Correlations in the Landscape

Florian Gmeiner

(NIKHEF, Amsterdam)

work in progress; some stuff in

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Outline

1. Introduction
2. Correlations
3. Models
4. Results
   - Δ^+ vs Δ^-
   - χ^{Sym} vs. χ^{Anti}
5. Conclusions

The Landscape

Problems

- It is too big to analyse with a case-by-case strategy
  $\rightsquigarrow$ approximations, statistics.
- How to make predictions?
  $\rightsquigarrow$ Selection mechanism / Anthropic reasoning?

"Bottom-up" approach

- No assumptions about underlying mechanisms.
- Search for correlations between 4d properties.
- Compare results of (large numbers) of different models.

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Correlations

Methods

Obtain statistical results about correlations between 4d properties in large sets of models by

- complete computation of all possible solutions (impossible) or
- choosing subsets in parameterspace, preferably completely at random. Due to computational complexity a random choice is not always possible.

Correlations

Caveats

The choice of subsets could influence the result
$\rightsquigarrow$ *unwanted correlations* $\rightsquigarrow$ make sure that one either

- uses subsets with the same probability density as the full set of solutions (hard) or
- uses different weights for the subsets (harder)

In any case one should repeat the analysis for a large set of subsets to minimise statistical error.

Models

- Type II orbifolds with D6–branes, $M^6 = T^6/G$ with $G \in \{\mathbb{Z}_2 \times \mathbb{Z}_2, \mathbb{Z}_6, \mathbb{Z}_6'\}$.

  [many people; see also talks by D. Bailin, G. Honecker]

- $N = 1$ susy, tadpoles cancelled.
- 4d properties accessible to algebraic methods:
  - gauge group
  - massless matter spectrum (chiral & non–chiral)
  - gauge couplings
- Compare with results of Gepner-Models. [Thesis of Tim Dijkstra]

Chiral matter

As an example we will use the chiral matter spectrum. Number of massless chiral matter states for branes a and b, wrapping cycles π_a and π_b in

- *bifundamental* reps.: $\chi^{ab} = \pi_a \circ \pi_b$,
- *symmetric* reps.: $\chi^{Anti_a} = \frac{1}{2} \left(\pi_a \circ \pi_{a'} - \pi_a \circ \pi_{O6} \right)$,
- *antisymmetric* reps.: $\chi^{Sym_a} = \frac{1}{2} \left(\pi_a \circ \pi a' + \pi_a \circ \pi_{O6} \right)$.

No restrictions imposed on the spectrum, all possibible models are considered.

Obdervables for correlations

- As a toy example we consider the correlations of values of

$$\Delta^{\pm} := \chi^{ab} \pm \chi^{ab'}$$

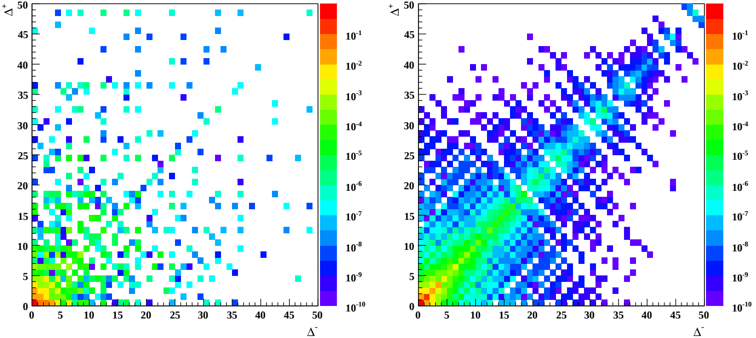
  and χ^{Anti_a} / χ^{Sym_a} for different constructions.
- Compare the results with those for a *random pairing* of the same set of branes.

