* 贝肯斯坦提出有界物质系统的熵－能比的普适熵界，称为贝肯斯坦熵界

$$\frac{S}{E} \le 2\pi R$$

非黑洞熵界.

S、E、R为空间尺度

* 't Hooft 熵界：一个边界面积为A的区域所含的熵满足 $S \le A/4$

BH饱和这样区域.

* Bousso 熵界 $S_L \le |A_B - A_{B'}|/4$

L是起于类光横截面B、止于类光横截面B'的类光超曲面，其膨胀θ处于非正或非正.

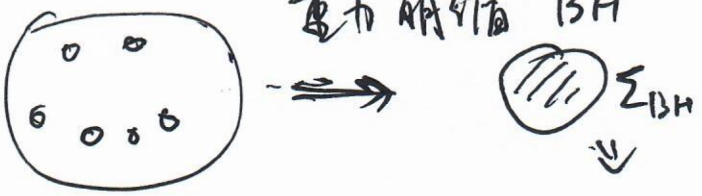
S_L为穿过L流向B的未来或B'的过去的熵通量.

A_B和$A_{B'}$分别是B和B'的面积.

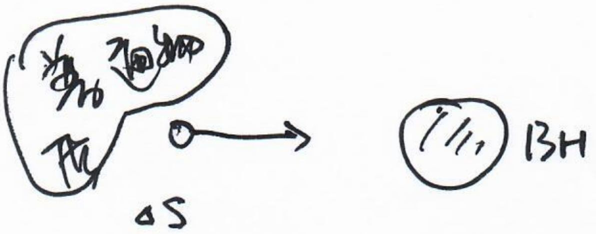
Holography.

$$S_{BH} = \frac{A(\Sigma_{BH})}{4G_N}$$

重力崩缩 BH



黑洞包括的信息量为 S_{BH}



$$S_{BH} + \Delta S \le \frac{A}{4}$$

ΔS 由贝肯斯坦提出的有界物体的熵一般的普适界. $\frac{\Delta S}{\Delta E} \le 2\pi R$ R 为该物体的半径.

由 't Hooft bound. $S_{BH} + \delta S \le \frac{A}{4}$

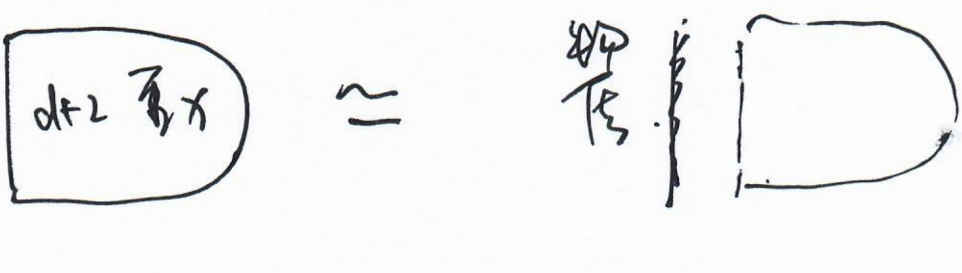
or Bousso 熵界.

⇒ $\boxed{\text{BH的熵最大}}$

⇒ 重力理论的自由度 $\sim \frac{A}{4G}$.

全息原理:

d+1维



QFT, spin 格 model

d+2维的 gravity theory ≃ (d+1)维的边界理论

AdS 时空 (Anti DeSitter space)

$\mathbb{R}^{2,d+1}$: $ds^2 = -(dX_0)^2 - (dX_{d+2})^2 + (dX_1)^2 + \cdots (dX_{d+1})^2$

$(X^0, \cdots X^{d+2})$ 内部超曲面

$$X_0^2 + X_{d+2}^2 = (X_1)^2 + \cdots + (X_{d+1})^2 + \underbrace{R^2}_{\text{AdS半径}}$$

Global 坐标 Poincaré 坐标

$$X_0 = R\cosh\rho\cos t = \frac{z}{2}\left(1 + \frac{R^2 + |\vec{x}|^2 - x_0^2}{z^2}\right)$$

$$X_{d+2} = R\cosh\rho\sin t = R\frac{x_0}{z}$$

$$X_i = R\sinh\rho\,\Omega_i = R\cdot\frac{x_i}{z}$$

$i = 1 \cdots d$

$$\sum_{i=1}^{d+1} (\Omega_i)^2 = 1$$

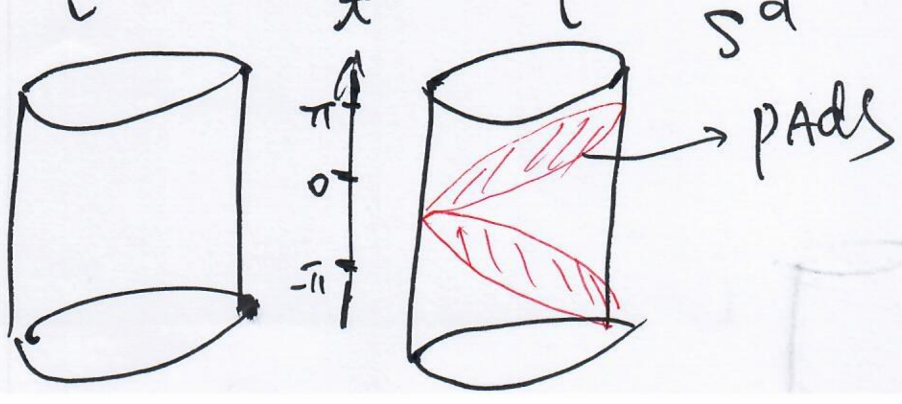
$$X_{d+1} = R\sinh\rho\,\Omega_{d+1} = \frac{z}{2}\left(1 - \frac{R^2 - |\vec{x}|^2 + x_0^2}{z^2}\right)$$

Global AdS

$$ds^2 = \underbrace{R^2}_{\text{半径}}\Big(-\cosh\rho\, dt^2 + d\rho^2 + \sinh^2\rho\,\underbrace{(d\Omega_d)^2}_{S^d}\Big)$$

