Title: Quantum Field Theory in Curved Spacetime (AM) - 2023-03-03

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Collection: Quantum Field Theory in Curved Spacetime

Date: March 03, 2023 - 10:00 AM

URL: https://pirsa.org/23030088

Abstract: https://pitp.zoom.us/j/95867663528?pwd=dmd5Y3FaVHJ0SnJWSlFscEY4cmhYUT09

a) physics of BHs

b) very early universe

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Literature: Birrell, Davies "Quantum Fields in Curved Space"

+ original papers

II) Derivation of BH entropy

J. Bekenstein: PRD, 7, 2333 (1973)

PRD, 9, 3292 (1974)

1. $ds^2 = -\left(1-\frac{2M}{r}\right)dt^2 + \frac{dr^2}{1-\frac{2M}{r}} + r^2 d\Omega^2 \quad , \quad r > 2M$

$\longrightarrow \left(1-\frac{2M}{r}\right)\left(-dt^2+dr_*^2\right)$

$\hbar = c = G = 1 \quad ; \quad g_{\mu\nu} = (-,+,+,+)$

Kruskal coordinates

$u = t - r_* \quad , \quad v = t + r_*$

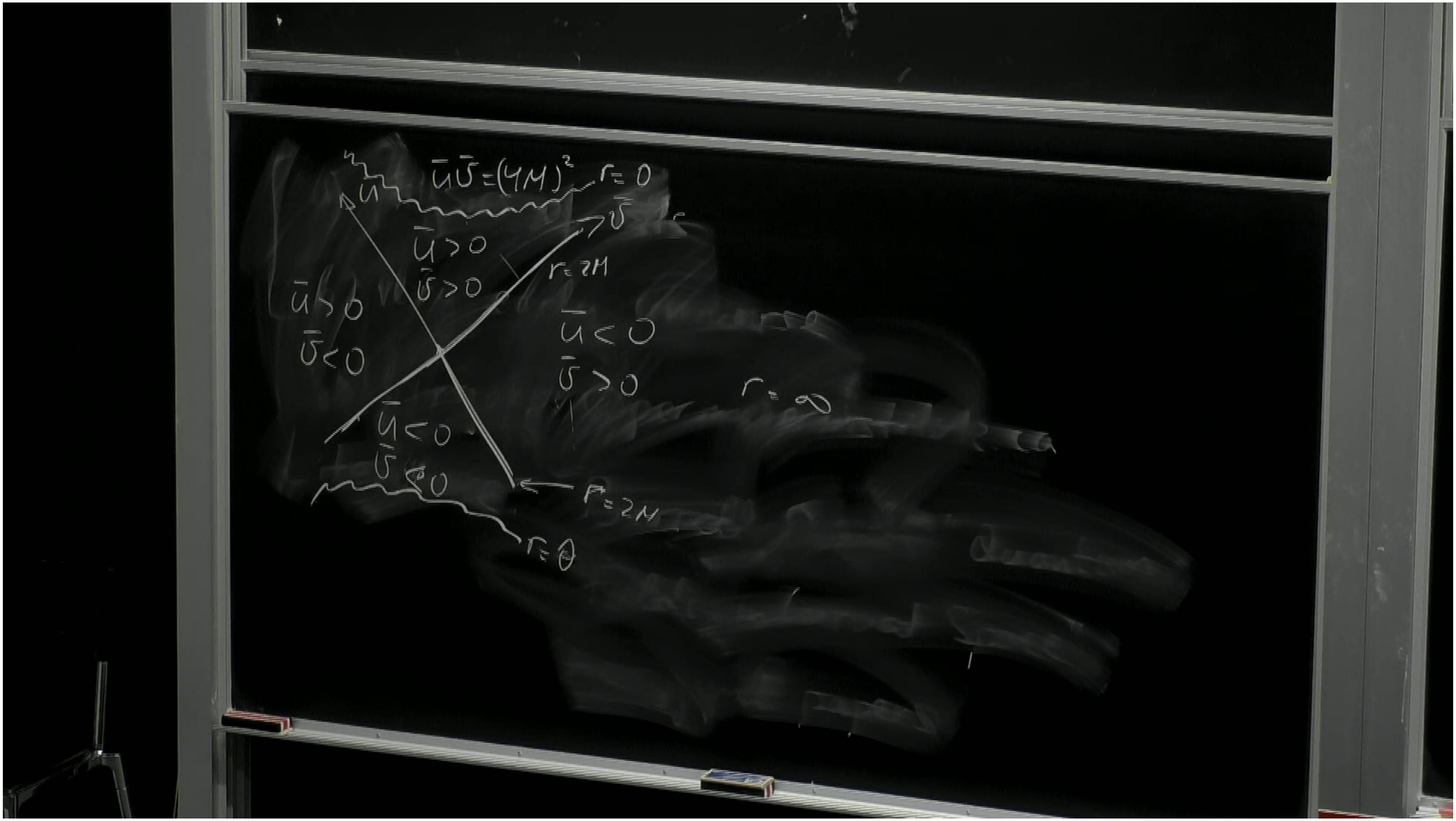
$r_* = \int \frac{dr}{1-\frac{2M}{r}} = r + 2M \ln\left(\frac{r}{2M}-1\right)$

