Heterotic model-building and F-theory duality

Callum Brodie
with Andre Lukas and Andreas Braun

Outline

Plan:
an overview of some general themes
in the context of one project

1. Idea of string model-building

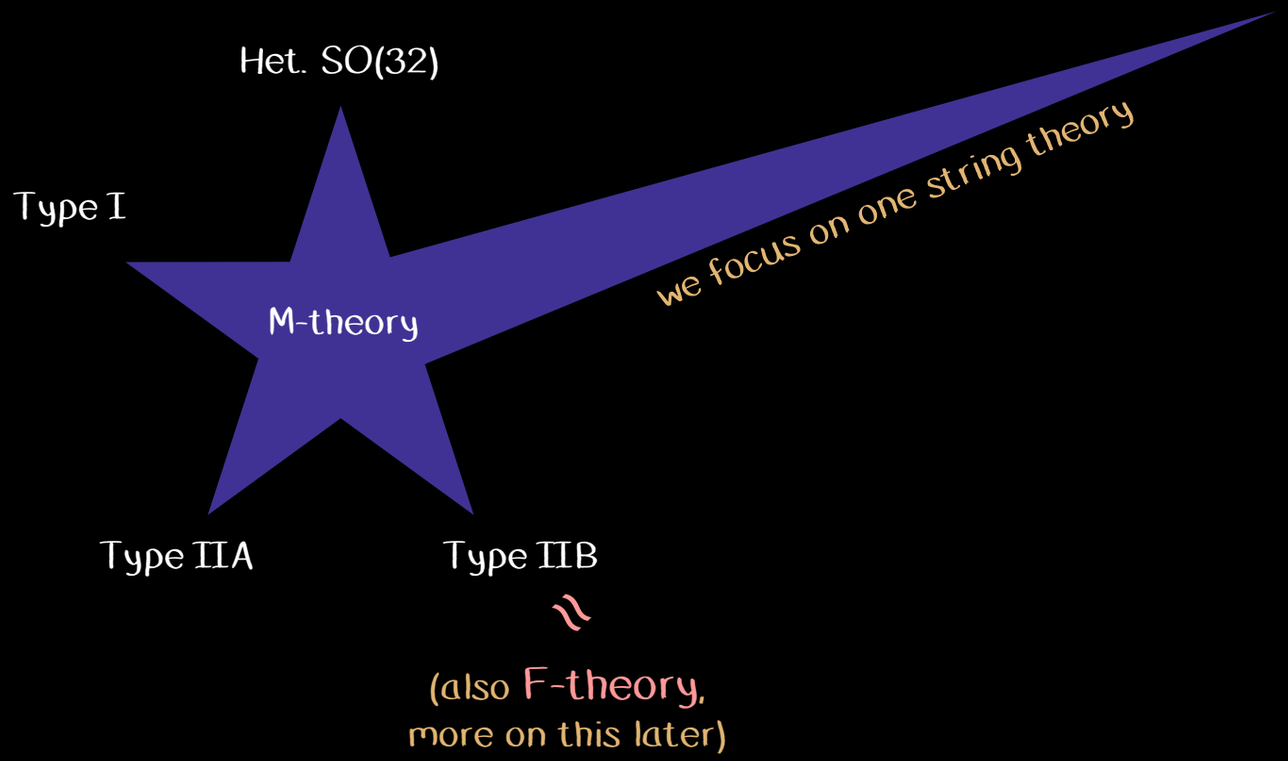
2. Line bundle sum models
(One popular model-building route)

