STRINGS '99

STRINGS ON ADS BACKGROUNDS

BASED ON HEP-TH/9905032
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OUTLINE :

- STRINGS ON ADS
- FROM ADS_3 TO ADS_{2d+1}
- GENERALIZED G/H COSETS
- SUPER COSETS
- SPECULATIONS

• STRINGS ON ADS

- GO BEYOND SUGRA APPROXIMATION
- COVARIANT FORMULATION OF STRING THEORY
- UNDERSTAND STRING THEORY WITH RR BACKGROUNDS
- STRING FIELD THEORY IN ADS BACKGROUNDS

APPROACHES:

NSR FORMALISM

NOT KNOWN HOW TO DESCRIBE A CONDENSATE OF RR VERTEX OPERATORS

BERENSTEIN, LEIGH, 9904104
D. POLYAKOV, 9812044/9907021

GS FORMALISM

CLASSICAL DESCRIPTION KNOWN FOR $AdS_5 \times S^5$ AND $AdS_3 \times S^3$

METSAEV, TSEYTLIN, 9805028
KALLOSH, RAJARAMAN, RAHMFELD, 9805217
PESANDO, 9808020
KALLOSH, RAHMFELD, 9808038
PESANDO, 9809145
RAHMFELD, RAJARAMAN, 9809164
PARK, REY, 9812062

CLASSICAL GS STRING IN FLAT SPACE CAN BE QUANTIZED. PROBLEMATIC IN CURVED SPACE

YU, ZHANG, 9812216
RAJARAMAN, ROZALI, 9902046

GS TYPE VARIABLES FOR NSR STRINGS

(A LA BERKOVITS)

EXISTS IN

$D=4$ — BERKOVITS, 9404162

$D=6$ — BERKOVITS, VAFA, 9407190

$D=10$, WITH $U(5) \subset SO(10)$ UNBROKEN — BERKOVITS, 9902099

HAVE BEEN USED TO DESCRIBE

$AdS_2 \times S^2$ WITH RR FLUX $\Rightarrow$ SATURDAY

$AdS_3 \times S^3$ WITH RR FLUX — BERKOVITS, VAFA, WITTEN, 9902098

$AdS_3 \times S^3$ IS DESCRIBED BY A SIGMA MODEL WITH TARGET SPACE THE GROUP MANIFOLD $PSL(2|2)$ COUPLED TO GHOSTS

DEFORMING THE RR FLUX TO NS FLUX YIELDS THE WZW MODEL FOR $PSL(2|2)$

PSL(2|2) WZW

$\updownarrow$ CHANGE OF VARIABLES

SL(2) X SU(2) N=1 WZW : STANDARD NSR FORMULATION OF STRINGS ON $AdS_3 \times S^3$ WITH ONLY NS FLUX

<u>IDEA</u>: FIND GENERALIZATIONS OF THESE THEORIES INVOLVING OTHER AdS SPACES.

WE WILL FIND EXACTLY SOLVABLE CFT'S, WHOSE GEOMETRY IS AdS, AND WHICH ARE HOLOGRAPHIC.

TO OBTAIN STRINGS WITH RR BACKGROUNDS, COUPLE TO APPROPRIATE GHOSTS & DEFORM ??

USE BOTH GROUPS AND SUPERGROUPS

FROM AdS_3 TO AdS_{2d+1}

$AdS_3 \sim SL(2)$

$$g = \begin{pmatrix} 1 & \bar\gamma \\ 0 & 1 \end{pmatrix} \begin{pmatrix} e^{-\phi} & 0 \\ 0 & e^{\phi} \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \gamma & 1 \end{pmatrix} = g_+ g_0 g_- \quad \text{GAUSS DECOMPOSITION}$$

$$S_{WZW}[g] = S_{WZW}[g_0] + \frac{k}{2\pi} \int tr\left(g_+^{-1} \partial g_+ \, g_0 \, \bar\partial g_- g_-^{-1} g_0^{-1} \right)$$

$$= \frac{k}{2\pi} \int \left(\partial\phi \bar\partial\phi + e^{2\phi} \partial\bar\gamma \bar\partial\gamma \right)$$

$$\Big\Downarrow \begin{array}{l} \text{-INTRODUCE AUXILIARY FIELDS} \\ \text{-RESCALE} \end{array}$$

$$= \frac{1}{4\pi} \int \left(\partial\phi\bar\partial\phi + \beta\bar\partial\gamma + \bar\beta\partial\bar\gamma - \beta\bar\beta e^{-2\phi/\alpha_+} - \frac{2}{\alpha_+}\phi\sqrt{g}R \right)$$

$$\alpha_+ = \sqrt{2(k-2)}$$

FREE FIELD THEORY PERTURBED BY THIS OPERATOR OF THE FORM $S\bar S$ WITH $S = \beta e^{-2\phi/\alpha_+}$

