Asymmetric Gepner models in type II superstrings

Dan Israël
LPTHE, Université Pierre et Marie Curie

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D.I., work in progress

Introduction

Type II compactifications with fewer moduli and susy's

- Besides flux compactifications of type II SUGRA ➥ are there models with a better grip on α' corrections ?
- NSNS three-form flux *alone* is not allowed because of the tadpole condition $\int_{\mathcal{M}_6} e^{-2\Phi} H \wedge \star H = 0$

Non-geometric compactifications/asymmetric freely-acting orbifolds

- Some of these constructions provide such examples
- However, there are build upon free theories of bosons and fermions, raising some questions:
  - ★ are they very specific to free CFT's ?
  - ★ do they have a (non-)geometrical interpretation in higher dimension (especially for free-fermion models)?
- Having more sophisticated examples will also teach us about quantum geometry of string theory

Asymmetric Gepner models

- Gepner models provide solvable *interacting* worldsheet theories for Calabi-Yau compactifications (in the stringy regime of negative Kähler moduli)
- As we will explain, one can construct type II asymmetric Gepner models in a rather systematic fashion
- One can expect that the asymmetric Gepner models are still understandable from a CY perspective.

A sufficient condition for non-geometry ?

- We will consider type II models whose spacetime supercharges come only from the left-movers
- SUGRA susy conditions : $\nabla^{\pm}_{M}\epsilon^{\pm} := (\nabla_M \pm \frac{1}{8} H_{MNP}\Gamma^{MNP})\epsilon^{\pm} = 0$
  - ➥ one would need that ∇_+ has special holonomy ($SU(3)$ in $d=6$) but not ∇_-, giving an $SU(3)$-structure compactification
  - ➥ Contradicts the statement that H-flux alone is not allowed

★ No standard SUGRA interpretation (*i.e.* geometric) is possible

Outline

Gepner models in a nutshell

$\mathcal{N} = (2,2)$ minimal models

- $\mathfrak{M}_k$ is an $\mathcal{N} = (2,2)$ superconformal field theories in two dimensions with central charges $c_L = c_R = 3 - \frac{6}{k}$, $k \in \{2, 3, \ldots\}$
- Splitting the Ramond and Neveu-Schwarz sectors according to the fermion number mod 2 ➥ coset CFT $(SU(2)_{k-2} \times U(1)_2)/U(1)_k$.
- Primary states are labelled by the triplet (j, m, s) with $2j = 0, \ldots, k-2$, $m \in \mathbb{Z}_{2k}$ and $s \in \mathbb{Z}_4$ (s even is NS, s odd is R)
- Primaries have and R-charge and conformal dimension

$$Q_R \equiv \frac{s}{2} - \frac{m}{k} \mod 2 \, , \quad \Delta \equiv \frac{s^2}{8} + \frac{4j(j+1) - m^2}{4k} \mod 1$$

Chiral rings

★ *Antichiral primaries* with $m = 2j$, $s = 0$ ➥ $h = -\frac{1}{2} Q_R = \frac{j}{k}$

★ *Chiral primaries* with $m = 2(j+1)$, $s = 2$ ➥ $h = \frac{1}{2} Q_R = \frac{1}{2} - \frac{j+1}{k}$

Building type II Gepner models

- Compactification to $d = 10 - 2n$ ➥ internal CFT with $c_L = c_R = 3n$
- Tensor product SCFT $\prod_{i=1}^{r} \mathfrak{M}_{k_i}$ with $3r - 6\sum_{i=1}^{r} \frac{1}{k_i} = 3n$
- Representations of the chiral algebra associated with the characters

$$\phi_{\mu}^{\lambda\,(\sigma)}(q) := \prod_{i=1}^{r} C_{m_i}^{j_i\,(s_i)}(q) \quad ➥ \quad Q_R(\mu,\sigma) \equiv \sum_{i=1}^{r}\left(\frac{s_i}{2} - \sum_{i=1}^{r}\frac{m_i}{k_i}\right) \mod 2$$

- Type II string compactification : $Q_R, \bar{Q}_R \in 2\mathbb{Z}+1$ and all chiral fermions in the same (NS or R) sector ➥ generalized GSO projection.