3. Current state of model-building, difficulties to be overcome

4. Heterotic/F-theory duality and possible uses

Note:  will denote a technical slide

Heterotic $E_8 \times E_8$



Heterotic $E_8 \times E_8$

reduces

at lower

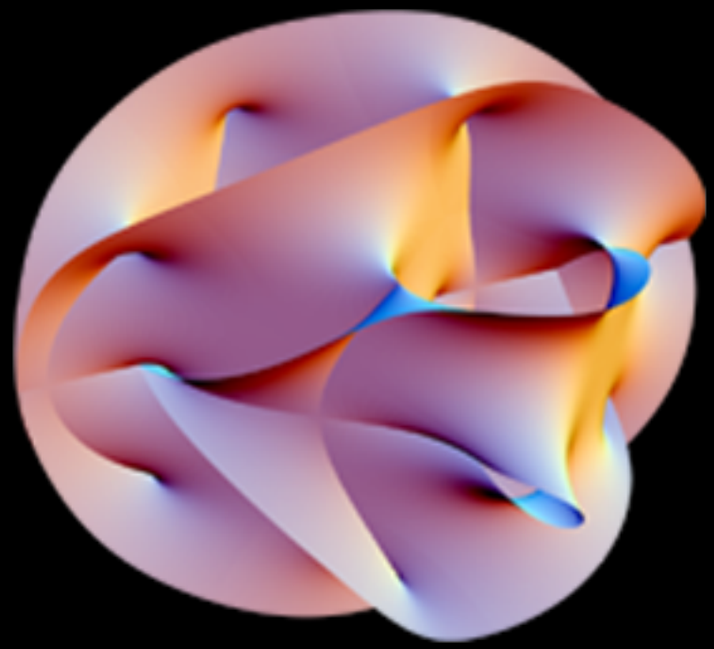
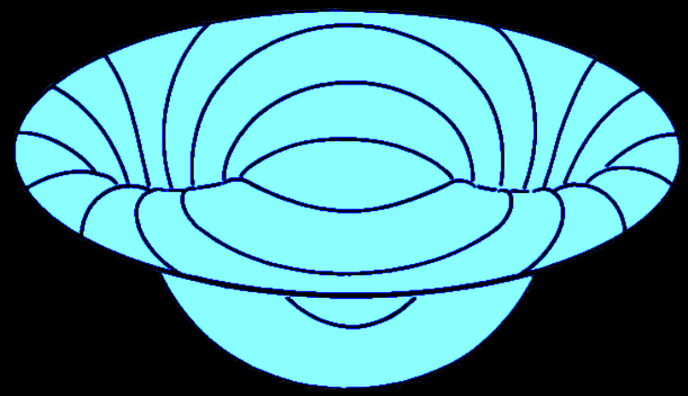
energies

N=1 SUGRA (EFT)

Field content:

- Gauge fields
- Fermions
- etc ...

Heterotic model-building

$\mathcal{L}_{\text{eff.}}$ +  + 

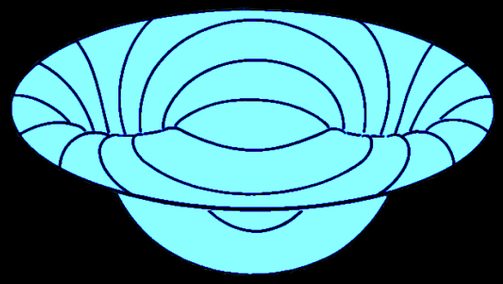
Low-energy theory in 10d

Compactification space

Field configurations

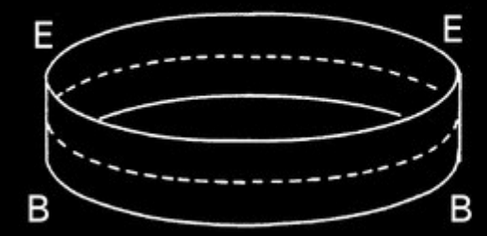
= Standard Model ?

