D-brane Spectrum and K-theory of a $D = 4$, $\mathcal{N} = 1$ Orientifold

John Maiden
University of Wisconsin, Madison

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1 Introduction and Motivation

What are we doing?

- Studying the spectrum of stable branes in an orientifold of the $T^6/\mathbf{Z}_2 \times \mathbf{Z}_2$

Why?

- Torsion charged D-branes and K-theory (Witten, hep-th/9810188; Uranga, hep-th/0011048)
- Important in constructing consistent flux vacua (Marchesano and Shiu, hep-th/0409132)
- Important in the landscape of string vacua (Gmeiner, Honecker, Lust, and Weigand, hep-th/0510170)
- Dark matter candidates (Shiu and Wang, hep-ph/0311228)

2 D-Brane Spectrum

BPS

- Fractional Branes (Untwisted NS-NS, R-R; Twisted NS-NS, R-R):
  - Singly Fractional
  - Totally Fractional
- Bulk Branes (Untwisted NS-NS, R-R)
- Stuck Branes (Untwisted NS-NS, R-R)

Non-BPS

- Torsion Branes (Untwisted NS-NS and/or Twisted NS-NS)
- Truncated/Integrally Charged Branes (Untwisted NS-NS; Twisted R-R)

3 Results

The RR tadpole cancelation condition for this model is

$$D3: \quad \sum_\alpha N_\alpha n_\alpha^1 n_\alpha^2 n_\alpha^3 = 16 \tag{3.1}$$

$$D7: \quad \sum_\alpha N_\alpha n_\alpha^1 m_\alpha^2 m_\alpha^3 = -16 \tag{3.2}$$

$$D7: \quad \sum_\alpha N_\alpha m_\alpha^1 n_\alpha^2 m_\alpha^3 = -16 \tag{3.3}$$

$$D7: \quad \sum_\alpha N_\alpha m_\alpha^1 m_\alpha^2 n_\alpha^3 = -16 \tag{3.4}$$

From Marchesano and Shiu (hep-th/0409132), using a probe brane that fills the non-compact directions, the K-theory constraints are

$$D9: \quad \sum_\alpha N_\alpha m_\alpha^1 m_\alpha^2 m_\alpha^3 \in 4\mathbb{Z} \tag{3.5}$$

$$D5: \quad \sum_\alpha N_\alpha n_\alpha^1 n_\alpha^2 m_\alpha^3 \in 4\mathbb{Z} \tag{3.6}$$

$$D5: \quad \sum_\alpha N_\alpha n_\alpha^1 m_\alpha^2 n_\alpha^3 \in 4\mathbb{Z} \tag{3.7}$$

$$D5: \quad \sum_\alpha N_\alpha m_\alpha^1 n_\alpha^2 n_\alpha^3 \in 4\mathbb{Z} \tag{3.8}$$

The torsion brane spectrum is

D-brane	$(r; s_1, s_2, s_3)$	n^2
D4	$r = 2, s_i = 2, s_j = s_k = 0^\dagger$	$\frac{1}{32}$
D8	$r = 2, s_1 = s_2 = s_3 = 2^\dagger$	$\frac{1}{32}$
D4	$r = 3, s_i = 1, s_j = s_k = 0$	$\frac{1}{32}$
D5	$r = 3, s_i = s_j = 1, s_k = 0$	$\frac{1}{16}$
D5	$r = 3, s_i = 2, s_j = s_k = 0$	$\frac{1}{16}$
D6	$r = 3, s_1 = s_2 = s_3 = 1^\dagger$	$\frac{1}{8}$
D6	$r = 3, s_i = 0, s_j = 1, s_k = 2^\dagger$	$\frac{1}{32}$
D7	$r = 3, s_i = 2, s_j = s_k = 1$	$\frac{1}{16}$
D8	$r = 3, s_i = s_j = 2, s_k = 1$	$\frac{1}{32}$
D9	$r = 3, s_1 = s_2 = s_3 = 2$	$\frac{1}{16}$

Table 1: Stable Torsion branes that only couple to the untwisted NSNS sectors. Branes that are shown to be inconsistent are marked with a dagger.

4 Conclusion and Future Work

Where do we go from here?

- Magnetic Flux
  - D9 branes with Magnetic Flux
  - General Flux Backgrounds
- Building Realistic D-brane Models
  - Different Choices of Discrete Torsion
- Landscape
  - Improved Statistics
- D-matter
  - Both torsion charged and integrally charged candidates