Title: On the Landscape of Non-Geometric String

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Abstract:

OUTLINE

(I) YOU'RE (PROBABLY) LOOKING IN THE WRONG PLACE

(II) T-DUALITIES AND ASYMMMETRIC ORBIFOLDS

(III) SEMI-FLAT SPACES AND "SPACES": GEOMETRY AND TOPOLOGY FROM EFFECTIVE FIELD THEORY

(V) T^3 FIBRATIONS:
TOPOLOGY AND, IN SOME
CASES, A BIT OF
GEOMETRY TOO.

(VI) MIRRORING THE
LOCAL MODEL OF A
CY WITH FLUX ~~ff~~

(VII) SOBERING YET
ALSO HOPEFUL CONCLUSION
NEW SCHEMES FOR
STRING COMPACTIFICATION

① YOU'RE LOOKING IN THE WRONG PLACE

- HOW "GENERIC" ARE IIB FLUX COMPACTIFICATIONS, IN THE SET OF VACUA?

- AMAZINGLY BIG NUMBERS — BIGGER THAN ANYTHING ELSE

- NO COMPARABLE "LANDSCAPE" IN OTHER STRING THEORIES THAT WE KNOW OF — — SHOULD WE BE SUSPICIOUS?

- WHERE IS THE TYPE

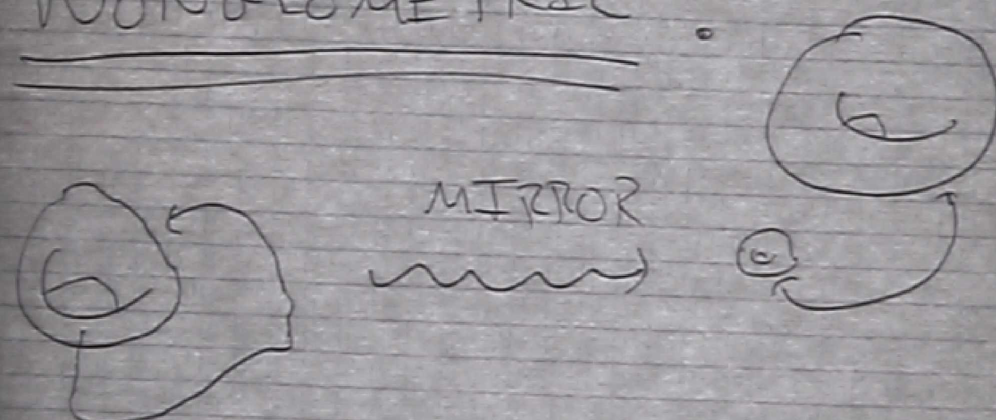
• TO UNDERSTAND THE PUZZLE: "EVERYTHING IS DUAL TO EVERYTHING ELSE". SO: THERE SHOULD BE ROUGHLY COMPARABLE NUMBERS IN ALL THEORIES -- SHOULDN'T THERE?

• (FOR NOW, IGNORE DYNAMICS -- NONPERT. POTENTIALS CAN "DUAL" TO TREE-LEVEL POTENTIALS. THIS MAY EVEN BE GOOD. THIS IS NOT WHERE THE

• FOR EXAMPLE: MIRRORS OF IIB FLUX VACUA SHOULD GIVE IIA FLUX LANDSCAPE.

• <u>TRY</u> IT: FIND THAT THE MIRRORS ARE

<u>NONGEOMETRIC</u>:



IIB
+
FLUX

S.H., B. WILLIAMS, J. M^{c}GREEVY

Also NOTED BY

II. T-DUALITY AND MIRROR SYMMETRY

TYPE II STRING THEORY ON A TORUS T^K HAS A PERTURBATIVE DUALITY GROUP WHICH INVOLVES:

- CHANGE OF BASIS $SL(K,\mathbb{Z})$
- B-FIELD SHIFTS THROUGH 2-CYCLES
- "T-DUALITIES" THROUGH 2-CYCLES.

