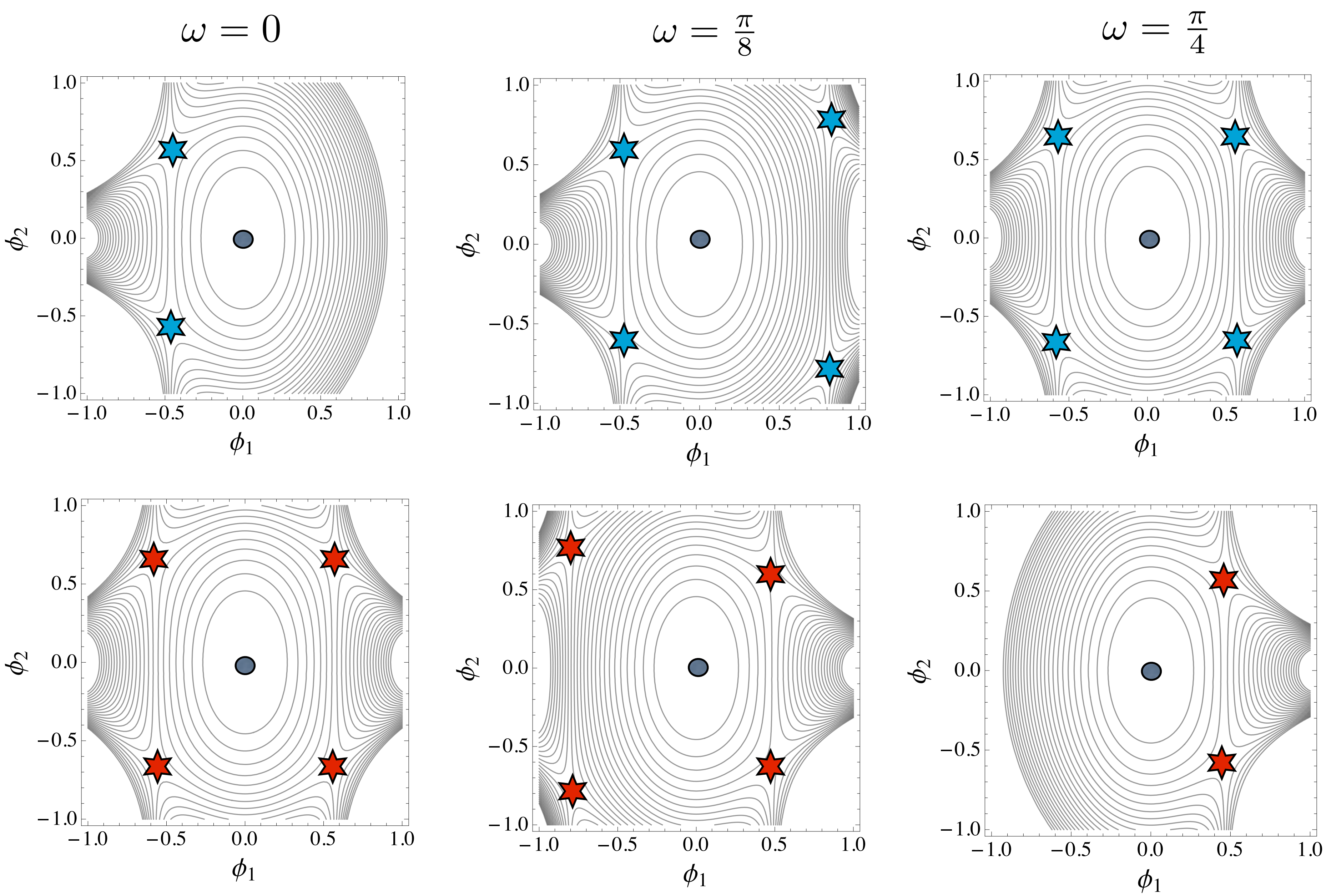
> NO ω-dependence at all !!

ii) spinorial (upper) & conjugate (lower) embeddings : $8_{s/c} = (1,1) + (3,1) + (1,1) + (1,3)$



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✡ (red star)	$SO(4)_c$	$\mathcal{N}=0$	×

