Heterotic non Calabi-Yau Compactifications

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Bethe Forum, Bad Honnef, October 2012

based on: arXiv:1005.5302, arXiv:1107.3573, arXiv:1210.nnnn to appear, with Cyril Matti, Michael Klaput and Eirik Svanes

Overview

- Introduction
- Cosets as examples of half-flat mirror spaces
- Gauge fields on cosets
- Including α' corrections
- Moduli stabilization
- Calabi-Yau manifolds and NS flux
- Conclusion

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SU(3) structures classified by 5 torsions classes $\mathcal{W}_1, \ldots, \mathcal{W}_5$ with

$$\mathrm{d}J = -\frac{3}{2} \mathrm{Im}(\mathcal{W}_1 \bar{\Omega}) + \mathcal{W}_4 \wedge J + \mathcal{W}_3$$

$$\mathrm{d}\Omega = -\mathcal{W}_1 J \wedge J + \mathcal{W}_2 \wedge J + \bar{\mathcal{W}}_5 \wedge \Omega$$

Interesting classes of SU(3) structure manifolds:

name	M_4	H	ϕ	$\mathcal{W}_i$	properties
CY	max. symm.	0	const	$\mathcal{W}_i = 0$	complex Kahler, CY
Strominger's	max. symm.	$\neq 0$	varies	$\mathcal{W}_1 = \mathcal{W}_2 = 0$ $\mathcal{W}_4 = \mathcal{W}_5/2 = d\phi$	complex
half-flat	domain wall	0	const	$\mathcal{W}_1^- = \mathcal{W}_2^- = 0$ $\mathcal{W}_4 = \mathcal{W}_5 = 0$	
nearly Kahler	domain wall	0	const	only $\mathcal{W}_1^+ \neq 0$	
gen. half-flat	domain wall	$\neq 0$	varies	$\mathcal{W}_1^- = \mathcal{W}_2^- = 0$ $\mathcal{W}_4 = \mathcal{W}_5/2 = d\phi$	

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Why allow for a 4d domain wall?

- Domain wall still consistent with 4d covariant theory

- But 4d superpotential, e.g. $W = e_i T^i$, has runaway directions and domain wall is "simplest" solution.

Two main questions addressed in this talk:

- In the context of half-flat/nearly Kahler manifolds:

  Can domain wall vacuum be lifted to a maximally-symmetric one, for example by α' corrections or non-perturbative effects?

- In the context of generalized half-flat manifolds:

  Is there a new perspective on CY compactifications with H-flux?

Cosets as examples of half-flat mirror spaces

(Gurrieri, Louis, Micu, Waldram, 2002)

half-flat mirror spaces: forms $(\omega_i, \tilde{\omega}^j)$ and (α_A, β^B) with

$$\mathrm{d}\omega_i = e_i \beta^0 \;, \quad \mathrm{d}\alpha_0 = e_i \tilde{\omega}^i$$

half-flat structure: $J = t^i \omega_i \;, \quad \Omega = Z^A \alpha_A + G_A \beta^A$

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Cosets as explicit examples: $\frac{G}{H} = \frac{SU(3)}{U(1)^2} \, , \ \frac{Sp(2)}{SU(2) \times U(1)} \, , \ \frac{G_2}{SU(3)}$

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focus on this one

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"natural" vielbein $e^1, \ldots, e^6$ from left-inv. one-form on SU(3):

$$\omega_1 = -\frac{1}{2\pi}\left(e^{12} + \frac{1}{2}e^{34} - \frac{1}{2}e^{56}\right) \qquad \tilde{\omega}^1 = \frac{4\pi}{3\mathcal{V}_0}\left(2e^{1234} + e^{1256} - e^{3456}\right)$$

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$$\alpha_0 = \frac{\pi}{2\mathcal{V}_0}\left(e^{136} - e^{145} + e^{235} + e^{246}\right) \qquad \beta^0 = \frac{1}{2\pi}\left(e^{135} + e^{146} - e^{236} + e^{245}\right)$$

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4d "moduli" fields: 3 T-moduli $T^i = t^i + i\tau^i$

dilaton $S = s + i\sigma$

no ``complex structure" moduli

Four-dimensional theory:

(Gurrieri, Lukas, Micu, 2004)

$$K = -\ln(S + \bar{S}) - \ln\kappa \ , \quad \kappa = d_{ijk} t^i t^j t^k$$

$$W \sim \int_X \Omega \wedge (H + idJ) \sim e_i T^i = T^3$$

runaway directions -> domain wall

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So far this generalizes to all half-flat mirror manifolds, but gauge fields are difficult to deal with in general....

Gauge fields on cosets

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-> line bundles $L = \mathcal{O}_X(\mathbf{p})$, with $c_1(L) = p\,\omega_1 + q\,\omega_2$

Take vector bundles to be sums of line bundles

$$V = \bigoplus_{a=1}^{n} \mathcal{O}_X(\mathbf{p}_a) \quad \text{where} \quad c_1(V) \sim \sum_{a=1}^{n} \mathbf{p}_a = 0$$

so that structure group of V is $S(U(1)^n) \subset SU(n) \subset E_8$.

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-> X nearly Kahler

Including α′ corrections

Bianchi identity: $dH = \frac{\alpha'}{4}\left(\operatorname{tr} F \wedge F + \operatorname{tr} \tilde{F} \wedge \tilde{F} - \operatorname{tr} R^{-} \wedge R^{-}\right)$

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Can be solved: $H \sim \mu(\mathbf{p}_a, \tilde{\mathbf{p}}_a)\alpha_0$ -> Killing spinor equations

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$$W \sim \int_X \Omega \wedge (H + idJ) \sim T + \mu$$

Can now fix remaining T-modulus but dilaton still runaway...

Moduli stabilization

Add gaugino condensate: $W = T + \mu + ke^{-cS}$

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F-flat conditions $F_S = F_T = 0$ lead to $\tau = 0$, $y = 0, \pi$ and

$$(1 - x)e^{-x} = \frac{\mu}{k} \qquad t = \frac{3x}{1 - x}\mu$$

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Two main differences to CY gaugino condensation and H-flux:

- Additional T-dependent contribution from torsion
- H-flux is not harmonic but bundle-induced

What about consistent field values, $t > 1$ (α′ expansion valid) and $s > 1$ (weak coupling)?

Tension: large t needs large flux μ and large s requires small μ

"Compromise" values for μ which lead to marginally consistent field values can be obtained for suitable bundle choices.

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flow eqs.
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A domain wall solution to these eqs. exists. It can also be obtained by solving 4d theory on CY with superpotential

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- Previously: H-flux requires non-Kahler spaces (Strominger system)
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+ : CY methods available   - : need to lift domain wall

Conclusion

- Non-Calabi-Yau compactifications of string theory are interesting but progress is hampered by the lack of examples.

  (Larfors, Lust, Tsimpis, 2010)
  (Gray, Larfors, Lust, 2012)

- Half-flat and gen. half-flat spaces provide solutions of the het. string if combined with a 4d domain wall.

- Coset provide explicit examples of half-flat spaces and α' corrections can be worked out explicitly.

- For cosets, a combination of α' and non-pert. effects can lift the domain wall to AdS. There are consistency issues....

- H-flux is consistent with keeping the internal space CY if the 4d space-time is a domain wall.

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