Gepner modular invariant ($K3 \times T^2$ example)

$$Z = \frac{1}{2^r}\sum_{\lambda,\mu,s_i}\sum_{b_0\in\mathbb{Z}_K, b_i\in\mathbb{Z}_2}(-1)^{b_0}\frac{\Theta_{s_0,2}(q)\Theta_{s_0+b_0+2\sum_{i=1}^{5}b_i,2}(\bar{q})}{\tau_2^{2}\eta^3\bar{\eta}^3}\,\frac{\Theta_{s_5,2}(q)\Theta_{s_5+b_0+2b_5,2}(\bar{q})\Gamma_{2,2}}{\eta^2\bar{\eta}^2}$$

$$\phi_{\mu}^{\lambda\,(\sigma)}(q)\,\phi_{\mu+\beta_0 b_0}^{\lambda\,(\sigma+b_0\beta_0+2\sum_i b_i\beta_i)}(\bar{q})\,\delta^{(1)}\left(\frac{Q_R-1}{2}\right)\prod_{i=1}^{5}\delta^{(1)}\left(\frac{s_0-s_i}{2}\right)$$

$K = \mathrm{lcm}\,(4, 2k_1, \ldots, 2k_r)$, $\beta_0 = (1,\ldots,1)$, $\beta_i = (0,\ldots,0,2,0,\ldots,0)$

- Generalized GSO induces twisted sectors labelled by b_0 and $\{b_i\}$.

Geometry & moduli

- A Gepner model $\prod_{i=1}^{r} \mathfrak{M}_{k_i}$ is believed to be the IR fixed point of the Landau-Ginzburg orbifold $(W(X_i) = \sum_{i=1}^{r} {X_i}^{k_i})/\mathbb{Z}_N$, $N = \text{lcm}(k_i)$.
- The latter is obtained in the regime $\text{Re}(t) \to -\infty$ of a $U(1)$, $\mathcal{N} = (2,2)$ gauged-linear sigma model with FI parameter t
- best described in the regime $\text{Re}(t) \gg 1$ as the Calabi-Yau sigma-model corresponding to the hypersurface $W(X_i) = 0$ in $\mathbb{CP}^{n+1}$ with complexified Kähler modulus t.
- Moduli space of non-linear sigma models on CY_3 spanned by the marginal chiral states (complex structure moduli space) and twisted chiral states (Kähler moduli space)
- Example: in the untwisted sector, marginal (a,a) states have $m_i = 2j_i$, $s_i = 0$ and are such that $\sum_i \frac{j_i}{k_i} = \frac{1}{2}$

  ➥ mapped to the monomial deformations $X_1^{2j_1} \ldots X_r^{2j_r}$ of $W(X_i)$

Some generalizations

- One has chosen the *diagonal* $SU(2)_{k_i-2}$ modular invariant for each minimal model ➥ one can use any of the ADE modular invariants
- New models by orbifoldizing a subgroup of the discrete global symmetry of the model $(\prod_i \mathbb{Z}_{k_i})/\mathbb{Z}_N$ ➥ CY orbifolds
- *Discrete torsion*, *i.e.* extra phases in the twisted sectors, can be added to the orbifold partition function.
- Conveniently described in the *simple current* formalism (more later)
- In the heterotic case, many such asymmetric constructions have been explored (Schellekens & collaborators)
- Orientifolds compactifications based on Gepner models have been studied also in depth (Brunner, Hori, Hosomichi & Walcher)
- Suprisingly, the type II asymmetric models that we shall present now were not investigated (as far as I know)

Asymmetric constructions: $K3 \times T^2$ models

The idea

- This first construction relies on a very simple observation:

Minimal models characters $C_m^{j\,(s)}(q)$ behave as $\chi^j(q)\Theta_{s,2}(q)\Theta_{m,k}(\bar{q})$ under modular transformations, as far as the (j,m,s) labels are concerned

- Comes from the implicit definition of minimal model characters $\chi^j \Theta_{s,2} = \sum_{m \in \mathbb{Z}_{2k}} C_m^{j\,(s)} \Theta_{m,k}$, where χ^j is an $SU(2)_{k-2}$ character.
- One can then replace, in the $K3 \times T^2$ partition function, the contribution of $S^1 \times \mathfrak{M}_{k_i}$ (the circle being at radius $\sqrt{\alpha' k_i}$) as

$$\frac{\Gamma_{1,1}(q,\bar{q})}{|\eta|^2} C_{m_i}^{j_i\,(s_i)}(q)\, C_{m_i+b_0}^{j_i\,(s_i+b_0+2b_i)}(\bar{q}) \longrightarrow$$

