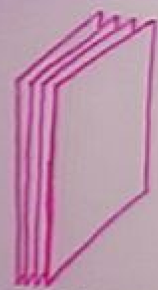
Title: Little String Theory From a Double Scaled Matrix Model

Date: Oct 13, 2006 11:45 AM

URL: http://pirsa.org/06100049

Abstract:

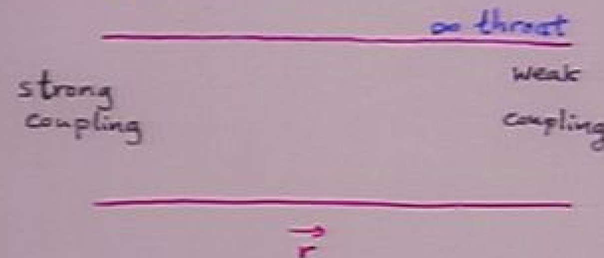


N_5 IIA NS5-branes

Type IIA LST:

- defined as worldvolume dynamics of IIA NS5-branes for $g_s \to 0$ α' fixed
- Hagedorn density of states, flows to (0,2) CFT in IR
- No direct Lagrangian description (nonlocal)

Gravity Dual: near-horizon NS5-brane solution



$$ds^2 = N_5 \alpha' \left[-dt^2 + d\vec{x}_5^{\,2} + dr^2 + d\Omega_3^2 \right]$$

$$e^{\phi} = g_s \, e^{-r}$$

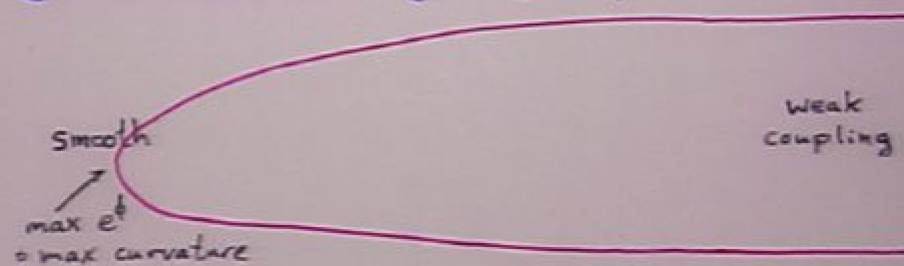
+ H flux

linear dilaton, strongly coupled for $r \to -\infty$

BOTH PICTURES DIFFICULT.

THIS TALK: LST on S^5

Lin + Maldacena: gave gravity solution for LST on S^5



Asymptotically: $ds^2 = N_5\alpha' \left[2r(-dt^2 + d\Omega_5^2) + dr^2 + d\Omega_3^2 \right]$

$e^\phi = g_s e^{-r}$

$+ H$ flux

- tunable maximum curvature, $R_{max}\alpha' \sim \frac{1}{N_5}$
- tunable maximum dilaton

MORE TRACTAB[LE]

FIELD THEORY: LST on S^5

GOAL: Determine field theory dual

- Explicit Lagrangian description of LST on S^5

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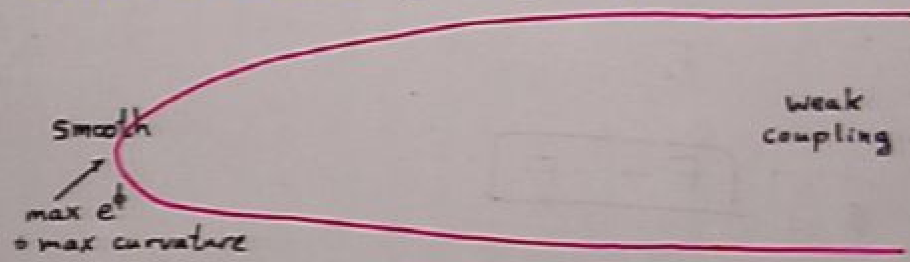