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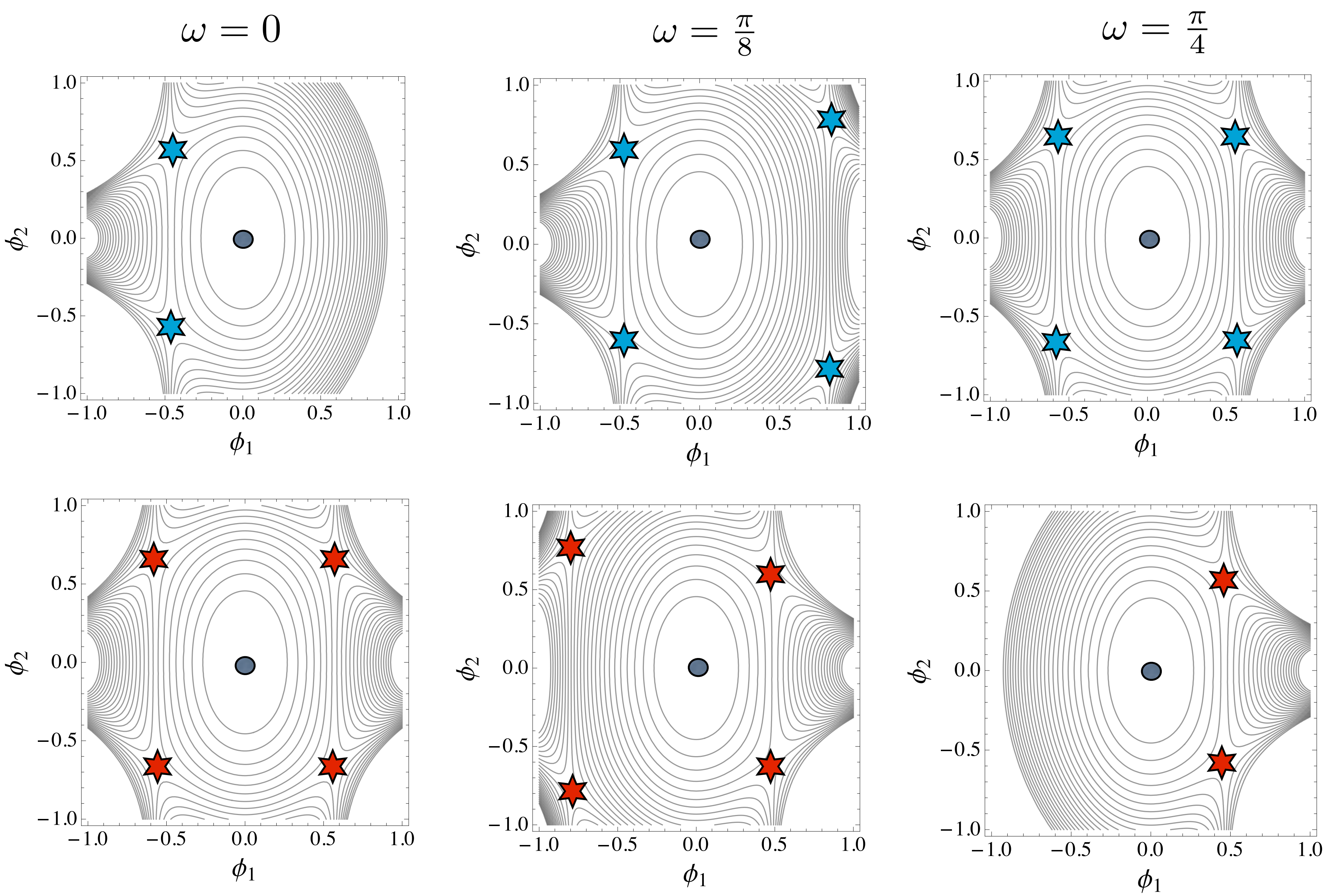

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Going to the origin : If a critical point is found at $\phi = \phi_0$ with a residual symmetry G_0 , it can always be brought to $\phi_0 = 0$ via a duality transformation. After this, the quantities in the theory (e.g. fermi masses) will adopt a form compatible with G_0

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Applicability : Pattern of fermi masses at $\phi_0 = 0$ preserving $G_0 = SO(4)_s$

$[\, I \rightarrow i \oplus \hat{i} \,]$

i) gravitino-gravitino mass $\mathcal{A}^{IJ}(\phi_0)$ ⇒ $\mathcal{A}^{ij} = \alpha\ \delta^{ij} \quad , \quad \mathcal{A}^{\hat{i}\hat{j}} = \alpha\ \delta^{\hat{i}\hat{j}}$

ii) gravitino-dilatino mass $\mathcal{A}_I{}^{JKL}(\phi_0)$ ⇒

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> Four parameters $\alpha, \beta, \gamma, \delta \in \mathbb{C}$

