Title: AdS/CFT Lecture (230428)

Speakers: David Kubiznak

Collection: AdS/CFT (2022/2023)

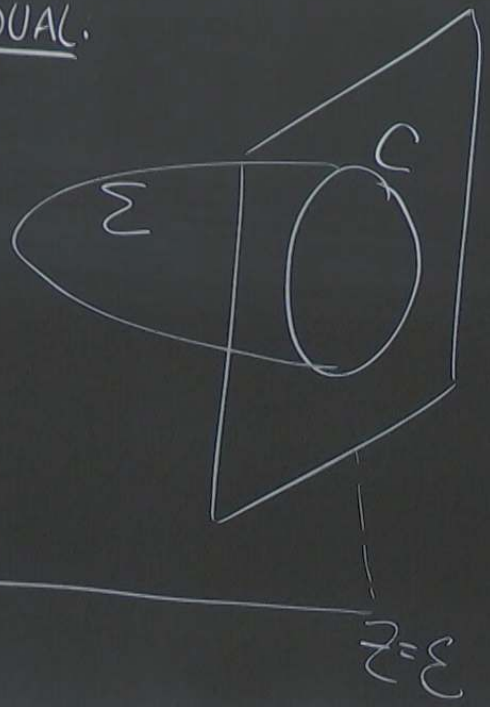
Date: April 28, 2023 - 9:00 AM

URL: https://pirsa.org/23040041

WILSON LOOPS: NON-LOCAL GAUGE INV. OPS.

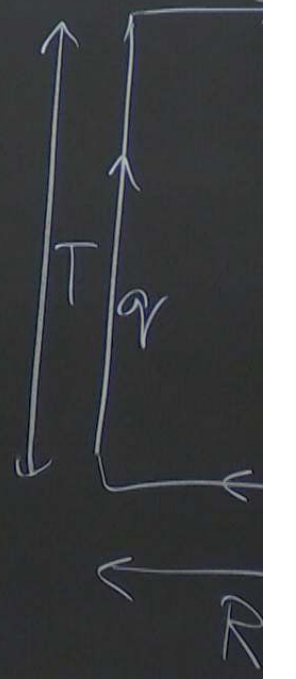
SPEC: CO

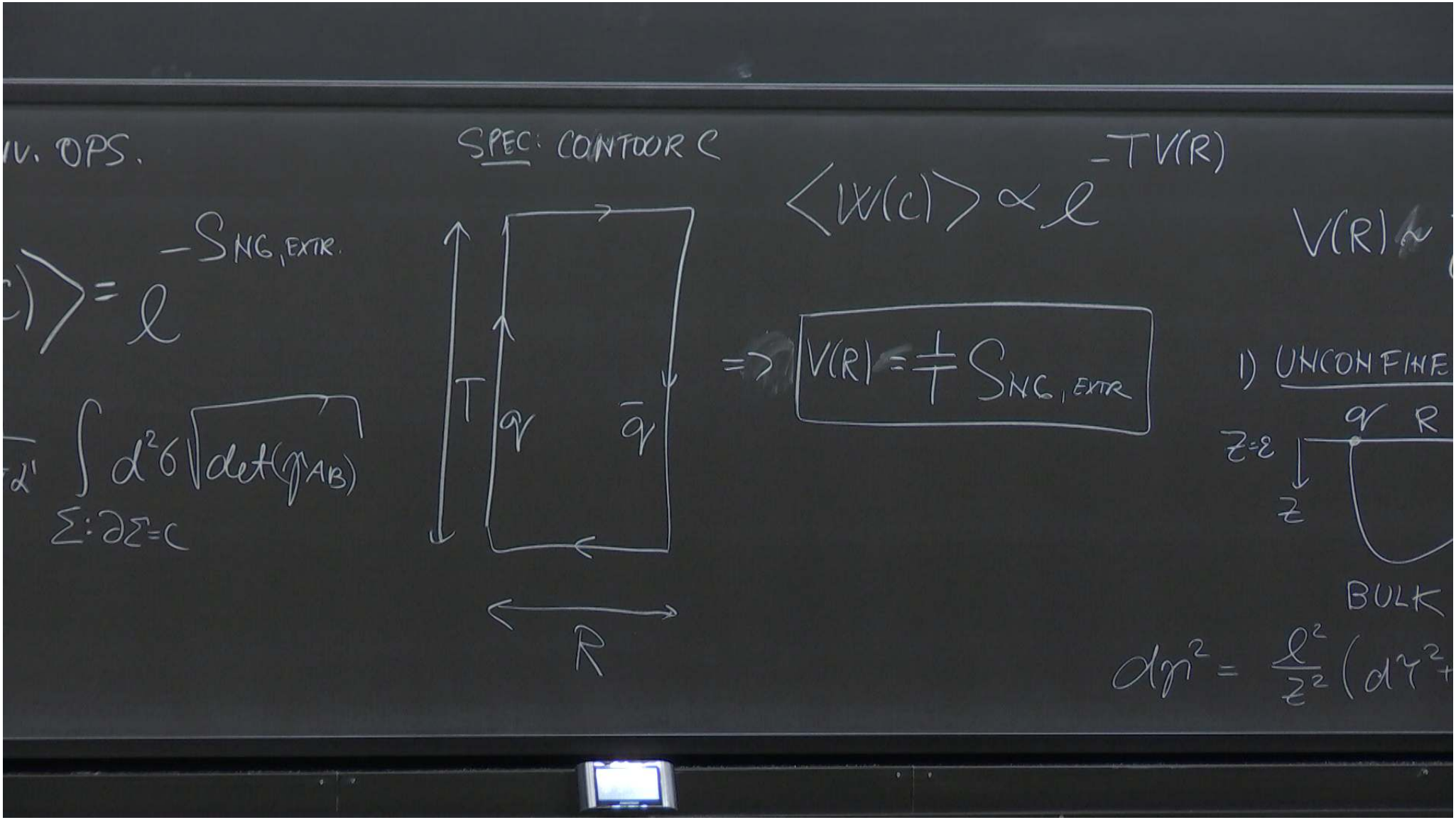
GRAVITY DUAL.