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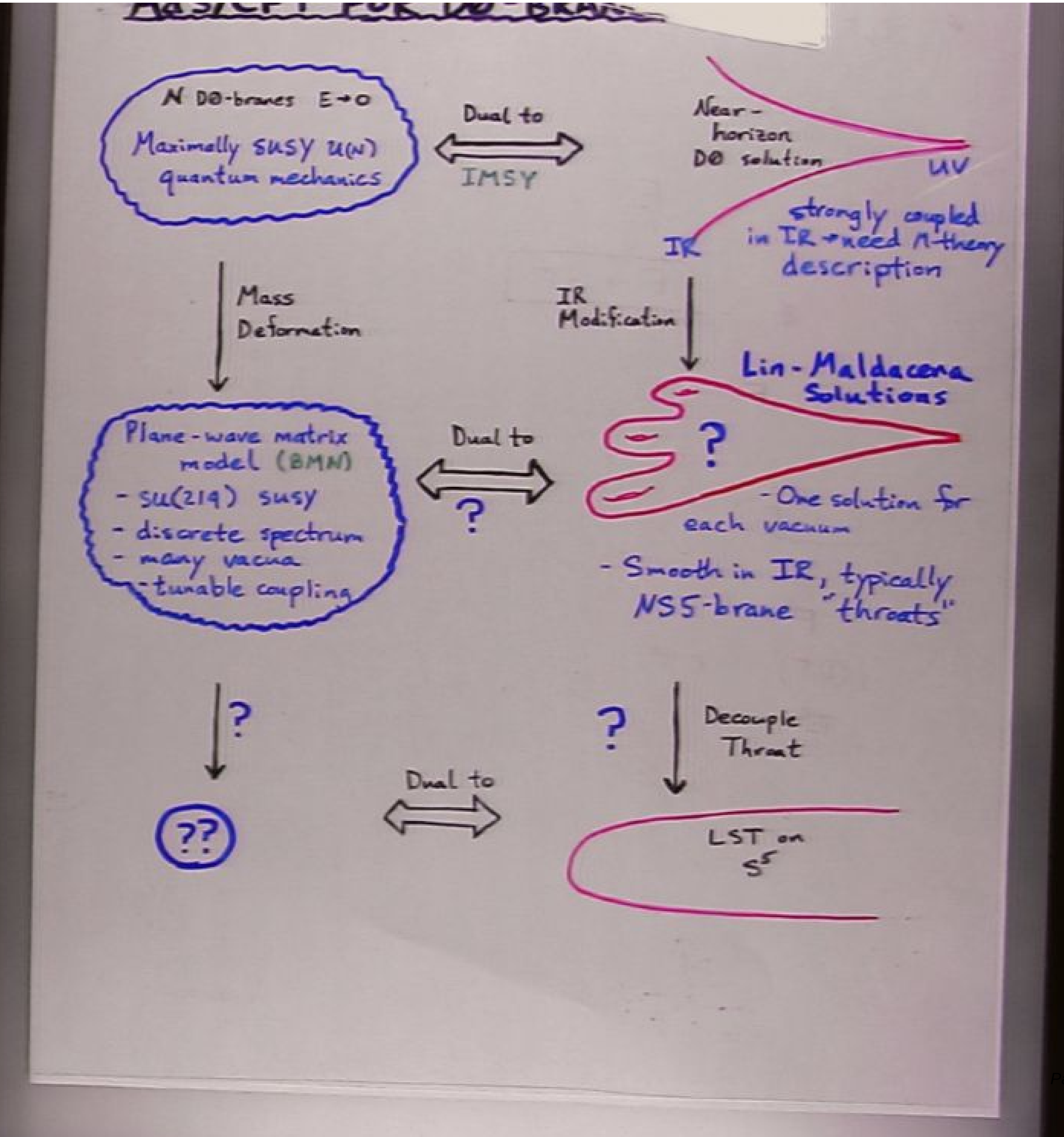
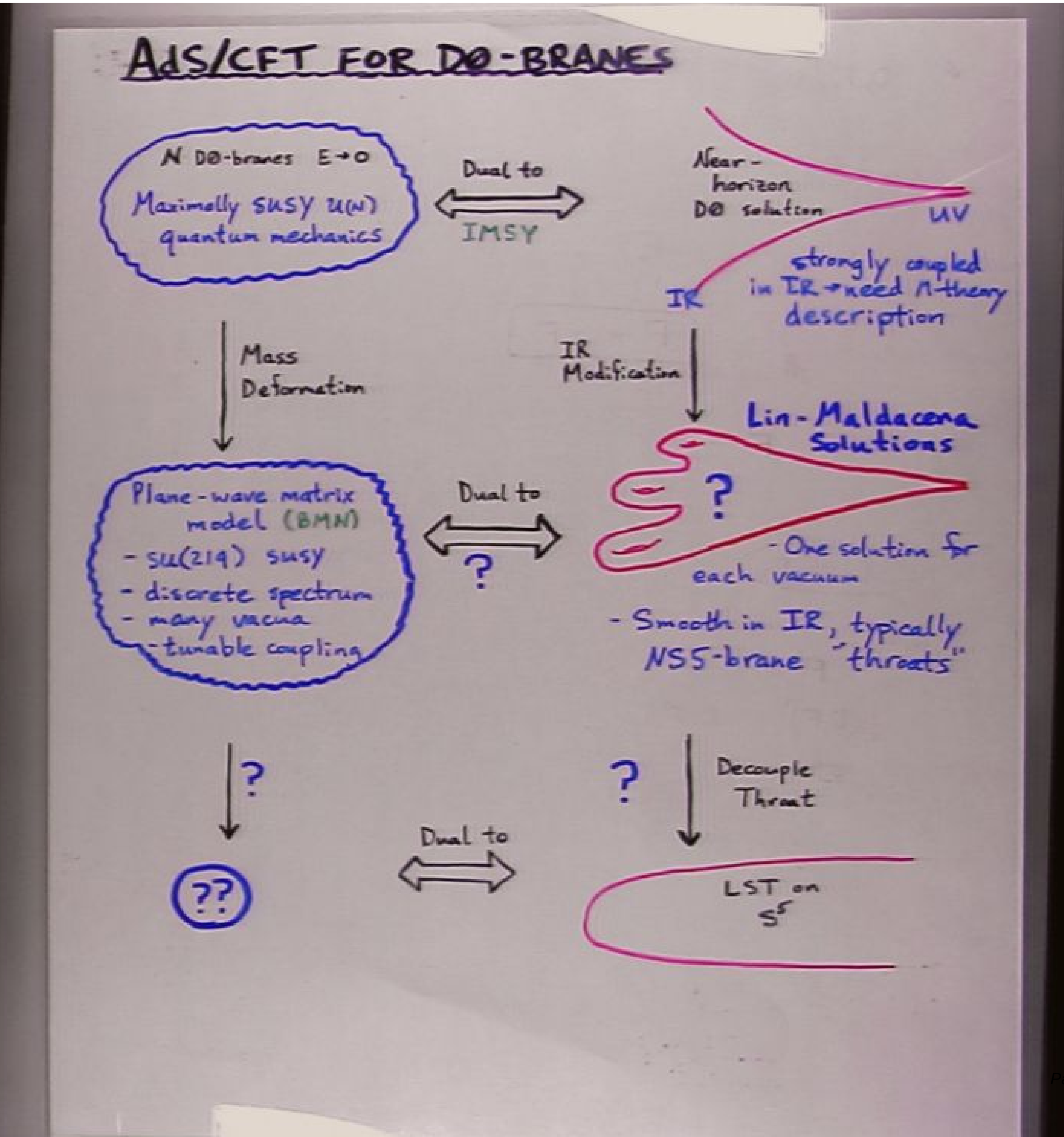

