

# Locality + Holography in AdS/CFT

w/ M.R.Douglas G.Horowitz E.Martinec

Holographic Principle: t'Hooft

Pert. String Theory Holographic: Thorn, Susskind  
Matrix Model /AdS/CFT: explicit NP  
realization.

Q1 What is real meaning of Holography?

Q2 " " Correspondence Principle w/ QFT?

Today: Crude beginning of A2.

Work in Progress

- I. Construct Local Free Fields
- II. Modification of locality by interactions?

Wish I could do  $\alpha'$  exp

Do t'Hooft 'N exp

Large  $N$  Counting  
 $(AdS_5 \times S^5, AdS_3 \times S^3 \times M^4)$   
 $\hookrightarrow q_S = q_{\text{SYM}}^2 \quad q_S N = (\ell_{k_S})^4$

$$O_i = \frac{1}{N} \text{tr } G_i$$

$$O_{i_1 \dots i_p} \subseteq \frac{1}{N^{p+1}} \text{tr } G_{i_1 \dots i_p}$$

$$\langle O_i \rangle \equiv 0 \\ \text{ex } O_0 \equiv 1$$

$$\langle O_i, O_j \rangle_c \sim 1$$

$$\langle O_{i_1}, \dots, O_{i_{2k}} \rangle \sim 1$$

$$\langle O_{i_1}, \dots, O_{i_p} \rangle_c \sim \frac{1}{N^{p-2}}$$

$$\langle O_{i_1}, O_{i_2}, O_{i_3}, O_{i_4} \rangle_c \sim 1$$

$$\approx \langle O_{i_1}, O_{i_3} \rangle \langle O_{i_2}, O_{i_4} \rangle + \text{perm}$$

$O_i$  ~ free fields     $O_{i_1 \dots i_p}$  composites

Correspondence

AdS scalars (gauge cond. in AdS)

$$O = [\square_r + \frac{1}{r^2+1} (\omega^2) - \frac{1}{r^2} L_I^2 - m_I^2] \Psi_I(\omega, J, r)$$

$$\langle L_I^2 \Psi_I^\dagger \rangle = C(J) \Psi_I^\dagger \langle \omega \rangle$$

$$ds^2 = -(r^2+1)dt^2 + \frac{dr^2}{r^2+1} + r^2 d\Omega_3^2$$

pos en solns     $|I, \omega, J\rangle$

$S^3 \times R$  (cAdS)<sub>boundary</sub>  
 (Horowitz + Ooguri, Mack + Luscher  
 Freedman + Brustein / Breitenlohner / AAT cAdS GG)

$$\rightarrow K^0 + P^0 \geq 0 \quad \text{with} \quad O_I(t, \Omega_3) = \sum e^{i\omega t} Y_J(\Omega_3) O_I(\omega, J)$$

$$\langle I, \omega, J \rangle \quad O_I(-\omega, J) |0\rangle \quad \omega > 0$$

$$\phi_I(t, r, \Omega_3) = \sum_{J, \omega > 0} \Psi_{I, \omega, J}(r, \Omega_3) O_I(\omega, J) e^{-i\omega t}$$

$$+ O_I(-\omega, J) \psi_{I, \omega, J}^*(r, \Omega_3) e^{i\omega t}$$

$$[O_I(\omega, J), O_M(\omega', J')]$$

$$= \delta(\omega - \omega') \delta_{JJ'} \delta_{IM} \epsilon_{IJ\omega}$$

↑  
det by norm

$$\mathcal{L}_a \Phi_I = [L_a, \Phi_I]$$

Leading order in  $\theta$

$\Phi_I$  unique local free fields  
 (BTW SUGRA local around background)

Next order

$$O_I O_J \sim \frac{i}{N} \epsilon_{IJK} O_K$$

Reduction in d.o.f.

$$\text{cf. QFT} \quad \underline{\underline{\partial}} \varphi = \varphi_1 \varphi_2 \quad \varphi = \frac{\varphi_0}{\text{d.o.f.}} + \frac{1}{2} \varphi_1 \varphi_2$$

## Interactions

$$\langle \Phi_I \Phi_J \Phi_K \rangle_c \sim \frac{1}{N}$$

$$\langle \square \Phi_I \Phi_J \Phi_K \rangle_o \equiv 0$$

Folk Thm (Bog + Shirk, Weinberg Vol I)  
local inf'l deformations of free field  
theory come from  $\tilde{\alpha}_0 \rightarrow \tilde{\alpha}_0 + \delta \tilde{\alpha}$

$$\Rightarrow \langle \square \varphi^{\text{loc}} \varphi^{\text{loc}} \varphi^{\text{loc}} \rangle_c \sim 0 \quad \langle \varphi^{\text{loc}} \varphi^{\text{loc}} \varphi^{\text{loc}} \rangle_c$$

$\Rightarrow (?) \underline{\Phi}_I$  non/local

$\Rightarrow \langle T \Phi_I \dots \Phi_K \rangle$  not "boost inv"  
but unnec if no local observables

$$\underline{\Phi}_I \rightarrow \underline{\Phi}_I + \frac{1}{N} \Delta I$$

Can we choose  $\Delta I$  so  $\underline{\Phi}_I$  local?

$$\underline{\Phi}_I(x) = \int \hat{G}(x, b) O_I(b)$$

$\langle \underline{\Phi}_I \underline{\Phi}_J \underline{\Phi}_K \rangle$  = singular (?) integral  
over bdry

Personal opinion:  $\Delta I$  ugly  
 $\langle T O_1 \dots O_N \rangle$  already  
extracted from o order field

## Conct Questions

Is locality restricted to free field theory?

Local fields deterministic funcs of boundary quantum variables?

Describe infalling Black hole observer.

These & other issues UAI

TO MRD EJM GH hep-th/9810....