Title: AdS/CFT Lecture (230428)

Speakers: David Kubiznak

Collection: AdS/CFT (2022/2023)

Date: April 28, 2023 - 9:00 AM

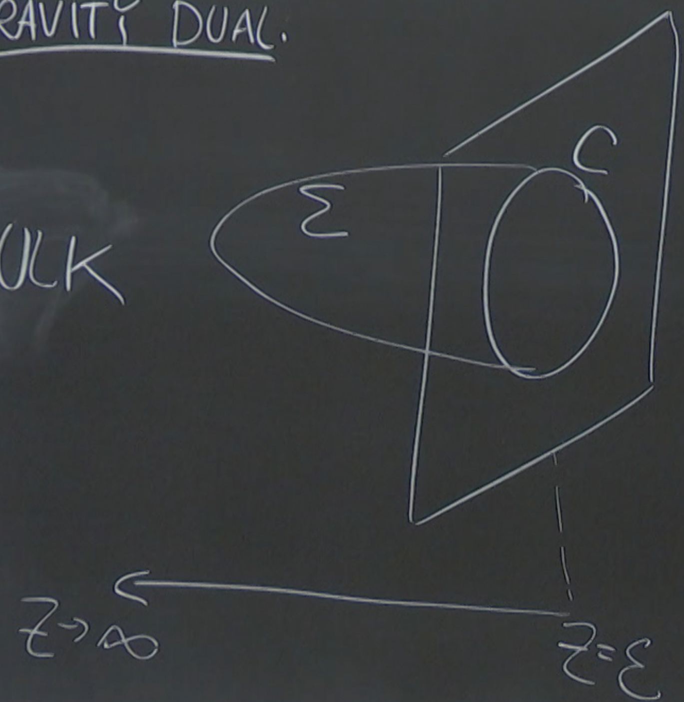
URL: https://pirsa.org/23040041

WILSON LOOPS: **NON-LOCAL** GAUGE INV. OPS.

SPEC: CO

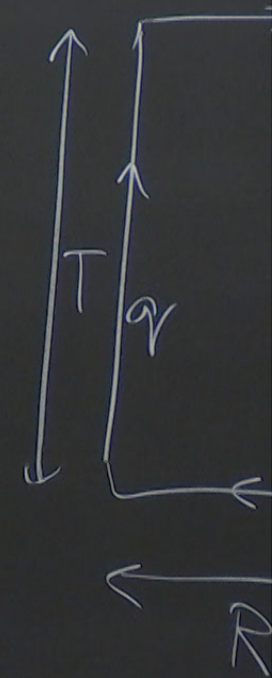
GRAVITY DUAL.

BULK



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

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

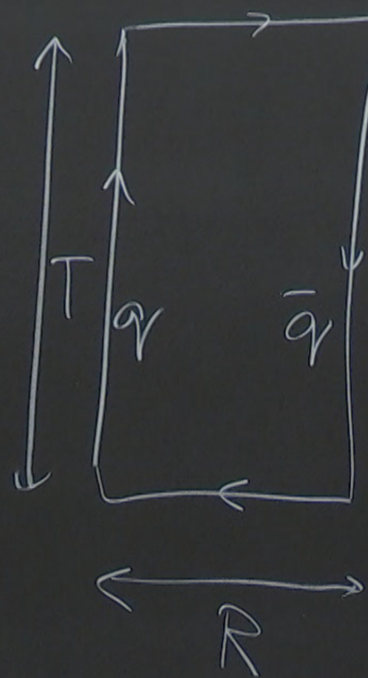


...V. OPS.

SPEC: CONTOUR C

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

$$\ldots\,\alpha' \int_{\Sigma:\,\partial\Sigma = C} d^2\sigma \sqrt{\det(\gamma_{AB})}$$

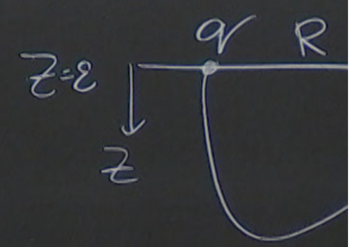


$$\langle W(C)\rangle \propto e^{-T V(R)}$$

$$\Rightarrow \boxed{V(R) = \frac{1}{T} S_{NG,\,EXTR}}$$

$V(R) \sim$ ...

1) UNCONFINE...