半径 t ↑

$\partial(gAdS_{d+2}) = \mathbb{R} \times S^d$



AdS space

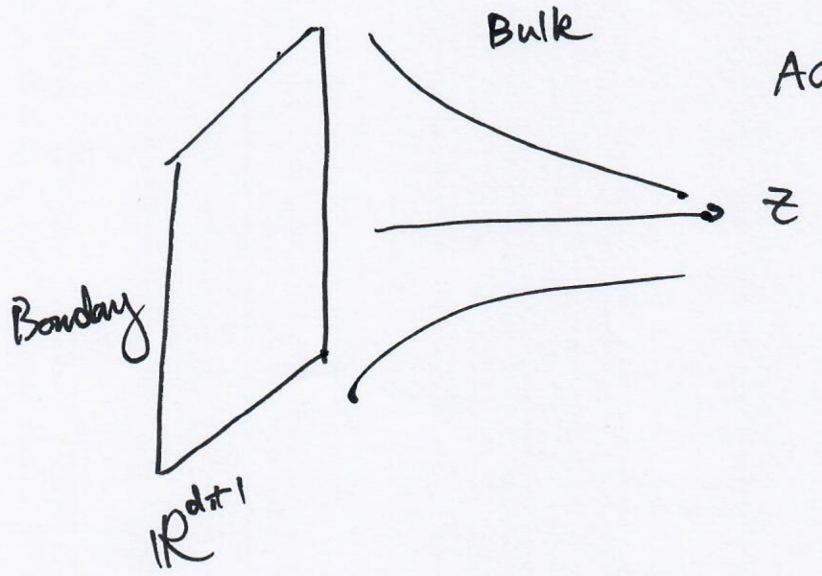
Maximally symmetric solution to the vacuum Einstein eq. with a negative cosmological constant.

$$S = \frac{1}{16\pi G_N}\int dx^{d+2}\sqrt{-g}\,[R-2\Lambda] \qquad \Lambda = \frac{-(d+1)d}{2R^2}$$

The metric of AdS_{d+2} (in Poincaré coordinate) is given

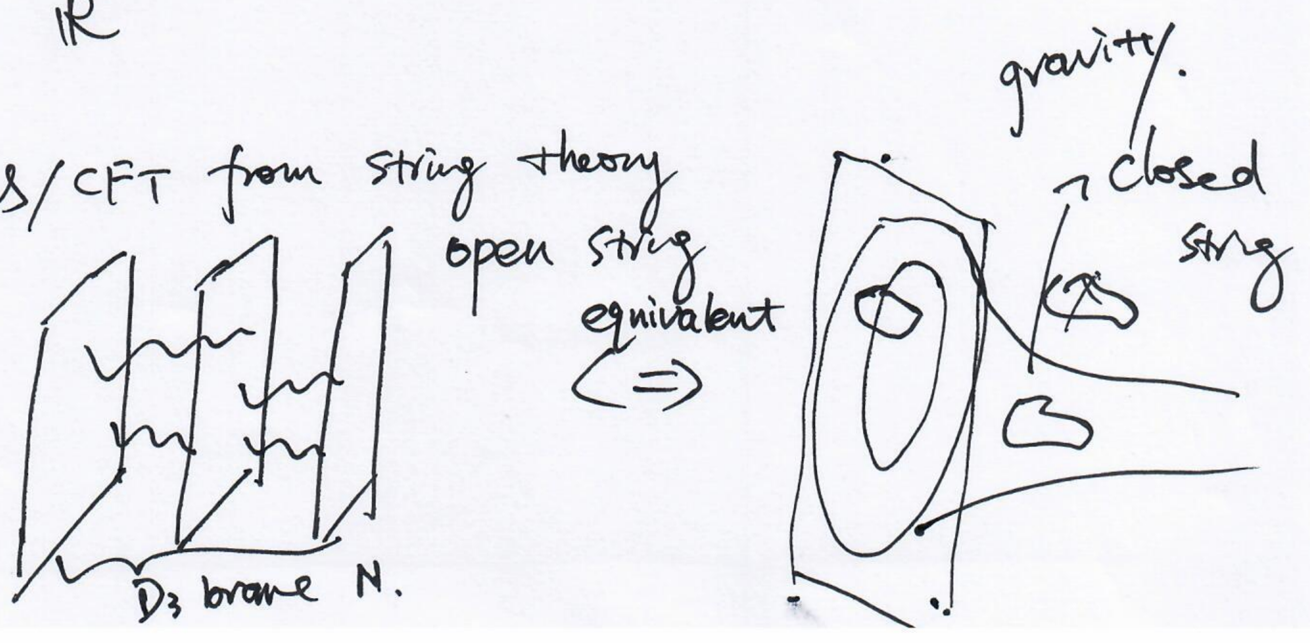
$$ds^2_{AdS_{d+2}} = R^2\left(\frac{dz^2 - dx_0^2 + \sum_{i=1}^{d} dx_i^2}{z^2}\right)$$

$$R_{\mu\nu\rho\sigma} = -R^2(g_{\mu\nu}g_{\rho\sigma} - g_{\mu\sigma}g_{\nu\rho})$$



AdS_{d+2}

AdS/CFT from string theory



Gauge theory (CFT) = String Theory (Gravity) in AdS space.