$$ds^2 = -\left(1-\frac{2M}{r}\right) du\, dv + r^2 d\Omega^2$$

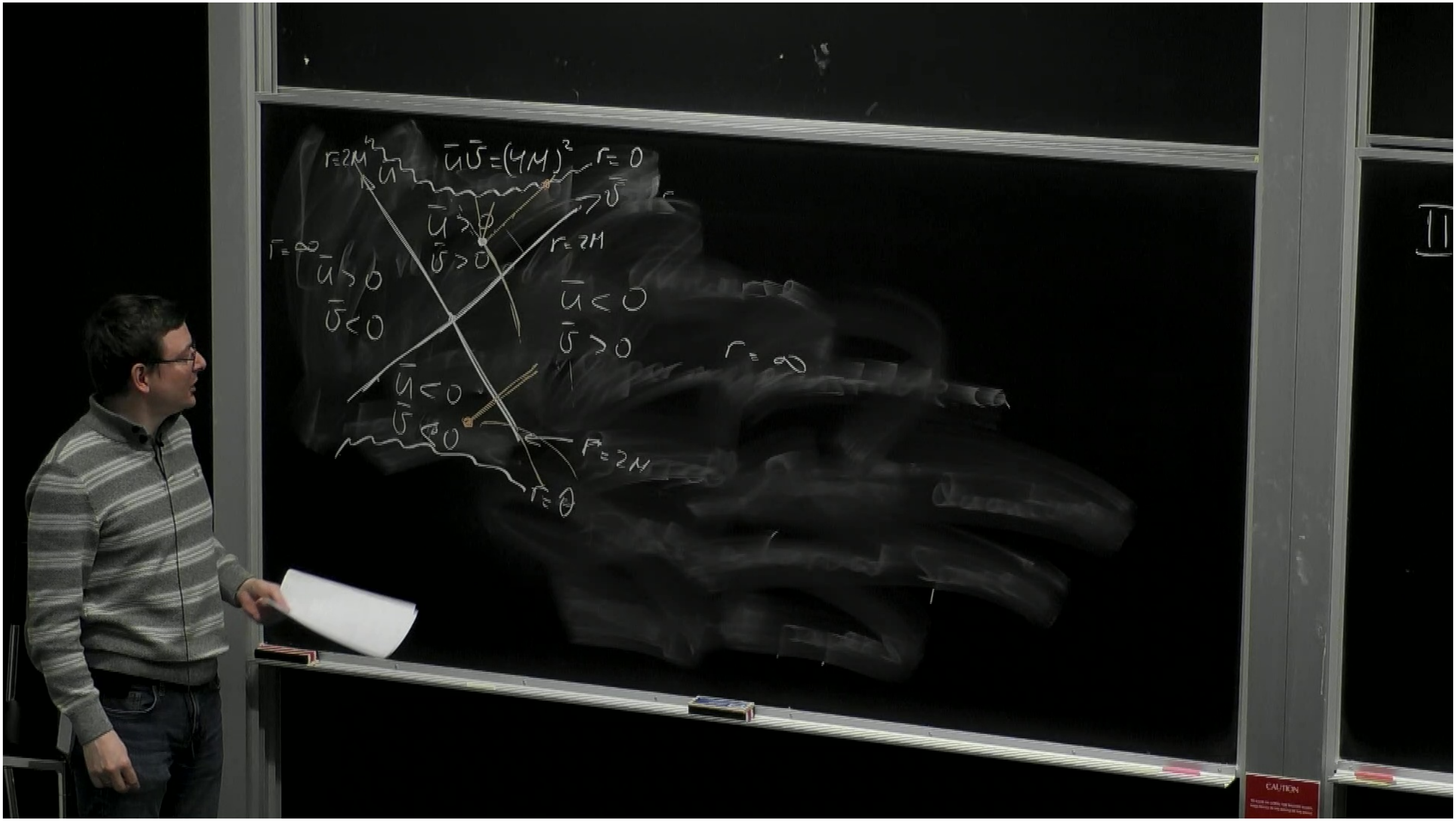
$$\left.\begin{aligned} \bar{u} &= f(u) = -4M e^{-\frac{u}{4M}} \\ \bar{v} &= g(v) = 4M e^{v/4M} \end{aligned}\right\} -\infty < \bar{u} < 0 \quad , \quad 0 < \bar{v} < \infty$$

