Title: Fun with ideal plasmas

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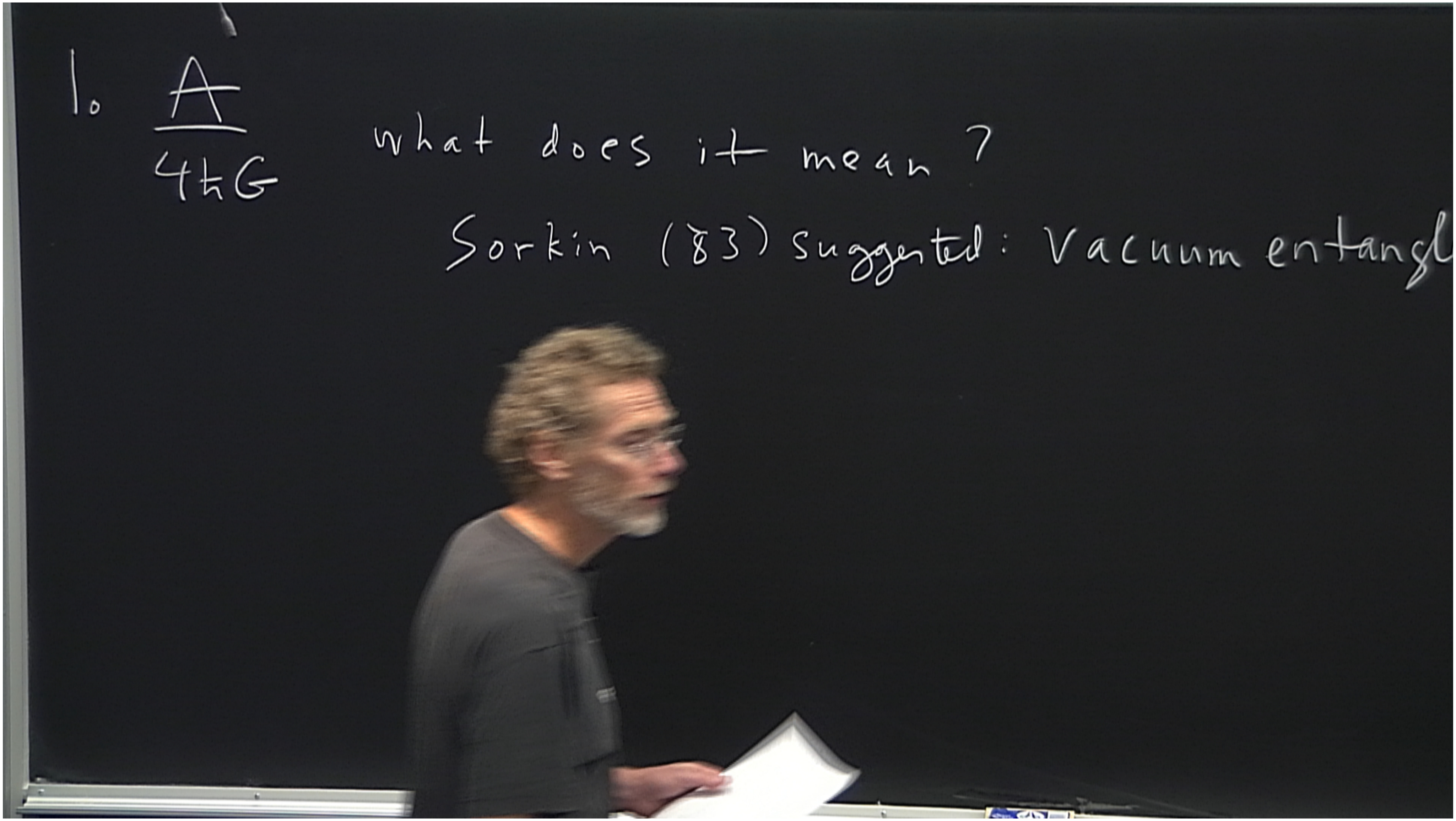
Abstract: I will sketch a few interesting phenomena involving ideal plasmas, including helicity conservation, frozen flux, the Blandford-Znajek mechanism, and self-confined Poynting jets, using the language of differential forms.