Typically $SU(N)$ gauge theory in large N limit

$N=4$. 4d $SU(N)$ SYM $\Longleftrightarrow$ Type IIB $AdS_5 \times S^5$

$\alpha' = l_s^2$

D3-brane 解:

$$ds^2 = \frac{1}{\sqrt{H(r)}} \sum_{\mu=0}^{3} dx^\mu dx_\mu + \sqrt{H(r)} \left(dr^2 + r^2 d\Omega_5^2 \right)$$

$$N = \int_{S^5} {}^*F_5$$

$$\boxed{R^4 = 4\pi (\alpha')^2 N g_s}$$

$$H(r) = 1 + \frac{R^4}{r^4}$$

$$\xrightarrow[r \to 0]{} ds^2 \cong \underbrace{\frac{R^2}{r^2} (dx^\mu dx_\mu) + \frac{R^2}{r^2} dr^2}_{AdS_5} \times \underbrace{R^2 (d\Omega_5)^2}_{S^5}$$

近视界极限

$$g_s = g_{YM}^2 \qquad \mathcal{L} = -\frac{1}{4 g_{YM}^2} \mathrm{Tr}(F^{\mu\nu} F_{\mu\nu}) + \cdots$$

经典引力

$$\frac{R}{l_s} \gg 1 \rightarrow \lambda \equiv N g_{YM}^2 \gg 1 \text{ 强耦合}$$

$$\frac{R}{l_p} \gg 1 \rightarrow N \gg 1, \quad \boxed{l_p = g_s^{1/4} l_s}$$

$$S_{IIB} = \frac{1}{4\kappa_B^2}\int \sqrt{G}\, e^{-2\Phi}\left(2R_G + 8\,\partial_\mu \Phi\, \partial^\mu \Phi - |H_3|^2 \right)$$

$$- \frac{1}{4\kappa_B^2}\int \left[\sqrt{G}\left(|F_1|^2 + |\tilde{F}_3|^2 + \frac{1}{2}|\tilde{F}_5|^2 \right) + A_4^+ \wedge H_3 \wedge F_3 \right]$$

$$F_1 = dC \qquad H_3 = dB \qquad F_3 = dA_2 \qquad F_5 = dA_4^+$$

$$\tilde{F}_3 = F_3 - C H_3\,, \quad \tilde{F}_5 = F_5 - \frac{1}{2} A_2 \wedge H_3 + \frac{1}{2} B \wedge F_3$$

附加辅助自对偶条件 $* \tilde{F}_5 = \tilde{F}_5$

C 是零形式 RR-form Axion.

targe space time. IIB SUGRA

N-D_3-brane.

$$S = \frac{1}{(2\pi)^7 l_s^8}\int d^{10}x \sqrt{-g}\left(e^{-2\phi}\left(R + 4|\nabla\phi|^2 \right) - \frac{2}{(8-p)!} F_{p+2}^2 \right) \quad \text{where } p = 3 \text{?}$$

AdS/CFT 对称性 matching

$$\underbrace{AdS_5}_{\Uparrow} \times S^5 \quad \Leftrightarrow \quad \mathcal{N}=4 \text{ SYM theory}$$

$S^5 \Downarrow$

$$SO(4,2) \times SO(6)$$

$SO(6) \Downarrow$ 内部空间

Isometry

$$\underbrace{SO(3,1) + \overset{SO(1,1)}{\text{Dilations}}}_{SO(4,2)}$$

$SU(4) \sim SO(6)$

$\Downarrow$

R-symmetry

$\Downarrow$

多余的 $\mathcal{N}=4$

in supercharge

$$\underbrace{2^{\overset{4}{D}/2} \times 4}_{\mathcal{N}} \times 2 = 32$$

SCFT

Fermionic sym.

$$\frac{32 \text{ supercharge}}{2^{D/2}}$$

$SL(2,\mathbb{Z})$

$$\boxed{\tau = \frac{i}{g_s} + \frac{C_0}{2\pi}}$$

$C_0 \Rightarrow$ axion.

$g_s \Downarrow$ Dilaton, $g_s = g_{YM}^2$

$$S: g_{YM}^2 \to \frac{16\pi^2}{g_{YM}^2}$$

$$T: \theta \to \theta + 2\pi$$

$\Downarrow$

CP 对称破缺.

$\Downarrow$

Montonen-Olive Dual

S-duality

Geometric Langlands duality

N=4 SYM

Action is following

$$\mathcal{L} = \mathrm{tr}\Big\{ -\frac{1}{2g^2} F_{\mu\nu}F^{\mu\nu} + \frac{\theta_I}{8\pi^2} F_{\mu\nu}\tilde{F}^{\mu\nu}$$
$$- \sum_a i\bar{\lambda}^a \bar{\sigma}^\mu D_\mu \lambda_a - \sum_i D_\mu X^i D^\mu X^i$$
$$+ \sum_{a,b,i} \underbrace{g C_i^{ab} \lambda_a [X^i, \lambda_b]}_{\text{Yukawa}} + \sum_{a,b,i} \underbrace{g \bar{C}_{iab} \bar{\lambda}^a [X^i, \bar{\lambda}^b]}_{\text{Yukawa}}$$
$$+ \frac{g^2}{2} \sum_{i,j} [X^i, X^j]^2 \Big\}$$

A_μ + 6 4 Scalars (Real) + 4 Fermion

symmetry of S^5 $\Leftrightarrow$ SO(6) R symmetry

adjoint representation of SO(N)

Further AdS_{d+2}/CFT_{d+1} Duality.

- AdS_4/CFT_3 ⇒ ABJM theory CS + matter with SUSY
- AdS_3/CFT_2 , • JT + Matter ⇔ SYK model

d	CFT	bulk	strong		weak
2	D1-D5	$AdS_3 \times S_3 \times T_4$	c		c
3	ABJM	$AdS_4 \times S_7$	$N^{3/2}$	$\leftarrow$	N^2 (UV).
4	$N=4$ SYM	$AdS_5 \times S_5$ (IIB)	N^2		N^2
6.	(2,0) model	$AdS_7 \times S_4$ (M).	N^3.	$\longrightarrow$	N^2 (IR)

Ty II B string

$\frac{R}{l_s} \gg 1 \;\&\; \frac{R}{l_p} \gg 1$

$\boxed{N=4 \text{ SYM}} \iff \boxed{AdS_5 \times S_5}$

GKPW 98'

$$Z_{CFT}(\partial M) \equiv Z_{Gravity}(M)$$

$$= \left\langle e^{\int d^{d+1}x \left[\delta g^{(0)}_{\mu\nu} T^{\mu\nu} + \phi^{(0)} O(x)\right]} \right\rangle = \int Dg_{\mu\nu} D\phi \, e^{-S(g,\phi)}$$