$$\langle W(C) \rangle = e^{-S_{NG,\,EXTR.}}$$

$$S_{NG} = \frac{1}{2\pi\alpha'} \int_{\Sigma:\,\partial\Sigma=C} d^2\sigma \sqrt{\det(g_{AB})}$$



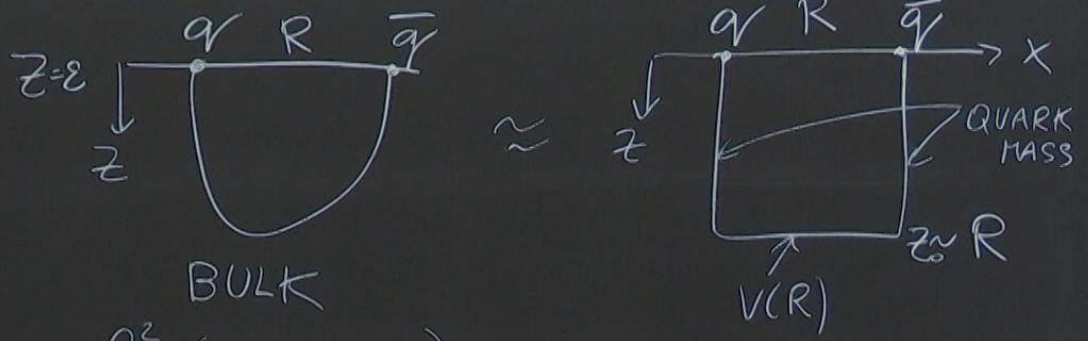

V. OPS.
SPEC: CONTOUR C
$\langle W(C) \rangle \propto e^{-TV(R)}$
$V(R) \sim$
$\langle C \rangle = e^{-S_{NG,EXTR.}}$
$\int_{\Sigma:\partial\Sigma=C} d^2\sigma \sqrt{\det(g_{AB})}$
T
q
$\bar{q}$
R
$\Rightarrow \boxed{V(R) = \pm S_{NG,EXTR}}$
1) UNCONFINE
q R
$z=\varepsilon$
z
BULK
$ds^2 = \frac{l^2}{z^2}(dx^2 +$