THE LAST IS "NONGEOMETRIC":

- CHANGES VOLUMES
- EXCHANGES MOMENTUM, WINDIN

HOW DOES THIS ACT ON THE METRIC & B-FIELD MODULI OF THE TORUS ?

$$\boxed{G+B \xrightarrow{\text{T-DUALITY}} (G+B)^{-1}\cdot\alpha'}$$

- FOR VANISHING B. CHANGES VOLUME OF THE TORUS : $\boxed{V \longrightarrow \alpha'^{k}/V}$

- IN A SENSE, GENERALIZES COORDINATE TRANSFORMATIONS ENTERS ON AN EQUAL FOOTING ... $SL(K, \mathbb{Z})$ THEY

- JUST AS WE CAN ORBIFOLD BY $SL(K,\mathbb{Z})$ TO GET SPACES MORE GENERAL THAN MANIFOLDS, WE CAN ORBIFOLD BY $SL(K,K;\mathbb{Z})$ ELEMENTS TO GET "THINGS" MORE GENERAL THAN SPACES: ASYMMETRIC ORBIFOLDS.

- FOR INSTANCE,

$$\left(T^4 \Big/ \begin{array}{c} T\text{-DUALITY ON} \\ \text{ALL COORDINATES} \end{array} \right) \text{ IS}$$

A CONSISTENT STRING

• NOT TOO MANY OF THESE. LEAVES THE IMPRESSION NONGEO. COMPACTIFICATIONS ARE "RARE" -- NOT TO WORRY ABOUT THEM IN BIG PICTURE.

WRONG.

III SEMI-FLAT SPACES AND "THINGS" -- GEOMETRY & TOPOLOGY FROM EFFECTIVE FIELD THEORY.

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WRONG.

III SEMI-FLAT SPACES AND "THINGS" -- GEOMETRY & TOPOLOGY FROM EFFECTIVE FIELD THEORY.

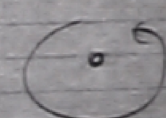
IN THE 10-K-DIM'L
EFFECTIVE THEORY OF
MASSLESS MODES, THE
$SL(K,K;\mathbb{Z})$ IS A MANIFEST
SYMMETRY -- UNLIKE IN
10D! AT THIS LEVEL
WE CAN USE $SL(K,K;\mathbb{Z})$
"MONODROMIES" TO BUIL
SPACES.

- THIS WORKS GEOMETRIC-ALLY, AND YOU DON'T LOSE MUCH INFORMATIO
- EXAMPLE: K3 SURFACE

• ~~[illegible]~~ SOME 2x2 MATRIX OF MODULI $G+B$ DESCRIBING (ALMOST) FLAT 2-TORI, VARY ALONG 2D BASE:

• IN CODIMENSION 2, THERE ARE "DEGENERATE LOCI" (POINTS) WHERE FIBER IS SINGULAR, BUT TOTAL SPACE IS SMOOTH:

$$\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} \quad G \quad \begin{bmatrix} 1 & 0 \\ -1 & 1 \end{bmatrix}$$



- BACK-REACTION OF MODULI GRADIENTS ON BASE CLOSES IT INTO A SPHERE.

- LOCAL GEOMETRY AT DEGENERATE LOCI WELL UNDERSTOOD -- IN 8D, EQUIVALENT TO AN EFFECTIVE BOUNDARY CONDITION ON MODULI AND 8D METRIC AT THE DEGENERATE LOCUS.

- HOW TO FIND 6D EFFECTIVE FIELD THEORY? USE THEORY OF LINEAR DIFFERENTIAL OPERATORS IN 6D TO FIND ZERO MODES OF FLUCTUATIONS OF 8D METRIC, B-FIELD, KK VECTORS, B-VECTORS, MODULI.
- SUPPLEMENT THE PDE'S WITH KNOWN

• SPECTRUM MATCHES THE KNOWN SPECTRUM OF K3 -- WITHOUT ANY APPEAL TO 10D GEOMETRY OR TOPOLOGY.