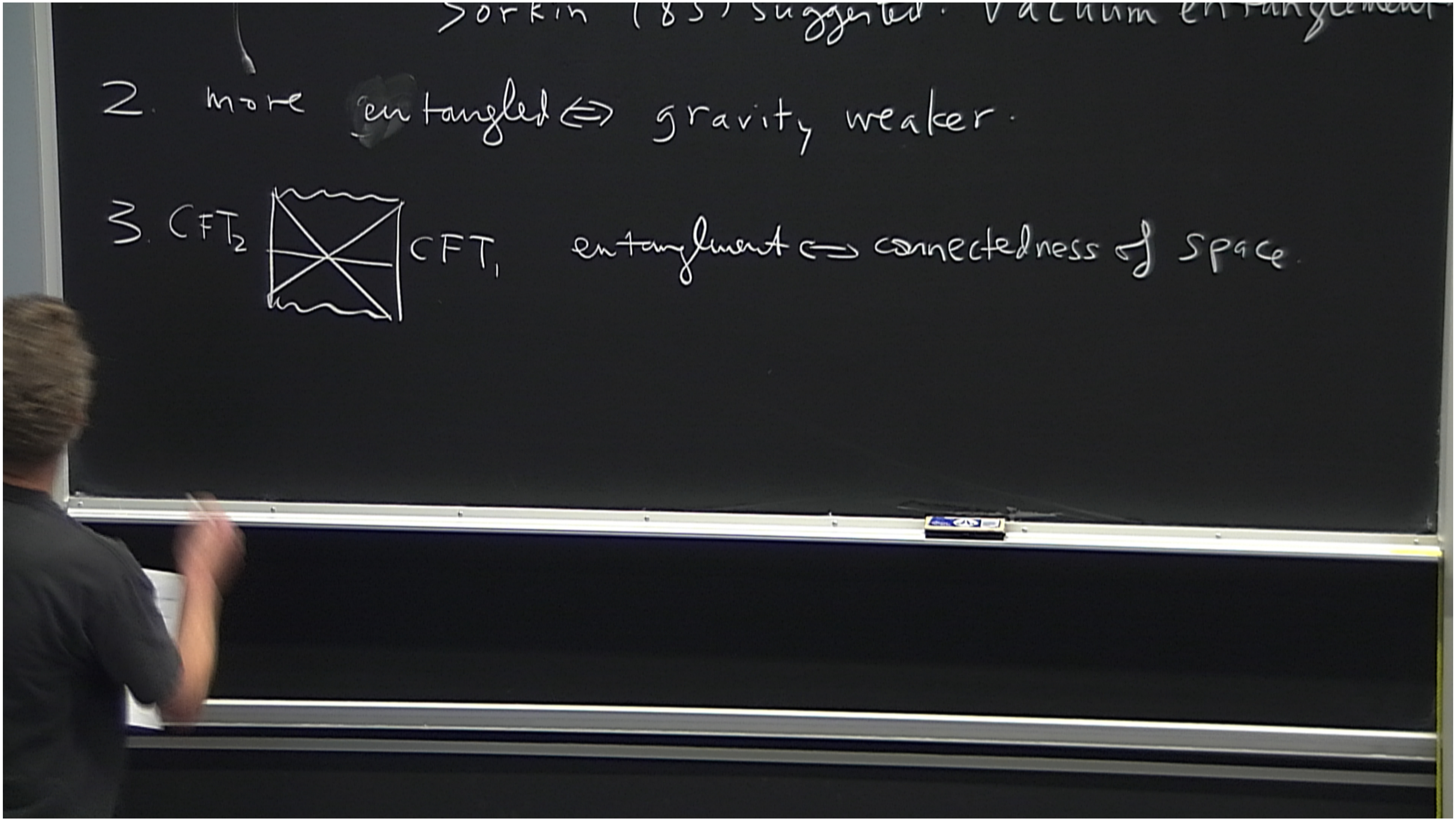
THE THIRD MAN?

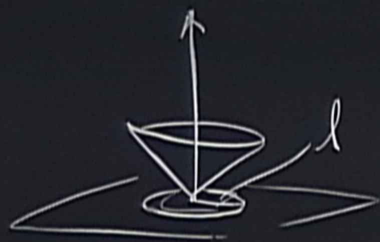
Ted Jacobson

UnruhFest

Perimeter Institute, Aug. 14, 2015


1. $\frac{A}{4\hbar G}$
what does it mean?
Sorkin (83) suggested: vacuum entangl


Sorkin ('83) suggested: Vacuum entanglement
2. more entangled ⟺ gravity weaker.
3. CFT2 CFT1 entanglement ⟺ connectedness of space.

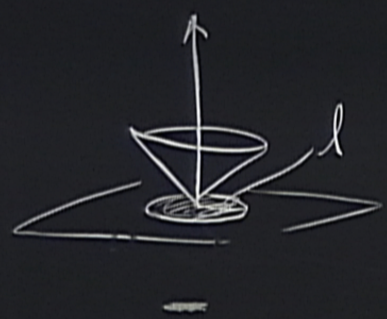


$$\delta A\big|_V$$

Area deficit:

$$A - 4\pi\left(\frac{V}{4\pi/3}\right)^{2/3}$$

at fixed volume.