$\langle W(C) \rangle \propto e^{-TV(R)}$

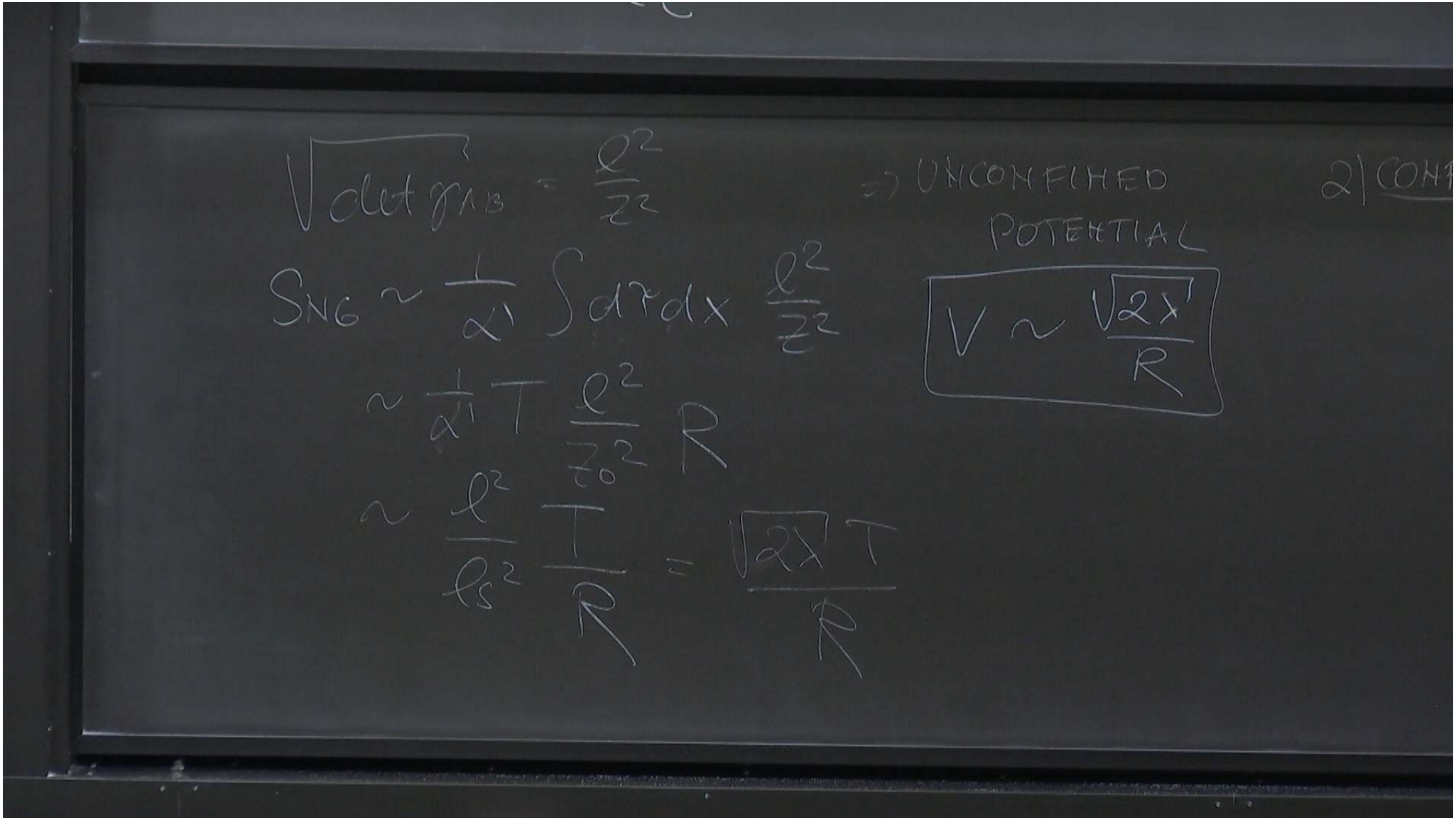
$V(R) \sim \begin{cases} 1/R & \text{UNCONFINED PHASE} \\ R & \text{CONFINED PHASE} \end{cases}$

$\Rightarrow \boxed{V(R) = \pm S_{NG,\,EXTR}}$

1) UNCONFINED PHASE



$$ds^2 = \frac{\ell^2}{z^2}(dt^2 + dx^2)$$


$\sqrt{\det g_{AB}} = \frac{\ell^2}{z^2}$
$\Rightarrow$ UNCONFINED POTENTIAL
2| CONF
$S_{NG} \sim \frac{1}{\alpha'} \int d\tau dx \frac{\ell^2}{z^2}$
$V \sim \frac{\sqrt{2\lambda}}{R}$
$\sim \frac{1}{\alpha'} T \frac{\ell^2}{z_0^2} R$
$\sim \frac{\ell^2}{\ell_s^2} \frac{T}{R} = \frac{\sqrt{2\lambda}\, T}{R}$

