Exploring new maximal supergravity

Adolfo Guarino

Albert Einstein Center (ITP)

University of Bern

GeNeZiSS XIX

Lausanne, 30th November 2012

in collaboration w/ A. Borghese, G. Dibitetto, D. Roest & O. Varela [1211.5335]

The old maximal SUGRA

Top-down approach

[Cremmer & Julia '79]
[de Wit & Nicolai '82, '87]
[Englert '82]

- 11d supergravity on the 7-sphere : SO(8)-gauged SUGRA with N=8 SUSY

Always believed to be unique !!

The old maximal SUGRA

Top-down approach

[Cremmer & Julia '79]
[de Wit & Nicolai '82, '87]
[Englert '82]

- 11d supergravity on the 7-sphere : SO(8)-gauged SUGRA with N=8 SUSY

Always believed to be unique !!

N=8 gravity multiplet

metric + 70 real scalars + 28 vectors (out of 56 elec/mag) + fermions

The old maximal SUGRA

Top-down approach

[Cremmer & Julia '79]
[de Wit & Nicolai '82, '87]
[Englert '82]

- 11d supergravity on the 7-sphere : SO(8)-gauged SUGRA with N=8 SUSY

Always believed to be unique !!

N=8 gravity multiplet

metric + 70 real scalars + 28 vectors (out of 56 elec/mag) + fermions

Smaller sectors

[Warner, '84]
[Bobev, Halmagyi, Pilch & Warner, '10]

- SU(3)-invariant sector : N=2 description (gravity + 1 vector + 1 hyper)

$$\mathcal{M}_{SK} = \frac{SL(2)}{SO(2)} \quad \text{and} \quad \mathcal{M}_{QK} = \frac{SU(2,1)}{SU(2) \times U(1)}$$

SU(3)-invariant critical points

[Warner '83, '84]
[Bobev, Halmagyi, Pilch & Warner '10]

SUSY	Symmetry	Cosm. constant	Stability
$\mathcal{N}=8$	SO(8)	$-6\ (\times 1)$	✓
$\mathcal{N}=2$	$\mathrm{SU}(3)\times\mathrm{U}(1)$	$-\frac{9}{2}\sqrt{3}\ (\times 1)$	✓
$\mathcal{N}=1$	G_2	$-\frac{216}{25}\sqrt{\frac{2}{5}\sqrt{3}}\ (\times 2)$	✓
$\mathcal{N}=0$	SO(7)	$-2\sqrt{5\sqrt{5}}\ (\times 1)$	×
		$-\frac{25}{8}\sqrt{5}\ (\times 2)$	×
$\mathcal{N}=0$	SU(4)	$-8\ (\times 1)$	×

SU(3)-invariant critical points

[Warner '83, '84]
[Bobev, Halmagyi, Pilch & Warner '10]

They all are consistent truncations of 11d supergravity on $Ads_4 \times S^7$ with a round , squashed, stretched or warped 7-sphere (SE_7) and 4-form flux [Nicolai & Pilch '12]

SUSY	Symmetry	Cosm. constant	Stability	Lifting to 11d
$\mathcal{N}=8$	SO(8)	$-6\ (\times 1)$	✓	[Freund & Rubin '80] [Englert '82]
$\mathcal{N}=2$	$SU(3)\times U(1)$	$-\frac{9}{2}\sqrt{3}\ (\times 1)$	✓	[Corrado, Pilch & Warner '01]
$\mathcal{N}=1$	G_2	$-\frac{216}{25}\sqrt{\frac{2}{5}\sqrt{3}}\ (\times 2)$	✓	[de Wit, Nicolai & Warner '85]
$\mathcal{N}=0$	SO(7)	$-2\sqrt{5\sqrt{5}}\ (\times 1)$	×	[Englert '82] [de Wit Nicolai '84]
		$-\frac{25}{8}\sqrt{5}\ (\times 2)$	×	
$\mathcal{N}=0$	SU(4)	$-8\ (\times 1)$	×	[Pope & Warner '85]

SU(3)-invariant critical points

[Warner '83, '84]
[Bobev, Halmagyi, Pilch & Warner '10]

They all are consistent truncations of 11d supergravity on Ads$_4$ x S^7 with a round , squashed, stretched or warped 7-sphere (SE$_7$) and 4-form flux [Nicolai & Pilch '12]

