A Duality Web for Non-supersymmetric Strings

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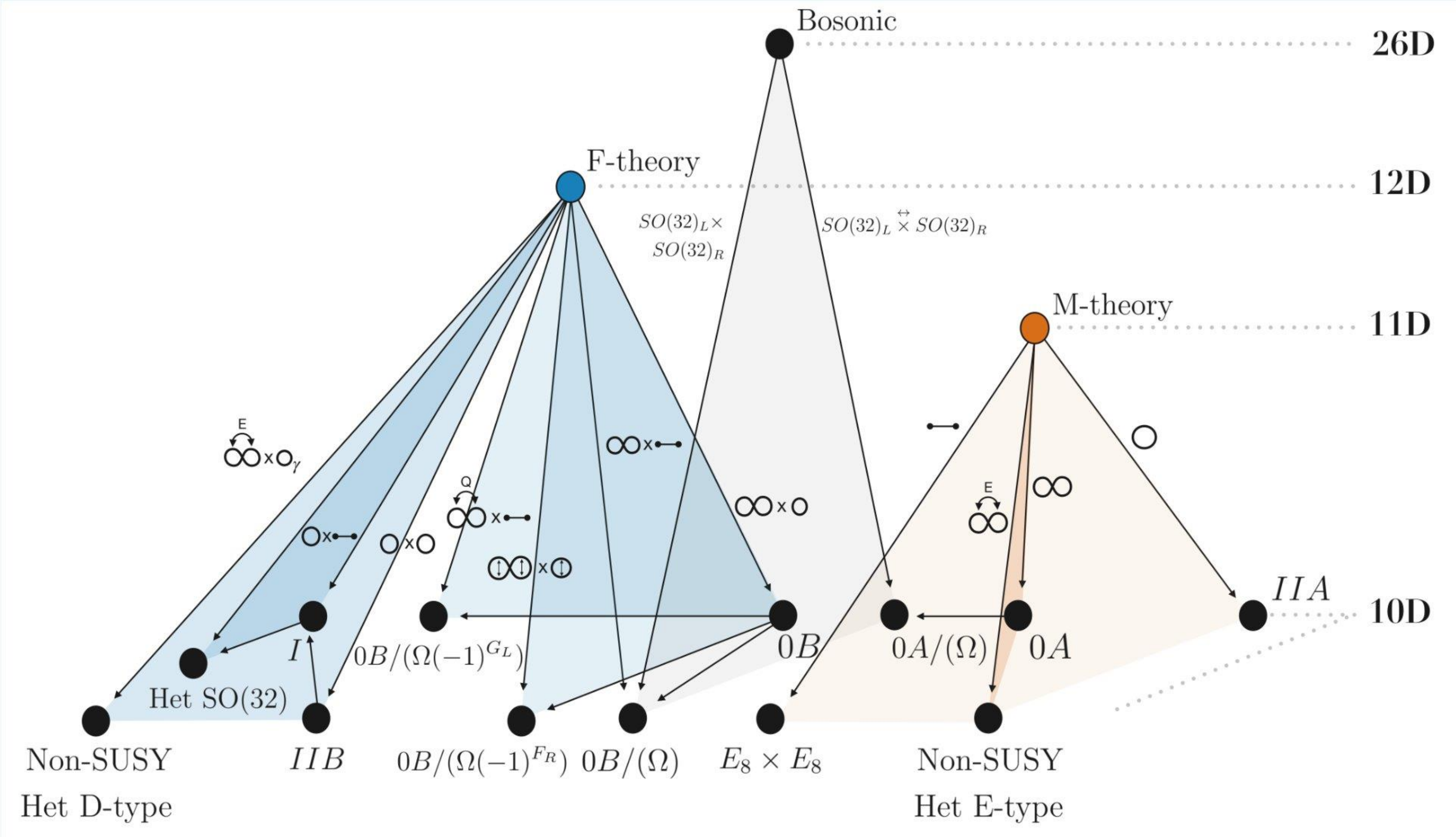
Based on

[Baykara, Delgado, Dudas, HPF, Vafa '26]

Talk @ Strings and Geometry @ Universitetshuset, Uppsala 2026

The duality web



One organizing picture:

- type 0A from M-theory
- type 0B from F-theory
- orientifolds from simple quotients
- bosonic duals at special corners

In this talk: focus on the type 0 orientifold branches and the BG/DMS conjectures.