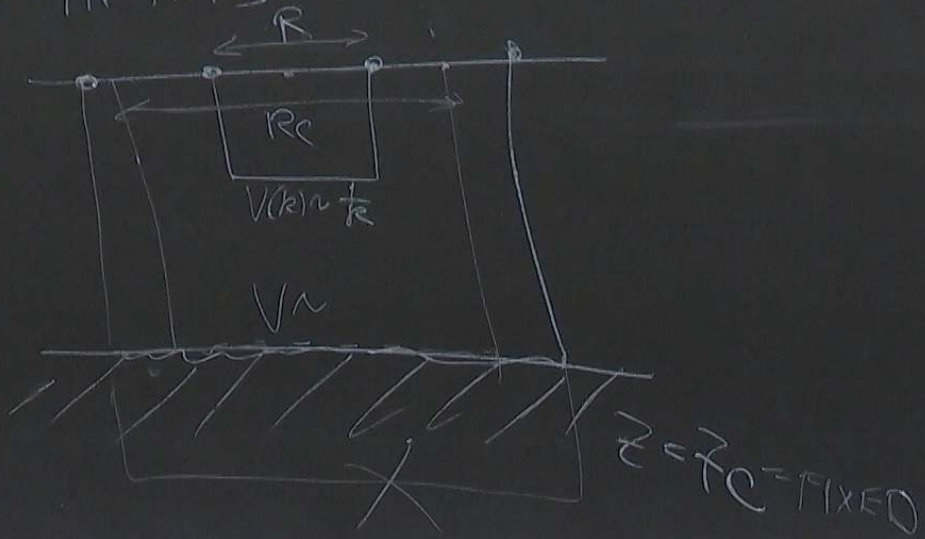
=> UNCONFINED POTENTIAL

$$V \sim \frac{\sqrt{2\lambda'}}{R}$$

2) CONFINED PHASE?

INTRODUCE A NEW SCALE

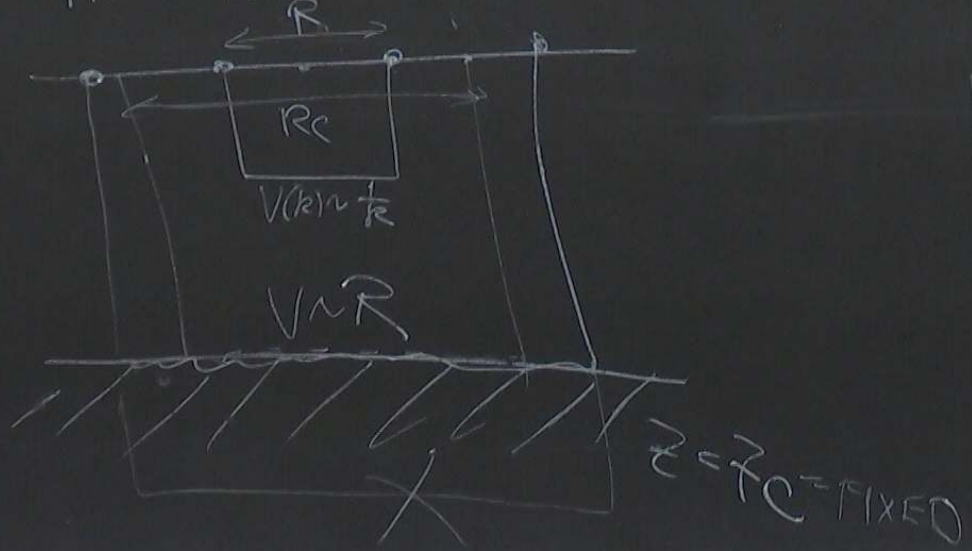
→ HOW DEEP MY STRING CAN GO IN AdS



2) CONFINED PHASE?