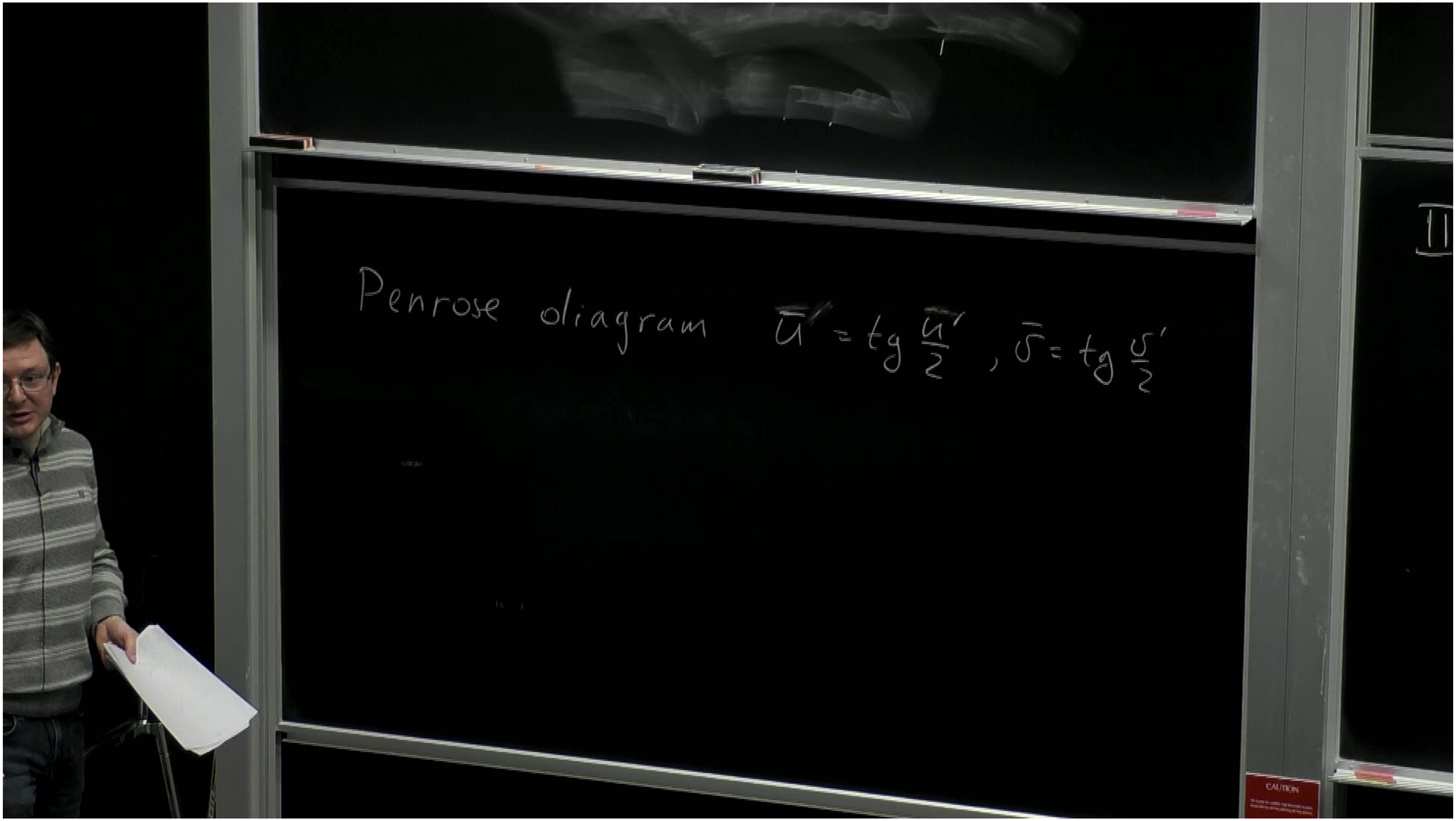
$$\bar{u}\bar{v} = 4M\left(1-\frac{r}{2M}\right) e^{\frac{r}{2M}}$$