Previous non-SUSY strong/weak dualities: [Bergman, Gaberdiel, '97]; [Blum, Dienes, '97]; [Kachru, Silverstein, '98]; [Blumenhagen, Kumar, '99]; [Bergman, Gaberdiel, '99]; [Dudas, Mourad, Sagnotti, '01]; [Bossard, Casagrande, Dudas, '25]; [Fraiman, HPDF, '25]

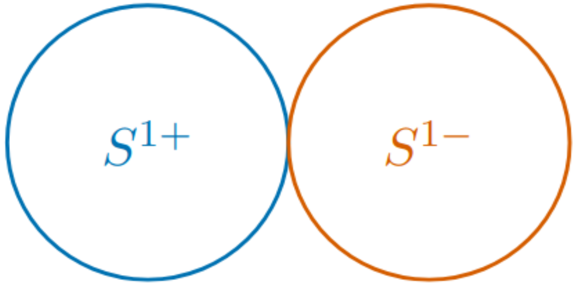
The basic geometry

- Type 0A is modeled by M-theory on a wedge of two circles.

$$M\text{-theory on } S^1_+ \vee S^1_- \quad \longleftrightarrow \quad 0A$$

- Type 0B arises by the corresponding F-theory construction.

$$F\text{-theory on } (S^1_+ \vee S^1_-) \times S^1 \quad \longleftrightarrow \quad 0B$$



two circles = doubled RR sectors

[Baykara, Dudas, Vafa, '26]

Basic $\mathbb{Z}_2$ quotients

The geometry has a few elementary involutions:

$$P^- : \ (\theta_+, \theta_-) \mapsto (\theta_+, -\theta_-)$$

$$P^+ : \ (\theta_+, \theta_-) \mapsto (-\theta_+, \theta_-)$$

$$P = P^+ P^- : \ \text{reflect both circles}$$

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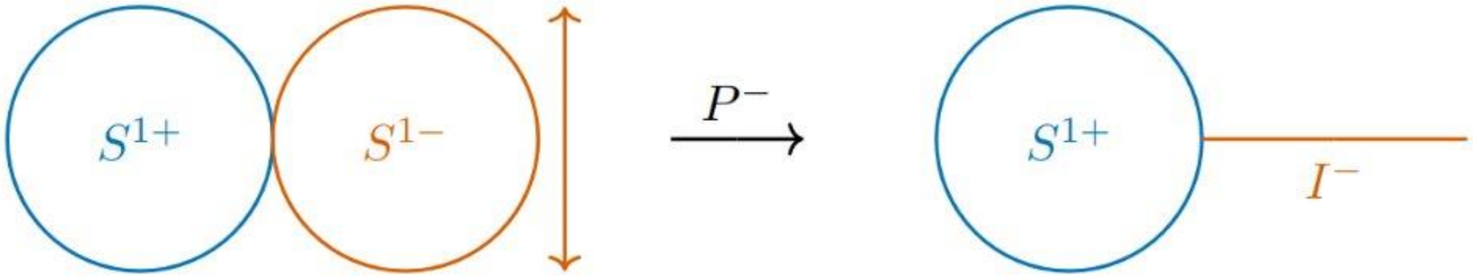
For this talk: the reflections give type 0 orientifolds. Exchange quotients populate the heterotic side of the web, but will stay in the background.

oA orientifold: $S^1 \vee I$

Reflect one circle:

$$S^1_+ \vee S^1_- \;/\; P^- \;=\; S^1_+ \vee I_-$$



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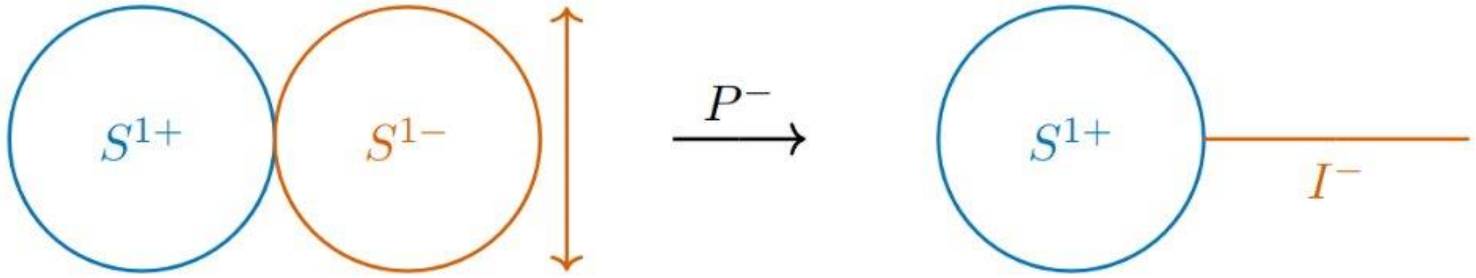

Worldsheet parity exchanges twisted and untwisted RR sectors; geometrically it is a reflection of one circle.

