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MOTIVATION: UNDERSTANDING SPATIOTEMPORAL ORGANIZATION OF QFT STATES ($\langle\rangle$) THROUGH THE KINEMATIC SPACE

FOCUS: CFTs AND SPHERES ($\Diamond$) ← Q0: ~~CONFORMAL~~; WIGGLING SPHERES

Ⓐ START: ENT. 1ST LAW

$$\delta S = \delta\langle H\rangle + O(\delta\rho)^2$$

← Q1: GO BEYOND THE FIRST LAW FOR NON-TRIVIAL EXCITED STATES ([illegible] HOLOGRAPHY)

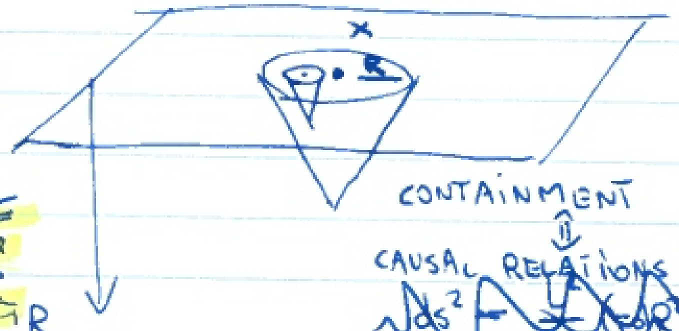
FOR A CFT WITH $\rho_V = \mathrm{tr}_{\bar{B}}(|0\rangle\langle 0| + \delta\rho)$:

(STRESS IT WORKS IN ANY d)

$$H_{mod} \sim \underbrace{\int_{B(R,\vec{x})} d^{d-1}x' \, \frac{R^2 - (\vec{x}-\vec{x}')^2}{R}}_{\text{CONVOLUTED}} T_{tt}$$

$\Box_{dS_d}\delta S - m^2\delta S = 0$ WITH $m^2L^2 = -d$ EXCITEMENT: CONVOLUTED BULK-BDRY PROP. IN dS_d:

$$ds^2_{dS_d} = \frac{\boxed{L^2}}{R^2}(-dR^2 + d\vec{x}^2)$$



t = const IN A CFT

Q2: CAN WE / SHALL WE FIX L? E.G. IN AdS/CFT $L^{d-2}/G_N \sim c$

CONTAINMENT RELATION OF Bs

$\Updownarrow$

CAUSAL RELATIONS IN dS_d, [illegible]

δS FOR LARGER BALLS CAN BE DET. FROM δS OF SMALLER BALLS

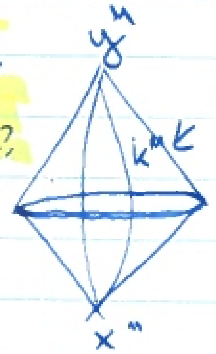
Ⓑ IDEA:

KINEMATIC SPACE: CFT

$\delta S \longleftrightarrow T_{tt}$

? $\longleftrightarrow$ GENERIC PRIMARY

Q4: WHAT IS THE CORRECT HOLOGRAPHIC DEF. OF ? FOR A GENERIC INTERACTING FIELD? FOR $T_{\mu\nu}$ WE EXPECT IT TO BE $S_{EE}|_{RT}$.



← CONFORMAL KILLING

$$\delta S \sim \int_{\text{CAUCHY}} \overset{\text{NORMAL}}{dN^\mu} K^\nu \langle T_{\mu\nu}\rangle \sim \underbrace{\int_{\Diamond} d^d\xi \, \frac{K^\mu K^\nu \langle T_{\mu\nu}\rangle}{|k|^2}}_{}$$

CONFORMALLY-INV. QTY ASSOCIATED WITH $\Diamond$

NATURAL GENERALIZATION:

Q3: $Q[O_{\mu_1\ldots\mu_L}]$ IS A SCALAR - HOW TO GENERATE TENSORS OR MAYBE THIS IS A WRONG QUESTION?