BULK

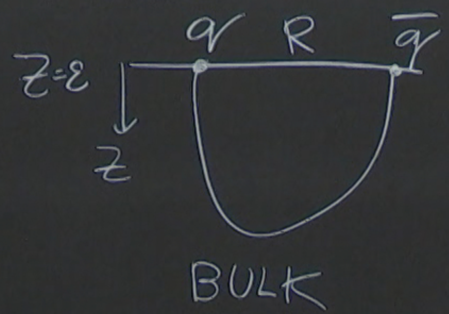
$$d\gamma^2 = \frac{\ell^2}{z^2}\left(dt^2 + \ldots\right.$$

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

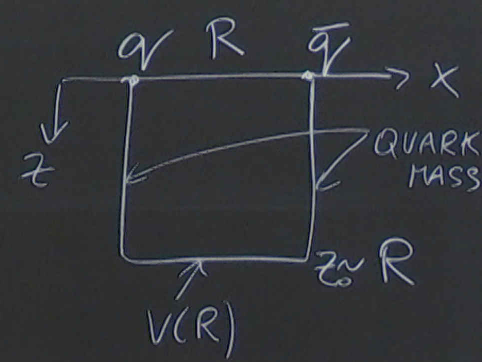
$$V(R) \sim \begin{cases} 1/R & \text{UNCONFINED PHASE} \\ R & \text{CONFINED PHASE} \end{cases}$$

$$\Rightarrow \boxed{V(R) = \frac{1}{T} S_{NG,\,EXTR}}$$

1) UNCONFINED PHASE



$\approx$



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

$$\sqrt{\det g_{AB}} = \frac{\ell^2}{z^2}$$

$\Rightarrow$ UNCONFINED POTENTIAL

2) CONF

$$S_{NG} \sim \frac{1}{\alpha'} \int d\tau\, dx \, \frac{\ell^2}{z^2}$$

$$\sim \frac{1}{\alpha'} T \frac{\ell^2}{z_0^2} R$$

$$\sim \frac{\ell^2}{\ell_s^2} \frac{T}{R} = \frac{\sqrt{2\lambda}\, T}{R}$$

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

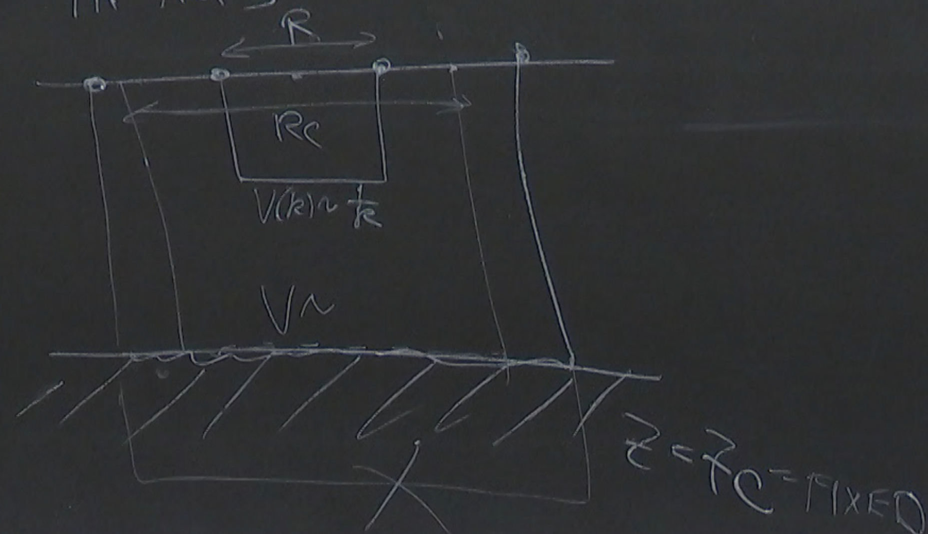
⇒ UNCONFINED POTENTIAL

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

2) CONFINED PHASE?