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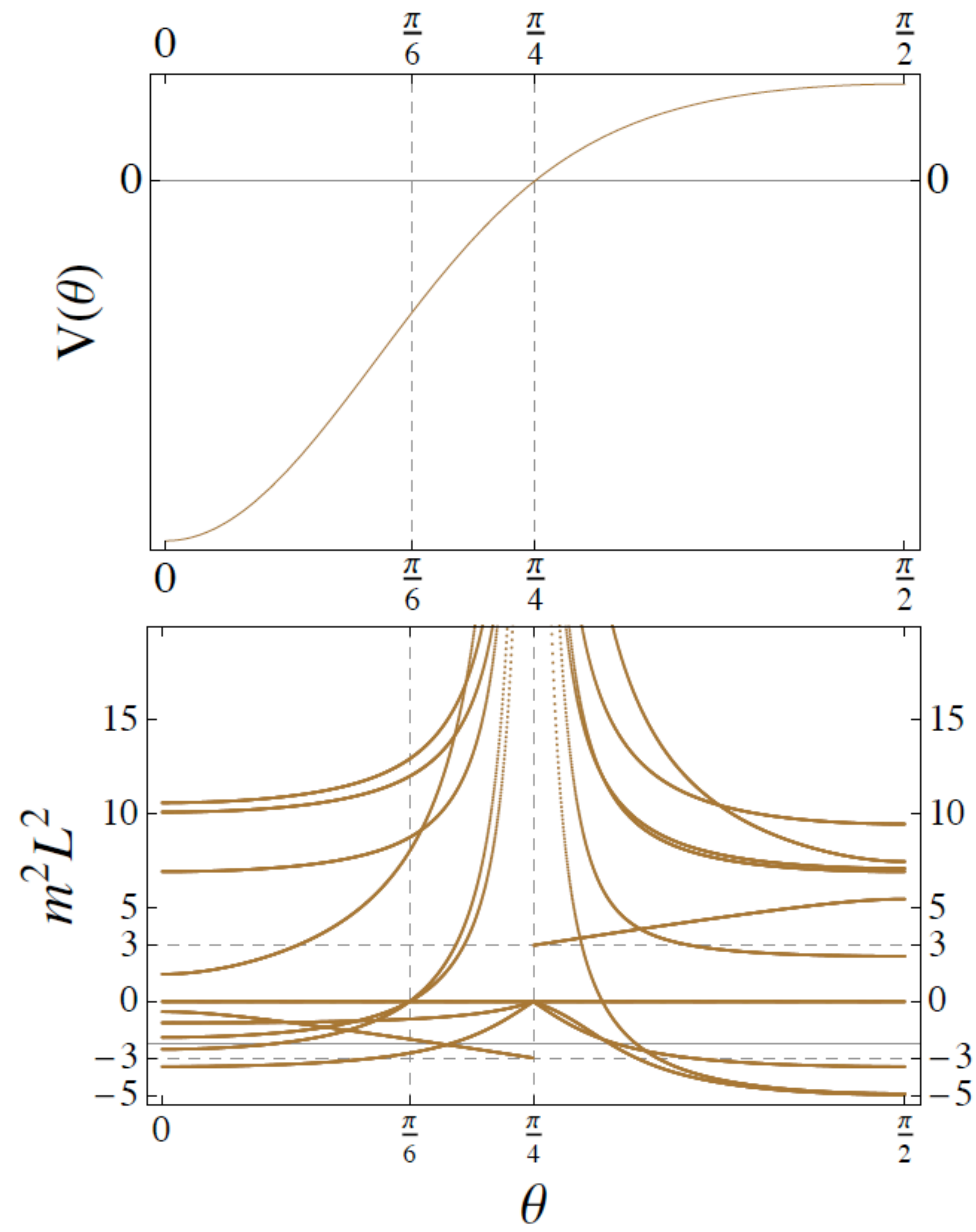
Solving QC & EOM : One-parameter family of theories compatible with $G_0 = SO(4)_s$

$$\alpha(\theta)\,,\ \beta(\theta)\,,\ \gamma(\theta)\,,\ \delta(\theta) \quad \Rightarrow \quad V(\theta) = -6\ \left(1 + \cos(4\theta) + \sqrt{2}\ \cos(2\theta)\,(\cos(4\theta)+5)^{1/2}\right)$$

$$0 \leq \theta \leq \tfrac{\pi}{2}$$

Gauge groups & AdS/Mkw/dS transitions

- The whole story of a solution preserving $G_0 = \mathrm{SO}(4)_s$ can be tracked