- $S\bar S$ IS EXACTLY MARGINAL WITH CONFORMAL WEIGHT $(1,1)$
- ONLY THINGS THAT COMMUTE WITH $\oint S$ ARE SL_2 CURRENTS
- CORRELATORS / CONFORMAL BLOCKS FROM FREE FIELDS WITH $\oint S$ INSERTIONS

GENERALIZE BY TAKING MORE FIELDS

USING FREE FIELD FORM GUARANTEES CONFORMAL INVARIANCE

$$S = \frac{1}{4\pi}\int\left(\partial\phi\bar\partial\phi + \beta_r\bar\partial\gamma_r + \bar\beta_r\partial\bar\gamma_r - \beta_r\bar\beta_r e^{-2\phi/\alpha_+} - \frac{2}{\alpha_+}\phi\sqrt{g}R\right)$$

$r = 1 \ldots d$

$\alpha_+ = \sqrt{2(k-2d)}$

INTEGRATE OUT $\beta_r, \bar\beta_r$

$$S = \frac{k}{2\pi}\int\left(\partial\phi\bar\partial\phi + e^{2\phi}\partial\bar\gamma_r\bar\partial\gamma_r\right) + \frac{1}{2\pi}\int(d-1)\phi\sqrt{g}R$$

$$\begin{cases} G: & ds^2 = k\left(d\phi^2 + e^{2\phi}d\gamma_r d\bar\gamma_r\right) \\ B: & B = k e^{2\phi} d\gamma_r \wedge d\bar\gamma_r \\ \Phi: & \Phi = (d-1)\phi \end{cases}$$

AdS_{2d+1}

ONE LOOP β-FUNCTIONS ARE SATISFIED

ONE LOOP CENTRAL CHARGE: $c = (2d+1) + \frac{6}{k}$

EXACT: $c = (2d+1) + \frac{6}{k-2d}$

* EINSTEIN FRAME:

$$ds_E^2 = e^{2\phi/(2d-1)}\left(e^{-2\phi}\, d\phi^2 + d\gamma_r\, d\bar{\gamma}_r\right)$$

DISTANCE ON BOUNDARY DIVERGES ~ HOLOGRAPHY

* LESS GLOBAL SYMMETRIES: B DETERMINES

COMPLEX STRUCTURE ON BOUNDARY

$$SO(2d) \longrightarrow U(d)$$

* THEORY HAS $d+1$ HOLOMORPHIC CURRENTS

* CONSTANT B-FIELD $\Longleftrightarrow$ NONCOMMUTATIVE GEOMETRY?

AdS_{2d+1} IS AN EXAMPLE OF A

NOVEL TYPE OF COSET CONSTRUCTION

G/H HOMOGENEOUS SPACE; USUALLY NOT CONFORMAL	NOVEL G/H COSET	STANDARD G/H COSET

$\longrightarrow$ LESS ISOMETRIES $\longrightarrow$

HINT OF EXISTENCE OF SUCH NOVEL COSETS – FEIGIN FRENKEL

– GERASIMOV, MOROZOV, OLSHANETSKY, MARSHAKOV, SHATASHVILI

– BARS

IDEA : $G \supset H$

H = PRODUCT OF SIMPLE FACTORS

DO A PARTIAL BOSONIZATION – JDB, FEHER

$$J_G = J_G[J_H, \phi_i, \beta_r, \gamma_r]$$

REMOVE THE DEGREES OF FREEDOM IN H

RECIPE :

① WRITE $g = g_+ h g_0 g_- \quad h \in H$

e.g. $\frac{SL(3)}{SL(2)}$ $g = \begin{pmatrix} 1 & \bar\gamma_1 & \bar\gamma_2 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & * & * \\ 0 & * & * \end{pmatrix} \begin{pmatrix} e^{-2\phi} & 0 & 0 \\ 0 & e^{\phi} & 0 \\ 0 & 0 & e^{\phi} \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ \gamma_1 & 1 & 0 \\ \gamma_2 & 0 & 1 \end{pmatrix}$

② DROP h

③ EVALUATE $S_{WZW}[g_+ g_0 g_-]$

e.g. $S = \frac{1}{2\pi} \int \left(3 \partial\phi \bar\partial\phi + e^{3\phi} (\partial\bar\gamma_1 \bar\partial\gamma_1 + \partial\bar\gamma_2 \bar\partial\gamma_2) \right)$

④ Introduce AUXILIARY VARIABLES β

e.g. $$S = \frac{1}{4\pi} \int \Big(\partial\phi\bar\partial\phi + \beta_1 \bar\partial\gamma_1 + \beta_2 \bar\partial\gamma_2 + \bar\beta_1 \partial\bar\gamma_1 + \bar\beta_2 \partial\bar\gamma_2 - \beta_1 \bar\beta_1 e^{-2\phi/\alpha_+} - \frac{4}{\alpha_+} \phi \sqrt{g} R \Big)$$

