Landscape of Supersymmetry Breaking Vacua in Geometrically Realized Gauge Theories

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Based on work in collaboration with Hirosi Ooguri : hep-th/0606061

New work open up new avenue for dynamical SUSY breaking

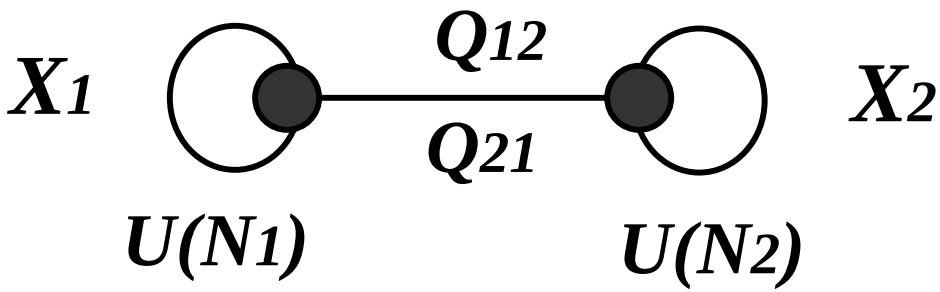
Intriligator, Seiberg and Shih hep-th/0602239

- ✓ ***Long-live meta-stable vacua are phenomenologically viable***
- ✓ ***This makes it easier to construct models that break SUSY***
- ✓ ***Free magnetic dual description is used to study IR physics***

We study models that are realized geometrically by D-branes wrapping 2-cycles in Calabi-Yau threefolds.

N=1 Supersymmetric Quiver Gauge Theory

Cachazo, Fiol, Intriligator, Katz and Vafa :0110028



$$W = W_1(X_1) + W_2(X_2)$$

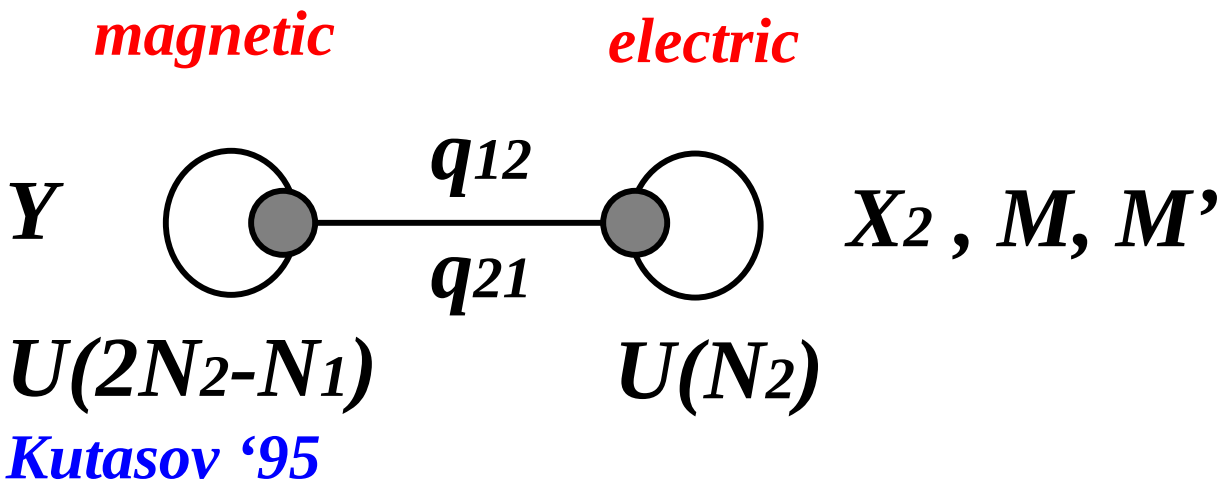
$$+ tr\, Q_{21} X_1 Q_{12} + tr\, Q_{12} X_2 Q_{21}$$