• BETTI NUMBERS CAN ALSO BE DEDUCED FROM RR SPECTRUM

• CYCLES CAN BE SEEN DIRECTLY WITH BRANES AS CONCEPTUAL AID:

"TERMINATION RULES" FOR VARIOUS 8D

• FOR K3, 8D EFF.
BRANES (PTLIKE IN 6D):

• 0-BRANE
• 2 BRANE (FILLS BASE)

• (p,q) 1-BRANES

TERM. RULES:

(0,1) 1-BRANE C
ONLY END ON A

$\begin{pmatrix}1 & 1\\ 0 & 1\end{pmatrix}$ MONODROMY DEGENERA

• FINITE, STRETCHING
EFFECTIVE 1-BRANES
REPRESENT 2-CYCLES

- FOR K3, 8D EFF. BRANES (PTLIKE IN 6D):
  - 0-BRANE
  - 2-BRANE (FILLS BASE)
  - (p, q) 1-BRANES

  TERM. RULES:

  (0, 1) 1-BRANE CAN ONLY END ON A $\begin{pmatrix}1 & 1\\ 0 & 1\end{pmatrix}$ MONODROMY DEGENERATION

- FINITE, STRETCHING EFFECTIVE 1-BRANES REPRESENT 2-CYCLES.

(0, 1)

- INTERSECTIONS CAN BE CALCULATED THIS WAY

- $\boxed{\text{ET CETERA !}}$

- NOTHING STOPS YOU FROM REPEATING THE EXACT SAME PROCEDURE ALLOWING $SL(2,2;\mathbb{Z})$ RATHER THAN JUST $SL(2,\mathbb{Z})$ DEGENERATIONS.

IV EXAMPLES OF (NONGEOMETRIC) T^2 FIBRATIONS

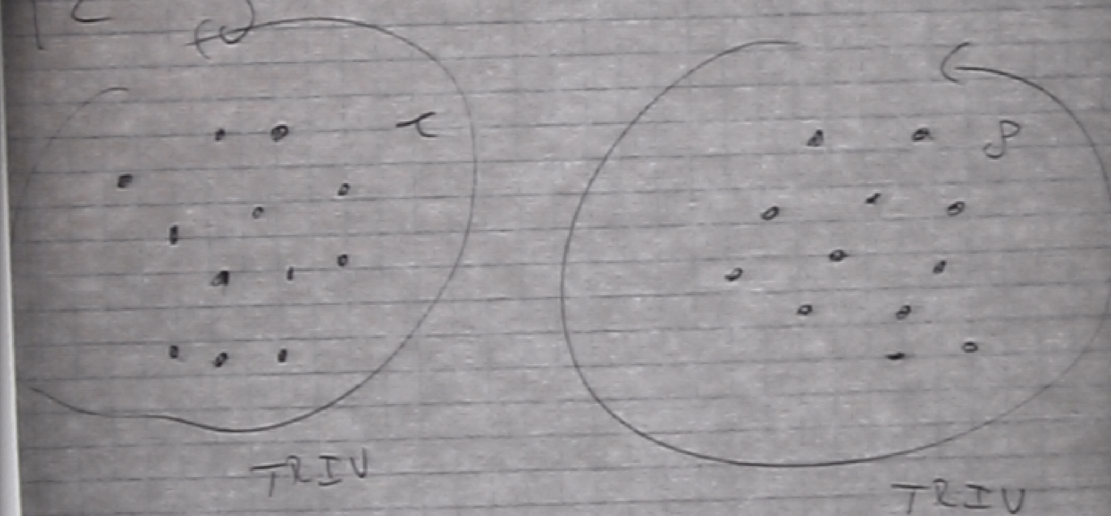
MANY EXAMPLES CAN BE GENERATED -- EVEN PRESERVING SUSY.

- T^2 FIBER, 2D BASE.
  - SEPARATE MODULI INTO τ AND $\rho \equiv B + i V_2$.
  - $SL(2,2;\mathbb{Z}) \simeq SL(2,\mathbb{Z})_\tau \times SL(2,\mathbb{Z}$

- EXACTLY ONE NEW COMPACT SOLUTION:

12 τ DEGENERATIONS

12 ρ DEGENERATIONS



- BASE IS S^2

SPECTRUM

• MATCHES SPECTRUM
OF AN ASYMMETRIC
ORBIFOLD

• MORE THAN ONE,
ACTUALLY -- THIS
MODULI SPACE CONNECTS
KNOWN SOLVEABLE CFT.