INTRODUCE A NEW SCALE

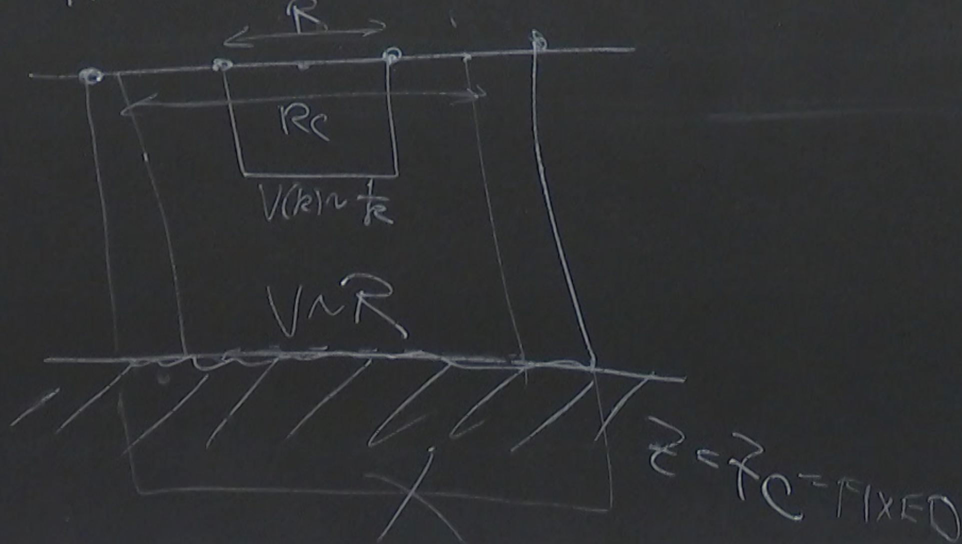
→ HOW DEEP MY STRING CAN GO IN AdS



2) CONFINED PHASE?