N D0-branes E→0
Maximally susy U(N) quantum mechanics
Dual to
IMSY
Near-horizon D0 solution
UV
IR
strongly coupled in IR → need M-theory description
Mass Deformation
IR Modification
Lin-Maldacena Solutions
Plane-wave matrix model (BMN)
- SU(2|4) susy
- discrete spectrum
- many vacua
- tunable coupling
Dual to
?
- One solution for each vacuum
- Smooth in IR, typically NS5-brane "throats"
?
?
Decouple Throat
Dual to
??
LST on S^5


AdS/CFT FOR D0-BRANES
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PLANE WAVE MATRIX MODEL

- Mass deformation of 0+1 maximal SYM preserving 32 susys $\supset SU(2|4)$:

$$H = \mathrm{Tr}\Big(\tfrac{1}{2}P_A^2 + \tfrac{1}{2}(X_i/3)^2 + \tfrac{1}{2}(X_a/6)^2 + \tfrac{i}{8}\Psi^T\gamma^{123}\Psi + \tfrac{i}{3}g\,\epsilon^{ijk}X^iX^jX^k - \tfrac{g}{2}\Psi^T\gamma^A[X_A,\Psi] - \tfrac{g^2}{4}[X_A,X_B]^2\Big)$$

$A = 1..9 \quad i = 1..3 \quad a = 4..9$

Parameters: N (size of matrices)

g tunable coupling

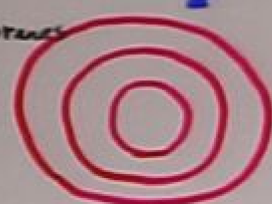
Vacua: require $[X^i, X^j] = \frac{i}{3g}\epsilon^{ijk}X^k \qquad X^a = 0$

$$X^i = \frac{1}{3g}\begin{pmatrix} J^i_{N_1} & & & \\ & J^i_{N_2} & & \\ & & \ddots & \\ & & & J^i_{N_K} \end{pmatrix}$$

general reducible rep. of su(2) algebra.

Classical picture → Dual description

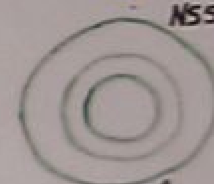
D2-branes



$R_i = N_i$

Concentric Fuzzy Spheres

NS5-branes



R^4_n = multiplicity of J^i_n

Concentric 5-branes

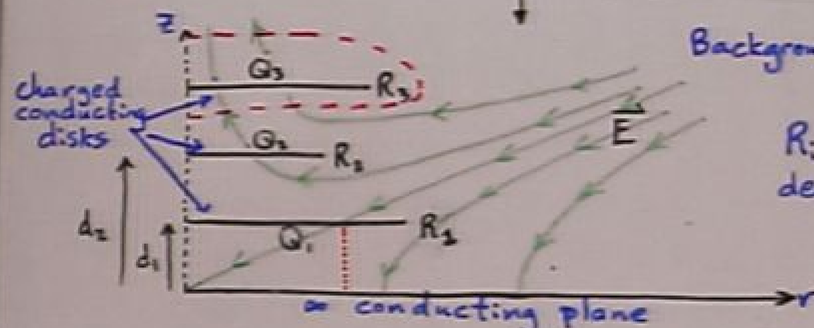
MVR, Sheikh-Jabbari, Maldacena

Lin-Maldacena Geometries

- Supergravity (IIA) solution dual to each vacuum given in terms of solution to auxiliary electrostatics problem:

vacuum with Q_i copies of d_i-dimensional irrep.

↕

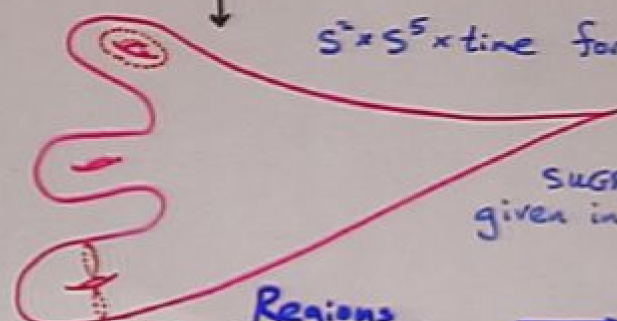


Background potl : $V = V_0 (r^2 z - \frac{2}{3} z^3)$

R_i determined so charge density vanishes at tip

Find $V(r,z)$ for given Q_i, d_i, V_0

↕



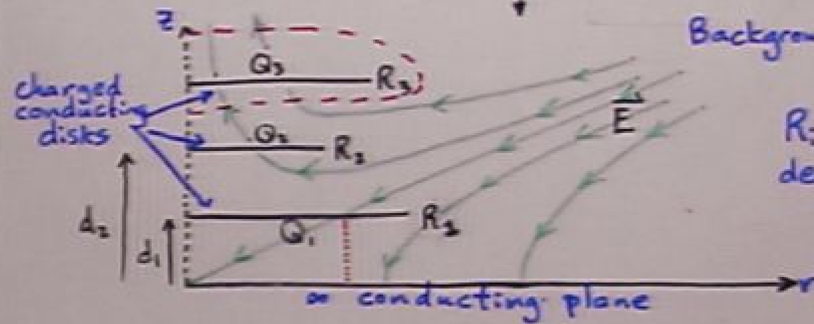
$S^2 \times S^5 \times$ time for each (r,z)