$8\pi G$

$$\delta A\big|_V = \frac{-\Omega_{d-2}\, l^d}{(d^2-1)} T_{00}$$

$$\delta A\big|_V = \frac{-\Omega_{d-2}}{2(d^2-1)}\, l^d \boxed{{}^{(d-1)}R} = 2G_{00}$$

Area deficit:

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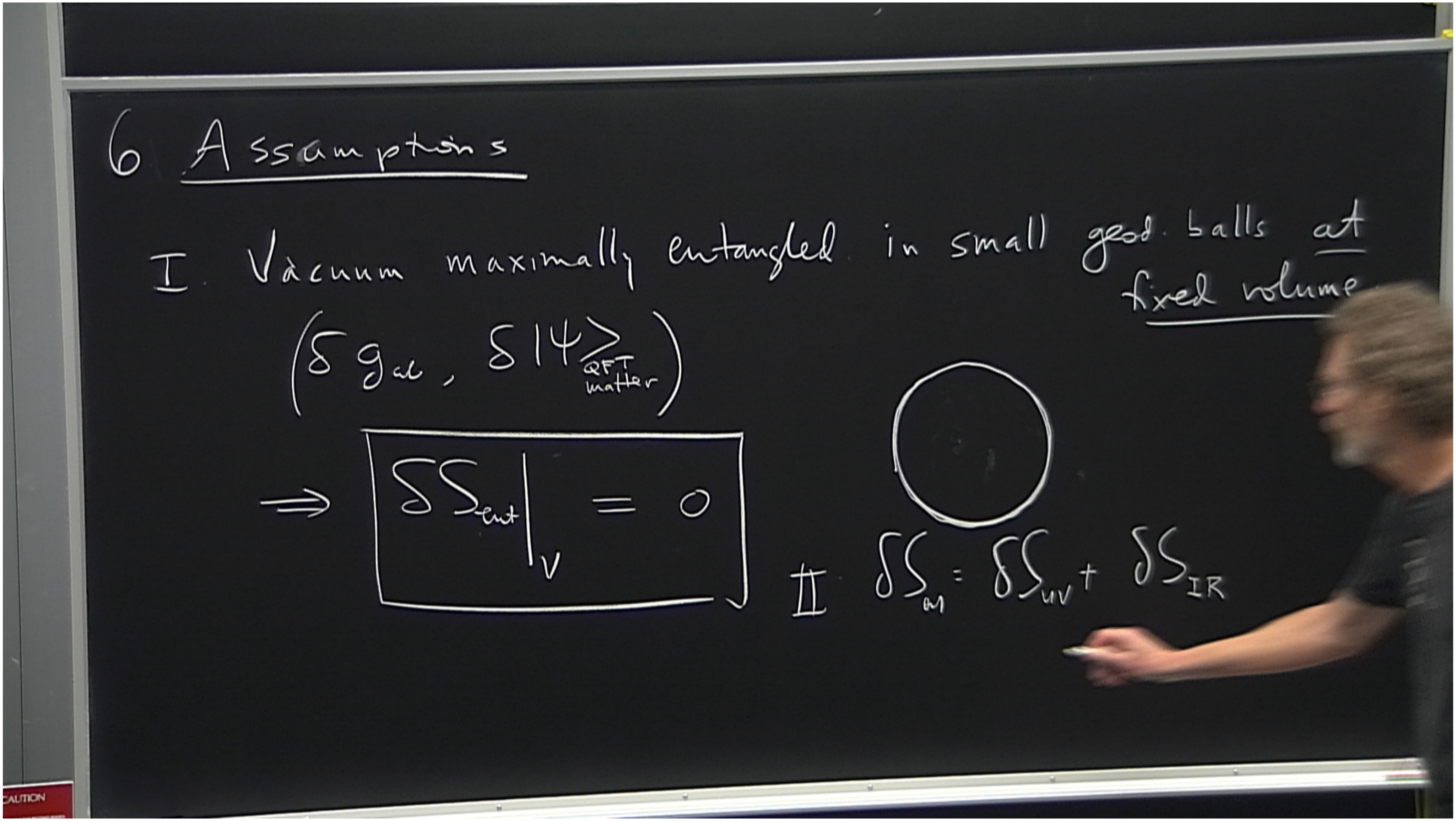
at fixed volume.

