Dielectric effect

N D0-brane in 4-form flux $F^{(4)}_{0ijk} = F_{ijk}$ (space-directions)

↓

Scalars Φ^i : $N \times N$ matrices.

Effective potential:

$$V = c\left[-\mathrm{Tr}\left([\Phi^i, \Phi^j]^2\right) - i\lambda F_{ijk}\,\mathrm{Tr}\left([\Phi^k, \Phi^j]\Phi^i\right)\right]$$

→ Eq. of motion:

$$[\Phi^i, \Phi^j] = -\frac{3}{4} i \lambda F_{ijk} [\Phi^j, \Phi^k]$$

$$\Downarrow$$

$$f\,\epsilon_{ijk}$$

Soln. $\Phi^i = -\frac{3}{8}\lambda f J_i$

$$[J_i, J_j] = 2i\,\epsilon_{ijk} J_k$$

J_i : SU(2) representation matrices.

& could be trivial ($\Phi^i = 0$, reducible or irreducible!)

Lowest energy comes from choosing $\Phi^i \propto$ irreducible matrix of rank N.

$$j = \frac{N-1}{2}$$

Physical interpretation:

* Spherical D2-brane carrying gauge field strength F_{ij} so as to produce D0 charge N.

Consider such a D2-brane of radius R.

$$V(R) = 4\pi T_2 \sqrt{R^4 + a^2 N^2} - b f R^3$$

$4\pi T_2$ ← D2-brane tension; $\sqrt{R^4 + a^2 N^2}$ ← constant; $b f R^3$ ← CS type term.

$$\simeq 4\pi T_2 \left(aN + \frac{R^4}{2aN} + \cdots \right) - b f R^3$$

$4\pi T_2 a = T_0$ ← D0-brane mass.

$$V(R) = N T_0 + u R^4 - b f R^3$$

Extremum at $R = 0$

$$R = \frac{3bf}{4u}$$ → Lower energy.

D2-brane puffs up & carries D0-charge.

This can be generalized to other branes by duality.

D3 brane in 7-form flux

$F^{(7)}_{\parallel ijk} \equiv F^{(3)}_{klm.}$ ⊥ to D3 & ijk.

⇒ Puffed up D5 wrapped along a 2-sphere in ijk direction. ⇒ ⊥ D3 & klm.

S-dual version:

D3 in $\mathcal{H}^{(3)}_{klm}$

⇓

NS-5 wrapped along a 2-sphere

⊥ D3 and (klm) direction.

In general if D3 has k ⊥ fluxes along different directions, the largest flux would win.

⇒ puff up in directions ⊥ to the largest 3-form flux.

Recall that in KKLT one needed to place $\overline{D3}$ at a place with large warping in order to reduce $\overline{D3}$ tension.

→ Uses Klebanov-Strassler throat.

Local geometry ~ conifold.

$$ds^2 = dr^2 + r^2 d\Omega_2^2 + (r^2 + a^2)\, d\Omega_3^2$$

↑ all inside CY_3.

A-cycle: Ω_3.

B-cycle: ⊥ to it (along r, θ, ϕ)

Put M units of F_3 flux through A-cycle.

K units of H_3 flux through B-cycle.

$M \ll K$

⇒ size of S^3 (A-cycle) $\sim \exp(-2\pi K/M g_s)$ ↓ small.

$\overline{D3}$-brane prefer lowest energy at the tip of the conifold $r = 0$.

$\perp$ flux: M unit of F_3 along A

K units of H_3 along B

↓

wins.

D3 $\Rightarrow$ NS-5 wrapped on an S^2

$\perp$ B cycle

$\Rightarrow$ Some S^2 inside A-cycle

↳ 3-d.

S^3 metric: $d\psi^2 + \sin^2\psi \, dR_2^2$

Fixed $\psi \Rightarrow S^2$.

ψ has to be determined dynamically from extremization of the potential.

* SUSY vacuum:

KM = const. + # of D3-branes.

= $-b$ to begin with.

$K \to K-1 \Rightarrow$

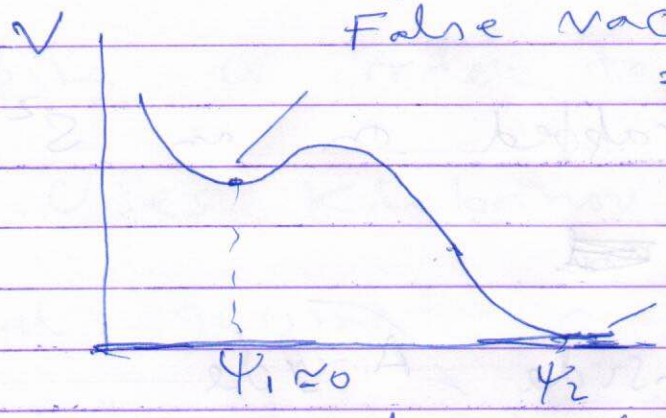
$(K-1)M$ = const. + # of D3-branes

$\Rightarrow$ new # of D3-branes = $(\hat{M}-b)$.

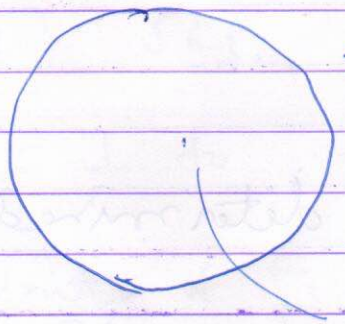
↳ SUSY config.

One can calculate the potential $V(\psi)$.

Result: ($p \ll M$)



For some choice of parameters.



$\psi = \psi_1$
$\Rightarrow$ $\overline{D3}$ charge carried by puffed up NS5

$\psi = \psi_2$ $\overline{D3}$ charge has gone.

Interpolation: ψ changes from $\psi_1 \simeq 0$ to $\psi_2 \simeq \pi$.

5-brane wrapping S^3 → A-cycle.

$\Downarrow$

responsible for K → K − 1.

Final decay rate

$$\sim \exp\left(-\frac{27\, b_0^2\, g_s M^6}{512\, \pi\, \phi^3}\right)$$

$b_0 = \frac{3}{32\pi^2} \sim 1$