Landscape of D=4 String $N=1$ SUSY Compactification

$\underline{\text{IIA}}_{10D}$ $\underline{\text{IIB}}_{10D}$ I Het32 HetE_8

R g_s

(dilaton radius
16 Wilson lines)

- existence proof.
- predictions. (possible?)
- understandings.

String Pheno after revolution
in 90's.

M-theory & IIA

- 11 SUGRA $/S^1$ $\Longleftrightarrow$ IIA $\underline{\text{m/0}}$

  R ; l_{11} $\Longleftrightarrow$ g_s . $l_s \sim \sqrt{\alpha'}$

- 11 SUGRA $/ \boxed{\begin{matrix}\text{ALE} \\ \text{(Tau-NUT)}\end{matrix}}$ $\Longleftrightarrow$ IIA

  w/ D6 . D6

  th/ 9707123

metric

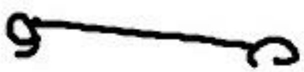
$$ds^2 = U(\vec{x})^{-1}(d\tau + \omega_i dx^i)^2 + U\, dx^i dx^i$$

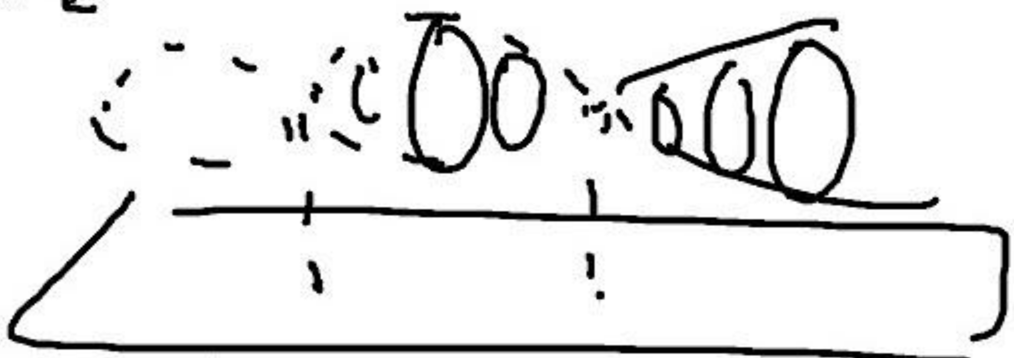
$$U(\vec{x}) = \left(1 + \sum_{I=1}^{N} \frac{1}{|\vec{x} - \vec{x}_I|}\right) \qquad (\tau, \vec{x}^i)$$

$(N-1)$ 2-cycls.

$$U(\vec{x}) = 1 + \Sigma \frac{1}{|\vec{x} - \vec{x}_I|}$$

$$\vec{x} \to \vec{x}_I$$





$$\begin{bmatrix} -2 & 1 & & \\ +1 & -2 & \ddots & \\ & \ddots & \ddots & 1 \\ & & 1 & -2 \end{bmatrix} = -\,-\; C_{A_{n-1}}$$

$\mathbb{C}^2/\mathbb{Z}_N$ singularity.

M-theory $/ \underbrace{\mathbb{C}^2/\mathbb{Z}_N}$ $\Longleftrightarrow$ $SU(N)$ in IIA.
(or $N \times D6$)

$\Downarrow$

A_{N-1} singularity
D_N singularity
$E_{6,7,8}$ singularity

$\Bigg\} \Rightarrow$ IIA w/ $O6$

Het/T^3 — $M/K3$ $\qquad$ $\mathrm{Het}/T^4 \Leftrightarrow \mathrm{II}/K3$

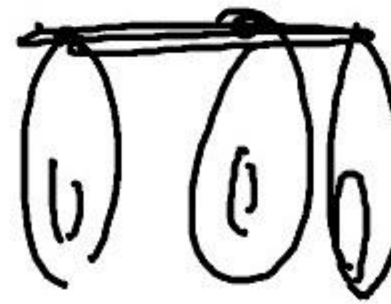
$[10-3=7D]$ $\qquad$ $[11-4=7D]$

massless spectrum below KK scale.

7D. metric
7D 2-form
7D vector 22
7D scalar $3\times 19+1$

$\underline{\underline{\mathrm{Het}/T^2}}$ — $F/\underline{\underline{\text{ellip. K3}}} = X$