$$\frac{1}{|\eta|^2} C_{m_i}^{j_i\,(s)}(q) \left(\Theta_{m_i+b_0,k_i}\, \chi^{j_i}(\bar{q})\, \Theta_{s_i+b_0+2b_i,2}(\bar{q}) \right)$$

$$= \sum_{\bar{m}_i \in \mathbb{Z}_{k_i}} \frac{\Theta_{m_i+b_0,k_i}(q)\Theta_{\bar{m}_i,k_i}(\bar{q})}{|\eta|^2} C_{m_i}^{j_i\,(s_i)}(q)\, C_{\bar{m}_i}^{j_i\,(s_i+b_0+2b_i)}(\bar{q})$$

- Sort of asymmetric freely-acting orbifold

Models

- For each of the 14 Gepner models for $K3$ ➥ one has two chose which pair of minimal models is 'twisted'
- List of 62 inequivalent asymmetric Gepner models for $K3 \times T^2$ (last two are twisted)

(2, 3, 10, 15), (2, 10, 3, 15), (2, 15, 3, 10), (3, 10, 2, 15), (3, 15, 2, 10), (10, 15, 2, 3)
(2, 3, 8, 24), (2, 8, 3, 24), (2, 24, 3, 8), (3, 8, 2, 24), (3, 24, 2, 8), (8, 24, 2, 3)
(2, 3, 9, 18), (2, 9, 3, 18), (2, 18, 3, 9), (3, 9, 2, 18), (3, 18, 2, 9), (9, 18, 2, 3)
(2, 3, 7, 42), (2, 7, 3, 42), (2, 42, 3, 7), (3, 42, 2, 7), (7, 42, 2, 3), (3, 7, 2, 42)
(2, 4, 6, 12), (2, 6, 4, 12), (2, 12, 4, 6), (4, 12, 2, 6), (6, 12, 2, 4), (4, 6, 2, 12)
(2, 4,5, 20), (2, 5, 4, 20), (2, 20, 4,5), (5, 20, 2, 4), (4, 5, 2, 20), (4, 20, 2, 5)
(2, 3, 12, 12), (2, 12, 3, 12), (12, 12, 2, 3), (3, 12, 2,12)
(3, 3, 4, 12), (3, 4, 3, 12), (3, 12, 3, 4), (4, 12, 3, 3)
(2, 5, 5, 10), (2, 10, 5, 5), (5, 5, 2, 10), (5, 10, 2, 5)
(2, 4, 8, 8), (2, 8, 4, 8), (8, 8, 2, 4), (4, 8, 2, 8)
(3, 4, 4, 6), (3, 6, 4, 4), (4, 4, 3, 6), (4, 6, 3, 4)
(3, 3, 6, 6), (3, 6, 3, 6), (6, 6, 3, 3)
(2, 6, 6, 6), (6, 6, 2, 6)
(4, 4, 4, 4)

- As we will see, 33 of them give exactly the same low-energy spectrum

Space-time susy & Ramond ground states

Relevant piece of the partition function for the discussion

$$\prod_{i=1}^{2} C_{m_i}^{j_i\,(s_i)}\ \bar{C}_{m_i+b_0}^{j_i\,(s_i+b_0+2b_i)} \prod_{i=3}^{4} \sum_{\bar{m}_i \in \mathbb{Z}_{k_i}} \Theta_{m_i+b_0,k_i} \bar{\Theta}_{\bar{m}_i,k_i}\ C_{m_i}^{j_i\,(s_i)}\ \bar{C}_{\bar{m}_i}^{j_i\,(s_i+b_0+2b_i)} \times \delta^{(1)}\left(\sum \frac{s_i}{4} - \sum \frac{m_i}{2k_i} - \frac{1}{2}\right)$$

- On the left-moving side ➥ the generalized GSO projection onto odd-integer R-charge still provides two spacetime supersymmetries
- On the right moving side, since $\bar{m}_{3,4}$ are unconstrainted, the right R-charge is not integer-valued ➥ no spacetime susy from the right
- Explicitely, the right Ramond ground states get a mass shift from the twisted T^2 lattice
- The right gravitinos are in the sector $j_i = 0, m_i = 0,\ s_i = 1 \mod 2$ and $b_0 = 1$ ➥ mass $M = \sqrt{\frac{1}{\alpha' k_3} + \frac{1}{\alpha' k_4}}$
- All the models have $\mathcal{N} = 2$ space-time supersymmetry, and no massless RR states.