INTRODUCE A NEW SCALE

→ HOW DEEP MY STRING CAN GO IN AdS

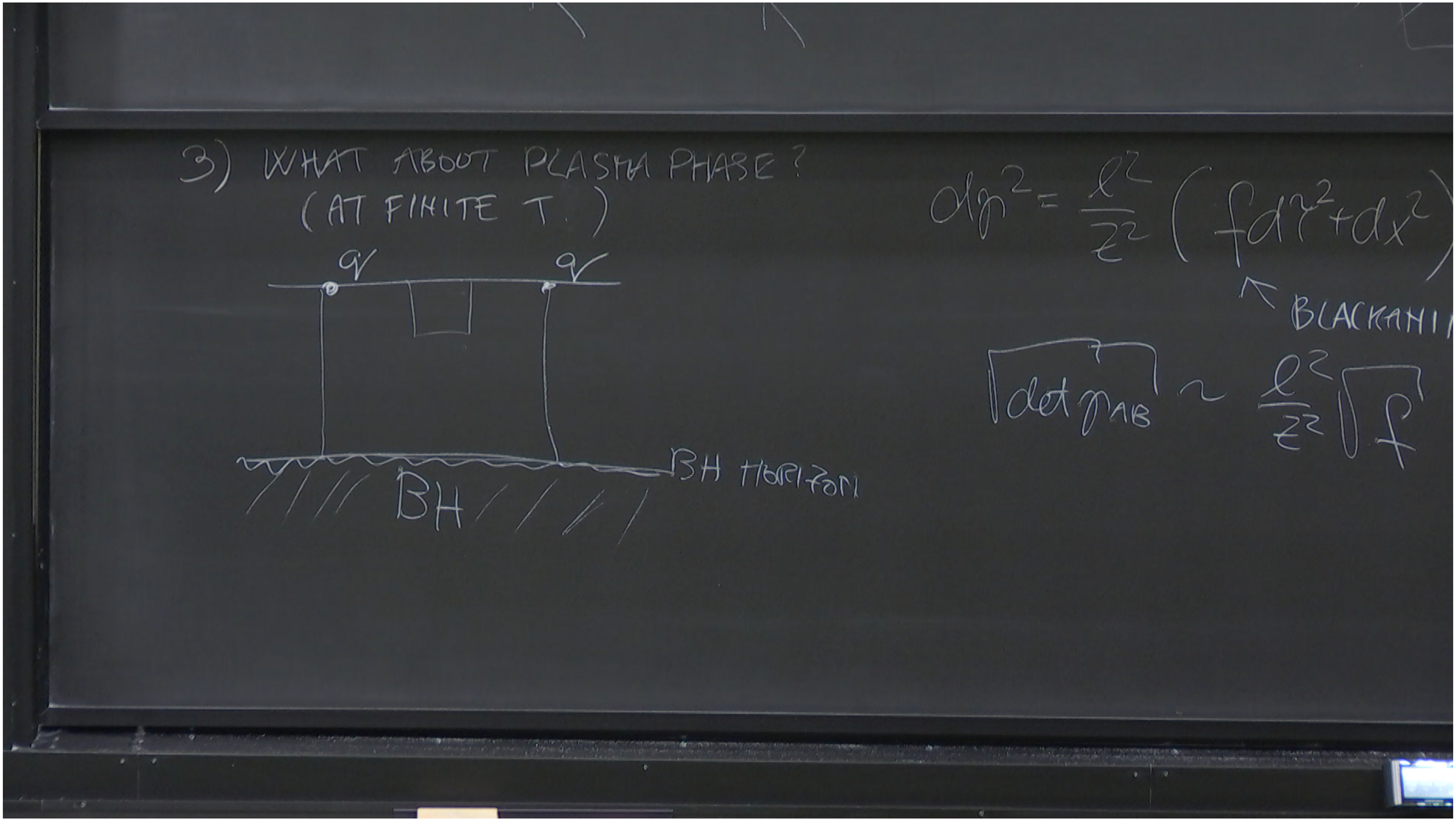


$$S_{NG} \sim \frac{1}{\alpha'} \int d\tau\, dx \; \frac{\ell^2}{z_c^2}$$

$$\sim \frac{\ell^2}{\ell_s^2}\frac{1}{z_c^2}\, T \cdot R$$

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

CONFINED



3) WHAT ABOUT PLASMA PHASE?
(AT FINITE T.)
q
q
BH HORIZON
BH
$ds^2 = \frac{\ell^2}{z^2}\left(f d\tau^2 + dx^2\right)$
BLACKENI
$\sqrt{\det g_{AB}} \sim \frac{\ell^2}{z^2}\sqrt{f}$

MIXED

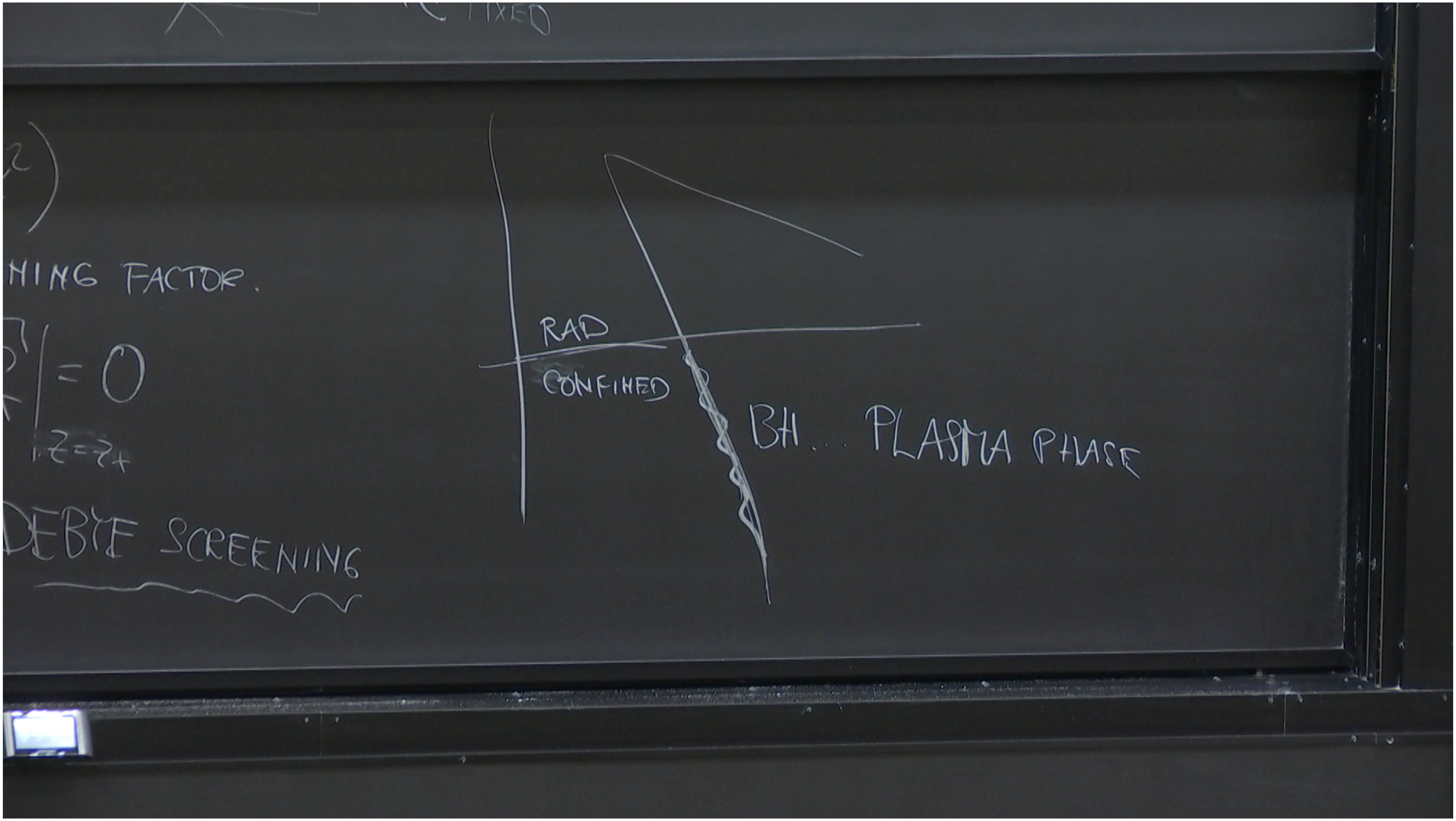
$$d\gamma^2 = \frac{\ell^2}{z^2}\left(f\,d\tau^2 + dx^2\right)$$