Choice of samples

Different strategies to obtain statistical results are used:

- For $T^6/\mathbb{Z}_2 \times \mathbb{Z}_2$ ($\mathcal{O}(10^{10})$ models) we use an explicit cutoff in the parameter space.
- For $T^6/\mathbb{Z}_6$ ($\mathcal{O}(10^{28})$) and $T^6/\mathbb{Z}_6'$ ($\mathcal{O}(10^{23})$ models) we use several random samples of different sizes.
- The Gepner models are a subset of models containing a realisation of the standard model *without tadpole cancellation* checked. This is a *biased subset*.

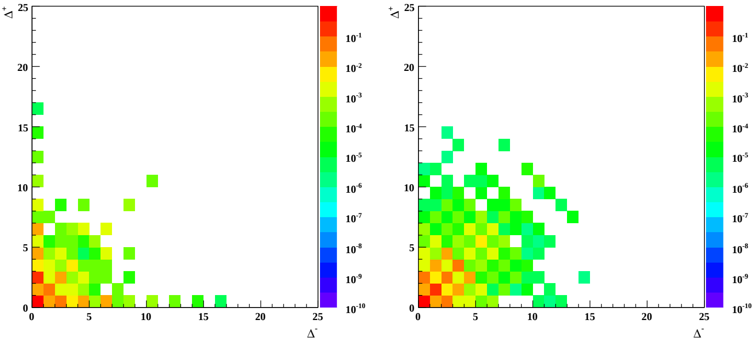
Δ^+ vs Δ^-



Correlation between number of bifundamental matter representations on $T^6/\mathbb{Z}_2 \times \mathbb{Z}_2$.

Left: actual result, right: random distribution.

Δ^+ vs Δ^-



Correlation between number of bifundamental matter representations on $T^6/\mathbb{Z}_6$.

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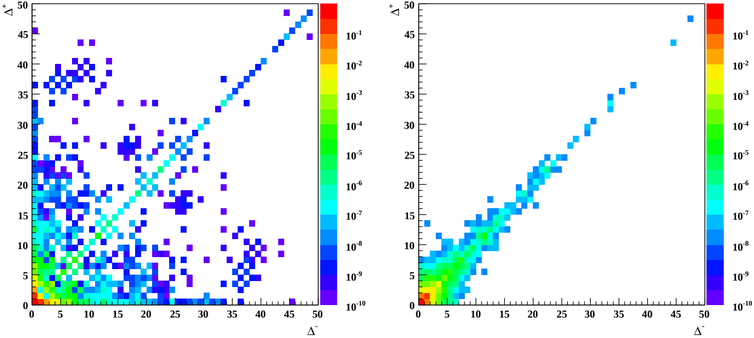
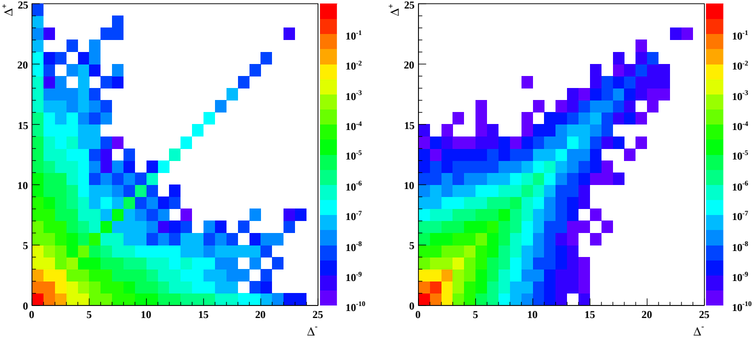


Correlation between number of bifundamental matter representations on $T^6/\mathbb{Z}_6'$.

Left: actual result, right: random distribution.

