Gaugino Condensation and Generation of Supersymmetric 3-Form Flux

in collaboration with:

G. Curio, G. Dall'Agata and D. Lüst

hep-th/0406118

Porto, 21.06.2004

Study: gaugino condensation in

$\mathcal{N} = 1^*$ SU(N) gauge theory, large N, large $g^2_{YM} N$

AdS/CFT correspondence $\longrightarrow$ Polchinski-Strassler solution of type IIB supergravity

Dynamical effect $\longrightarrow$ growth of 3–form flux?

Show: Hodge type $(3,0)$, IASD $\longrightarrow$ supersymmetry?

$\mathcal{N} = 1^*$: mass deformation of $\mathcal{N} = 4$ $SU(N)$

$$W = m_{ij}\, \phi_{(i}\, \phi_{j)}, \quad m_{ij} = m \quad , \quad i = 1,2,3$$

Confining phase: $<\bar{\lambda}\bar{\lambda}> = m^3$ at large $g^2_{\mathrm{YM}} N$

Gaugino condensation: order m^3 effect in dual supergravity solution

Dual supergravity solution describing RG–flow: warped solution with 3–form flux

$$ds^2 = Z^{-1/2}\,\eta_{\mu\nu}\,dx^{\mu\nu} + Z^{1/2}\,g_{mn}\,dx^m dx^n \quad ,$$
$$G_3 = F_3 - \tau H_3 \quad , \quad F_3 = dC_2 \quad , \quad H_3 = dB_2$$
$$G_3 = G_3(x^m) \quad , \quad \tau = \tau(x^m)$$

Exact supergravity solution not known. Iterative expansion in powers of m

Polchinski-Strassler 2000: order m, $\tau = \tau_0$

Freedman/Minahan 2000: order m^2, $d\tau \neq 0$

Here: order m^3

Radial coordinate $\longrightarrow$ energy scale in dual FT

$$r^2 = x^m\,x^m = \bar{z}^i\,z^i, \quad , \quad i = 1,2,3$$

Large $r \longrightarrow$ UV regime

Mass deformation $\longrightarrow$ 2–form–potential

$A_2 = C_2 - \tau_0 B_2 \qquad (G_3 = dA_2)$

$W = m\,\Phi_i^2 \longrightarrow$ dimension $\Delta = 3$

$$A_2 = m\, r^{\Delta-4}\, \varepsilon_{i\bar{j}\bar{k}}\, \frac{z^i}{r}\, d\left(\frac{\bar{z}^j}{r}\right) \wedge d\left(\frac{\bar{z}^k}{r}\right)$$

Polarisation tensor of type $(1,2)$

3-form flux $G_3 = dA_2$ has $(1,2)_P, \ldots,$ but NO $(3,0)$-piece

Gaugino condensate (chiral primary)

$< \bar{\lambda}\bar{\lambda} + \cdots > = m^3 \,, \quad \Delta = 3$

Singlet of $SU(3) \subset SU(4)_R$ of $\mathcal{N} = 4$ SYM

2–form potential

$$A_2^{(2,0)} = m^3 \, r^{-\Delta} \, \varepsilon_{ijk} \, f\left(\frac{z}{r}, \frac{\bar{z}}{r}\right) \frac{z^i}{r} d\left(\frac{z^j}{r}\right) \wedge d\left(\frac{z^k}{r}\right) .$$

Polarisation tensor $(3,0)$, singlet of $SU(3)$

Determine f: type IIB EOM for $G_3 = dA_2$

Schematically

$$d\left[Z^{-1} \, (\star - i) \; G_3\right] = m \, d\tau \wedge d\bar{z}^i \wedge dz^j \wedge dz^k \, \varepsilon_{\bar{i}jk}$$

Homogeneous and inhomogeneous solutions at order m^3

Homogeneous solution: $(\star - i)G_3 = 0$

$\longrightarrow$ ISD

$\longrightarrow$ G_3 does NOT contain $(3,0)$–piece

$f = c =$ constant, undetermined at large r, fixed by physics in IR

Inhomogeneous solution: uniquely fixed

$\longrightarrow$ G_3 HAS $(3,0)$–piece, $\quad G^{(3,0)} \propto m\, \partial\tau$

CAN be written as $\qquad G^{(3,0)} = \partial\, A_2^{(2,0)}$,

$$A_2^{(2,0)} = m^3\, r^{-\Delta}\, \varepsilon_{ijk}\, f\, \frac{z^i}{r}\, d\left(\frac{z^j}{r}\right) \wedge d\left(\frac{z^j}{r}\right)$$

$$f = \left(\frac{\bar{z}^2}{r^2}\right)^2$$

$m^3 : G^{(3,0)} \longrightarrow \varepsilon_{ijk} \quad$ gaugino condensate vev

Supersymmetry:

Gaugino condensate preserves $\mathcal{N} = 1$ supersymmetry. IASD $G^{(3,0)} \longrightarrow$ supersymmetry?

Graña/Polchinski 2000,

Giddings, Kachru, Polchinski 2001:

supersymmetric G_3-flux in type IIB is ISD, of type $(2,1)_P$.

Type B spinor ansatz:

one globally defined six-dimensional Weyl spinor $\eta \longrightarrow$ transverse six–dimensional space has SU(3) group structure (J, Ω)

More general spinor ansatz: Dall'Agata 2004

Type D: η, $\chi \longrightarrow$ SU(2) structure (J^i, w_m)

$$w_m = \chi^T \gamma_m \eta$$

Result:

PS background at order m^3 with IASD flux $G^{(3,0)}$ is supersymmetric, SU(2) structure

Type D ansatz: manifestation of dielectric nature of solution Pilch and Warner 2004

Projector for D3 (UV) and D5/NS5 (IR)

Summarising:

Input: m

$\downarrow$

Output: $G^{(3,0)}$ at order m^3

$\swarrow \quad \searrow$

| SU(2) structure | | polarisation ε_{ijk} |

SU(2) structure helpful in finding the exact type IIB solution associated to the $\mathcal{N} = 1^*$ gauge theory.