⑤ ADJUST BACKGROUND CHARGES SO THAT SCREENERS (MARGINAL PERTURBATIONS) HAVE THE RIGHT CONFORMAL WEIGHT

e.g. $\frac{-4}{\alpha_+} \phi \sqrt{g} R \Longrightarrow \frac{-2}{\alpha_+} \phi \sqrt{g} R$

⑥ (INTEGRATE OUT THE AUXILIARY FIELDS)

eg $\rightarrow$ THE PREVIOUS AdS_5 SOLUTION

FEATURES:

- HOLOMORPHIC CURRENTS ~ $n^+ g_0$
- ANTI HOLOMORPHIC CURRENTS ~ $g_0 n^-$
- # ISOMETRIES ~ $\dim(G) + \dim(G_0)$
- ISOMETRIES $\not\subseteq G$, BUT CONTAIN H

QUESTION:

- IS THERE A BRST-TYPE DEFINITION OF THESE COSETS?

BUILD STRING THEORIES ?

S^{2d+1} IS ANALYTIC CONTINUATION OF AdS_{2d+1} ??

$\alpha_+ \Longrightarrow i\alpha_+$

WORKS FOR $d=1$

$$S = S(AdS_5 ; \alpha_+) + S(AdS_5 ; i\alpha_+)$$

BACKGROUND WITH $C=10$

INTRODUCE $N=1$ WORLD-SHEET SUSY VIA SUPERFIELDS

RESULT:

$$\begin{aligned} S(AdS_5 ; \alpha_+)_{N=1} = \frac{1}{4\pi} \int \Big(& -\lambda^L \bar\partial \lambda^L + \partial\lambda^R \lambda^R - \sigma_r \bar\partial \psi_r^L - \bar\sigma_r \partial \bar\psi_r^R \\ & + \partial\phi \bar\partial\phi + \beta_r \bar\partial \gamma_r + \bar\beta_r \partial \bar\gamma_r \\ & - e^{-2\phi/\alpha_+} \left(\bar\beta_r - \frac{2}{\alpha_+} \lambda^R \sigma_r\right)\left(\beta_r - \frac{2}{\alpha_+}\lambda^L \bar\sigma_r\right) \\ & - e^{-4\phi/\alpha_+} \sigma_r \bar\sigma_r \sigma_s \bar\sigma_s \Big) \end{aligned}$$

$$S = S(AdS_5 ; \alpha_+)_{N=1} + S(AdS_5 ; i\alpha_+)_{N=1}$$

IS A CRITICAL NSR BACKGROUND WITH $C=15$

THEORY HAS $(9,9)$ SUPERSYMMETRIES

(OK BECAUSE $SO(4) \longrightarrow U(2)$)

SUSYS:

+	+	+	+	+
+	−	+	+	−
−	+	+	+	−
+	−	+	−	+
−	+	+	−	+
+	+	−	+	−
+	+	−	−	+
+	−	−	+	+
−	+	−	+	+

SUPERCOSETS

$\frac{SL(3|3)}{SL(2) \times SL(2)}$

HAS $AdS_5 \times S^5$ TARGET SPACE

18 ANTICOMMUTING SCALARS

$C = -8$

FERMIONIC / BOSONIC B-FIELDS TURNED ON

$\frac{SL(4|4)}{Sp(2) \times Sp(2)}$

HAS $AdS_5 \times S^5$ TARGET SPACE

32 ANTICOMMUTING SCALARS (RELATION TO GS?)

$C = -22$

FERMIONIC / BOSONIC B-FIELDS TURNED ON

QUESTIONS / SPECULATIONS

- ARE ALL THESE THEORIES HOLOGRAPHIC ?
- TO WHAT EXTENT ARE THESE CFT'S EXACTLY SOLVABLE? (ITERATED SCREENERS ...)
- ARE THESE STRING THEORIES UNITARY ?
- IS THERE A BRANE INTERPRETATION? ("GAS" OF NS5/F1 ?) NONCOMMUTATIVE FIELD THEORIES ?
- DO EVEN AdS SPACES

  (e.g. $AdS_2 \times S^2 \times S^1$ WITH

  $$dB = d\varphi_{S^1} \wedge \left(d\mathrm{vol}(S^2) + d\mathrm{vol}(AdS_2) \right)$$

  EXACTLY CONFORMAL?)
- WHAT IS THE SPACETIME INTERPRETATION OF THE BACKGROUND FIELDS IN THE SUPERCOSETS? DO SOME ALREADY HAVE RR FIELDS TURNED ON ?
- WHICH DEFORMATIONS DO THE THEORIES HAVE, AWAY FROM "WZ" POINT ?
- USE $AdS_5 \times S^5$ THEORY + U(5) COVARIANT FORMULATION OF $d=10$ STRING THEORY TO FIND FORMULATION OF $AdS_5 \times S^5$ WITH RR FLUX

  CONJECTURE: IT IS A DEFORMATION OF $\dfrac{GL(3|3)}{GL(2|2)}$

  WORK IN PROGRESS WITH N.BERKOVITS