[Jafferis, Klebanov, Pufu & Safdi '11]
[Bobev, Halmagyi, Pilch & Warner '09]
[Corrado, Pilch & Warner '01]
[Ahn & Woo '00]

Domain walls
&
RG-flows

[Gauntlett, Sonner & Wiseman '09]

SUSY	Symmetry	Cosm. constant	Stability
$\mathcal{N}=8$	SO(8)	$-6\ (\times 1)$	✓
$\mathcal{N}=2$	$SU(3)\times U(1)$	$-\frac{9}{2}\sqrt{3}\ (\times 1)$	✓
$\mathcal{N}=1$	G_2	$-\frac{216}{25}\sqrt{\frac{2}{5}\sqrt{3}}\ (\times 2)$	✓
$\mathcal{N}=0$	SO(7)	$-2\sqrt{5\sqrt{5}}\ (\times 1)$	×
		$-\frac{25}{8}\sqrt{5}\ (\times 2)$	×
$\mathcal{N}=0$	SU(4)	$-8\ (\times 1)$	×

Lifting to 11d

[Freund & Rubin '80]
[Englert '82]

[Corrado, Pilch & Warner '01]

[de Wit, Nicolai & Warner '85]

[Englert '82]
[de Wit Nicolai '84]

[Pope & Warner '85]

SU(3)-invariant critical points

[Warner '83, '84]
[Bobev, Halmagyi, Pilch & Warner '10]

They all are consistent truncations of 11d supergravity on $Ads_4 \times S^7$ with a round , squashed, stretched or warped 7-sphere (SE_7) and 4-form flux [Nicolai & Pilch '12]

[Jafferis, Klebanov, Pufu & Safdi '11]
[Bobev, Halmagyi, Pilch & Warner '09]
[Corrado, Pilch & Warner '01]
[Ahn & Woo '00]

Domain walls
&
RG-flows

[Gauntlett, Sonner & Wiseman '09]

SUSY	Symmetry	Cosm. constant	Stability	Lifting to 11d
$\mathcal{N}=8$	SO(8)	$-6\ (\times 1)$	✓	[Freund & Rubin '80] [Englert '82]
$\mathcal{N}=2$	$SU(3)\times U(1)$	$-\frac{9}{2}\sqrt{3}\ (\times 1)$	✓	[Corrado, Pilch & Warner '01]
$\mathcal{N}=1$	G_2	$-\frac{216}{25}\sqrt{\frac{2}{5}\sqrt{3}}\ (\times 2)$	✓	[de Wit, Nicolai & Warner '85]
$\mathcal{N}=0$	SO(7)	$-2\sqrt{5\sqrt{5}}\ (\times 1)$	×	[Englert '82] [de Wit Nicolai '84]
		$-\frac{25}{8}\sqrt{5}\ (\times 2)$	×	
$\mathcal{N}=0$	SU(4)	$-8\ (\times 1)$	×	[Pope & Warner '85]

AdS/CMT applications : Holographic superconductivity

[Gauntlett, Sonner & Wiseman '09, '09]
[Donos & Gaunlett '11]
[Bobev, Kundu, Pilch & Warner '11]

The new maximal SUGRA

Purely 4d approach

[de Wit, Samtleben & Trigiante '07]
[See Paul's talk]

- Most general SUGRA with N=8 SUSY : Embedding Tensor Formalism (ETF)

$$A_M = \Theta_M{}^{\alpha}\, t_{\alpha}$$

4d vectors (M=1,...56)

Emb. Tensor (selector)

$E_{7(7)}$ generators (global symmetry)

The new maximal SUGRA

Purely 4d approach

[de Wit, Samtleben & Trigiante '07]
[See Paul's talk]

- Most general SUGRA with N=8 SUSY : Embedding Tensor Formalism (ETF)

$$A_M = \Theta_M{}^{\alpha}\, t_{\alpha}$$

4d vectors (M=1,...56)

Emb. Tensor (selector)

$E_{7(7)}$ generators (global symmetry)

- Group theory argument : ω-parameter family of new SO(8)-gauged SUGRA's !!