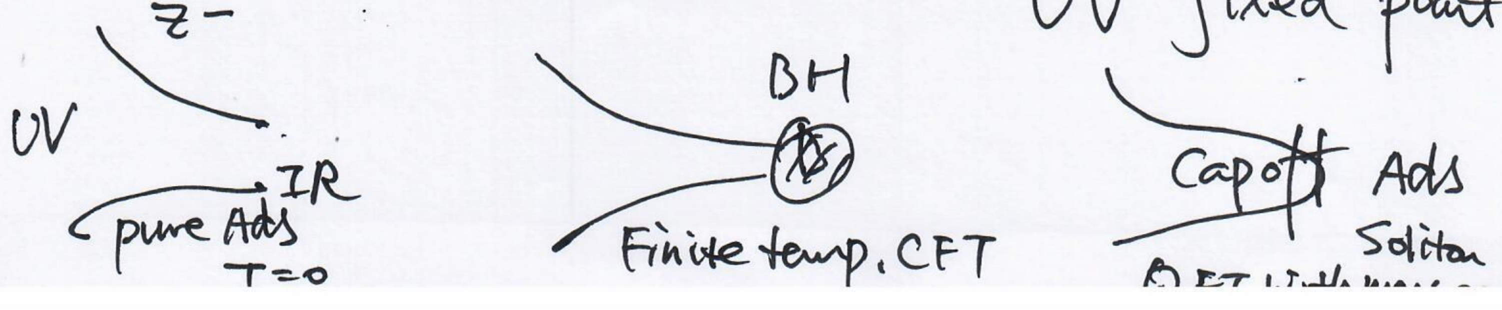
$$\simeq e^{-S(g,\phi)}\Big|_{\text{on-shell}}$$

$$\phi(x,z)\Big|_{z\to 0} = \phi^{(0)} z^{\Delta_-} + \cdots + O z^{\Delta_+} + \cdots$$

$$\Delta = 2 \pm \sqrt{4 + m^2 R^2} \qquad d=4$$

基本的形式 AdS/CFT

渐近 AdS 空间 $\iff$ generic QFT with UV fixed point



E.g. 我们知道 # of degrees of freedom bounded by $N = \frac{A}{4G_N}$. For AdS_5 space.

$$G_N^{(5)} = \frac{G_N^{(10)}}{V_5} \sim \frac{g_s^2(\alpha')^4}{R^5}.$$

IIB string theory in $AdS_5 \times S_5$.

$$16\pi G_N^{(10)} = (2\pi)^7 g_s^2(\alpha')^4$$

$\Rightarrow$ 5D 牛顿常数.

又∵ 黑洞自由度 $N = \frac{A}{4G_N} \sim A \cdot \frac{R^5}{g_s^2(\alpha')^4}$

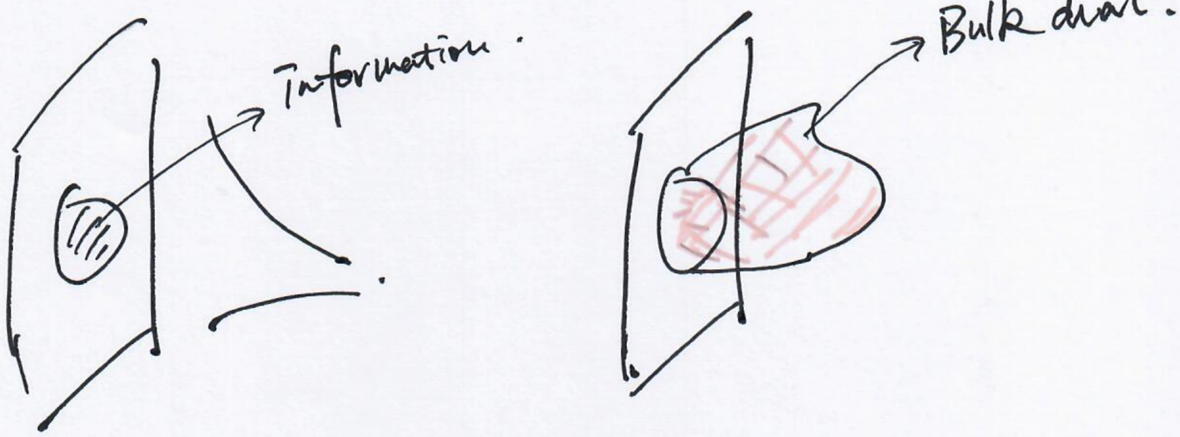
其中利用全息原理:

$$N \sim A \cdot \frac{R^5}{g_s^2(\alpha')^4} = A \cdot \frac{R^8 \cdot R^{-3}}{g_{YM}^4(\alpha')^4} = A \cdot \frac{R^{-3}(g_{YM}^2 N)^2}{g_{YM}^4}$$

$$= \frac{A}{R^3} N^2$$

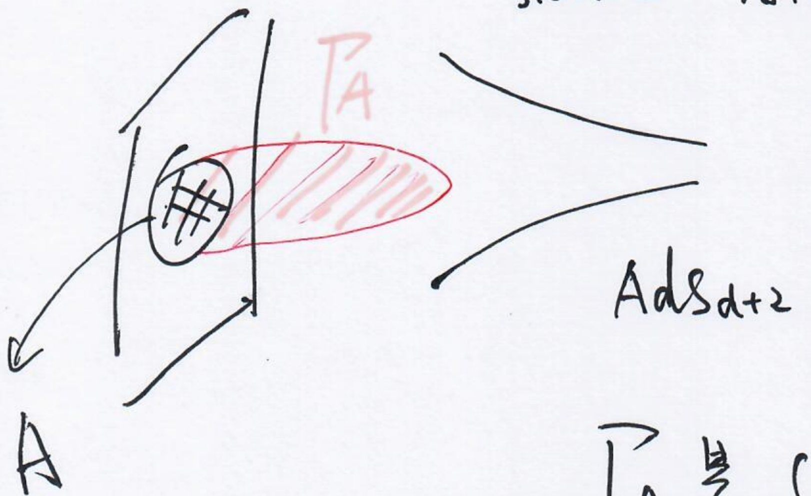
$$= \frac{L^3}{\delta^3} N^2$$

一个有趣的问题？



RT 2006. formula.

static 渐近AdS时空



$$S_A = \min_{\Gamma_A}\left[\frac{A(\Gamma_A)}{4G_N}\right]$$

极小曲面

Γ_A 是 co-dim=2 的曲面.