Open sector: SO(n) × SO(32−n), with two species of non-BPS D9-branes.

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0B orientifolds from F-theory

Start from **$(S^1 \vee S^1) \times S^1$** and quotient the standalone circle:

$$(S^1 \vee S^1) \times S^1 \longrightarrow (S^1 \vee S^1) \times I$$

This is the basic **0B/Ω** orientifold. It keeps two RR two-forms **B^+, B^-**.

[Bergman, Gaberdiel, '97]
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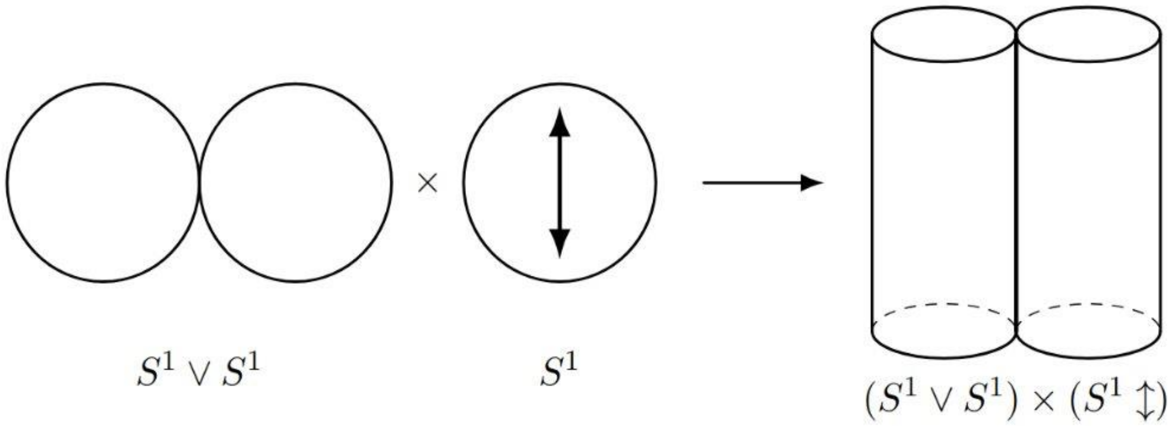

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0B orientifolds from F-theory

Other choices:

- add the quantum symmetry Q $\rightarrow$ tachyon-free U(32) Sagnotti model

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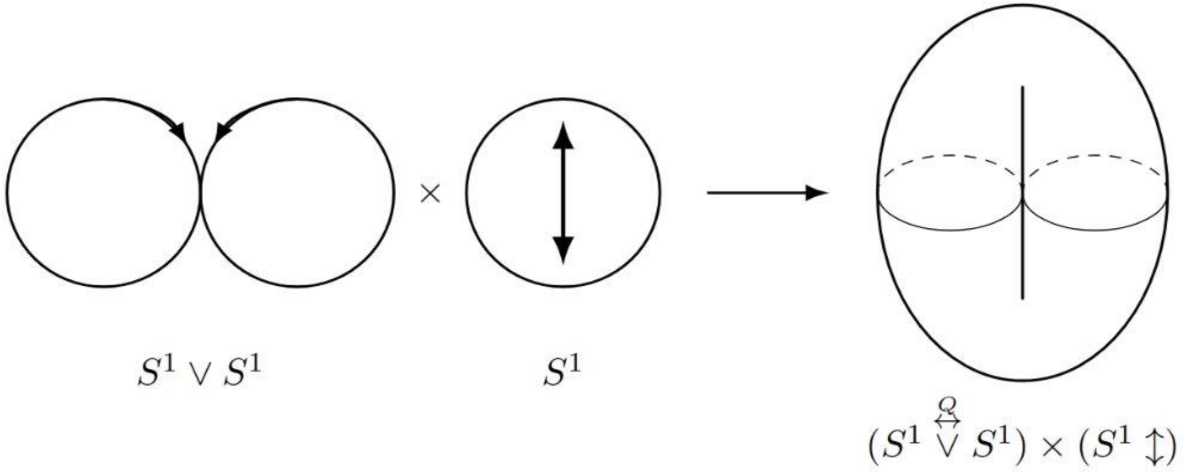