We assume : $\Lambda_1 \gg \Lambda_2$

$$W_1(X_1) = \text{cubic}$$

Critical point -t1, +t1

Dual description for the model



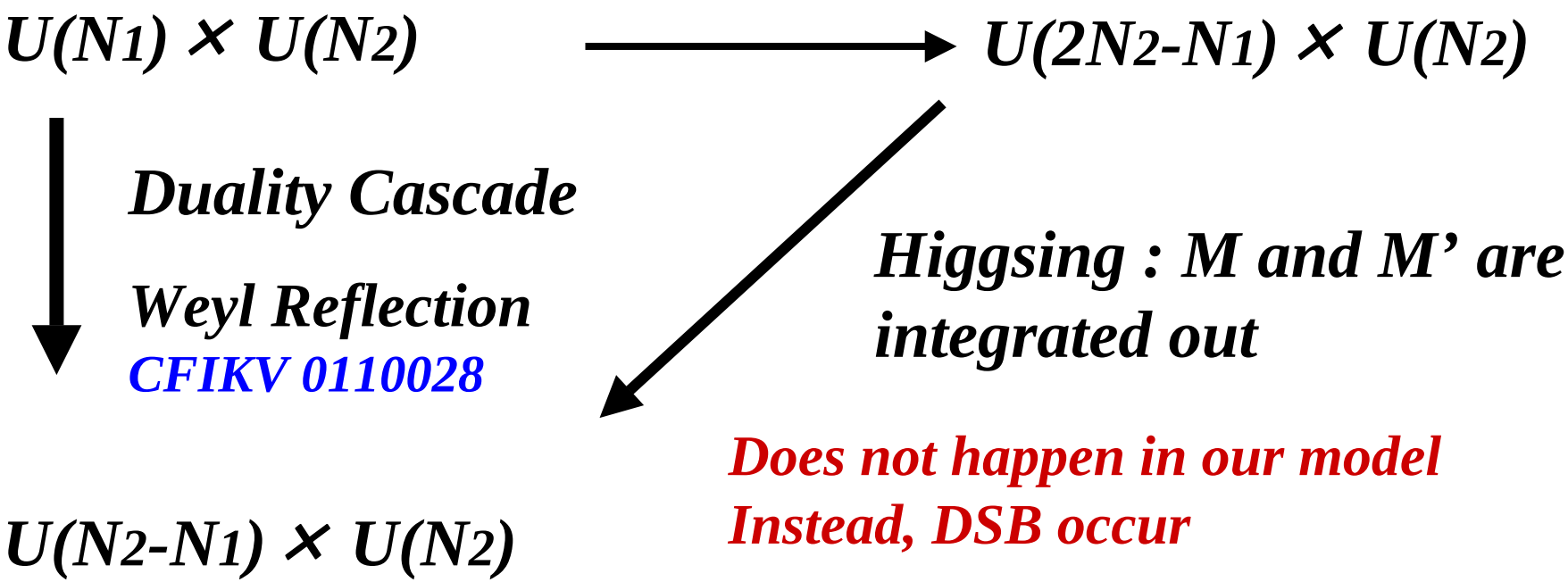
Kutasov '95

$$M \Leftrightarrow Q_{21} X_1 Q_{12}\,, \qquad M' \Leftrightarrow Q_{21}\, Q_{12}$$

$$W = \tilde{W}_1(Y) + W_2(X2)$$
$$+ \mathrm{tr}\, M\,(q_{21}\, q_{12} - \mu 1) + \mathrm{tr}\, M'(q_{21}\, Y\, q_{12} - X_2)$$

Focus on : $N_1/2 < N_2 < 2N_1/3$

- ✓ *Both $U(2N_2-N_1)$ and $U(N_2)$ in Dual are IR free*
- ✓ *Sutable to study low energy physics*
- ✓ *Can be regarded as the end of Duality Cascade*



At the tree level, there is no solution to the F-term condition

$$q_{21} = \begin{pmatrix} \mu 1 \\ 0 \end{pmatrix} \qquad q_{12} = \underbrace{\begin{pmatrix} \mu 1 & 0 \end{pmatrix}}_{N_2} \Big\} 2N_2\text{-}N_1$$

$$Y = \begin{pmatrix} t_1 1_{r1} & 0 \\ 0 & -t_1 1_{r2} \end{pmatrix} \qquad M = \begin{pmatrix} 0 & 0 \\ 0 & X \end{pmatrix} \begin{matrix} \Big\} 2N_2\text{-}N_1 \\ \Big\} N_1\text{-}N_2 \end{matrix}$$

flat direction

$$X_2 = q_{21}\, Y\, q_{12} \qquad M' = 0$$

One-loop effective potential gives mass for X

All the moduli are locally stabilized

There are $2N_2$-N_1 meta-stable vacua

There are unbroken non-abelian gauge groups

$$U(r_1) \times U(r_2) \times U(N_1\text{-}N_2)$$

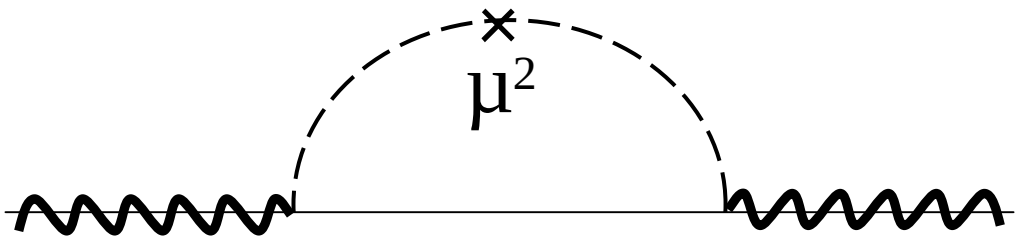
Gauge fields are massless and exist at low energy.

How about gaugino?

F-term for M is non-vanishing.
This yields soft –breaking B-term

$$L_{B\text{-}term} = h\,\mu^2\,tr \begin{pmatrix} 0 & 0 \\ 0 & 1_{N1-N2} \end{pmatrix} q_{21} q_{12}$$

This generates gaugino masses at one-loop for entire gauge group



- ✓ *Low energy limit is the bosonic pure QCD*
- ✓ *Supersymmtry is not restored in the IR*
- ✓ *Lowest energy exitations are QCD glueballs*

Dual description can be used to identify and explore both SUSY breaking vacua and SUSY vacua within the single framework

We can evaluate the decay rates of the meta-stable vacua into the supersymmetric vacua.
They can be made parametrically small.

UV

$U(N_1) \times U(N_2)$ *Asymptotically free*

$U(2N_2-N_1) \times U(N_2)$ *IR free*

Supersymmetry breaking

Bosonic Pure $U(r_1) \times U(r_2) \times U(N_1-N_2)$

Low energy

IR

Comments

We show landscape of inequivalent meta-stable vacua where supersymmetry is dynamically broken

For $SU(N_1) \times SU(N_2)$, degeneracy of meta-stable vacua are resolved by one-loop correction

This may help us understand the landscape of string vacua

Can we describe the SUSY breaking vacua geometrically in the string theory language?