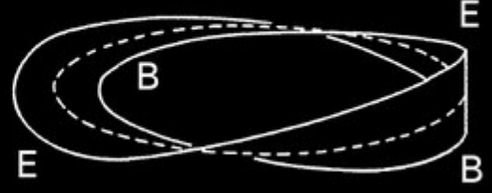
Field configurations and line bundle sums



Gauge field strength configuration

Choice of vector bundle





Simple choice: line bundle sum

$$V = \bigoplus_{i=1}^{n} L_i$$

- Properties easier to compute
- Can be enumerated
- Can be scanned over

advantages

Route to the Standard Model

1. Get correct field content and gauge group.

2. Avoid disaster.

3. Get correct couplings.

State of heterotic model-building

1. Get correct field content and gauge group.

   Fairly well developed.

2. Avoid disaster.

   Doable on per-model basis.

3. Get correct couplings.

   Still quite far off.

Moduli stabilisation

One approach:
Yukawa couplings by duality

Hard to compute Yukawa couplings in heterotic $E_8 \times E_8$

Use another approach...

Het. $E_8 \times E_8$ ⟷ F-theory

Duality

Hard to compute Yukawa couplings over here

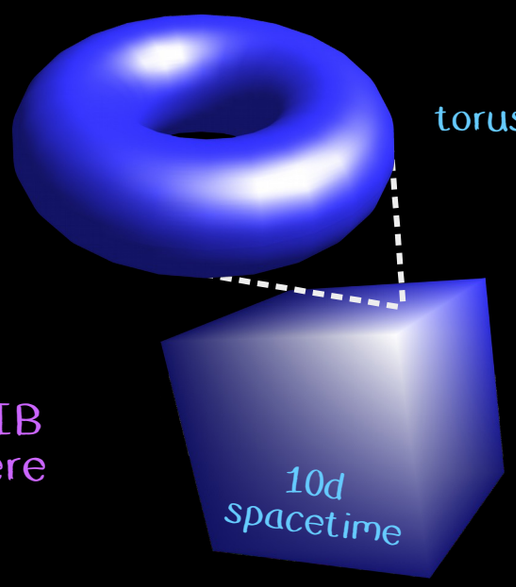
Easier to compute Yukawa couplings over here

But this requires working with a certain class of compactifications

Heterotic/F-theory duality

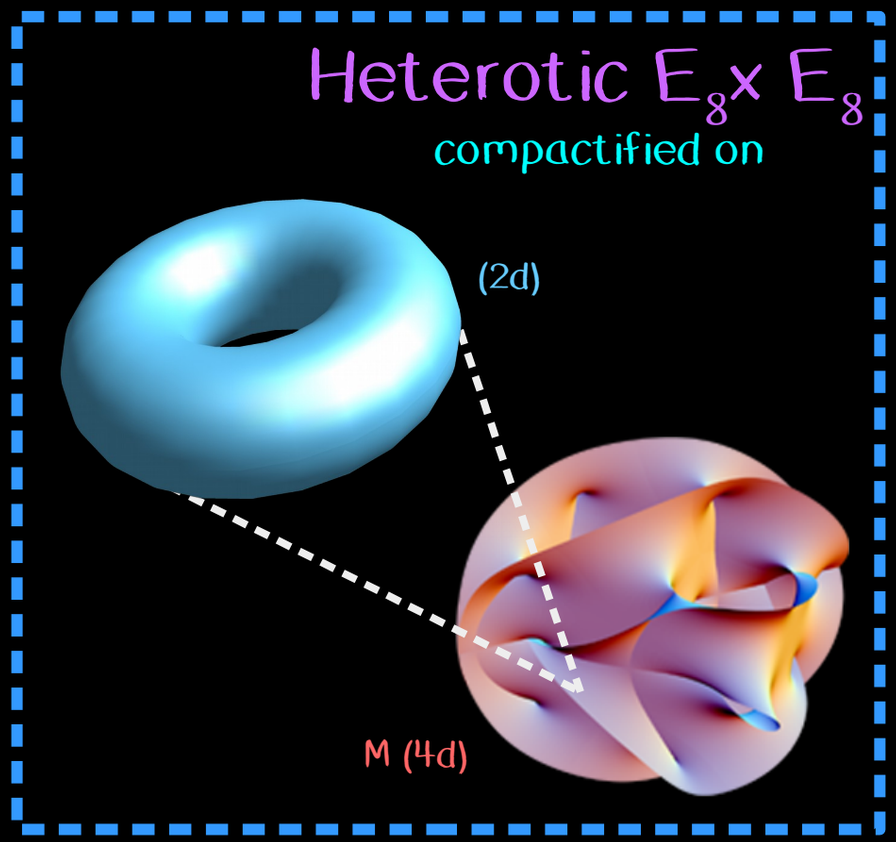
What is F-theory?