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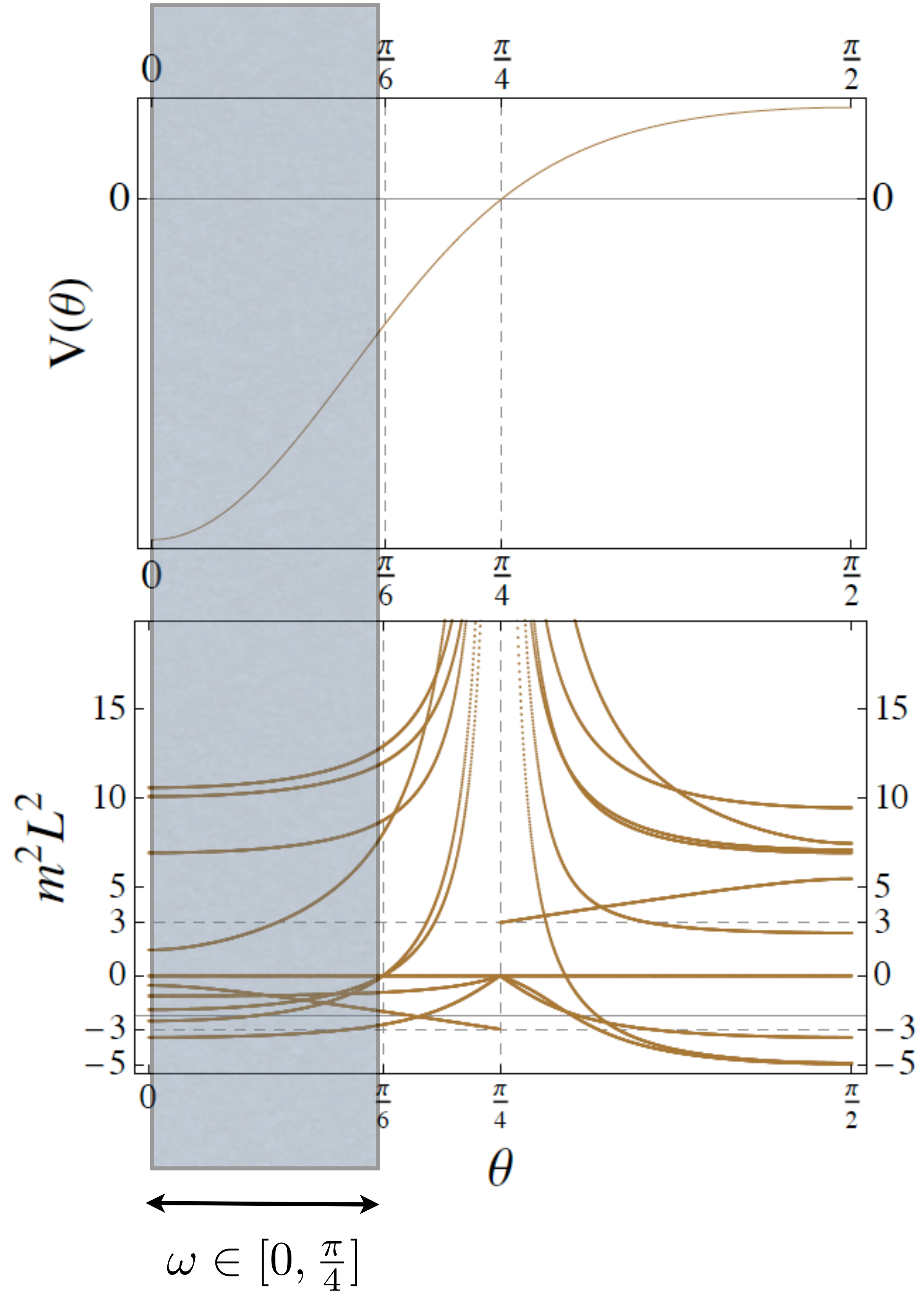
  $i)$ $0 \leq \theta < \frac{\pi}{6} \rightarrow G = SO(8)$