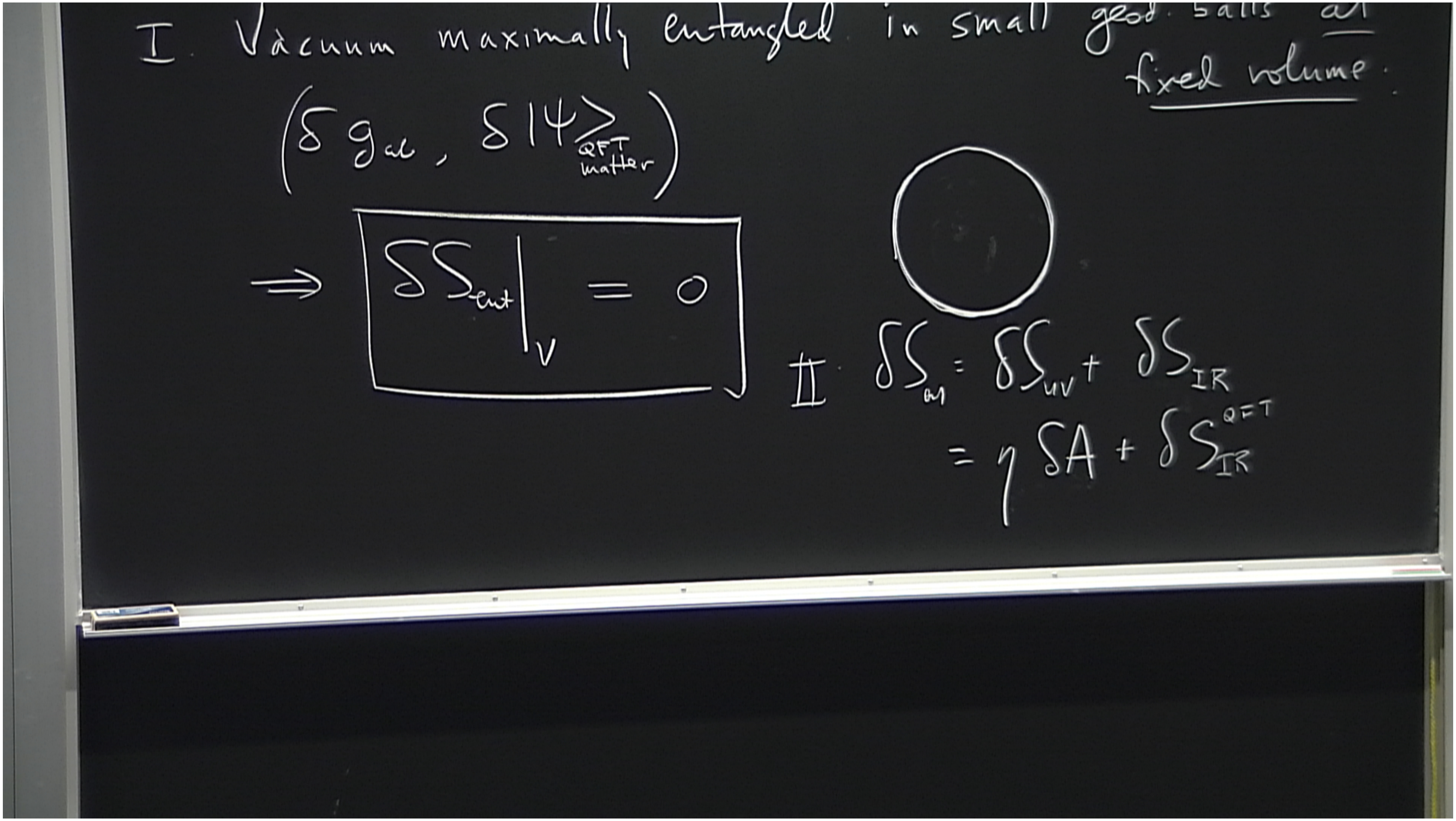
6 Assumptions

I. Vacuum maximally entangled in small geod. balls at fixed volume.

$$\left(\delta g_{ab},\ \delta|\psi\rangle_{\substack{\text{QFT}\\ \text{matter}}}\right)$$

$$\Rightarrow \boxed{\delta S_{ent}\Big|_V = 0}$$


6 Assumptions
I. Vacuum maximally entangled in small geod. balls at fixed volume
$(\delta g_{ab}, \delta|\psi\rangle_{\text{QFT matter}})$
$\Rightarrow \delta S_{ent}|_V = 0$
II. $\delta S_{ent} = \delta S_{UV} + \delta S_{IR}$