SUGRA solution given in terms of $V(r,z)$

Regions between plates ⟶ NS 5-brane throats

... of d_i - dimensional irrep.

$\updownarrow$



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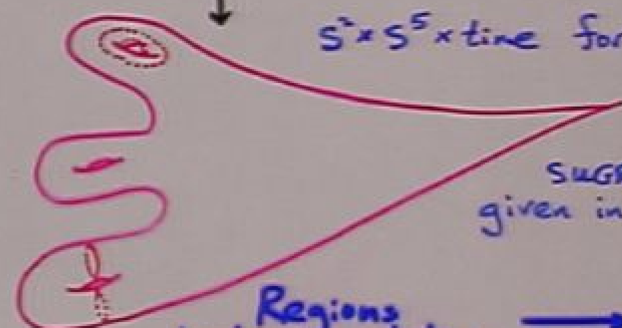

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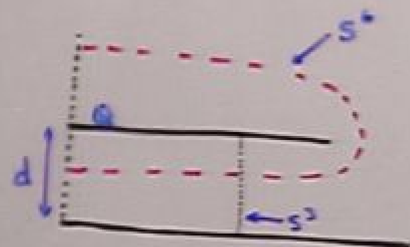
SUGRA solution given in terms of $V(r,z)$

Regions between plates $\longrightarrow$ NS5-brane throats

Lin-Maldacena: Single throat geometry has d / Q units of NS5/D2 flux through S^3/S^6.



recall: $X^i = \frac{1}{3g}\begin{pmatrix} J^i_d & & \\ & \ddots & \\ & & J^i_d \end{pmatrix}$ ($\leftarrow Q$) associated with → Q D2-branes, → d NS5-branes

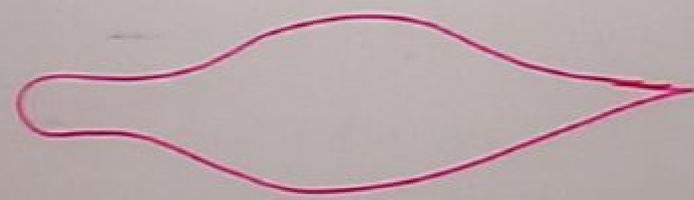
Remaining parameter: V_0

scaling this doesn't change metric, takes

$$e^\phi \longrightarrow \frac{V_0}{\tilde{V}_0} e^\phi$$

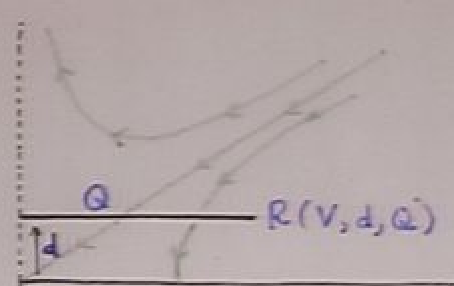
Associate $V_0 \sim \frac{1}{g_s} \sim \frac{1}{g^2}$

Simplest case: single throat



$$X^i = \frac{1}{3g}\begin{pmatrix} J_d^i & & \\ & \ddots & \\ & & J_d^i \end{pmatrix} \quad (Q \text{ blocks})$$