$$Q[O]_{\mu_1\ldots\mu_L} \sim \int_{\Diamond} d^d\xi \, |k|^{\Delta-L-d} K^{\mu_1}\ldots K^{\mu_L} \langle O_{\mu_1\ldots\mu_L}\rangle$$

FOR SCALARS: ① $\sim$ OPE BLOCK $= O_\Delta O_{\Delta'} \to O_\Delta$ | ② PROBE HOLO: $\Box_{AdS}\phi - m^2_{AdS}\phi = 0$, $S_{[illegible]} = S_{[illegible]}\,\phi$

WHAT ABOUT dS_d ? IT TURNS OUT FOR $O_{\mu_1 \ldots \mu_L} \neq$ CONSERVED CURRENT

$$\Box_{dS_d} Q - m_Q^2 Q \neq 0 \quad \text{FOR ALL } m_Q^2$$

IDEA BEHIND ⓑ : "SACRIFICE" dS_d AT A PRICE OF SATISFYING WAVE EQS:

$$\exists M_\Diamond : \overset{EQ_1}{\Box_{M_\Diamond} Q - m_Q^2 Q = 0} \;, \; M_\Diamond = \frac{SO(2,d)}{SO(1,d-1)\times SO(1,1)}$$

Q5: IS IT WORTH IT ?

Q6: $ds_{M_\Diamond}^2 = \frac{\partial^2 \overset{\exists M}{\nu}}{\partial x^\mu \partial y^\nu} dx^\mu dx^\nu$; $ds_{M_\Diamond}^2 = \frac{4L^2}{(x-y)^2}\left(-\eta_{\mu\nu} + \frac{2(x_\mu-y_\mu)(x_\nu-y_\nu)}{(x-y)^2}\right) dx^\mu dy^\nu =$

CAN ONE USE IT FOR HIGHER-d GEN OF DIFF. ENTROPY ?

WHERE'S dS_d ?

IT IS A CODIM-d SUBMANIFOLD.

$$= -\frac{L^2}{l^2}\left(\eta_{\mu\nu} - \frac{2}{l^2} l_\mu l_\nu\right)\left(\overset{\text{SPACES}}{dc^\mu dc^\nu} - \underset{\text{TIMES}}{dl^\mu dl^\nu}\right)$$

Q7: CAN ONE HAVE ANOTHER METRIC WITH $(2d-1,1)$ SIGNATURE ? SIGN. (d,d).

: PRESERVING 2-DERIV. EOM. → REDUNDANCY : DOUBLING GEOM.

Q8: DO $M_\Diamond$ AND EQ_1 + ADDITIONAL EQS. WITH AT MOST 2 DERIVS + "INI. COND" LEAD UNIQUELY TO Q ?

WHY Q8 INTERESTING ? → $d=2$

$$M_\Diamond = dS_2 \times dS_2 \;\Leftrightarrow\; SO(2,2) \sim SO(1,2)\times SO(1,2)$$

ONE CAN CALCULATE EE IN A CFT_2 (AND HOLO) IN CLOSED FORM FOR UNIV. STATES OBTAINED BY ACTING WITH LOC. CONF. TRAFO ON $|0\rangle$

$$S_{EE} = S_L[T] + S_R[\bar{T}] \quad \text{WITH} \quad \delta^2 \frac{\partial^2}{\partial u \partial v} S_R(T) = \frac{c}{6} \mathrm{EXP}\left(-\frac{12}{c} S_R\right.$$

LIOUVILLE EQUATION.

IF WE EXPAND ON TOP OF THE VACUUM L. EQ → WAVE EQ. IN dS_d WITH POTENTIAL.

Q9: → IS KINEMATIC SPACE A DYNAMICAL GEOMETRY ?

Q10: → 1^{st} LAW OF ENT. <-> LINEARIZED EINSTEIN EQS: LIOUVILLE EQ <-> NONLINEAR EINSTEI IN AdS_3 ???

Q11: A LOT OF INTERESTING STRUCTURE, NICE LANGUAGE WHAT IS IT GOOD FOR ?