  [unstable AdS_4 solutions]



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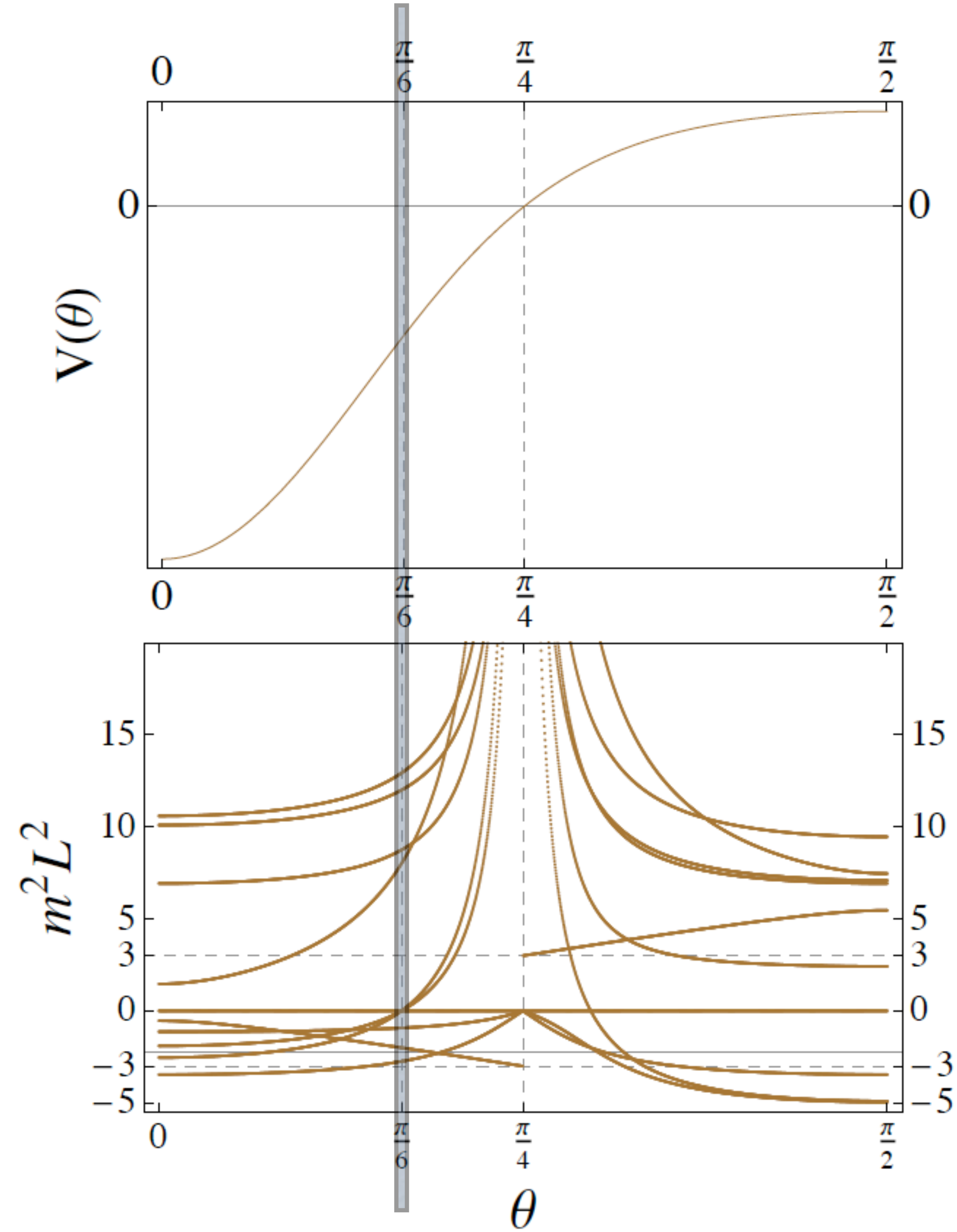
$ii) \quad \theta = \frac{\pi}{6} \quad \rightarrow \quad G = SO(2) \times SO(6) \ltimes T^{12}$

[unstable AdS_4 solution]