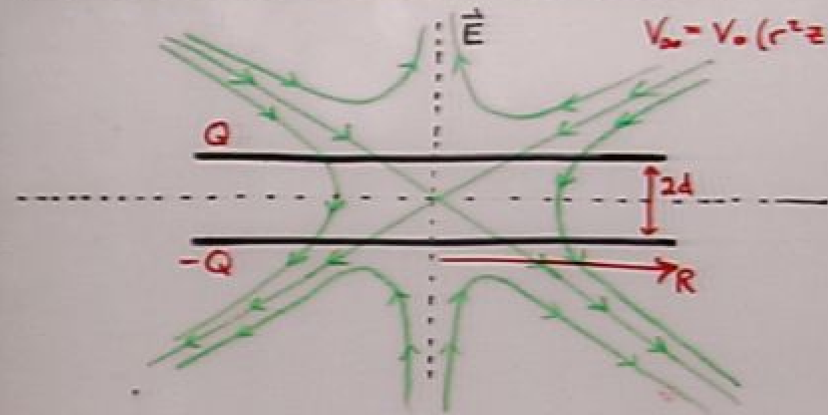
Q copies of d dimensional irrep.



Single charged disk

THE ELECTROSTATICS PROBLEM: SIMPLEST CASE

$V_\infty = V_0 \left(r^2 z - \frac{2}{3} z^3\right)$



$V_0 = 0$: Maxwell
Clausius
Helmholtz
Kirchhoff
Polya-Szego
Nicholson
Love 1949

Solution: $V = V_0 R^3 \phi_{\frac{d}{R}}\left(\frac{r}{R}, \frac{z}{R}\right)$

solve for ϕ with fixed potential Δ on plates.

$$\phi_\kappa(r,z) = \frac{1}{2}\left(\Delta + \frac{2}{3}\kappa^3\right) \int_{-1}^{1} dt\, f(t) \left\{ \frac{1}{\sqrt{r^2 + (z+\kappa+it)^2}} - \frac{1}{\sqrt{r^2 + (z-d+it)^2}} \right\}$$

$$f(t) - \int_{-1}^{1} dx\, K(t,x)\, f(x) = 1 - \frac{2\kappa}{\Delta + \frac{2}{3}\kappa^3}\, t^2$$

$$K(t,x) = \frac{\kappa/\pi}{\kappa^2 + (x-t)^2}$$

CONSTRAINT:

$\sigma \to 0$ at edge $\Longrightarrow$ $f(1) = 0$

FIXES $\Delta(\kappa)$ (potl on plates)
↓
FIXES $R(V_0, Q, d)$

DECOUPLING LIMIT

Want infinite throat in geometry

Need $R \to \infty$, d fixed

Scale V_0 to get non-trivial solution between plates

$$V = \frac{1}{g_0} \sin\left(\frac{\pi z}{d}\right) I_0\left(\frac{\pi r}{d}\right)$$

Requires: $Q \to \infty$, $R \to \infty$, d fixed, $V_0 \to \frac{1}{g_0}(Rd)^{-\frac{3}{2}} e^{\frac{\pi R}{d}}$

Field theory: $N = Qd \to \infty$, d fixed = # fivebranes

$\frac{1}{g^2} \lambda^{3/8} e^{-a\lambda^{1/4}/d^{5/4}}$ fixed

★ LST for d NS5-branes on S^5 described by large N limit with $\lambda \sim d^5 \ln^4(N)$ ★