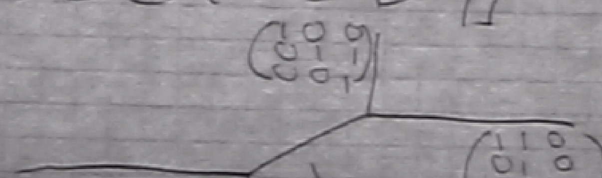
• 4D BASE :

• ρ AND τ DEGENERATE
ALONG CURVES IN
BASE

• BASE MUST BE POSITIVELY
CURVED SURFACE FOR SUSY

T^3 FIBRATIONS

- FIRST, THE GEOMETRIC CASE: $SL(3,\mathbb{Z})$ MONODROMIES
- DEGENERATE LOCI ARE CODIMENSION 2 -- LINE SEGMENTS IN 3D BASE
- SEGMENTS HAVE JUNCTIONS! MORE COMPLICATED!

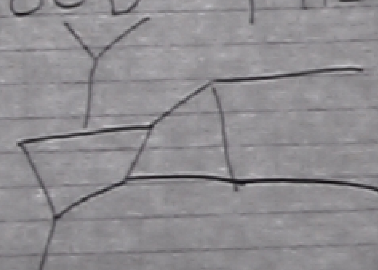


BASE

• MONODROMIES MULTIPLY TO 1 AT JUNCTIONS.

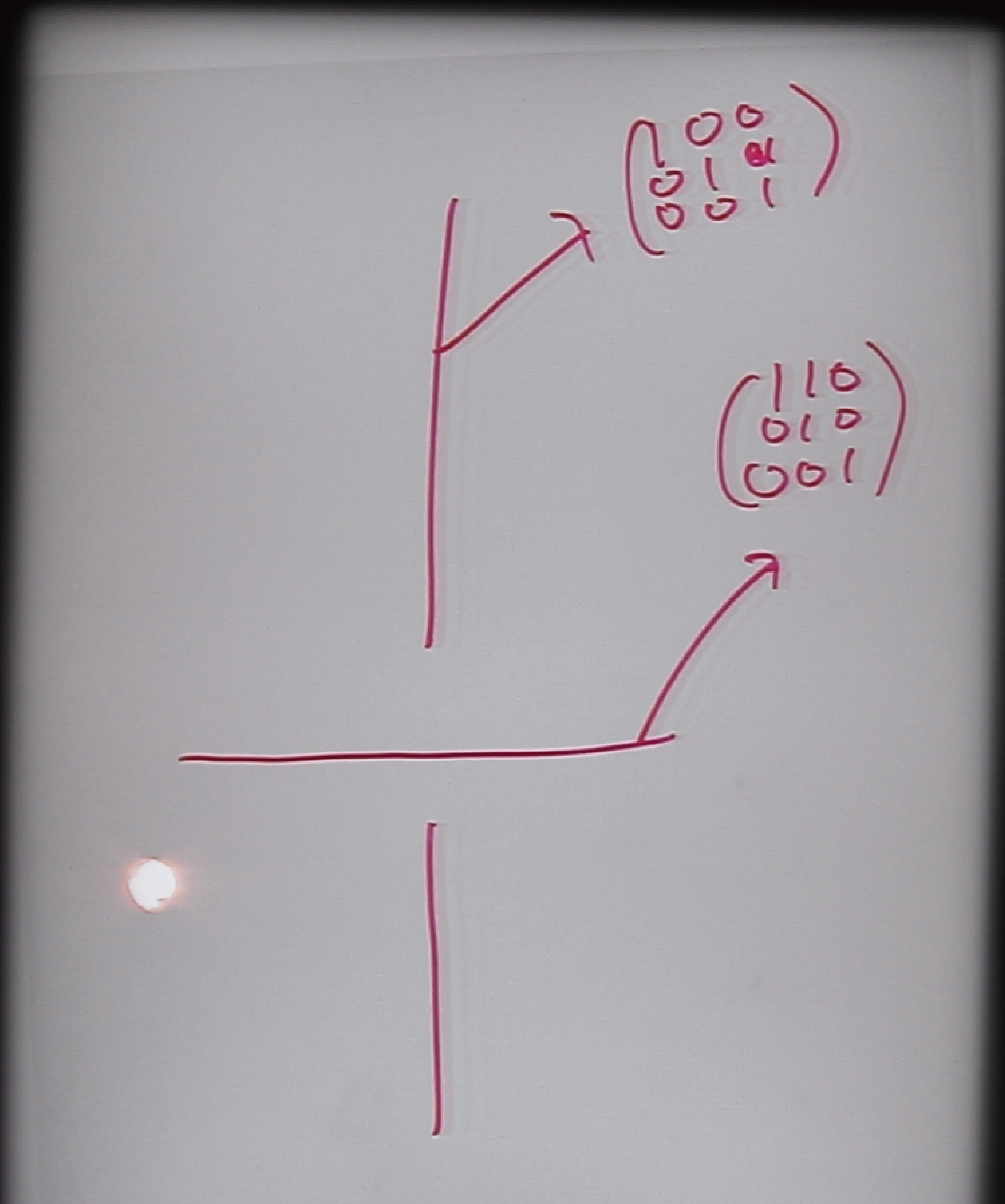
• CY_3 = GRAVITATING "COSMIC STRING" JUNCT IN 7D EFF THY OF GRAVITY + SCALARS WHICH CLOSES THE SPACE.