[Dall'Agata, Inverso & Trigiante '12]

The new maximal SUGRA

Purely 4d approach

[de Wit, Samtleben & Trigiante '07]
[See Paul's talk]

- Most general SUGRA with N=8 SUSY : Embedding Tensor Formalism (ETF)

$$A_M = \Theta_M{}^{\alpha}\, t_{\alpha}$$

4d vectors (M=1,...56)

Emb. Tensor (selector)

$E_{7(7)}$ generators (global symmetry)

- Group theory argument : ω-parameter family of new SO(8)-gauged SUGRA's !!

[Dall'Agata, Inverso & Trigiante '12]

- ω-parameter : Determines which 28 out of the 56 electric/magnetic vectors span the SO(8) group

$$\Theta_{\text{elec}}{}^{\alpha} \propto \cos(\omega)$$

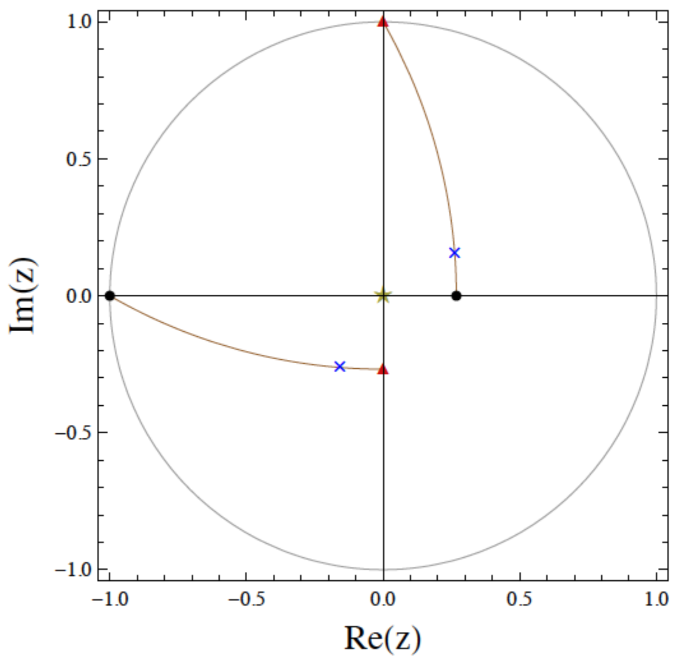
$$\Theta_{\text{mag}}{}^{\alpha} \propto \sin(\omega)$$

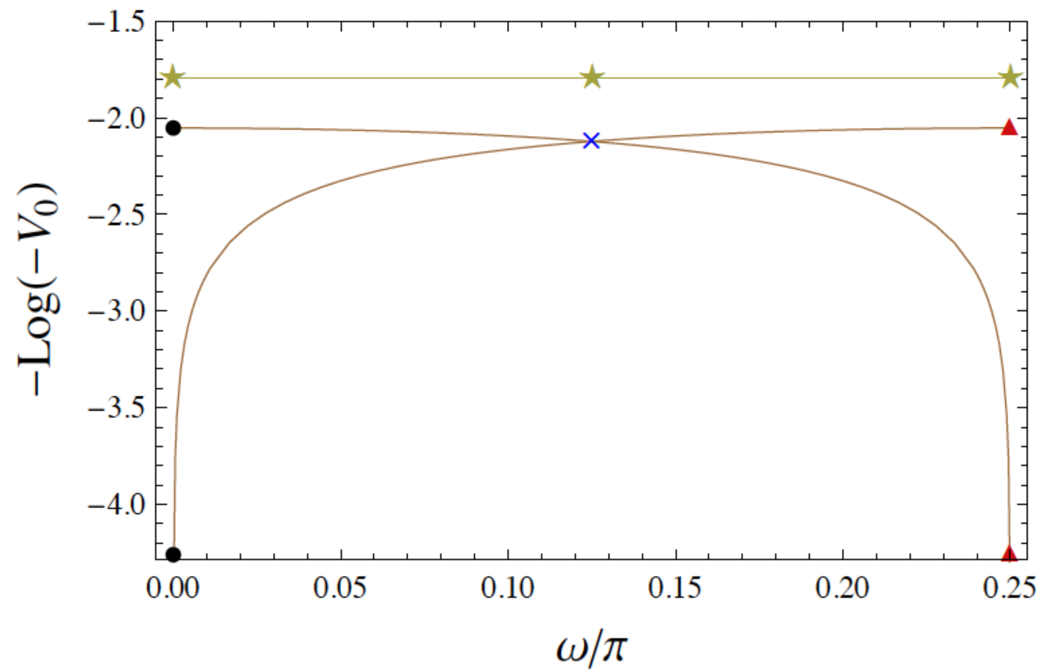
$$\Rightarrow \quad V(\Theta\,,\,\vec{\phi}) = V(\omega\,,\,\vec{\phi})$$

ω-dependent scalar potential !!