THE DOUBLE-SCALING LIMIT

Usual 't Hooft limit: $N \to \infty$ λ fixed

- only planar diagrams remain
- free strings in bulk

Our limit: $N \to \infty$ $\lambda \sim d^5 \ln^4(N)$

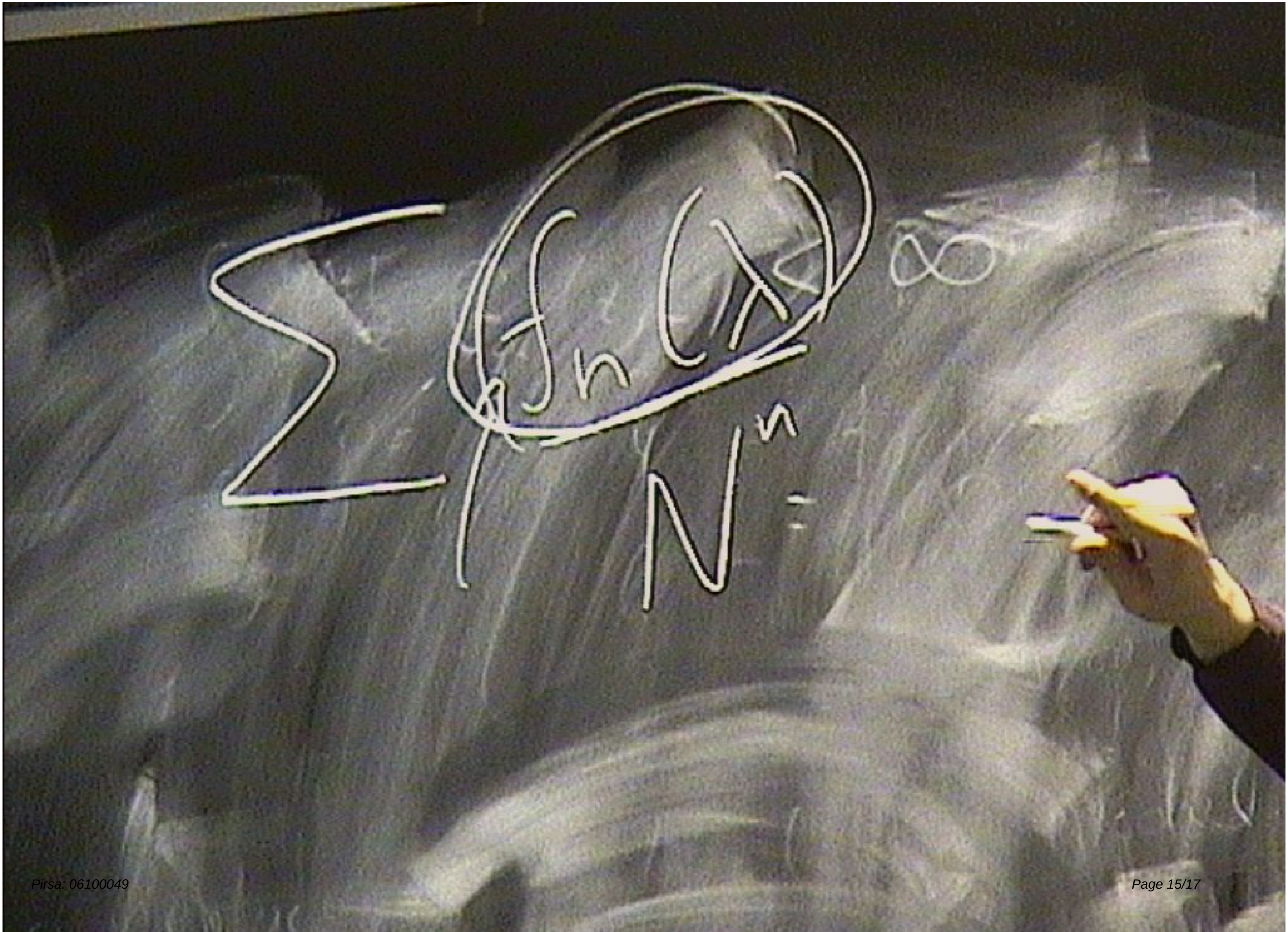
- $g_s \to 0$ asymptotically but not at $r=0$