$\partial\Gamma_A = \partial A$ $\qquad$ $\Gamma_A \sim A$ 中间不能包含 singular Region 同伦.

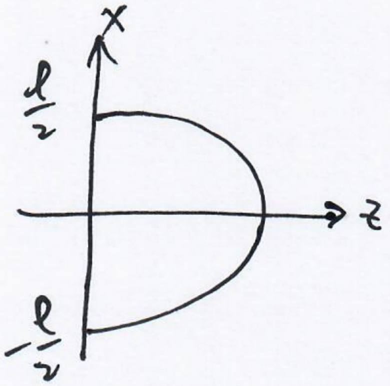
$$ds^2 = R^2\left(\frac{dz^2 + dx^\mu dx_\mu}{z^2}\right) = R^2\left(\frac{dz^2 - \cancel{dt^2} + dx_i^2}{z^2}\right)$$

$$A(\Gamma_A) = R^d \int_{\underset{\text{cutoff}}{\epsilon}}^{dz} \frac{dz}{z^{2d/2}} \int_{\partial A} d^{d-1}x \Rightarrow S_A = \frac{R^d}{4G_N} \cdot \frac{A(\partial A)}{(d-1)\,\epsilon^{d-1}}$$

$\sim c$

e.g. For 2D CFT

$$ds^2 = \frac{R^2}{z^2}\left(-\cancel{dt}^2 + dx^2 + dz^2\right)$$



$$ds^2 = \frac{R^2}{z^2}\left(dx^2 + dz^2\right)$$

其中取 $x(z)$ or $z(x) = z$

induced: $$ds^2 = \frac{R^2}{z^2}\left(1 + \left(\frac{dz}{dx}\right)^2\right)(dx)^2$$

$$S = R\int_{-\ell/2}^{\ell/2} \frac{1}{z}\sqrt{1+(z')^2}\, dx$$

EoM: $z z'' + (z')^2 + 1 = 0$

$x = \pm\frac{\ell}{2}$, $z = 0$. $\Big\}$ $\Rightarrow$ geodesic line

$$z^2 + x^2 = \frac{\ell^2}{4}$$

circle

$$ds^2\Big|_{\Gamma_A} = R^2 \times \frac{\ell^2}{z^2(\ell^2 - 4z^2)}\, dz^2$$

$$A(\Gamma_A) = 2R\int_{\epsilon}^{\ell/2} \frac{dz}{z} \times \frac{\ell}{\sqrt{\ell^2 - 4z^2}} = \boxed{2R\log\frac{\ell}{\epsilon}} = \frac{c}{3}\log\frac{\ell}{\epsilon}$$

$$\boxed{c = \frac{3R}{2G_N}}$$

Higher-dim strip.

poincare coordinate

$$ds^2 = \frac{R^2}{z^2}\left(dz^2 - \cancel{dt^2} + dx_i^2\right)$$

其中 $x_1 \in [-\frac{l}{2}, \frac{l}{2}]$

$x_{2,3,\ldots,d-1} = (-\infty, +\infty)$

$$ds^2 = \frac{R^2}{z^2}\left((1+(z')^2)dx_1^2 + dx_2^2 + \cdots\right)$$

$$\cancel{A = R^d L^{d-1}}$$

$$A = R^d L^{d-1} \int_{-l/2}^{l/2} \frac{1}{z^d}\sqrt{1+(z')^2}\, dx_1$$

EOM: $\quad z z'' + d(z')^2 + d = 0$

$$\frac{dz}{dx} = \sqrt{\frac{C - z^{2d}}{z^{2d}}}$$ C is constant.

$$\left.\frac{dz}{dx}\right|_{z=z_*} = 0 \quad \Rightarrow \quad \frac{dz}{dx} = \sqrt{\frac{z_*^{2d} - z^{2d}}{z^{2d}}}$$

$$\Rightarrow \frac{l}{2} = \int_0^{z_*} dz \frac{z^d}{\sqrt{z_*^{2d} - z^{2d}}} = \frac{\sqrt{\pi}\,\Gamma(\frac{d+1}{2})}{\Gamma(\frac{1}{2d})} z_*$$

$$A = R^d L^{d-1} \int_{-\frac{l}{2}}^{\frac{l}{2}} dx \, \frac{z_*^d}{z^{2d}}$$

$$= 2R^d L^{d-1} \int_{\epsilon}^{z^*} \frac{z_*^d}{z^d} \frac{dz}{(z_*^{2d} - z^{2d})^{1/2}}$$

$$= 2R^d L^{d-1} \int_{\frac{\epsilon}{z_*}}^{1} z_*^{1-d} dx \, x^{1-d-1} (1-x^{2d})^{\frac{1}{2}-1}$$

$$= 2R^d L^{d-1} \frac{B(\frac{1-d}{2d}, \frac{1}{2})}{2d} z_*^{1-d} + \frac{2R^d}{d-1}\left(\frac{L}{a}\right)^{d-1}$$

$$S_A = \frac{1}{4G_N^{(d+2)}}\left[\frac{2^d \pi^{d/2} R^d}{1-d}\left(\frac{\Gamma(\frac{d+1}{2d})}{\Gamma(\frac{1}{2d})}\right)^d \left(\frac{L}{l}\right)^{d-1}\right.$$

$$\left. + \boxed{\cancel{\frac{2R^d}{d-1}\left(\frac{L}{a}\right)^{d-1}}}\right]$$