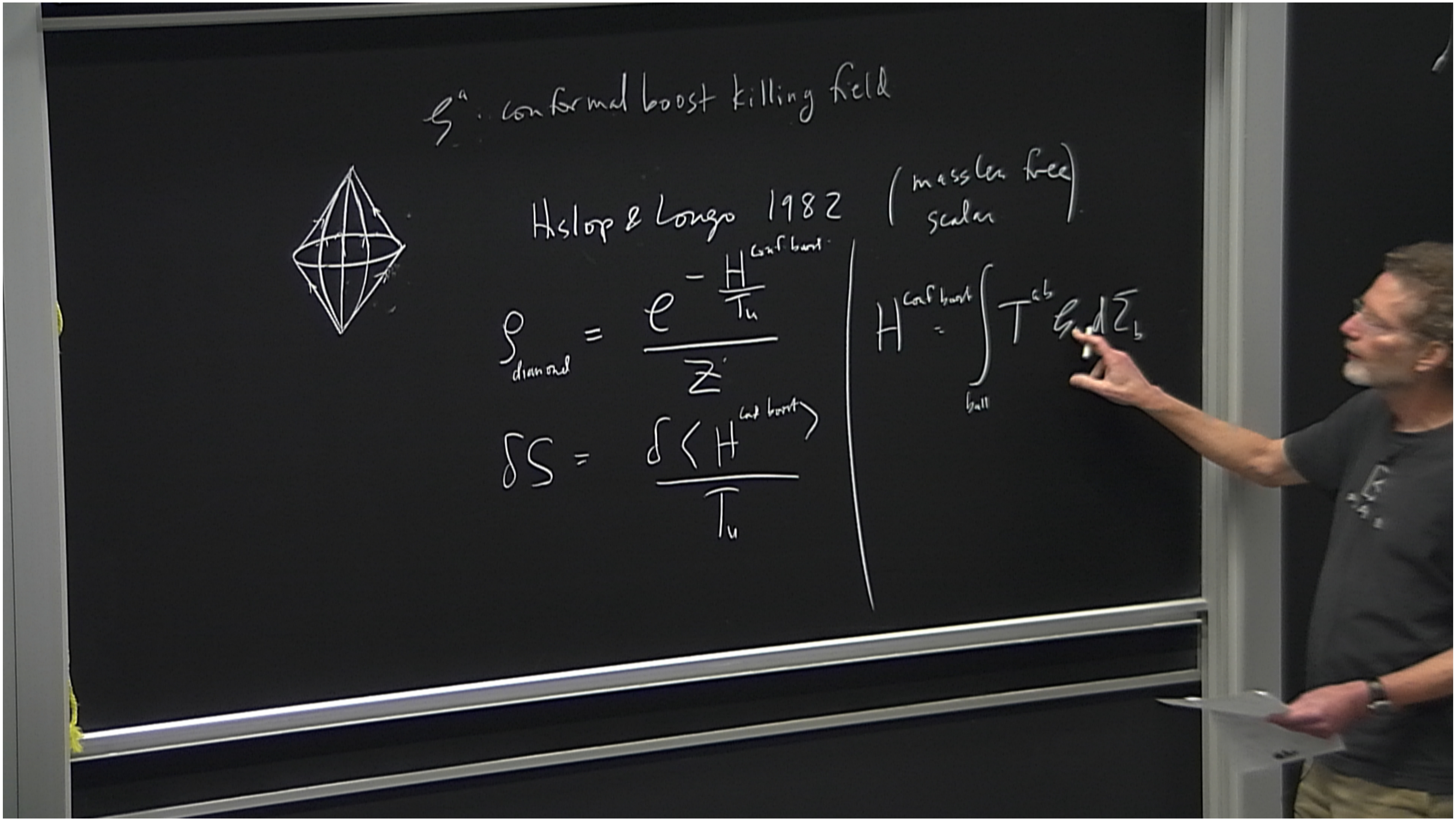

I. Vacuum maximally entangled in small geod. balls at fixed volume.
(δ g_ab , δ|ψ>_QFT matter)
⇒ δS_ent|_V = 0
II. δS_ent = δS_UV + δS_IR
= η δA + δS_IR^QFT