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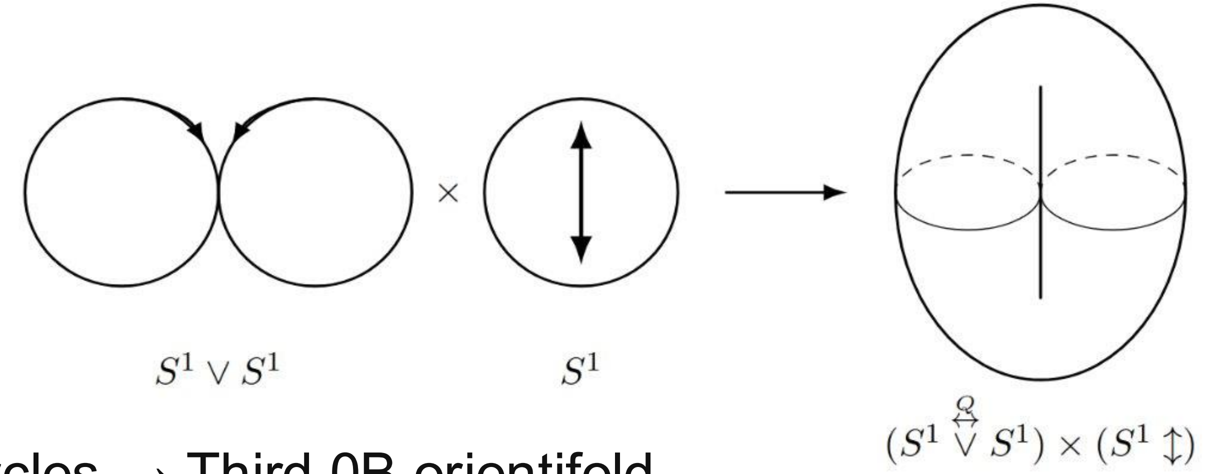
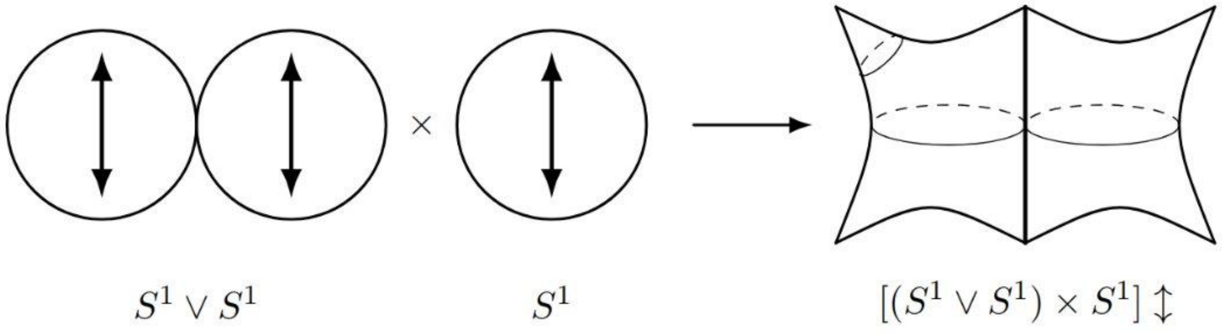


- Reflect all circles → Third 0B orientifold



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The special $SO(32)^2$ orientifold

Generic open-sector gauge group:

$$G = (SO(n) \times SO(32-n))^2$$

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Why special? no massless fermions, so a purely bosonic dual is plausible.

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Tachyons: singlet closed-string tachyon plus a bifundamental **(32,32)** open-string tachyon.

[Bergman, Gaberdiel, '97]

Bergman–Gaberdiel duality

$$0B/\Omega \text{ with } SO(32)^2 \quad \Longleftrightarrow \quad \text{bosonic string on } T^{16}$$

$$\Gamma_{16,16} = [D_{16} \oplus D_{16}], \qquad \mathfrak{g} = \mathfrak{so}(32)_L \oplus \mathfrak{so}(32)_R$$

Matches: metric, dilaton, gauge fields, singlet tachyon, bifundamental tachyon.