$\Downarrow$

发散! ⇒ Area law

EE for sphere

$$A = R^d \, \mathrm{Vol}(S^{d-1}) \cdot \int_0^{l} dr \, \frac{r^{d-1}}{z^d} \sqrt{1 + \left(\frac{dz}{dr}\right)^2}$$

$$\Rightarrow \text{EOM}: \; r z z'' + (d-1) z (z')^3 + (d-1) z z' + dr (z')^2 + d1$$

$$= 0.$$

minimal surface $\Rightarrow \; r^2 + z^2 = l^2.$

$$\text{Area} = \mathrm{Vol}(S^{d-1}) \, R^d \cdot \int_{a/l}^{1} dy \, \frac{(1-y^2)^{(d-2)/2}}{y^d}$$

$$= \frac{2\pi^{d/2} R^d}{\Gamma(d/2)} \left[\frac{1}{d-1} \left(\frac{l}{a}\right)^{d-1} - \frac{d-2}{2(d-3)} \left(\frac{l}{a}\right)^{d-3} + \cdots \right]$$

$$S_A = \frac{2\pi^{d/2} R^d}{4 G_N^{(d+2)} \Gamma(d/2)} \int_{a/l}^{1} dy \, \frac{(1-y^2)^{\frac{d-2}{2}}}{y^d}$$

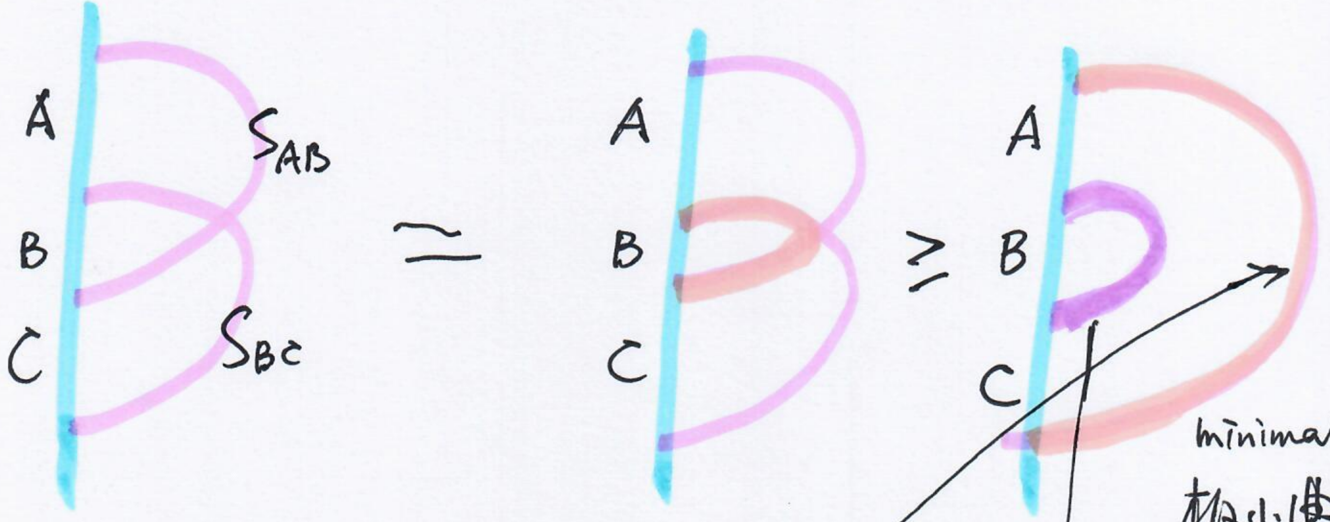
Central charge

$$= \begin{cases} P_1 \left(\frac{l}{a}\right)^{d-1} + P_2 \left(\frac{l}{a}\right)^{d-3} + \cdots C_0 \log \frac{l}{a} & d \text{ even} \\ P_1 \left(\frac{l}{a}\right)^{d-1} + P_2 \left(\frac{l}{a}\right)^{d-3} + \cdots \boxed{(-1)^{\frac{d-1}{2}} F} & d \text{ odd} \end{cases}$$

F = proportional to

[illegible]

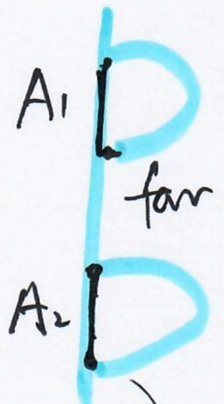
強劣加法性 Strong subaddivity Headricle – Tadashi 2007

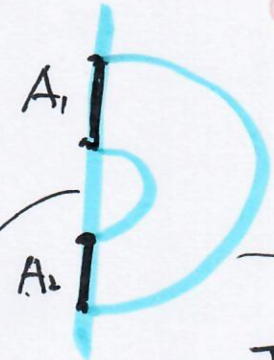


minimal
極小曲面.

$$\underline{S_{AB}} + \underline{S_{BC}} \geq \underline{S_{ABC}} + \underline{S_B}$$

phase transition. $A = A_1 \cup A_2$ (disconnected sum)