$$\eta\, \delta A|_V + \delta S_{IR} = 0$$

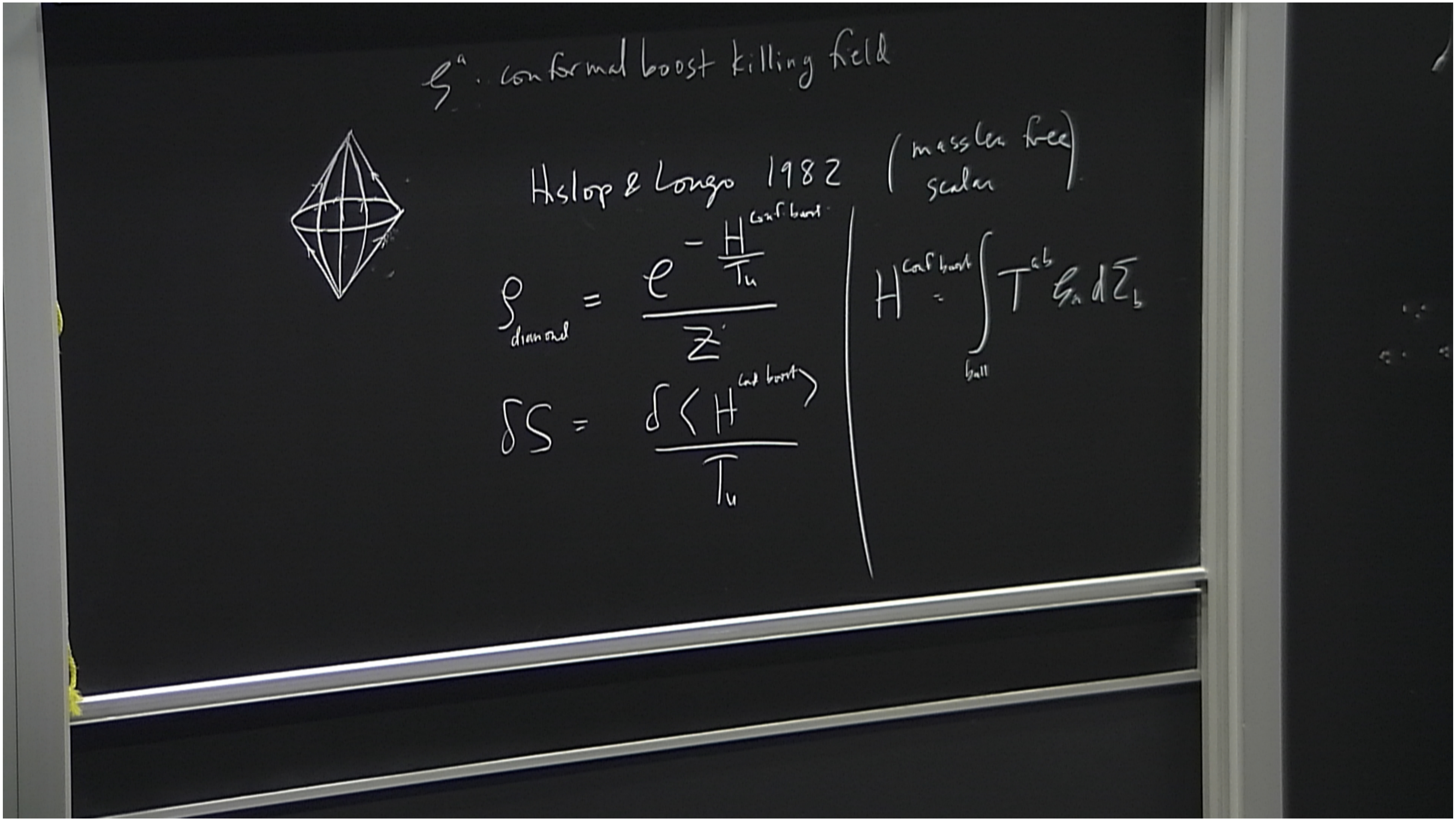
a) vacuum : $\delta A|_V = 0 \Leftrightarrow R_{ab} = 0$