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Apparent mismatches:

- bosonic side: Narain moduli in the bi-adjoint
- 0B side: an extra RR two-form B^-

The D1⁺ becomes the bosonic string

In the $SO(32)^2$ background, the **D1⁺** worldsheet has

$$8_L + 8_R \text{ transverse scalars} \quad + \quad 32_L + 32_R \text{ fermions}$$

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The 32 left- and right-moving fermions are the fermionized form of the 16 compact bosons of the bosonic string.

$$D1^+ \quad \longleftrightarrow \quad \text{fundamental bosonic string}$$

This is the cleanest evidence for the duality.

Puzzle I: Narain moduli

- The bosonic compactification has tree-level massless Narain moduli.

- The weakly coupled 0B orientifold has no such massless scalars.

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Resolution: in a non-supersymmetric theory these scalars are not protected.

$$V(\phi) = V(\phi_*) + \frac{1}{2}\, m^2_{\alpha\beta}\, \delta\phi^\alpha \delta\phi^\beta + \cdots$$

[Ginsparg, Vafa, '87]

Gauge invariance makes the enhanced-symmetry point an extremum; quantum corrections can lift the would-be moduli before reaching the 0B dual frame.

Puzzle II: the extra B^-

The 0B orientifold has two RR two-forms:

$$B^+, \quad B^-$$

B^+ couples to $D1^+$, the bosonic fundamental string.

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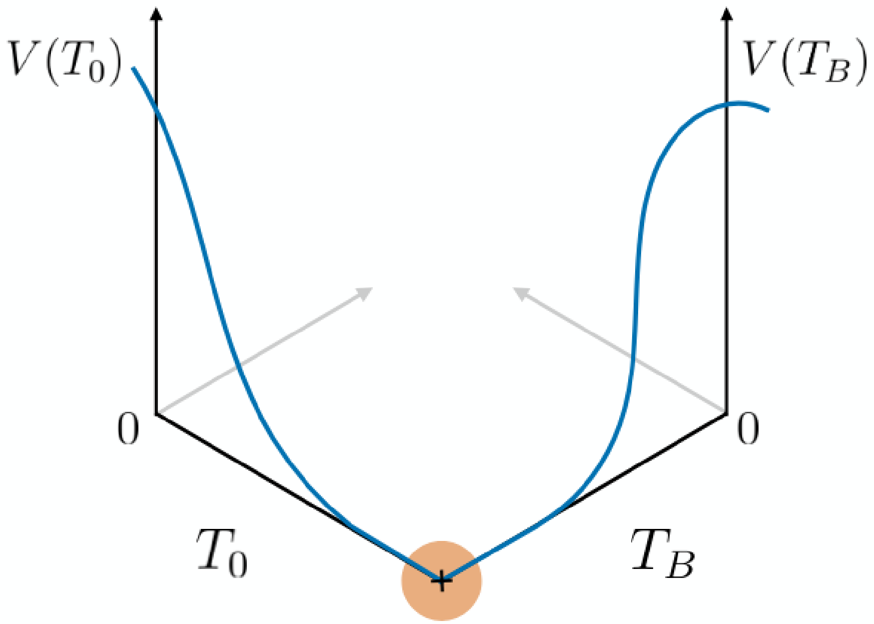

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B^- has no perturbative bosonic counterpart.

Proposed mechanism:

$D1^-$ becomes tensionless along the tachyon trajectory; condensation of $D1^-$ strings Higgses the two-form B^-.

Tachyon condensation is part of the duality map.

Dudas-Mourad-Sagnotti duality: the 0A analogue

$$0A/\Omega \quad \Longleftrightarrow \quad \text{bosonic string orientifold on } T^{16}$$

Same pattern of mismatches:

- bosonic side: Narain moduli
- 0A side: extra RR fields A^{+} and C^{+}

Same type of resolution:

Narain moduli are lifted; tachyon condensation geometrically shrinks one circle of $S^1 \vee S^1$ and removes A^{+}, C^{+} from the light spectrum.

[Dudas, Mourad, Sagnotti, '01]

Takeaways

1. Geometry: $S^1 \vee S^1$ and $(S^1 \vee S^1) \times S^1$ organize type 0 orientifolds.

2. Dualities: BG and DMS become sharper when viewed through these quotients.

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Thanks for your attention!