Napoli RTN workshop 10/10/2006

Metastable Supersymmetry Breaking and Gauge/Gravity Duality

Riccardo Argurio (ULBrussels)

Based on work in progress with
M. Bertolini, S. Franco and S. Kachru

Dynamical Supersymmetry breaking (DSB) in a stable vacuum is displayed only in few chiral (and complicated) models.

An alternative is DSB in a metastable “vacuum” $\equiv$ only locally stable. (Dimopoulos, Dvali, Rattazzi, Giudice ’97)

(Meta)stability:

at classical level

+ lifting of pseudo-moduli

+ long enough lifetime

Metastable DSB using Seiberg dualities

(Intriligator, Seiberg, Shih '06)

$SU(N_c)$ SQCD with $N_c \leq N_f < \frac{3}{2}N_c$ and $m \ll \Lambda$

Electric: IR strongly coupled

Magnetic: IR free $M, q, \tilde{q}$

Canonical Kähler potential, $W = mM - \mu q M \tilde{q}$.

DSB by rank condition ($F_M \neq 0$) around $M = 0$ with

$$V_{\text{meta}} \sim N_c |m|^2$$

(SUSY vacua at $M \neq 0$)

Metastable DSB in gravity/string theory

Introduce p $\overline{D3}$-branes in the Klebanov-Strassler background created by M fractional branes.

(Kachru, Pearson, Verlinde '01)

$\overline{D3}$s are attracted to the smoothed tip, but they cannot annihilate perturbatively (if $p \ll M$, otherwise Myers effect).

These are metastable states of the $SU(2M-p) \times SU(M-p)$ gauge theory.

Warning / Problem

Properties of non SUSY states are not protected when parameters are varied, e.g.

$$\lambda = g_{YM}^2 N \equiv g_s N$$

from small (gauge theory) to large (gravity).

(Local) stability is not granted to persist on both sides.

ISS in gravity ?

KPV in gauge theory ?

Set up which is under reasonable control on both sides:

$\mathcal{N} = 1$ Quiver gauge theories from $D3$s at singularities, with no external flavors.

In order to find a subsector similar to massive SQCD we need to generate masses dynamically

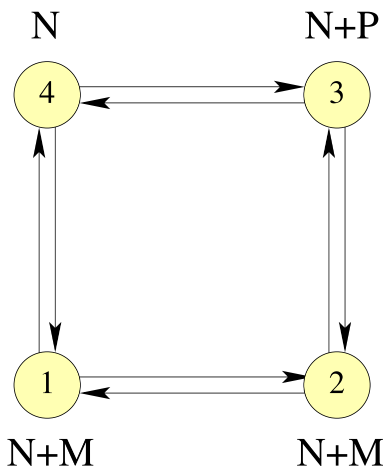
$$W = XYZ \quad \rightarrow \quad W = \langle X \rangle YZ, \qquad \langle X \rangle \neq 0$$

But since $V \sim |\langle X \rangle|^2$, the VEV $\langle X \rangle$ must be constrained otherwise $V \rightarrow 0$.

Interesting way out: X is a meson in $N_f = N_c$ SQCD, so that

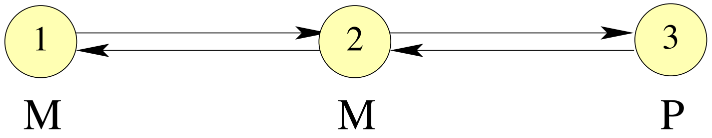
$$\det X = \Lambda^{2N_c} \qquad (B = \tilde{B} = 0)$$

Our example: Conifold$/Z_2$ (non chiral)

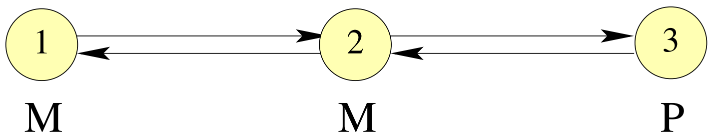


$$
\begin{aligned}
W \;=\;& X_{32}X_{21}X_{12}X_{23} \\
& -X_{32}X_{23}X_{34}X_{43} \\
& +X_{14}X_{43}X_{34}X_{41} \\
& -X_{14}X_{41}X_{12}X_{21}
\end{aligned}
$$

The addition of P and M fractional branes leads to a cascade, and at the bottom we have



$$W = X_{23}X_{32}X_{21}X_{12}$$



$W = X_{23}X_{32}X_{21}X_{12}$

$SU(M)_1$ has $N_f = N_c$. Mesons $\mathcal{M} = X_{21}X_{12}$, $\langle\mathcal{M}\rangle \neq 0$.

$\longrightarrow$ mass for $SU(P)_3$ flavors: $W = \langle\mathcal{M}\rangle X_{23}X_{32}$.

Vacuum energy is $V \sim \sum_{i=1}^{P} |m_i|^2$.

So $\det\langle\mathcal{M}\rangle = \Lambda^{2M}$ keeps $V > 0$ only if $P = M$.

In ISS the case of $N_f = N_c$ SQCD is more subtle.

- Pseudo-moduli are still massless at one-loop.
- Need to have a good estimate of the lifetime.

But:

Argument following the decoupling of one massive flavor from $N_f = N_c + 1$ SQCD.

Dual geometry

The singular geometry is $x^2y^2 = uv$.

The SUSY vacuum corresponding to the 3-node quiver with equal ranks is

$$(xy - \epsilon)^2 = uv$$

with $D5$-branes wrapped on a small S^2 at the line of C^2/Z_2 singularities $xy = \epsilon$.

What about the metastable states ?

Add M $\overline{D3}$-branes (not more, not less)

$\longrightarrow$ they are attracted to the tip and more specifically to the wrapped $D5$-branes.

$\longrightarrow$ they get dissolved as gauge flux.

Possibly, no Myers effect here due to cancellations.

Warning: Stability to be checked; beyond probe approximation

Open problems

• Full SUGRA analysis: backreaction of wrapped $D5$-branes.

(But: possibly orbifold of Klebanov-Strassler.)

• Generalizations possible $\longrightarrow$ many other non chiral quivers.

$\star$ Try also other interesting settings,
e.g. chiral (runaway) quivers like dP_1 ...