↖ BLACKANING FACTOR.

$$\sqrt{\det \gamma_{AB}} \sim \frac{\ell^2}{z^2}\sqrt{f}\,\Big|_{z=z_+} = 0$$

$$S_{NG} = 0 = V(R)$$

DEBYE SCREENING


HING FACTOR.
= 0
DEBYE SCREENING
RAD
CONFINED
BH ... PLASMA PHASE

- CFT AT FINITE TEMPERATURE

NEA

RECALL: NON-EXTREMAL BLACK BRANE SOLUTION OF IIB SUGRA

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

$$H = 1 + \frac{\ell^4}{r^4}, \quad \underbrace{f = 1 - \frac{r_0^4}{r^4}}_{\text{HORIZON AT } r = r_0}$$

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

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

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

$$ds^2 = \underbrace{\frac{\ell^2}{z^2}\left(-f\,dt^2 + dx_1^2 + dx_2^2 + dx_3^2 + \frac{dz^2}{f}\right)}_{AdS_5 \text{ PLANAR BH}} + \underbrace{\ell^2 d\Omega_5^2}_{S_5 \text{ WITH RADIUS } \underline{\ell}}$$

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

<u>SPEC</u>: BH TEMP $\leftrightarrow$ T ... CFT

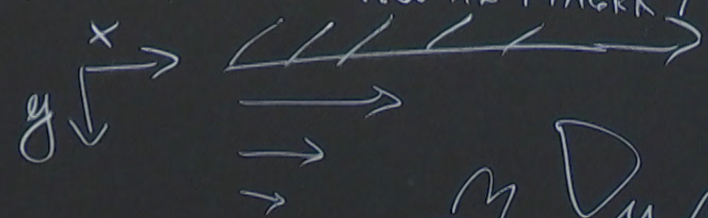
$$T = \frac{1}{\pi z_0}, \quad f(z_0) = 0$$

• 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 MOVING FINGER v



$$\eta \, \partial_y v_x$$

SHEAR VISCOSITY

$f = 1 - \left(\frac{r}{r_0}\right)^4$

RATIO

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

...DYNAMICS.

$$\boxed{\frac{\eta}{s} \overset{AdS/CFT}{=} \frac{1}{4\pi}}$$

.... <u>MOST IDEAL FLUID</u>

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

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

$\lambda_{MFP} \ll \lambda_{FLUCTUATIONS}$

DESCRIBED BY

$$\boxed{\nabla_\mu T^{\mu\nu} = 0}$$

d ... EOM

$T^{\mu\nu}$ .. $\frac{d(d+1)}{2}$ COMPTS.

TO REDUCE THE # OF COMPTS OF $T^{\mu\nu}$

YOU INTRODUCE CONSTITUTIVE RELS