The ω-story of the old critical points

EXAMPLE : the N=2 SU(3)xU(1)-invariant critical point

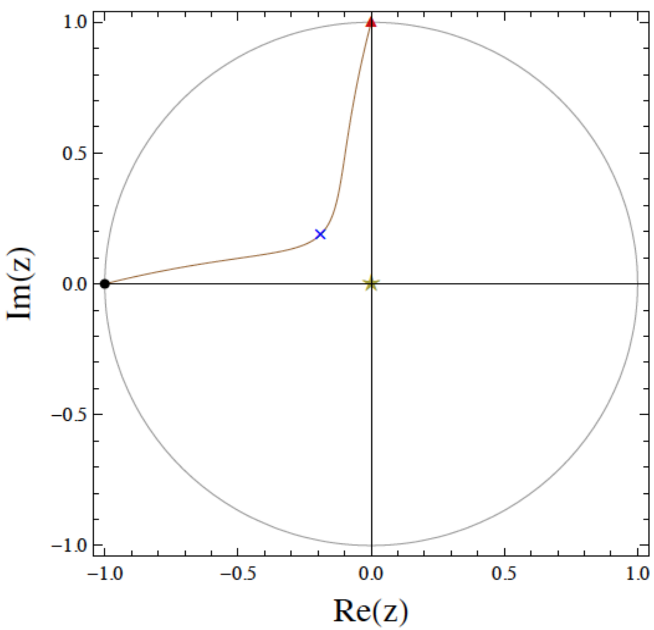


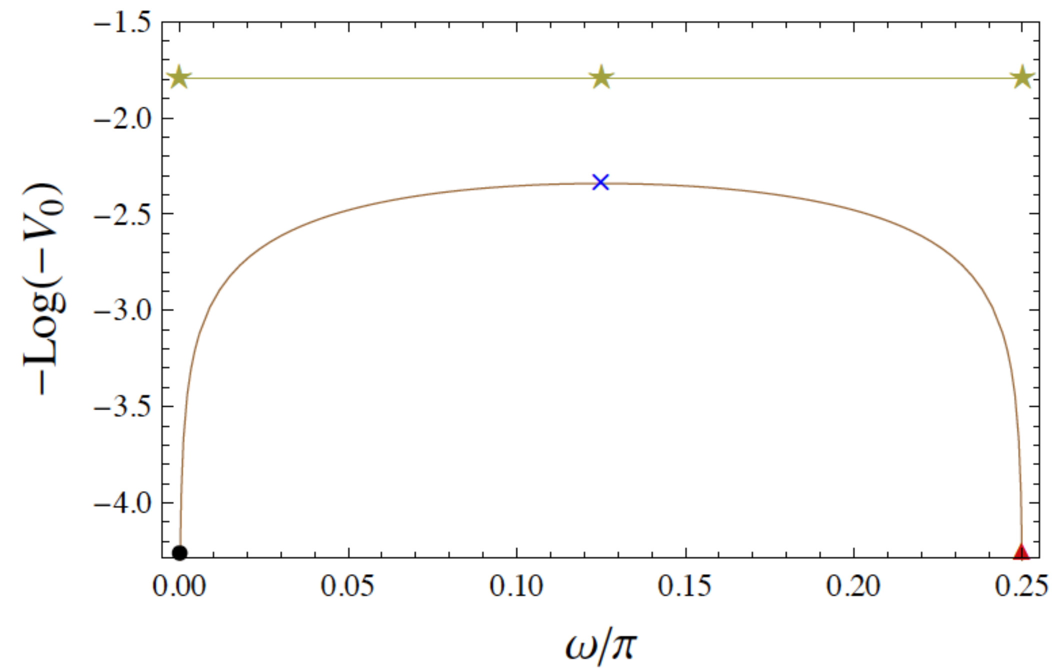


- There are new solutions which move to the field-boundary at ω = n pi/4
- Analogous ω-stories for : N=1 G2-inv , N=0 SO(7)-inv , N=0 SU(4)-inv

