Topological D-branes and Matrix Factorisations

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Introduction

- String theory in 4+6 dimensions can be formulated on Calabi-Yau backgrounds
- In the open string sector D-branes will appear as non-perturbative objects
- They can be described in terms of
  - σ-model
  - supergravity
  - conformal field theory
  - Landau-Ginzburg theories

Moduli spaces

- Open string moduli (like D-brane positions) and closed string moduli (like Calabi-Yau parameters) are not independent
- The closed string background determines allowed branes and their moduli space (tree level)
- D-branes: backreaction on closed string moduli space (higher loops)
- What is their connection? How do brane moduli react on closed string deformations?
- Generally this is expected to be encoded in an effective spacetime superpotential which depends on open *and* closed string moduli
- Matrix factorisation technique via Landau-Ginzburg description (topologically twisted)

From CFT to Calabi-Yau

CY		Landau-Ginzburg		CFT
$W(x_i) = 0$	$\longleftrightarrow$	superpotential $W(x_i)$	$\longleftrightarrow$	Gepner models $\otimes_i (N=2)_{k_i}/\mathbb{Z}_d$

- This describes string theory in 4+6 dimensions with $\mathcal{N} = 2$ SUSY, compactified on Calabi-Yau
- Projection on the chiral ring of BPS-states can be done by topological twisting
- These correspondences are well established in the closed string case and partially in the open string case, but only at *special points in moduli space*

Supersymmetric boundary conditions

- Introduction of a boundary breaks $\frac{1}{2}$ of the SUSY
- In order to preserve B-SUSY (Warner problem) one must consider vector bundles
- They have a representation as Chan-Paton factors and contribute to the BRST operator with

$$Q = \begin{pmatrix} 0 & J(x_i) \\ E(x_i) & 0 \end{pmatrix}$$

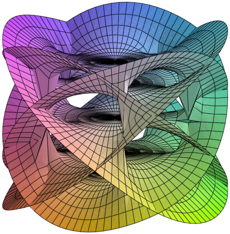
so that $W(x_i) = J(x_i)E(x_i) = E(x_i)J(x_i) = Q(x_i)^2$

- The study of the category of matrix factorisations is a challenging mathematical problem
- Its equivalence to the category of D-branes is an important technical tool

D2-branes on the quintic

- It is possible to construct the open string moduli space perturbatively and sometimes also exactly, e.g. for

$$W = x_1^5 + x_2^5 + x_3^5 + x_4^5 + x_5^5$$



- Using a correspondence to geometric objects on the Calabi-Yau, we can construct the moduli space of 2-branes
- Deformations of the complex structure (closed string background)

$$W = x_1^5 + x_2^5 + x_3^5 + x_4^5 + x_5^5 + \lambda^i G_i(x_1, \dots, x_5)$$

collapses the moduli space to a discrete subspace

Effective Superpotential

- The new moduli space is the vanishing locus of a *bulk induced* effective superpotential

$$\mathcal{W}_{eff} \sim \lambda^i w_i^{(open)}$$

- The expression on the rhs is explicitly known

(in terms of hypergeometric functions)

- By invoking correspondence to CFT we could show that

RG flow = gradient flow of superpotential

- Bulk deformations are in correspondence with differentials on the open string moduli space

Further directions

- Extend the analysis to finite bulk deformations
- Construct explicit examples of open-closed moduli spaces
- Identify flat coordinates on this open-closed moduli space
- This gives information about open-closed Picard Fuchs equations and open-closed mirror symmetry