Massless spectra

- On the left, one still looks for chiral states with $Q_R = \sum_i \frac{2j_i}{k_i} = 1$, but there exists an important new constraint : the mass shift from the twisted torus lattice should vanish

$$2j_3 + b_0 \equiv 0 \mod 2k_3 \ , \quad 2j_4 + b_0 \equiv 0 \mod 2k_4$$

- For each such left chiral states, one looks for right states of dimension 1/2 (not necessarily chiral in principle)
  ➥ one finds that only the subset of the original massless states satifying the above conditions are massless (both untwisted & twisted)
- The theory has a right $SU(2)_{k_3-2} \times SU(2)_{k_4-2}$ affine symmetry, leaving invariant the massless states but acting on the massive spectrum
- As the $U(1)^2$ affine currents of the T^2 CFT are not lifted, one can move away from this extended symmetry point
  ➥ generically gravitini masses are $M = \sqrt{\frac{T_2}{U_2} + \frac{(T_1 \pm 1)^2}{U_2 T_2}}$.

Scan of all models

- All the models have an $\mathcal{N} = 2$ supergravity multiplet, and three vector multiplets (STU) corresponding to the torus moduli and to the axio-dilaton
- Out of the 62 inequivalent asymmetric Gepner models, 33 don't have any other multiplets

  ➥ STU supergravity at low energies
- The other 29 models have some sporadic hypermultiplets corresponding to the surviving K3 moduli, with no regular pattern
- Unlike type II compactifications on CY_3, the dilaton sits in a vector multiplet ➥ the hypermultiplets moduli space receives no quantum corrections
- Are there other descriptions under STU triality (*e.g.* in heterotic) ?
  ★Heterotic duals, if any, should have some nonperturbative nature (as U and S are exchanged).

Simple currents and three-folds constructions

Simple current extensions & discrete torsion

As often, finding generalizations requires a bit of formalism

- A *simple current* J is a primary such that by fusion with a generic primary (in particular with themselves) gives a single primary : $J \star \phi_\mu = \phi_\nu$
- In a rational CFT a simple current $J_\imath$ generates an final Abelian group $\mathbb{Z}_{n_\imath}$, $n_\imath$ being the *length* of the simple current
- The action of a simple current on a primary defines its *monodromy charge* $Q_\imath(\mu) = \Delta(\phi_\mu) + \Delta(J_\imath) - \Delta(J_\imath \star \phi_\mu) \mod 1$
- Two-currents are *mutually local* if $Q_\imath(J_\jmath) = 0$

Minimal models simple currents

- Simple currents $J_{m,s}$ of the mininimal models : primaries of quantum numbers $(j = 0, m, s)$

$$J_{m,s} \star V^{j'\,(s')}_{m'} = V^{j'\,(s'+s)}_{m'+m} .$$

- $\mathfrak{L}_{m,s}$, the length of the orbit generated by the simple current $J_{m,s}$, is the smallest integer such that (for odd k)

$$\mathfrak{L}_{m,s} s \equiv 0 \mod 4,\ \mathfrak{L}_{m,s} m \equiv 0 \mod 2k$$

- The diagonal partition function of a given RCFT can be extended by a set of simple currents $\{J_\imath, \imath = 1, \ldots, M\}$ as

$$Z = \sum_\mu \prod_{\imath=1}^{M} \sum_{b_\imath \in \mathbb{Z}_{n_\imath}} \phi_\lambda(q)\, \phi_{\lambda + \sum_{\imath=1}^{M} \beta_\imath b_\imath}(\bar{q})\, \delta^{(1)}\left(Q_\imath(\mu) + X_{\imath\jmath} b_\jmath\right),$$

  with $\beta_\imath$ such that $J_\imath \star \phi_\mu = \phi_{\mu+\beta_\imath}$.
- The selection rule depends on the ($\mathbb{Q}$-valued) $M \times M$ matrix $X_{\imath\jmath}$ whose symmetric part is determined by the relative monodromies of the currents:

$$X_{\imath\jmath} + X_{\jmath\imath} = Q_\imath(J_\jmath) \mod 1$$

- The antisymmetric part, called *discrete torsion*, should merely be such that for all entries of X

$$\gcd(n_\imath, n_\jmath)\, X_{\imath\jmath} \in \mathbb{Z}$$

- If the left and right Kernels of X are different, the simple-current extended modular invariant is asymmetric.