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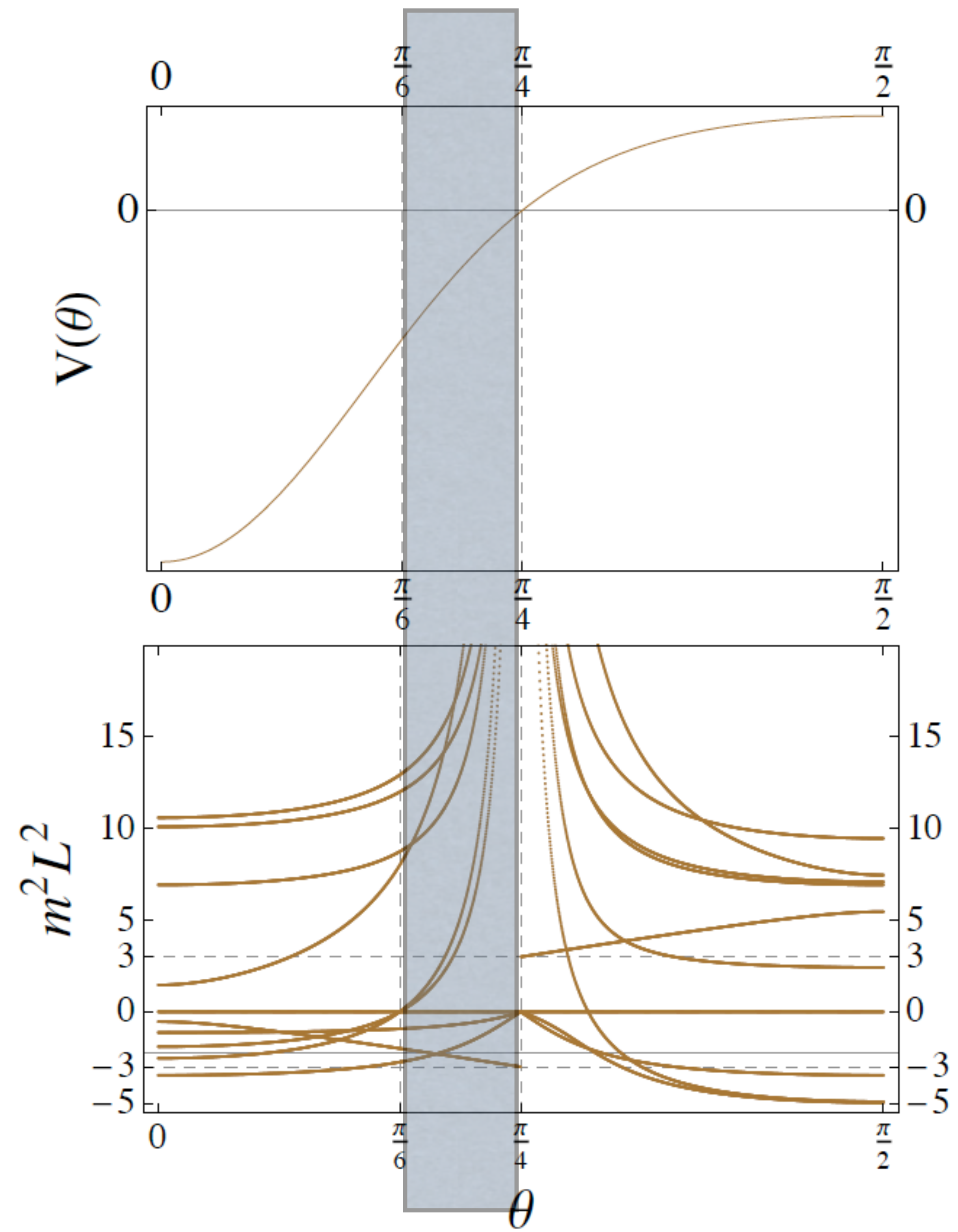

$iii)\quad \frac{\pi}{6} < \theta < \frac{\pi}{4} \quad \rightarrow \quad G = SO(6,2)$

[unstable AdS_4 solutions]