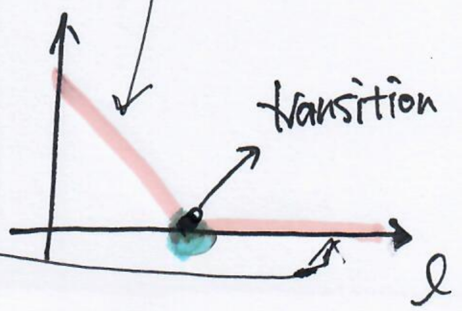


Consistent with [Calabrese – Cardy – Tonni 2009]

closed

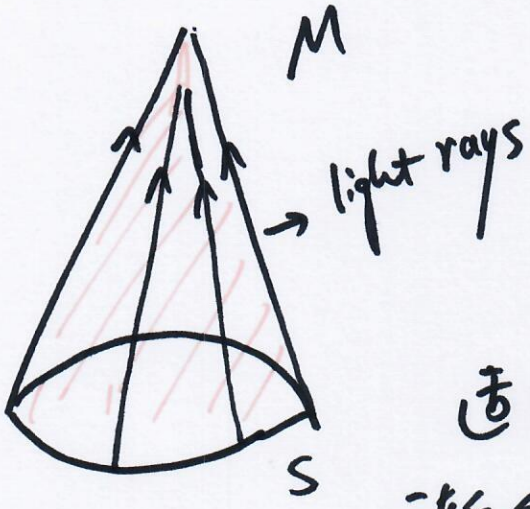
$$I(A_1 : A_2) = S_{A_1} + S_{A_2} - S_{A_1 \cup A_2}$$

l is distance of A_1 A_2



transition point.

light sheet



类光测地线族构成的子流形

具有非正的膨胀(expansion)

HRT formula.

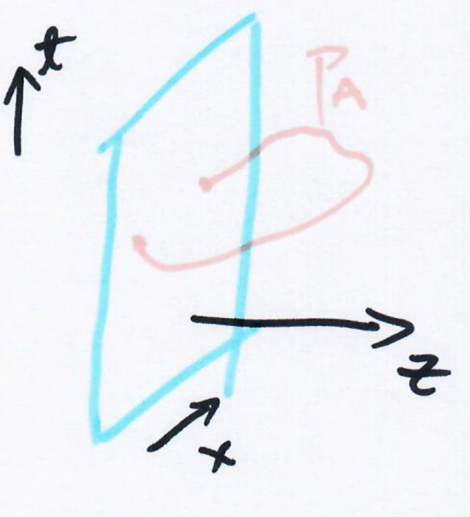
适用于一般含时间依赖的渐近AdS时空.

Covariant HEE

$$S_A = \min_{\Gamma_A^{ext}} \operatorname*{Ext}_{\Gamma_A}\left[\frac{A(\Gamma_A)}{4G_N}\right]$$

Extremal surface 中选择面积最小的.

Lorentzian AdS中的极值曲面(Extremal surface)



可应用非平衡物理过程.

Comment: 由静态 → 非静态.

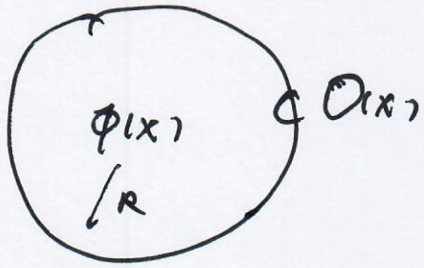
极小曲面 → 外曲率迹 $=0$ 的超曲面.

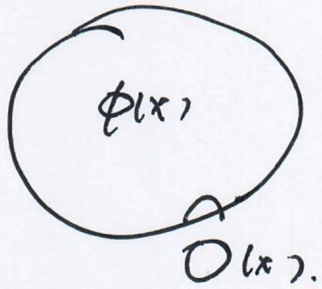
puzzle of the bulk locality

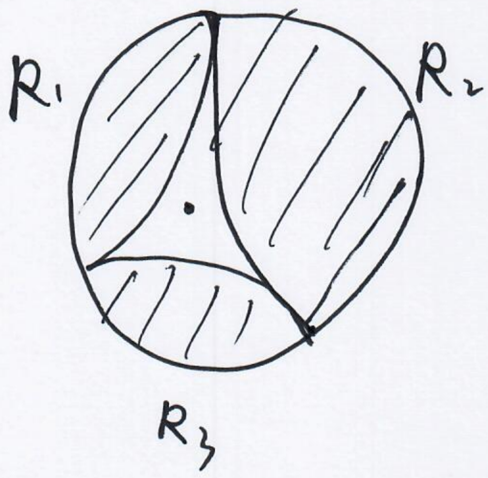
space like separated $\Rightarrow [\phi(x), O(x)] = 0$

$\Downarrow$ Schur's Lemma

$\phi(x) = I$.







$[\phi(x), O(x)] = 0$.

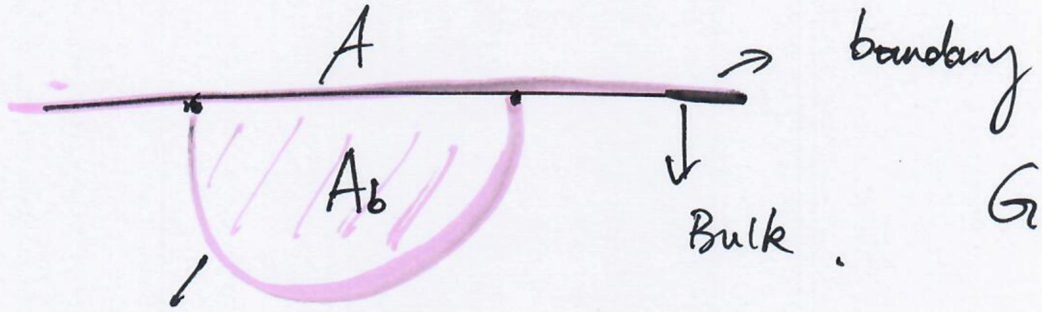
code subspace

Quantum Correction to HEE

1307.2892

FLM.

$$S(A) = S_{cl}(A) + S_q(A) + O(G_N).$$



$G \propto N^2$.

minimal surface.

$$S_{cl}(A) = \frac{(\text{Area})_{min}}{4G_N}.$$

$$S_q(A) = S_{Bulk\text{-}ent} + \frac{\delta A}{4G} + \langle \Delta S_{W\text{-}like} \rangle + S_{\text{Counterterms}}.$$

Bulk entanglement.

change in the Area
源于背景的 shift 量子修正.

Wald-like entropy.