INTRODUCE A NEW SCALE

→ HOW DEEP MY STRING CAN GO IN AdS

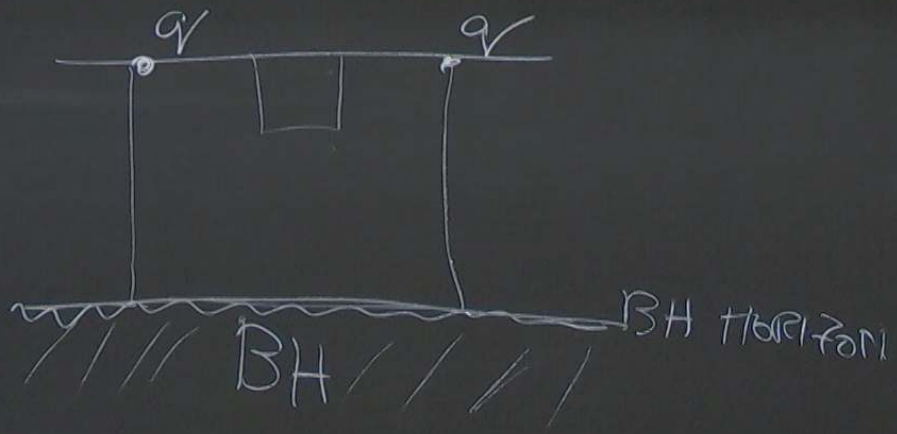


$$S_{NG} \sim \frac{1}{\alpha'} \int dx\, dx \, \frac{l^2}{z_c^2}$$

$$\sim \frac{l^2}{l_s^2} \frac{1}{z_c^2} T \cdot R$$

$$\boxed{V(R) \sim R}$$ CONFINED

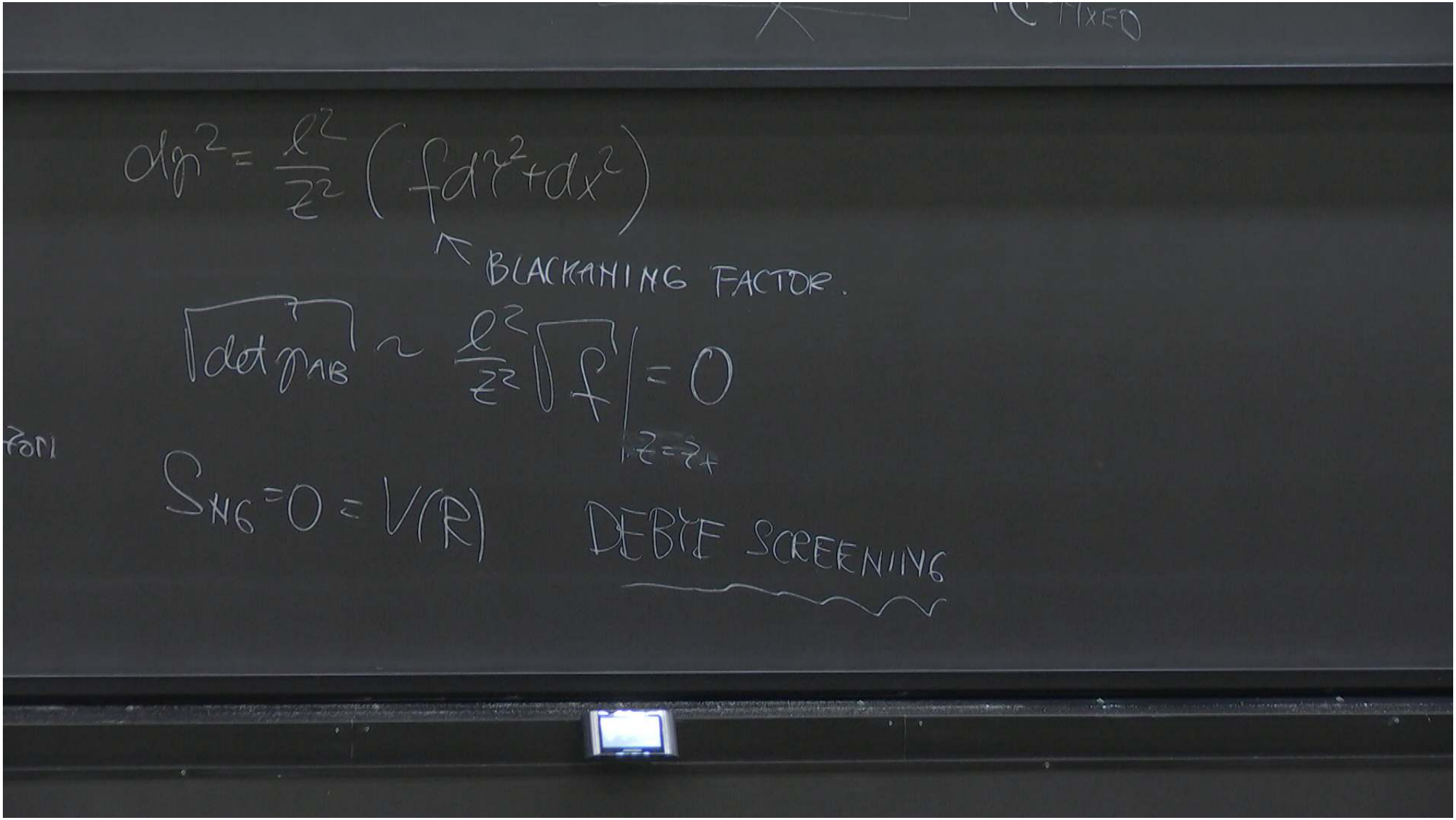
3) WHAT ABOUT PLASMA PHASE?
(AT FINITE T.)