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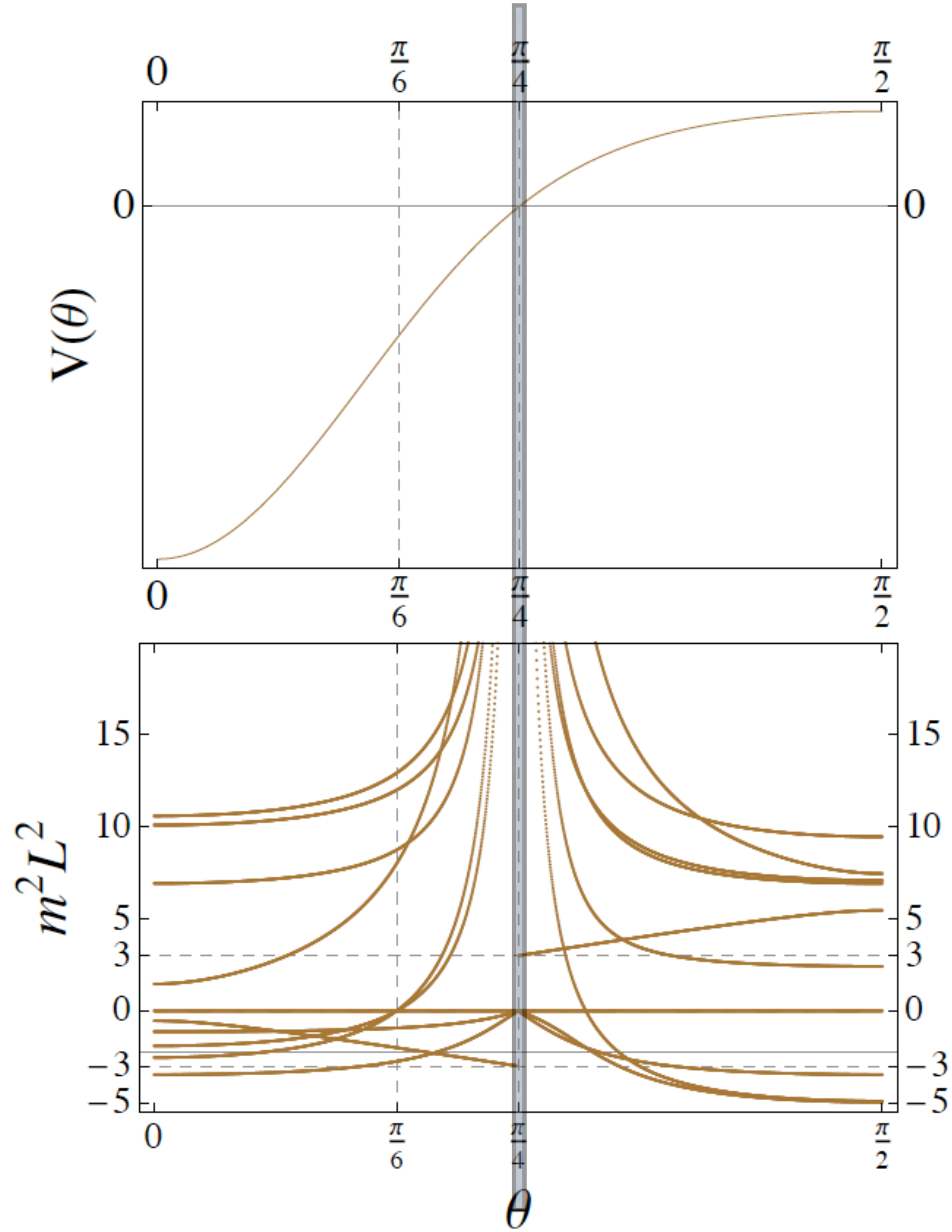

$iv)\quad \theta = \frac{\pi}{4} \quad \rightarrow \quad G = SO(3,1)^2 \ltimes T^{16}$

[Mkw solution with flat directions]