torus geometrises a field

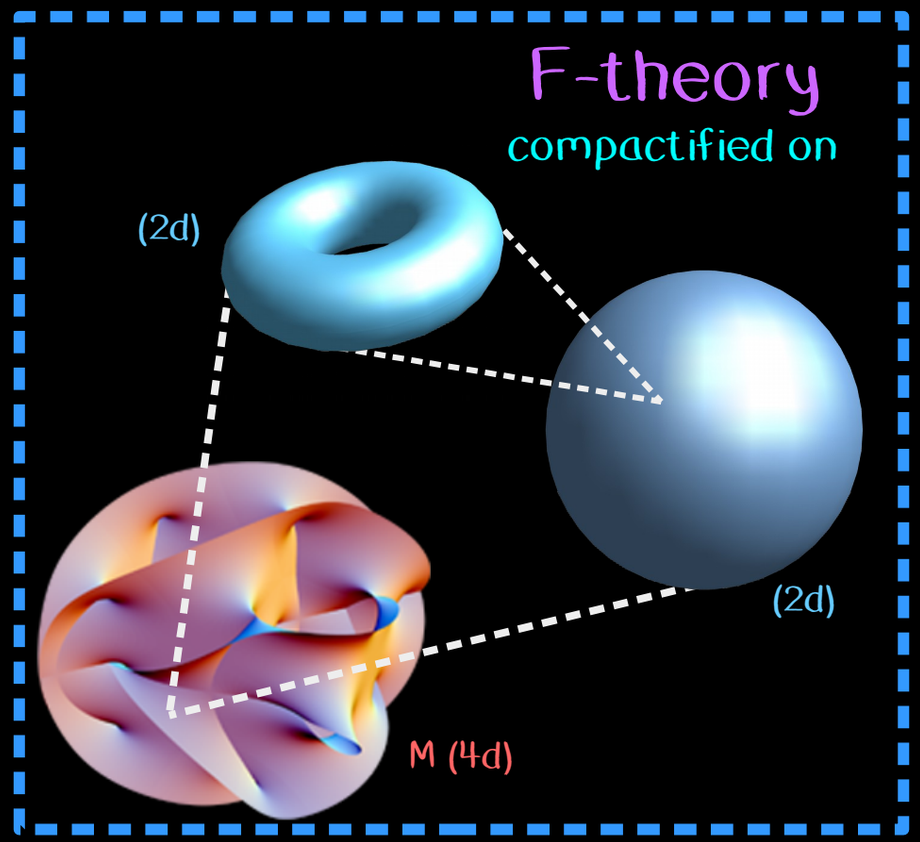


$\equiv$ F-theory (12d)

What is the duality?



