Heterotic Brane Wrapping Rules

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based on work in progress with Fabio Riccioni

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Outline

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Question

- Branes are massive objects with a number of worldvolume and transverse directions; they play an important role in string theory

- Question : What can we learn about branes using supergravity as a low-energy approximation to string theory ?

Standard Maximal Supergravity

- "standard supergravity" describes physical states only
- standard supergravity is complete
- dual potentials can be added and are relevant for branes
- by definition "standard potentials" couple to "standard branes", i.e. branes with 3 or more transverse directions

"Non-standard" Maximal Supergravity

- The (D-2)-form potentials that are dual to the coset scalars are "non-standard". They couple to "defect-branes"
- "non-standard" supergravity contains additional
  - (D-1)-form potentials dual to mass parameters. They couple to domain walls
  - D-form potentials that describe no degrees of freedom at all. They couple to space-filling branes
- all these "non-standard" branes require orientifolds

non-standard supergravity is not complete!

One Approach

- introduce mixed-symmetry fields such as the dual graviton

- "non-standard" Kaluza-Klein monopoles?
  - relation with very extended Kac-Moody algebra E_{11}

P. West (2001)

- alternative approach: "stringy geometry"

Wrapping Rules Standard Geometry

$$\text{any brane} \quad \begin{cases} \text{wrapped} & \rightarrow & \text{undoubled} \\ \text{unwrapped} & \rightarrow & \text{undoubled} \end{cases}$$

Outline

Half-supersymmetric IIA/IIB Branes

- we have classified all half-supersymmetric branes that couple to non-standard potentials
- a light-cone rule selects which components of a T-duality representation correspond to a supersymmetric brane
- we restrict to T-duality representations which contain at least one brane that follows from a brane in ten dimensions
- for these cases we find the following elegant wrapping rules

IIA/IIB Wrapping Rules

$$\mathrm{T}_F \sim 1 : \quad \begin{cases} \text{wrapped} & \rightarrow & \text{doubled} \\ \text{unwrapped} & \rightarrow & \text{undoubled} \end{cases}$$

$$\mathrm{T}_D \sim 1/g_s : \quad \begin{cases} \text{wrapped} & \rightarrow & \text{undoubled} \\ \text{unwrapped} & \rightarrow & \text{undoubled} \end{cases}$$

$$\mathrm{T}_S \sim 1/g_s^2 : \quad \begin{cases} \text{wrapped} & \rightarrow & \text{undoubled} \\ \text{unwrapped} & \rightarrow & \text{doubled} \end{cases}$$

New Wrapping Rules

$$\mathrm{T}_E \sim 1/g_s^3 \; : \quad \begin{cases} \text{wrapped} & \to \quad \text{doubled} \\ \text{unwrapped} & \to \quad \text{doubled} \end{cases}$$

$$\mathrm{T}_{\text{space}-\text{filling}} \sim 1/g_s^4 \; : \quad \text{wrapped} \quad \to \quad \text{doubled}$$

Outline

Heterotic Supergravity

- the field content of half-maximal supergravity plus vector multiplets is determined by the very extended KM algebra SO(8,8+n)

Wrapping Rules

- we have classified the branes of the toroidally compactified heterotic theory and shown that the same wrapping rules apply as in the IIA/IIB case

Duality

heterotic on T^4 $\overset{\text{S-duality}}{\leftrightarrow}$ IIA on K3

- heterotic truncation : $1/(g_s)^\alpha$ with even α
- orbifold truncation : $\text{K3} = T^4/\mathbb{Z}_2 \rightarrow$ even cycles

IIA $\overset{\text{heterotic truncation}}{\rightarrow}$ 10D heterotic

torus $\downarrow$ reduction torus $\downarrow$ reduction

6D IIA $\overset{\text{orbifold truncation}}{\rightarrow}$ 6D heterotic

K3 Wrapping Rules

- the S-duality between heterotic on T^4 and IIA on K3 works, at the level of supersymmetric branes, provided we apply the same wrapping rules as before to (the even cycles of) K3

Outline

Summary

- In this talk I discussed the supersymmetric branes of IIA, IIB and the heterotic theory and showed how the branes in different dimensions are related via the same wrapping rules

- the same wrapping rules work not only for a torus reduction but also for the K3 manifold

Open Issue

- what is the meaning of the wrapping rules ?

- new objects or new geometry ?