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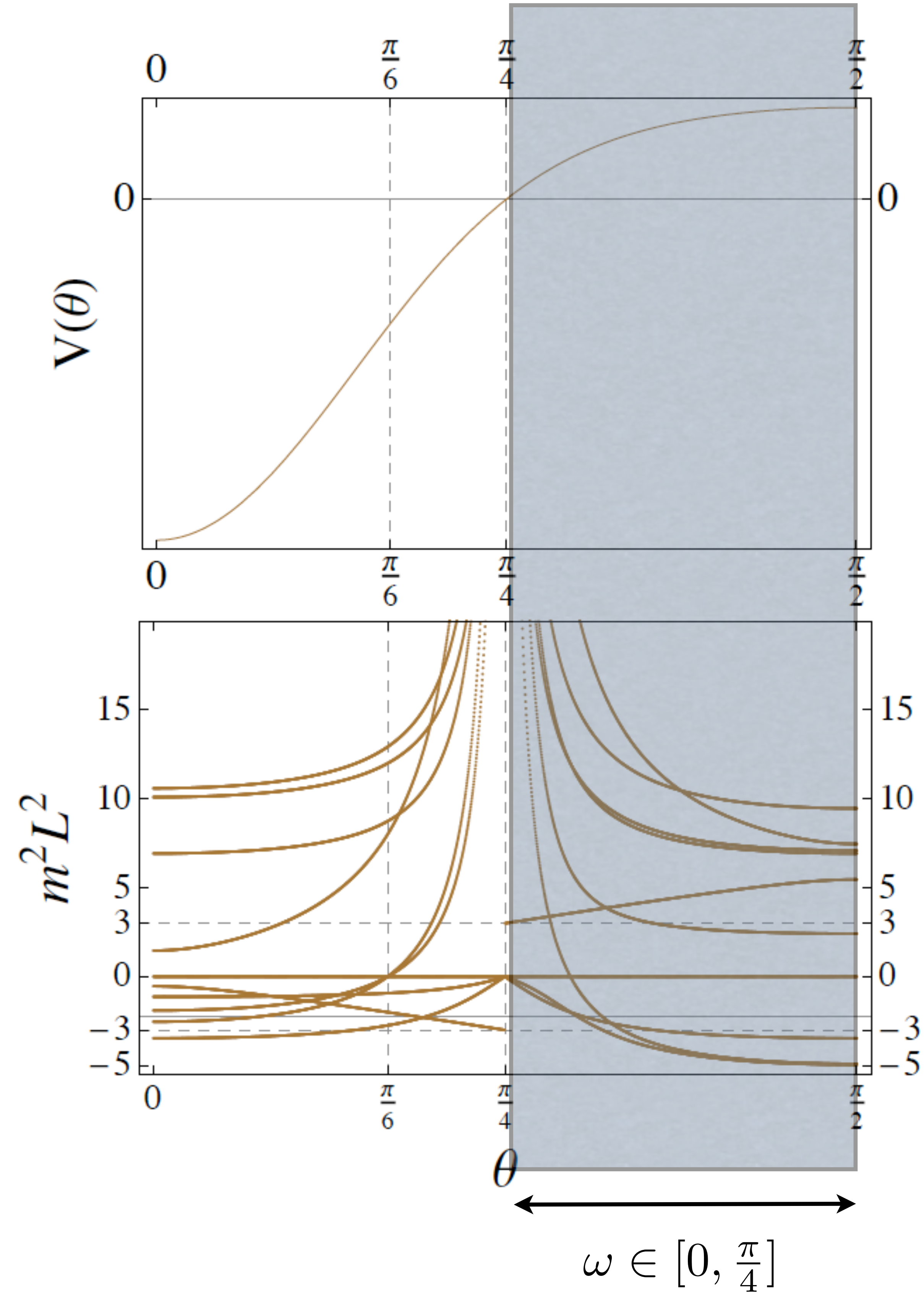

$v) \quad \frac{\pi}{4} < \theta \leq \frac{\pi}{2} \quad \rightarrow \quad G = SO(4,4)$

[dS_4 solutions with tachyon dilution]

[Dall'Agata & Inverso '12]

Final remarks

- Electromagnetic U(1) rotations pick up a physically relevant direction in the space of the embedding tensor deformations and provide new vacua of $\mathcal{N}=8$ supergravity with interesting properties : increase of critical points, partial $\mathcal{N}=2 \rightarrow \mathcal{N}=1$ breaking, stability without SUSY, ...

- Small residual symmetry groups like SU(3) & SO(4) show ω-dependent mass spectra. Triality restores $\frac{\pi}{4}$-periodicity.

- Critical points running away at $\omega = n\,\frac{\pi}{4}$ in one theory, show up in another. The entire story of a solution can be tracked by computing fermi masses in the GTTO approach

- Tachyon dilution around AdS/Mkw/dS transitions.

- All these solutions can be obtained as $Z_2 \times Z_2$ Type IIB orientifolds with non-geometric fluxes (both electric and magnetic). Lifting to M-theory including vectors from A_3 and A_6 ? And oxidation to DFT ?

[de Wit & Nicolai '13]

[Blumenhagen, Gao, Herschmann & Shukla '13]

Thank you all !!