Dielectric effect

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

Scalars $\Phi^i$: $N \times N$ matrices.

Effective potential:

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

$E_{ij}$ of motion:

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

Solutions: $\Phi^i = -\frac{3}{8} i \lambda f J_i$

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

$J_i$: 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 $N$.

$$i = \frac{N-1}{2}$$
Physical interpretation:

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

Consider such a D2-brane of radius $R$.

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

D2-brane tension $T_0$ constant term

$$\geq 4\pi T_2 \left( a N + \frac{R^4}{2an} \right) - b f R^3$$

$$4\pi T_2 a = T_0$$

D0-brane mass

$$V(R) = N T_0 + \phi a R^4 - b f R^3$$

Extremum at $R = 0$

$$R = \frac{3bf}{4n}$$

Lesser energy.

D2-brane puffs up & carries D0-charge.
This can be generalized to other branes by analogy.

D3 brane in 7-form flux

\[ F^{(7)}_{ijklm} = F^{(3)}_{k} \perp D3 \]

\[ \Rightarrow \text{Put up D5 along a 2-sphere in } ijk \text{ direction.} \perp D3 \& klm \]

S-Dual version:

D3 in \( H_{k} \)

NS-5 wrapped along a 2-sphere \( \perp D3 \) and \( (k)lm \) direction.

In general if D3 has \( I \) fluxes

\( \Rightarrow \) stuff up in directions \( \perp \) to the largest 3-form flux.
Recall that in KKLT one needed to place D3 at a place with large warping in order to reduce D3 tension.

- Uses Klebanov-Strassler throat.

Local geometry ~ comifold:

\[ ds^2 = dz^2 + \sum_{i=1}^{2} \delta_i dz^2 + (x^2 + \delta_i x^2) ds_i^2 \]

all inside CY3.

\( \bullet \) A-cycle: \( R_3 \).

B-cycle: 1 to \( \phi \) (along \( \delta_i, \theta_i \phi \))

Put \( M \) units of \( F_3 \) flux through A-cycle.

\( K \) units of \( H_3 \) flux through B-cycle.

\( M \ll K \)

\( \exists \) size of \( S^3 \sim \exp(-2\pi K/M \phi) \)

\( 1 \) A-cycle.

Small.

D3-brane have lowest energy at the tip of the comifold \( r=0 \).
1 flux: M unit of $F_3$ along A

$K$ units of $H_3$ along B

works.

$D_3 \to NS-5$ wrapped on an $S^2$

+ B cycle

inside $A$-cycle

$S^2$ metric:

$$ds^2 + \sin^2 \theta \, d\Omega_2$$

Fixed $\theta \equiv S^2$.

$\theta$ has to be determined dynamically for

extremisation of the potential.

$S$ SUSY vacuum:

$$KM = \text{const.} + \# \text{ of } D3\text{-brane}$$

$k \to k-1 \Rightarrow$

$\text{const}(k-1) M = \text{const.} + \# \text{ of } D3\text{-branes}$

new $\# \text{ of } D3\text{-branes} = (M-k)$

$\to$ SUSY config.
One can calculate the potential \( V(\phi) \).

Result: \( b < c M^4 \)

False vacuum:
- \( \phi_1 \)
- \( \phi_2 \)

True vacuum:
- Puffed up NS-5 carrying D3 charge
- \( \phi_2 = \phi_f \) D3 charge has gone.

For some choice of parameters:

\[ \phi = \phi' \]

Interpolation: \( \phi \) Changes from \( \phi_1 = 0 \) to

\[ \phi_2 = \pi \]

5-brane wrapping \( S^3 \rightarrow A\)-cycle.

\[ \rightarrow \phi \rightarrow \phi + 1 \]

Final decay rate:

\[ \text{exp} \left( -\frac{27 b_0 95 M^6}{512 \pi^2 \phi^3} \right) \]

\[ b_0 = 0.93266 \]