b) matter $\rightarrow$ i) conformal

ii) non-conformal



ξ^a : conformal boost killing field
Hislop & Longo 1982
(massless free scalar)
$\rho_{\text{diamond}} = \frac{e^{-\frac{H^{\text{conf boost}}}{T_u}}}{Z}$
$\delta S = \frac{\delta \langle H^{\text{conf boost}} \rangle}{T_u}$
$H^{\text{conf boost}} = \int_{\text{ball}} T^{ab} \xi_a d\Sigma_b$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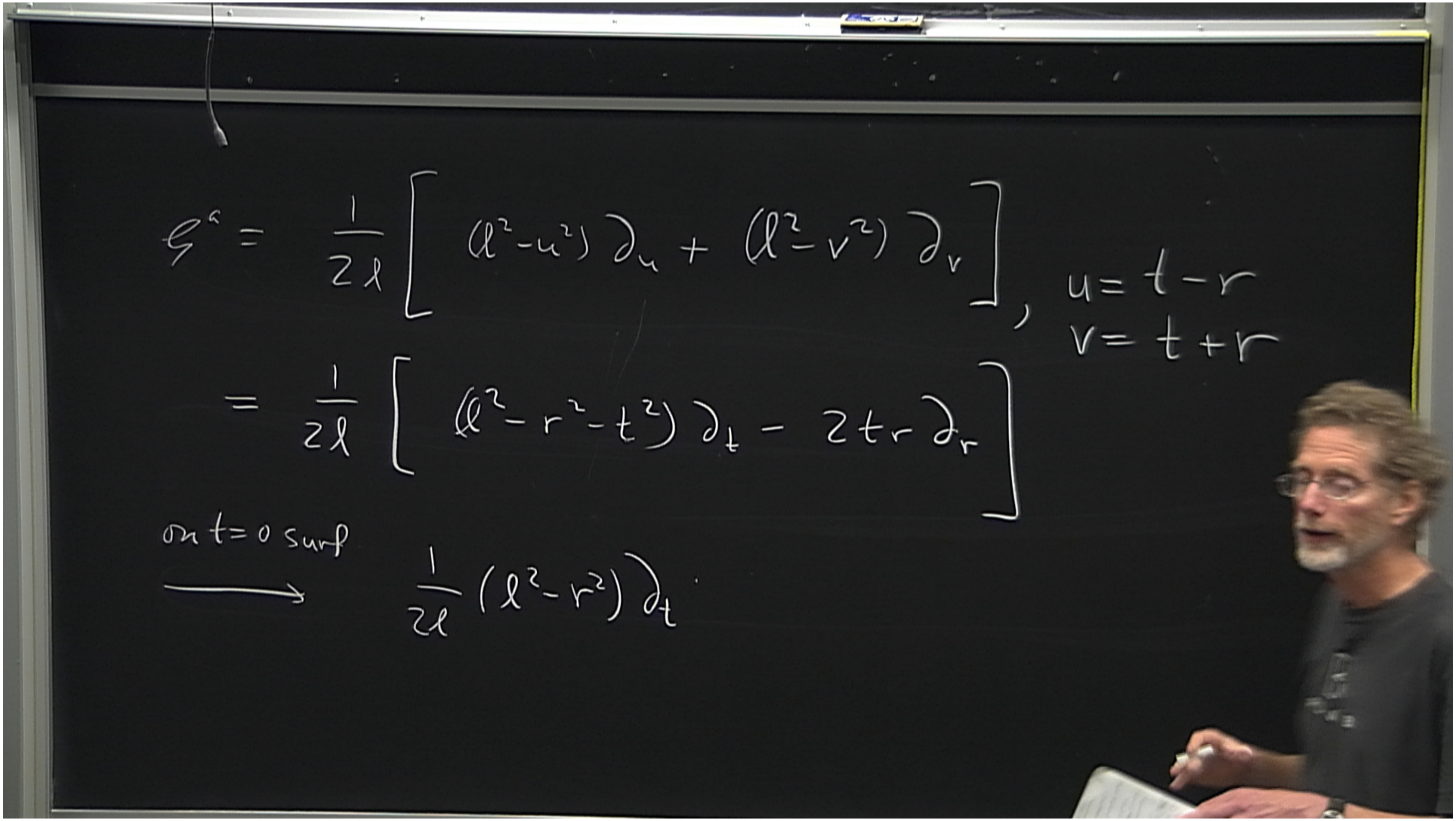
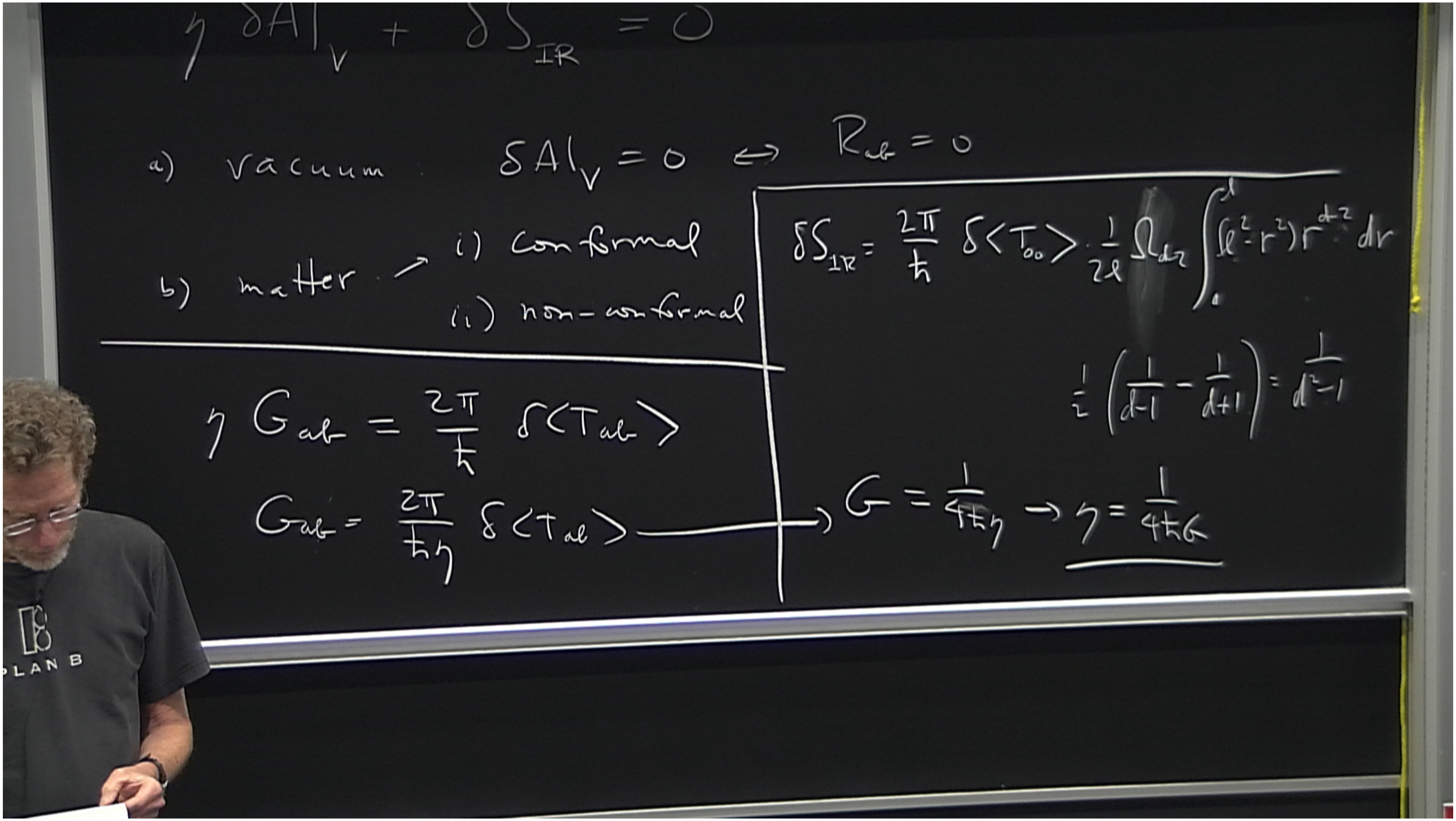