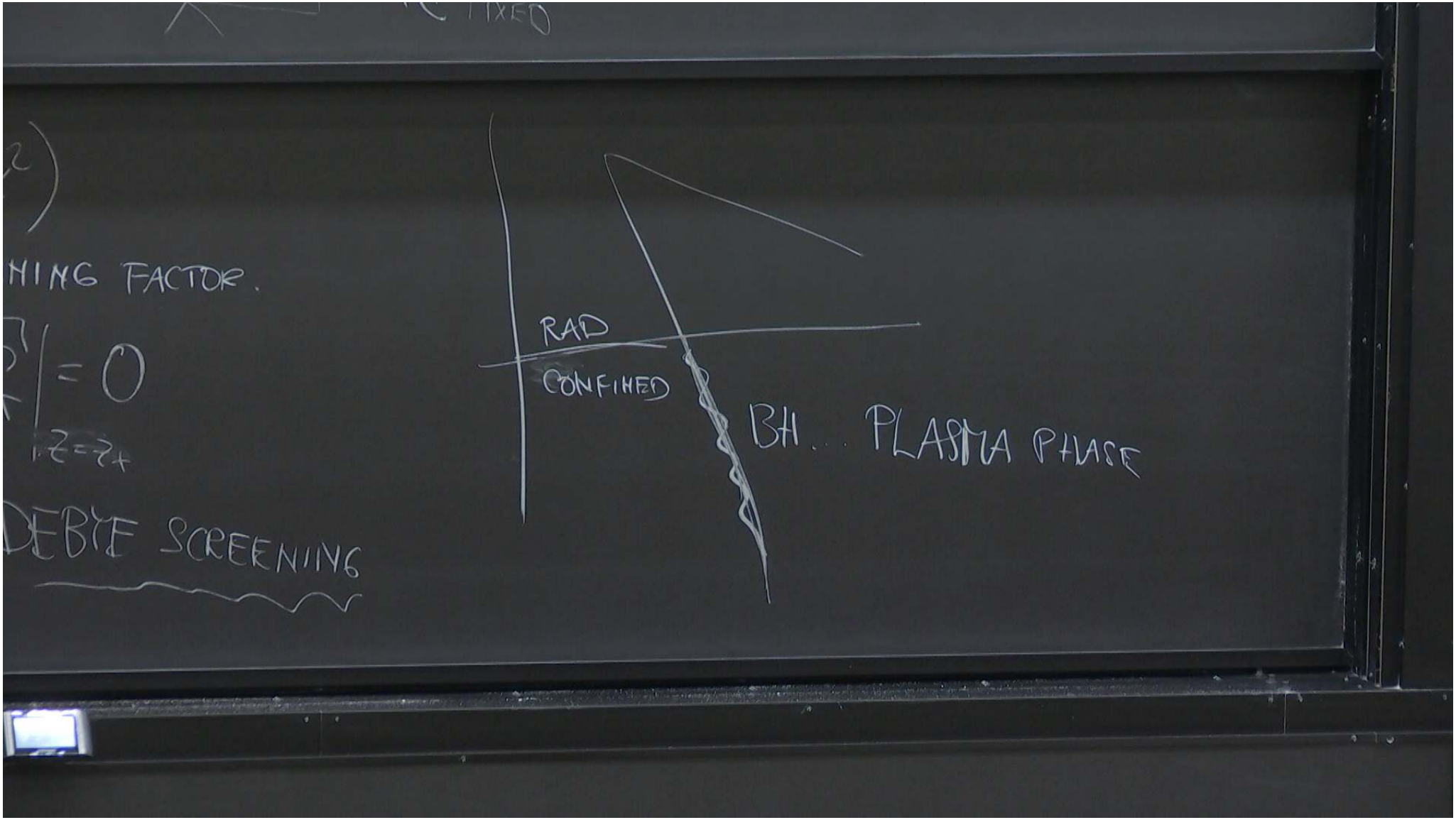


$$ds^2 = \frac{l^2}{z^2}\left(f dt^2 + dx^2\right)$$

↖ BLACKENING

$$\sqrt{\det g_{AB}} \sim \frac{l^2}{z^2}\sqrt{f}$$


MIXED
$ds^2 = \frac{\ell^2}{z^2}\left(f dt^2 + dx^2\right)$
BLACKENING FACTOR.
$\sqrt{\det g_{AB}} \sim \frac{\ell^2}{z^2}\sqrt{f}\Big|_{z=z_+} = 0$
$S_{NG} = 0 = V(R)$
DEBYE SCREENING