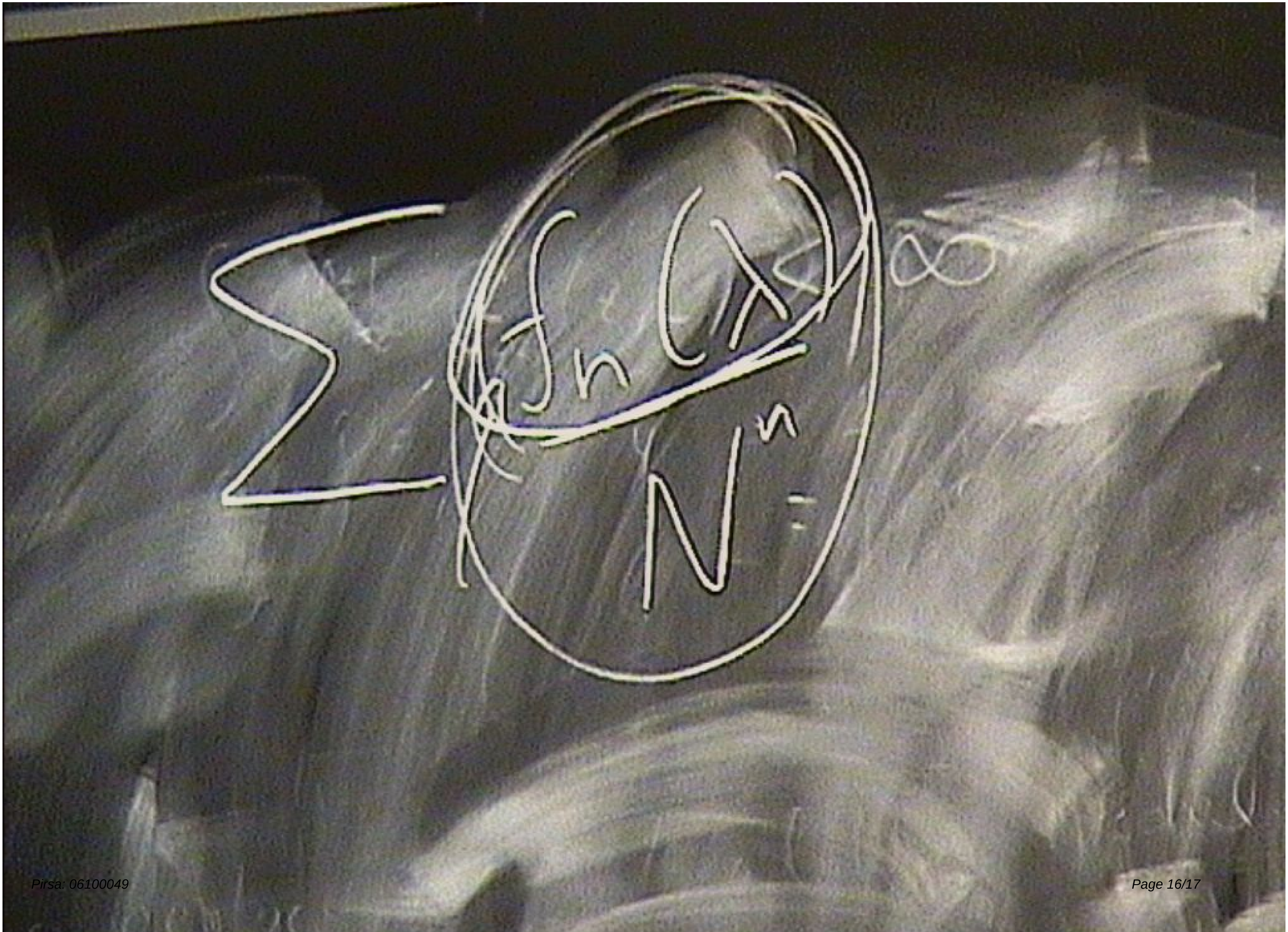
∴ interacting strings → all terms in genus expansion must contribute

PREDICTS

$$f_n \sim c_n \left[\lambda^{5/8} e^{\frac{a \lambda^{1/4}}{d}} \right]^n \quad \text{as } \lambda \to \infty$$

↑ sum of all genus n diagrams for a physical observable




$\sum \frac{f_n(x)}{N^n}$
∞

LIMITS OF PWMM

① Finite g, N — IIA strings / M theory on LM geometries

② M-theory limit — M-theory on max. SUSY plane-wave

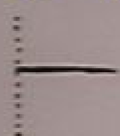
$N \to \infty$

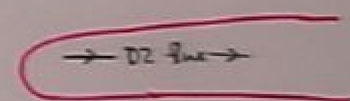
$\lambda \sim N^4$

③ D2-brane limit — Max. SUSY $U(Q)$ gauge theory on S^2

$N \to \infty$

$\lambda \sim N^2$ Q fixed

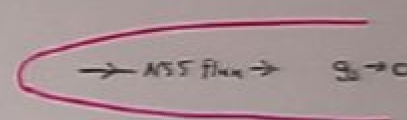




④ NS5-brane limit — LST on S^5

$N \to \infty$

$\lambda \sim \ln^4(N)$ d fixed



⑤ t'Hooft limit — Free strings on LM geometry

$N \to \infty$

λ fixed