• THE QUINTIC IS UNDERSTOOD THIS WAY:

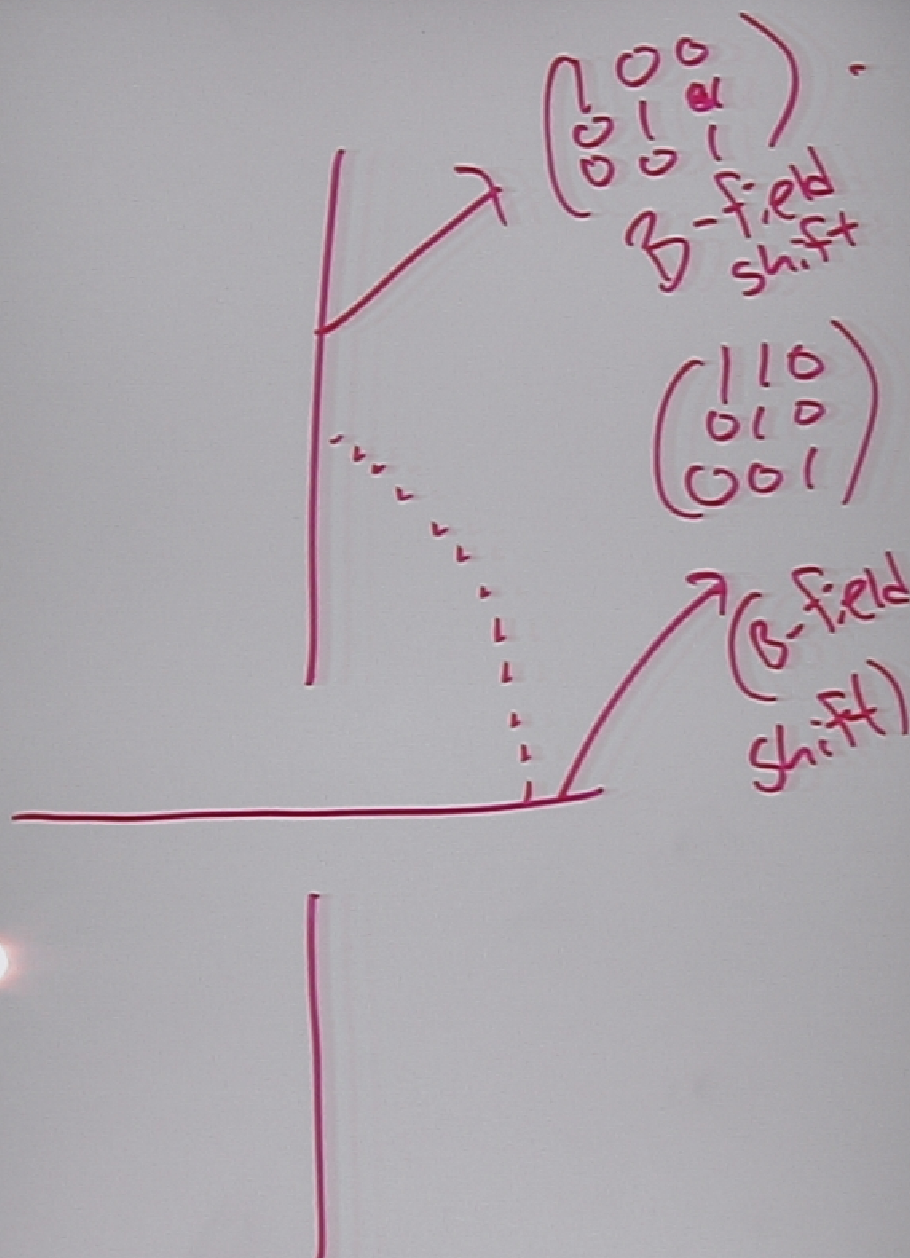


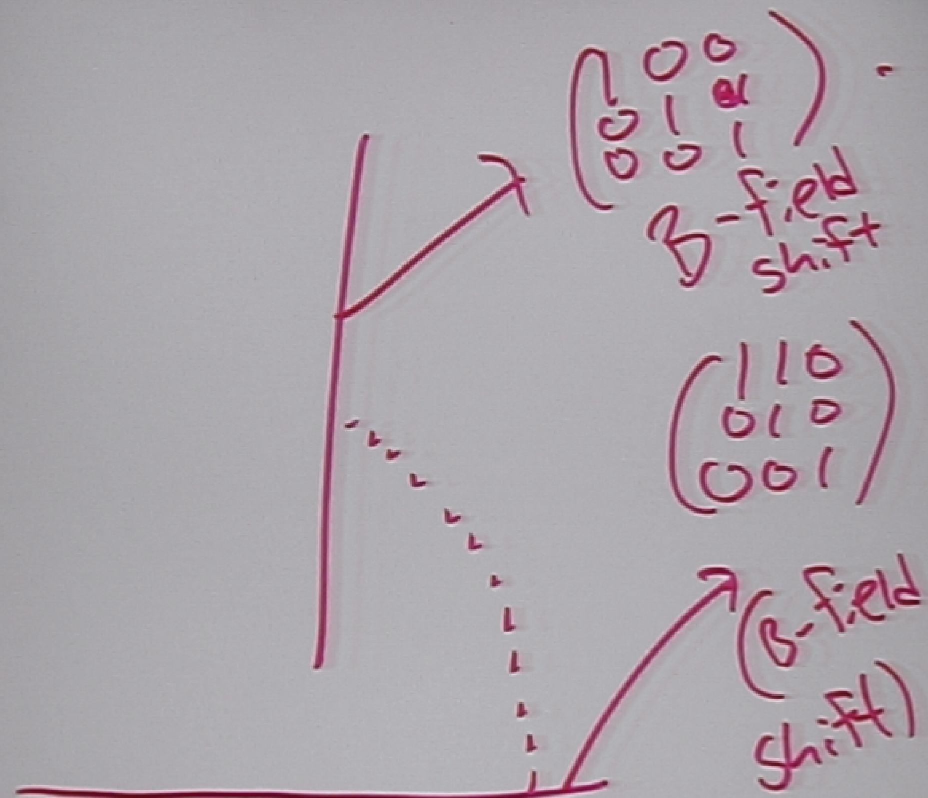
... ETC

=



1 0 0
0 1 α
0 0 1
1 1 0
0 1 0
0 0 1


1 0 0
0 1 α
0 0 1
B-field shift
1 1 0
0 1 0
0 0 1
(B-field shift)



SYZ mirror:
conjugate by
T-duality on
T^3:
tric

points
and
complex
submanifolds

$\downarrow$

no points, nec.

not nec.

points
and
complex
submanifolds

no points, nec.
not nec. subfld
of
itself