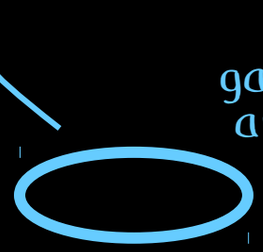
dual



Spotlight on some details

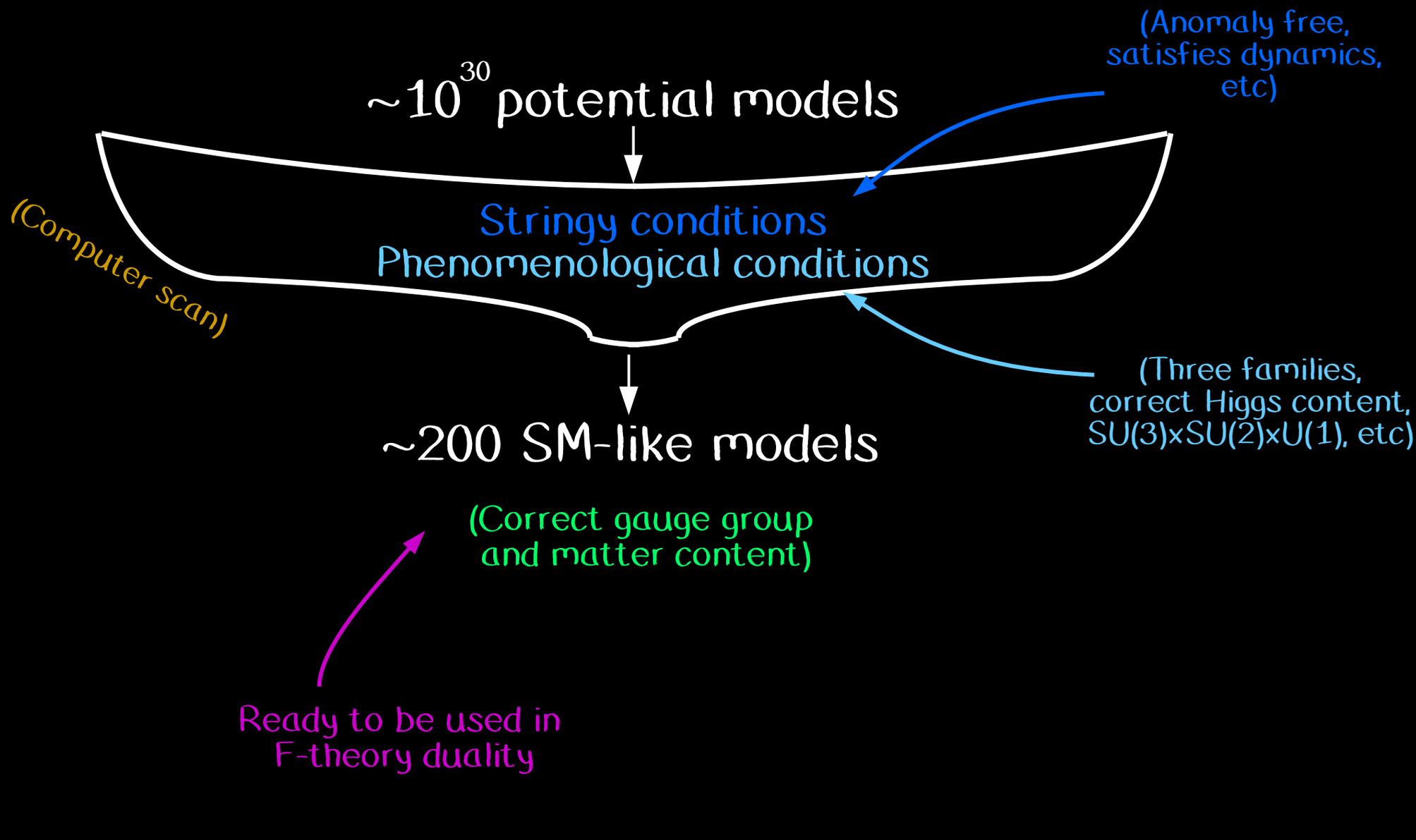
- Have to work with elliptically fibered spaces
  (torus attached to each point)

- E_8 → SU(5) → SU(3)×SU(2)×U(1)
  vector bundle; Wilson line



- Matter content ⟷ Topological numbers

Results:
Scanning over models



Summary

- Heterotic $E_8 \times E_8$ supplies one popular route for string model-building.

- Line bundle sum models are an attractive model-building route in heterotic string theory.

- Heterotic/F-theory duality might be useful to give insights into the properties of these models.

- For details: our paper should be out this month.