$K3 \times T^2$ asymmetric models as simple current extensions

Aim of the exercise : asymmetric $K3 \times T^2$ models from a simple current extension

- One starts with an ordinary Gepner model for $K3 \times T^2$ with torus moduli $U = i\alpha' \sqrt{k_3 k_4}$, $T = i\sqrt{\frac{k_4}{k_3}}$

  ➥ rational torus $U(1)_{k_3} \times U(1)_{k_4}$ with extended chiral algebra
- A generic simple current of the model has quantum numbers (α, β left $\mathbb{Z}_{2k_3} \times \mathbb{Z}_{2k_4}$ charges of the T^2)

  $$(j_1 = 0, \ldots, j_4 = 0; s_0, \ldots, s_5; m_1, \ldots, m_4; \alpha, \beta)$$
- The usual Gepner model is a simple current extension with

$$\begin{aligned} J_0 &= (0, \ldots, 0; 1, \ldots, 1; 1, \ldots, 1; 0, 0) \\ J_i &= (0, \ldots, 0; 2, 0, \ldots, 0, 2, 0, \ldots, 0; 0, \ldots, 0; 0, 0)\ , \quad \text{i=1,...,4} \end{aligned}$$

- The J_0-extension enforces the generalized GSO projection, while the J_i extensions align the all fermions in the Ramond or Neveu-Schwarz sector

- We add a simple current extension that is *not mutually local with the Gepner simple current* J_0, but local with respect to the simple currents $\{J_i\}$

$$J_\alpha = (0,\ldots,0;0,\ldots,0;0,0,\mathbf{2},0;\mathbf{2},0)$$
$$J_\beta = (0,\ldots,0;0,\ldots,0;0,0,0,\mathbf{2};0,\mathbf{2})$$

- One checks that $Q_0(J_\alpha)=1/k_3$ and $Q_0(J_\beta)=1/k_4$

➥ $X^{sym}_{0\alpha}=\frac{1}{2k_3}$ and $X^{sym}_{0\beta}=\frac{1}{2k_4}$

- This non-locality messes up the GSO projection, which is shifted in the twisted sector as $\delta^{(1)}\left(\frac{Q_R-1}{2}+X_{0\alpha}B_\alpha+X_{0\beta}B_\beta\right)$
- A specific choice of discrete torsion, such that $X_{0\alpha}=X_{0\beta}=0$, preserves projection onto $Q_R\in 2\mathbb{Z}+1$ states on the left

$$Z=\frac{1}{\tau_2^2|\eta|^4}\frac{1}{2^r}\sum_{\lambda,\mu}\sum_{b_0\in\mathbb{Z}_K}(-1)^{b_0}\delta^{(1)}\left(\frac{Q_R-1}{2}\right)\sum_{r_\alpha\in\mathbb{Z}_{k_3}}\delta^{(1)}\left(\frac{m_3-n_\alpha+\mathbf{b_0}}{k_3}\right)\sum_{r_\beta\in\mathbb{Z}_{k_4}}\delta^{(1)}\left(\frac{m_4-n_\beta+\mathbf{b_0}}{k_4}\right)$$
$$\sum_{B_\alpha\in\mathbb{Z}_{k_3},B_\beta\in\mathbb{Z}_{k_4}}\prod_{i=1}^{r+1}\sum_{b_i\in\mathbb{Z}_2}\delta^{(1)}\left(\frac{s_0-s_i}{2}\right)\phi^\lambda_\mu(q)\,\phi^\lambda_{\mu+\beta_0b_0+\sum_{i=1}^{r+1}\beta_ib_i+\mathbf{B}_\alpha\mathbf{b_3}+\mathbf{B}_\beta\mathbf{b_4}}(\bar{q}) \quad (1)$$

★ However right R-charges no longer odd integers in the new twisted sectors $(B_\alpha\neq 0, B_\beta\neq 0)$

★ $X_{\alpha 0}=\frac{1}{k_3}$, $X_{\beta 0}=\frac{1}{k_4}$ ➥ right gravitini get a mass from the T^2 lattice.