$O(2,18)/O(2)\times O(18) \ni P$



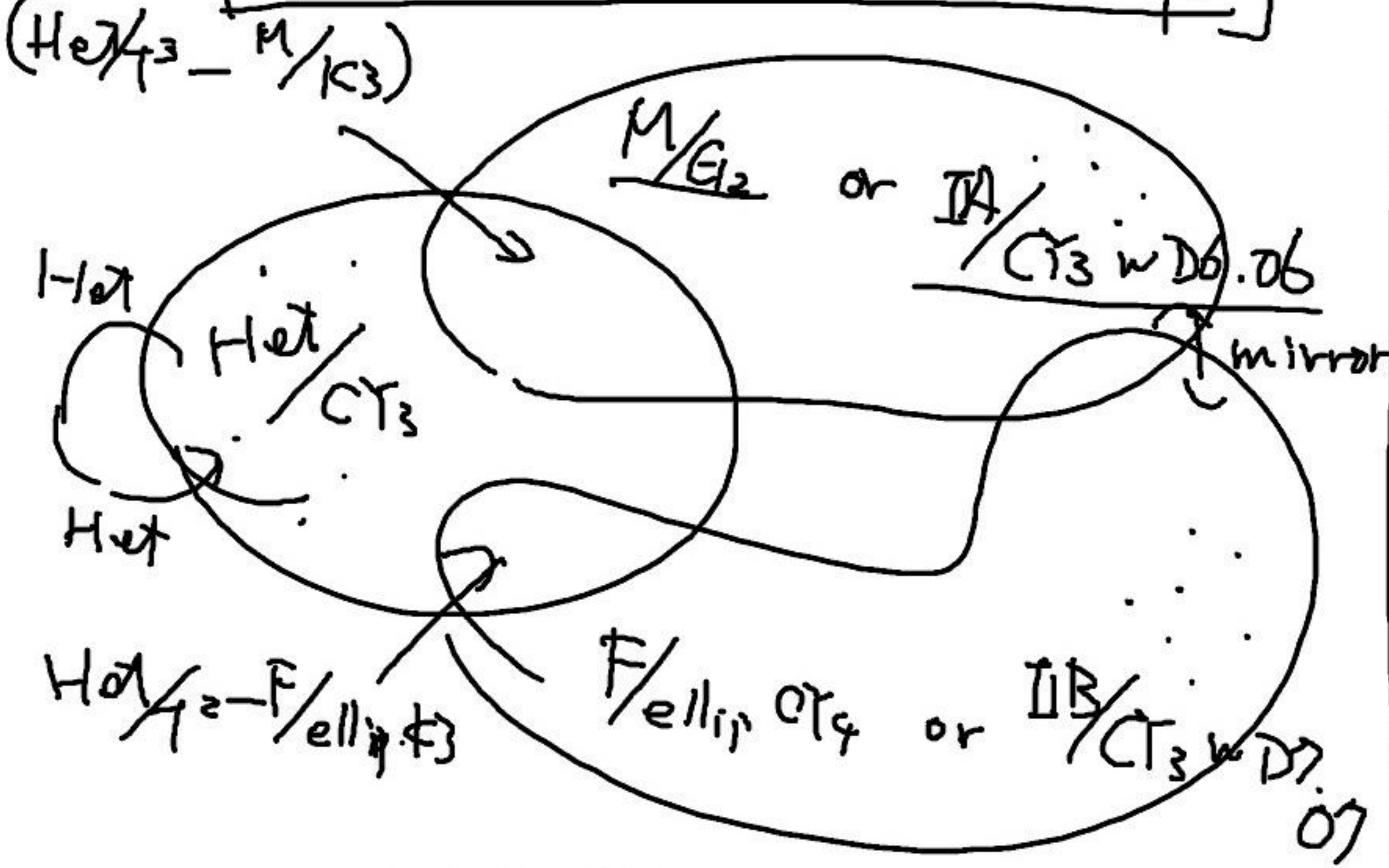
$\underline{\pi} : X \longrightarrow \mathbb{P}^1$

$\mathbb{P}^1 \rightarrow$ 

$F/\text{ellip. } X_d \simeq \mathbb{B}/B_{d-1}$

$\pi : X_d \longrightarrow B_{d-1}$

D=4 N=1 SUSY Landscape



Non-geometric phase

$\underline{\underline{CY_3}}$ on worldsheet non-lin σ-model.

quintic $(5) \subset \mathbb{P}^4$

$F^{(5)}$

$\underline{\underline{U(1)}}$

$\Phi_i \quad i = 1, \cdots, 5 \qquad +1$

$P \qquad -5,$

D-term

$$\sum_i |\Phi_i|^2 - 5|P|^2 - r = 0$$

superpot

$$W = P \cdot F^{(5)}(\Phi_i)$$

$\underline{r \gg 0}$

$\Rightarrow$ CY_3 target nonlin σ model.

$\underline{r \ll 0}$

$\langle P \rangle \neq 0$. $\langle \phi_i \rangle = 0$.

non geometric.

Orbifold / fractional branes.

* Toroidal orbifold.

  $\left(T^d/P\right) \xrightarrow{\text{blow up}} \underline{\underline{CY_3}}$

  - particular choice of topology of CY_3.
  - particular choice of pts in moduli space.

— Het orbifold.

vector bdle moduli, ...

— IIB D3-brane at singularity.

eg. D3-brane at $\mathbb{C}^3/\mathbb{Z}_3$ singularity,

3-types.

$\mathbb{C}^3/\mathbb{Z}_3 \Rightarrow \mathbb{P}^2 \supset \mathbb{P}^1$

$$\begin{cases} \cdot\ D7 + \overline{D5} + \tfrac{1}{2} D3 \\ \cdot\ 2\overline{D7} + D5 + \tfrac{1}{2} D3 \\ \cdot\ D7 \end{cases}$$