FIXED
MING FACTOR.
= 0
DEBYE SCREENING
RAD
CONFINED
BH... PLASMA PHASE

- CFT AT FINITE TEMPERATURE

NEA

RECALL: NON-EXTREMAL BLACK BRANE SOLUTION OF IIB SUGRA

$$ds_{10}^2 = H^{-1/2}\left(-f\,dt^2 + dx^2 + dy^2 + dz^2\right) + H^{1/2}\left(\frac{dr^2}{f} + r^2 d\Omega_5^2\right)$$

$$H = 1 + \frac{\ell^4}{r^4}, \qquad f = 1 - \frac{r_0^4}{r^4}$$

HORIZON AT $r = r_0$

NEAR HORIZON LIMIT: $r_0 < r \ll \ell$ ... f RETAINS UNCHANGED

$$H \simeq \frac{\ell^4}{r^4}$$

$$ds^2 \simeq \frac{r^2}{\ell^2}\left(-f dt^2 + dx_1^2 + \dots dx_3^2\right) + \frac{\ell^2}{r^2}\left(\frac{dr^2}{f} + r^2 d\Omega_5^2\right), \quad z = \frac{\ell^2}{r}$$

$$ds^2 = \frac{\ell^2}{z^2}\left(-f dt^2 + dx_1^2 + dx_2^2 + dx_3^2 + \frac{dz^2}{f}\right) + \ell^2 d\Omega_5^2$$

AdS_5 PLANAR BH

S_5 WITH RADIUS ℓ

- PROPERTIES OF THIS BH DETERMINE PROPS. OF THE CFT.

SPEC: BH TEMP $\leftrightarrow$ T... CFT

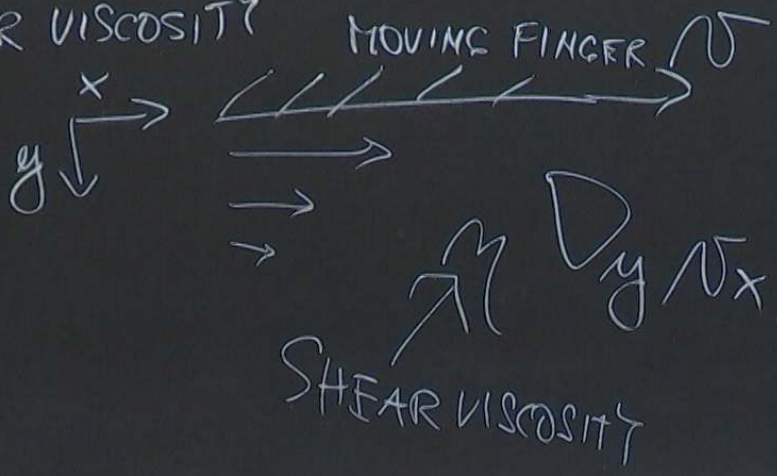
$$T = \frac{1}{\pi z_0}, \quad f(z_0) = 0$$

- BEWARE: $X^\mu \to \lambda X^\mu$, $z \to \lambda z$, $z_0 \to \lambda z_0$

CALCULATION OF THE SHEAR VISCOSITY OF QGP

QGP... STRONGLY COUPLED SOUP OF PARTICLES... WELL DESCRIBED BY HYDRODYNAMICS.

SHEAR VISCOSITY



$f = 1 - \left(\frac{\epsilon}{\epsilon_0}\right)$

RATIO $\frac{\eta}{s}$ .. EXTREMELY SMALL

DYNAMICS.