Asymmetric CY three-folds

- Start with a Gepner model for a CY 3-fold. We also consider an extension with a simple current that is *not* mutually local with J_0

$$I = (j_1 = 0, \dots, j_5 = 0; s_0 = 0, \dots, s_5 = 0; m_1 = \nu_1, \dots, m_5 = \nu_5)$$

- Abelian group isomorphic to $\mathbb{Z}_N$ with $N = \text{lcm}\left(\frac{\text{lcm}(\nu_i, 2k_i)}{\nu_i}\right)$
- One checks that $Q_0(I) = \frac{1}{2}\sum_i \frac{\nu_i}{k_i} \mod 1$
- As before one can restore the left GSO projection by adding a specific discrete torsion, giving a lower-triangular X-matrix with non-zero entries

$$X_{II} = \frac{1}{4}\sum_i \frac{\nu_i^2}{k_i} \quad , \qquad X_{I0} = \frac{1}{2}\sum_i \frac{\nu_i}{k_i}$$

- Defines a consistent model as long as $\nu_i := 2\rho_i \in 2\mathbb{Z}$, $i = 1, \dots, 5$.

The partition function for the CY_3 Gepner model extended with the simple current I reads then, with $\beta_I = (2\rho_1, \dots, 2\rho_5)$

Asymmetric CY_3 Gepner model

$$Z = \frac{1}{\tau_2^2 |\eta|^2} \frac{1}{2^5} \sum_{\lambda,\mu} \sum_{b_0 \in \mathbb{Z}_K} (-1)^{b_0} \, \delta^{(1)} \left(\frac{Q_R - 1}{2} \right) \sum_{B \in \mathbb{Z}_N} \boldsymbol{\delta}^{(1)} \left(\sum_{\mathbf{i=1}}^{\mathbf{r}} \frac{\boldsymbol{\rho}_\mathbf{i}(\mathbf{m}_\mathbf{i} + \mathbf{b}_\mathbf{0} + \boldsymbol{\rho}_\mathbf{i} \mathbf{B})}{\mathbf{k}_\mathbf{i}} \right)$$
$$\prod_{i=1}^{r} \sum_{b_i \in \mathbb{Z}_2} \delta^{(1)} \left(\frac{s_0 - s_i}{2} \right) \Theta_{s_0,2}(q) \, \Theta_{s_0 + b_0 + \sum_i b_i, 2}(\bar{q}) \, \phi^{\lambda}_{\mu}(q) \, \phi^{\lambda}_{\mu + \beta_0 b_0 + \sum_{i=1}^{r+1} \beta_i b_i + \boldsymbol{\beta}_\mathbf{I} \mathbf{B}}(\bar{q})$$

- On the left there is still a projection onto states with odd integral R-charge ➥ one gravitino
- On the right the R-charge of a generic state is non-integer $\bar{Q}_R = 1 + 2B \sum_{i=1}^{r} \frac{\rho_i}{k_i} \mod 2$
- The would-be massless 'right' gravitino would have $2j_i = m_i = s_i = B = 0$ and $b_0 = 1$ but the projection $\sum_{i=1}^{r} \frac{\rho_i}{k_i} = 0 \mod 1$ is not satisfied generically.

★ *Type II compactifications with $\mathcal{N} = 1$ space-time susy*

Conclusions and future directions

Conclusions

- Somewhat suprisingly, there were still unexplored corners of Gepner model constructions nearly 30 years after their discovery.
- The asymmetric Gepner model construction provides examples of type II vacua whose space-time supersymmetry comes only from the left-movers on the worldsheet
- It indicates, as argued earlier, that these compactifications cannot have a standard geometrical interpretation
- At least in the $K3 \times T^2$ case (for which the relevant computations have been done) the (freely-acting) quotient lifts many, if not all, the moduli of the underlying CY compactification
- In these constructions, there are also no Ramond-Ramond fluxes available
- Standard orientifold compactifications (Pardisi-Sagniotti-Stanev open descendants) are not compatible with the discrete torsion

Directions for future work

- Analyze the asymmetric three-folds in detail
- Understand the asymmetric models from the four-dimensional effective supergravity of CY compactifications with Q or R gaugings
- Is there a ten-dimensional picture in terms of generalized geometry ?
- Can this formulation being extended to heterotic models, for which the asymmetric constructions are ubiquitous ?
- Are there more sophisticated orientifold parity symmetries that are consistent with these models ? (remark : no RR tadpoles here)