Genuine new critical points

EXAMPLE : a novel N=1 SU(3)-invariant critical point





- There are genuine solutions which move to the boundary at ω = n pi/4

- Analogous ω-stories : novel   N=0 G2-inv   and   N=0 SU(3)-inv

SU(3)-invariant critical points of new maximal SUGRA

SUSY	Symmetry	CC ($\omega = 0$)	Stability	CC ($\omega = \pi/8$)	Stability	ω-dep.
$\mathcal{N} = 8$	SO(8)	-6 ($\times 1$)	✓	-6 ($\times 1$)	✓	×
$\mathcal{N} = 2$	SU(3) × U(1)	-7.794 ($\times 1$)	✓	-8.354 ($\times 2$)	✓	×
$\mathcal{N} = 1$	G_2	-7.192 ($\times 2$)	✓	-7.943 ($\times 2$)	✓	×
		–	–	-7.040 ($\times 1$)	✓	×
$\mathcal{N} = 1$	SU(3)	–	–	-10.392 ($\times 1$)	✓	×
$\mathcal{N} = 0$	SO(7)	-6.687 ($\times 1$)	×	-6.748 ($\times 2$)	×	×
		-6.988 ($\times 2$)	×	-7.771 ($\times 2$)	×	×
$\mathcal{N} = 0$	SU(4)	-8 ($\times 1$)	×	-8.581 ($\times 2$)	×	×
$\mathcal{N} = 0$	G_2	–	–	-10.170 ($\times 1$)	✓	×
$\mathcal{N} = 0$	SU(3)	–	–	-10.237 ($\times 2$)	✓?	✓

Old supergravity solutions

New supergravity solutions

Further remarks

Physical mass spectra

- The residual symmetry does not uniquely determine the mass spectra
- First example of ω-dependent mass spectra in the new maximal supergravity.

Further remarks

Physical mass spectra

- The residual symmetry does not uniquely determine the mass spectra
- First example of ω-dependent mass spectra in the new maximal supergravity.

Domain-walls and RG flows

- ω-dependent N=2 superpotential for the SU(3)-invariant sector

$$\mathcal{W}_{+} = (1-|z|^2)^{-3/2}\,(1-|\zeta_{12}|^2)^{-2}\,\left[(e^{2i\omega}+z^3)\,(1+\zeta_{12}^4)+6\,z\,(1+e^{2i\omega}z)\,\zeta_{12}^2\right]$$

- New domain-wall solutions at $\omega \neq 0$: Prediction of the free energy F_{IR}/F_{UV}

$$\left.\frac{V_{\mathcal{N}=8}}{V_{\mathcal{N}=2}}\right|_{\omega=\frac{\pi}{8}} = \frac{4}{\sqrt{\frac{3}{2}\left(3+(827-384\sqrt{2})^{1/3}+(827+384\sqrt{2})^{1/3}\right)}} \sim 0.718$$

EXAMPLE : N=2 , SU(3)xU(1)-inv solution

Further remarks

Physical mass spectra

- The residual symmetry does not uniquely determine the mass spectra
- First example of ω-dependent mass spectra in the new maximal supergravity.

Domain-walls and RG flows

- ω-dependent N=2 superpotential for the SU(3)-invariant sector

$$\mathcal{W}_{+} = (1-|z|^2)^{-3/2}\,(1-|\zeta_{12}|^2)^{-2}\,\left[(e^{2i\omega}+z^3)\,(1+\zeta_{12}^4)+6\,z\,(1+e^{2i\omega}z)\,\zeta_{12}^2\right]$$

- New domain-wall solutions at $\omega \neq 0$: Prediction of the free energy F_{IR}/F_{UV}

$$\left.\frac{V_{\mathcal{N}=8}}{V_{\mathcal{N}=2}}\right|_{\omega=\frac{\pi}{8}} = \frac{4}{\sqrt{\frac{3}{2}\left(3+(827-384\sqrt{2})^{1/3}+(827+384\sqrt{2})^{1/3}\right)}} \sim 0.718$$

EXAMPLE : N=2 , SU(3)xU(1)-inv solution

Lifting to 11d SUGRA on XXX ??

… thank you all !!