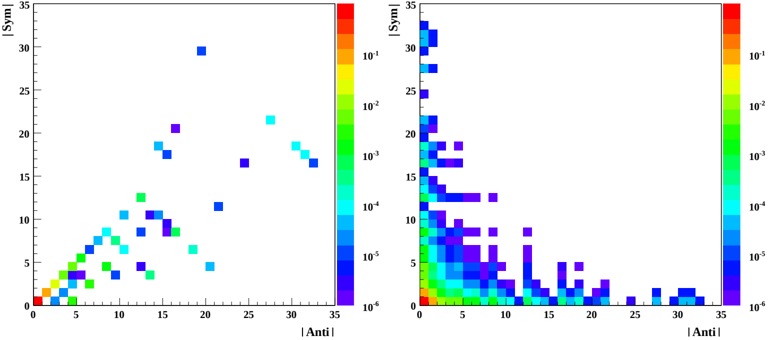
Δ^+ vs Δ^-



Correlation between number of bifundamental matter representations in Gepner subset.

Left: actual result, right: random distribution.

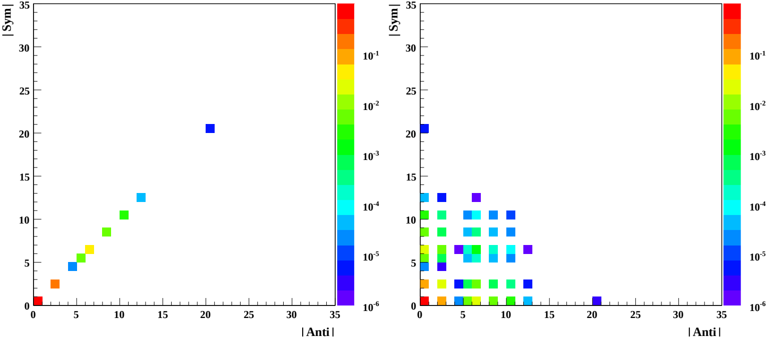
χ^{Sym} vs. χ^{Anti}



Correlation between number of symmetric and antisymmetric representations on $T^6/\mathbb{Z}_2 \times \mathbb{Z}_2$.

Left: actual result, right: random distribution.

χ^{Sym} vs. χ^{Anti}



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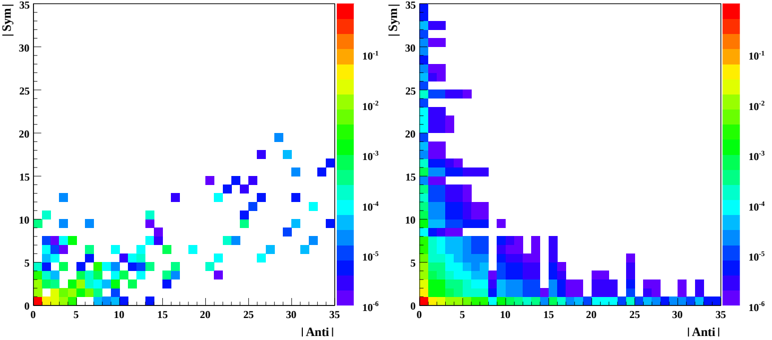

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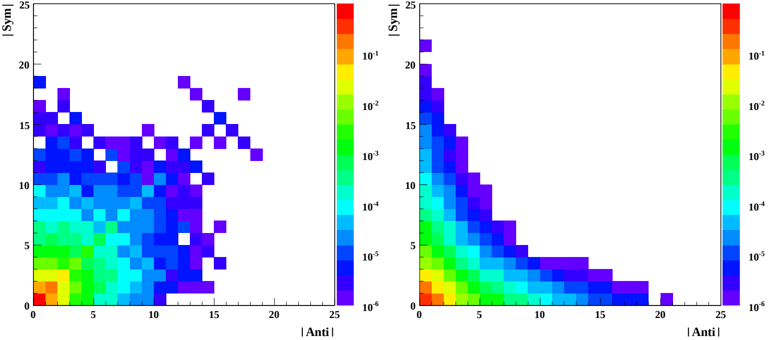

Correlation between number of symmetric and antisymmetric representations in Gepner subset.

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Conclusions

Summary

- Using a very simple example we showed that interesting correlations might exist.
- If true in a wider range of constructions this could lead to interesting insights into the structure of the Landscape.

Outlook

- More systematic approach using a bigger class of observables.
- Include more sophisticated compactifications, in particular also heterotic ones.

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