$\frac{\eta}{s} \overset{\text{AdS/CFT}}{=} \frac{1}{4\pi}$ ... MOST IDEAL FLUID

MEASURED: $\frac{\eta}{s} = \frac{1}{4\pi}(1, 2.5)$

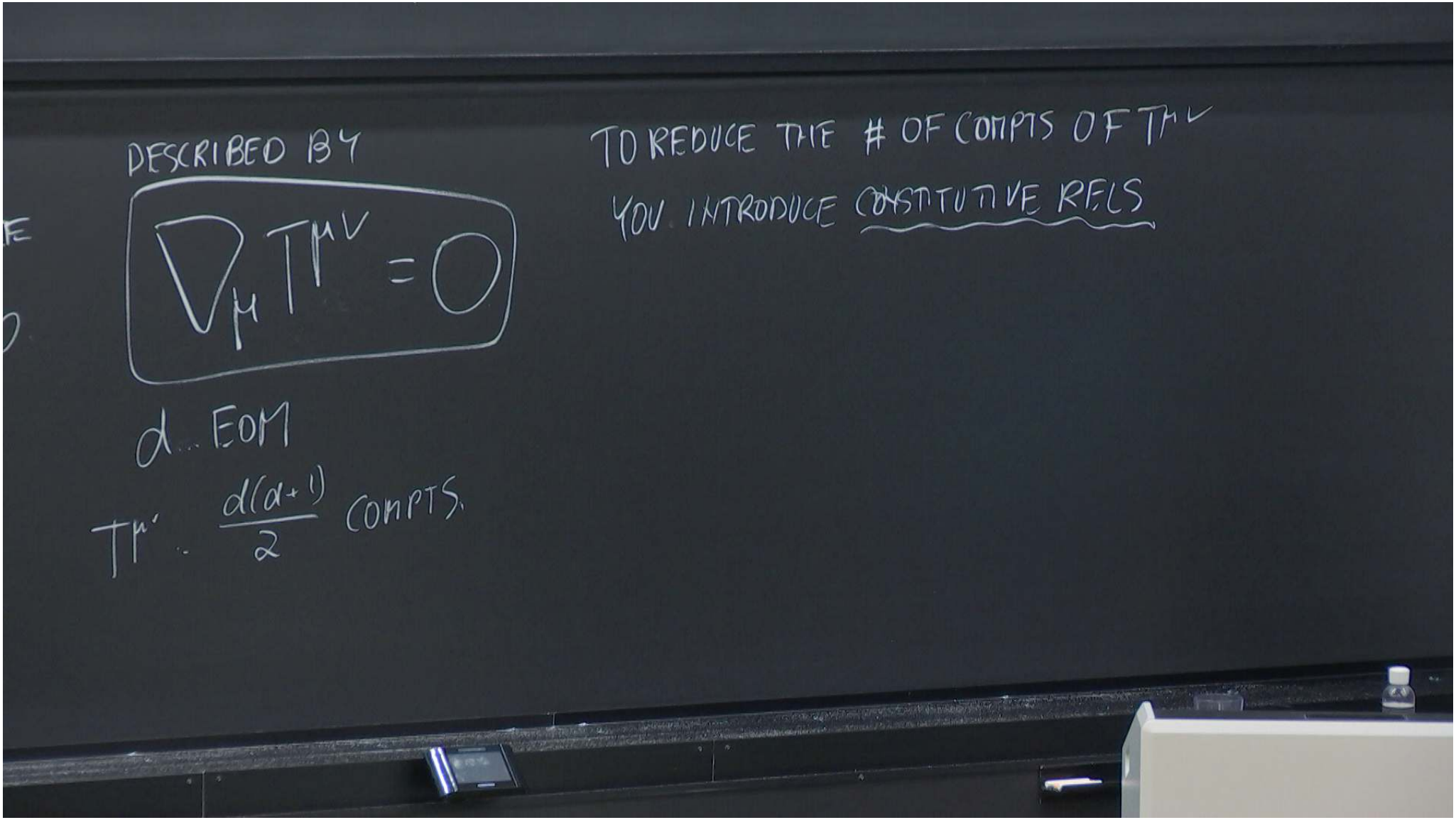
C.F. WATER ... 10^3 BIGGER THAN THIS.

RELATIVISTIC HYDRODYNAMICS

LOCAL EQ., SLOWLY VARIES FROM PLACE TO PLACE

$q \to 0, \omega \to 0$

$\lambda_{MFD} \ll \lambda_{FLUCTUATIONS}$


DESCRIBED BY
$\nabla_\mu T^{\mu\nu} = 0$
d... EOM
$T^{\mu\nu}$... $\frac{d(d+1)}{2}$ COMPTS.
TO REDUCE THE # OF COMPTS OF $T^{\mu\nu}$
YOU INTRODUCE CONSTITUTIVE RELS