$\xi^a = \frac{1}{2\ell}\left[(\ell^2-u^2)\partial_u + (\ell^2-v^2)\partial_v \right], \quad u = t-r, \quad v = t+r$
$= \frac{1}{2\ell}\left[(\ell^2-r^2-t^2)\partial_t - 2tr\,\partial_r \right]$
$\xrightarrow{\text{on } t=0 \text{ surf}} \frac{1}{2\ell}(\ell^2-r^2)\partial_t$

$$\xi^a = \frac{1}{2l}\left[(l^2-u^2)\,\partial_u + (l^2-v^2)\,\partial_v \right], \quad \begin{array}{l} u = t-r \\ v = t+r \end{array}$$

$$= \frac{1}{2l}\left[(l^2-r^2-t^2)\,\partial_t - 2tr\,\partial_r \right]$$

on $t=0$ surf $\longrightarrow$ $\frac{1}{2l}(l^2-r^2)\,\partial_t$


$\eta\, \delta A|_V + \delta S_{IR} = 0$
a) vacuum : $\delta A|_V = 0 \Leftrightarrow R_{ab} = 0$
b) matter → i) conformal
ii) non-conformal
$\delta S_{IR} = \frac{2\pi}{\hbar}\, \delta\langle T_{00}\rangle \cdot \frac{1}{2\ell}\, \Omega_{d-2} \int_0^{\ell} (\ell^2 - r^2)\, r^{d-2}\, dr$
$\frac{1}{2}\left(\frac{1}{d-1} - \frac{1}{d+1}\right) = \frac{1}{d^2-1}$
$\eta\, G_{ab} = \frac{2\pi}{\hbar}\, \delta\langle T_{ab}\rangle$
$G_{ab} = \frac{2\pi}{\hbar\eta}\, \delta\langle T_{ab}\rangle \longrightarrow G = \frac{1}{4\hbar\eta} \rightarrow \eta = \frac{1}{4\hbar G}$
PLAN B

III: guess: $\delta S_{IR} \propto \delta \langle T_{ab} \rangle - \underset{\propto}{\frac{1}{d}} \delta \langle T \rangle g_{ab}$

where $\boxed{G^{MSS}_{ab} = -\lambda g_{ab}}$

compare to MSS

replace $\delta A\big|^{flat}_{V}$ by $\delta A\big|_{V,\lambda}$,

$\propto \left(G_{00} + \lambda g_{00} \right)$