引入的 Counterterms 让计算 finite.

$$S_{reg\text{-}cone} = S_{Bulk\text{-}ent} + \langle \Delta S_{W\text{-}like} \rangle$$

$S_{Bulk\text{-}ent}$ 即 field theory 所说 固定背景上的 QFT entropy

=> classical + Bulk entropy 满足 strong subadditivity

$$S_{\ldots} = -\frac{\mathrm{Tr}[\partial_n \hat{\rho}_n]\big|_{n=1}}{\mathrm{Tr}[\rho_1]}$$

为了计算 $S_{\ldots}$ 利用 Lagrangian formalism.

$$\mathcal{L}(\hat{g}_n, h, \varphi)$$

h: metric 扰动 $\qquad \varphi \longrightarrow$ 其他物质场

$$S_{\ldots} = \underbrace{\left\langle \int d\tau\, \partial_n \mathcal{L} \right\rangle}_{\text{对应来自路径积分 path-In}} = \int d\tau \left\langle E_{\mu\nu}(\hat{g}+h, \varphi)\, \partial_n \hat{g}^{\mu\nu}\right.$$

$$+\, d\Theta(\hat{g}, h, \varphi, \partial_n \hat{g}) - \int d\tau\, d\Theta(\hat{g}, \partial_n g)$$

$E_{\mu\nu}$ 是运动方程，$\neq 0$ Due to Quantum fluctuation.

Θ 是边界项. Associated with Wald-like entropy.

第一项. $\int d\tau \langle E_{\mu\nu} \rangle \partial_n \hat{g}^{\mu\nu} = -\frac{1}{2} \int d\tau \langle T_{\mu\nu} \rangle \partial_n \hat{g}^{\mu\nu}$

$\hat{g} \to \hat{g} + \bar{h}$

$$\Rightarrow E_{\mu\nu}(\hat{g}+\bar{h}) = -\langle E_{\mu\nu} \rangle = \frac{1}{2}\langle T_{\mu\nu} \rangle$$

量子的配分函数

$$Z_{q,n} = \mathrm{Tr}\left[\rho\, e^{-\int_0^{2\pi n} d\tau \cdot H_{b,n}(\tau)}\right] = \mathrm{Tr}[\hat{\rho}_n^n]$$

$$\hat{\rho}_n \doteq \rho\, e^{-\int_0^{2\pi} H_{b,n}(\tau)}. \qquad H_b(\tau) = H_b(\tau + 2\pi).$$

$H_{b,n}$. 是时间依赖的 Hamiltonian.

Bulk的 density matrix $\hat{\rho}_n$

$\hat{\rho}_n$ 对应的 Bulk geometry 是 $\hat{g}_n \doteq g_n / Z_n$.

但是 ignoring UV divergencies.

认为 UV regulator 是 Local. Covariant.

这样 $S_q = -\partial_n (\log Z_{q,n} - n \log Z_{q,1})_{n=1}$

$$= -\partial_n (\log \mathrm{Tr}[\hat{\rho}_n^n] - n \log \mathrm{Tr}(\hat{\rho}_1))_{n=1}$$

$$= S_{Bulk-ent} + S_{\cdots}$$

$$\Downarrow$$

$$-\partial_n (\log \mathrm{Tr}[\rho_1^n] - n \log \mathrm{Tr}[\rho_1])|_{n=1}$$

$$\int d\tau\, E(\hat{g}+\bar{h})\,\partial_n \hat{g} = \partial_n I_n(\hat{g}+\bar{h})\big|_{n=1} - \int d\tau\, d\Theta(\hat{g}+\bar{h}, \partial_n \hat{g})$$

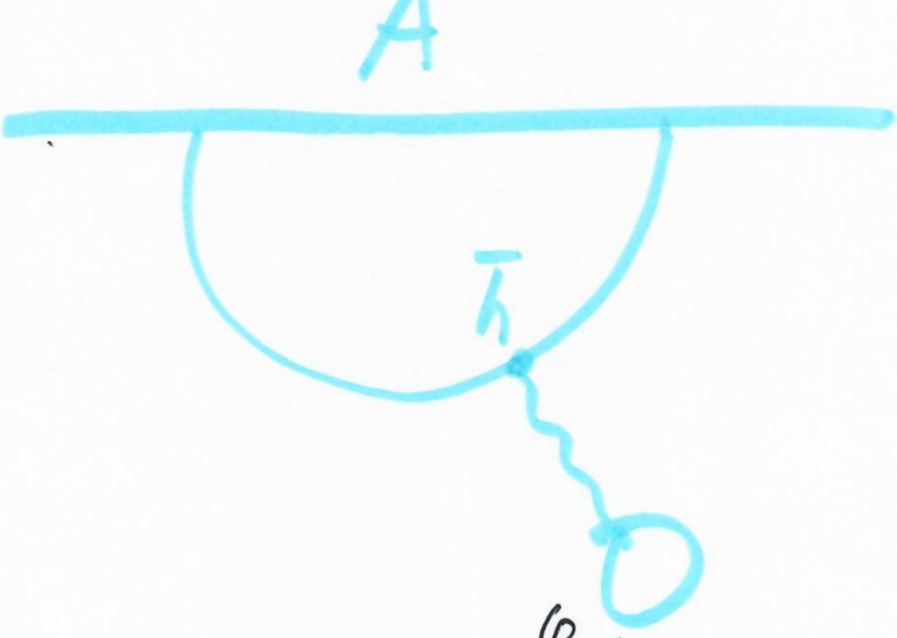
$I_n(\hat{g}_n+\bar{h}) = I_n(\hat{g}_n)$ up to 1st order.

$\Downarrow$

对应着移动几何 $\frac{\delta A}{4G_N}$

若是有高阶导的 这下找对移应着.

δS_{W}-like..



φ, h.

还需要引入 $\frac{1}{\epsilon^{D-2}}\int R$ in Counterterms.

$\Downarrow$

$\frac{\text{Area}}{\epsilon^{D-2}}$. 让 · $\frac{\text{make Bulk quantum}}{\text{gravity finite}}$