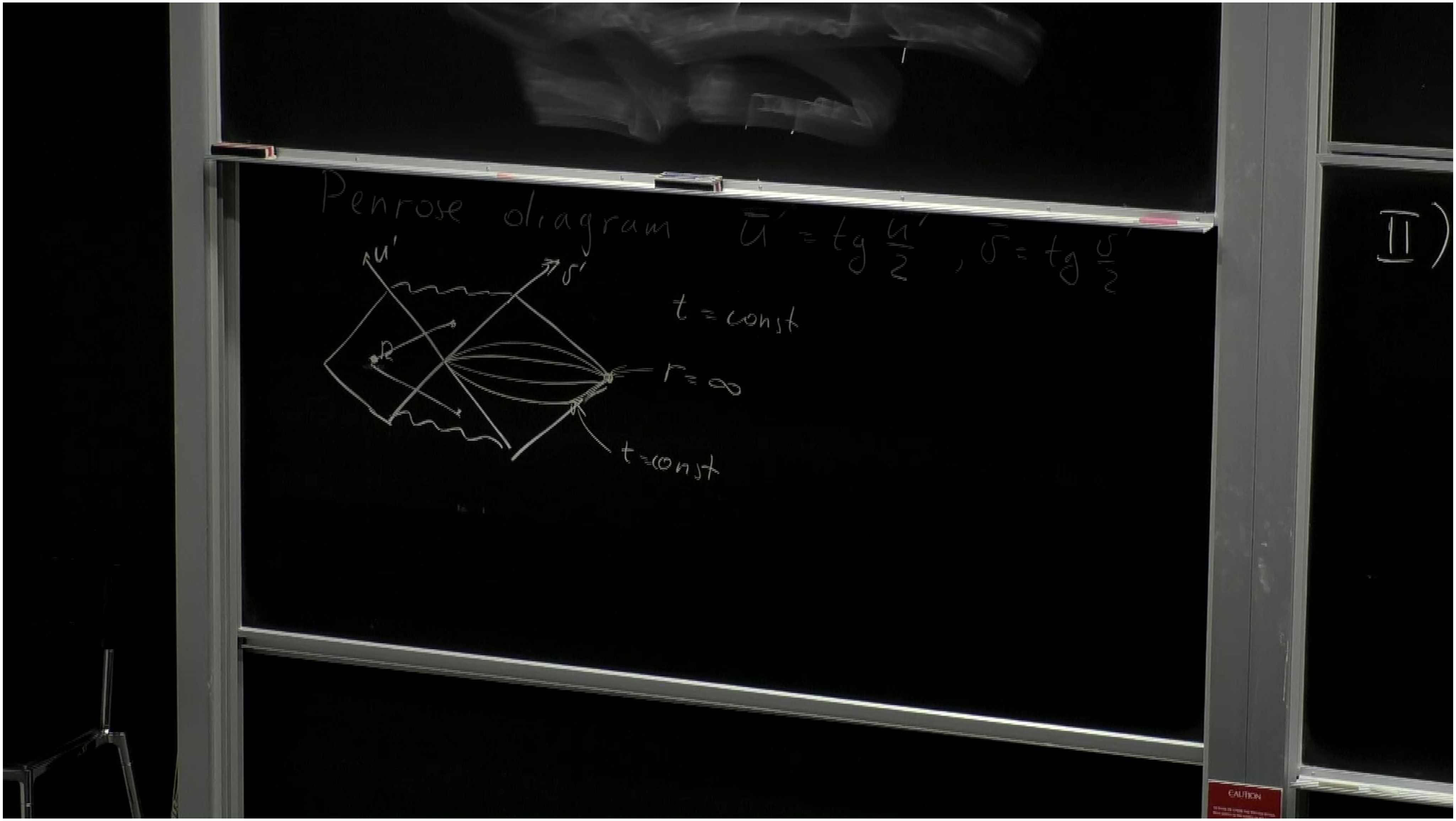
$$ds^2 = -\frac{2M}{r(\bar{u},\bar{v})} e^{-\frac{r(\bar{u},\bar{v})}{2M}} d\bar{u}\, d\bar{v} + r^2(\bar{u},\bar{v})\, d\Omega^2$$

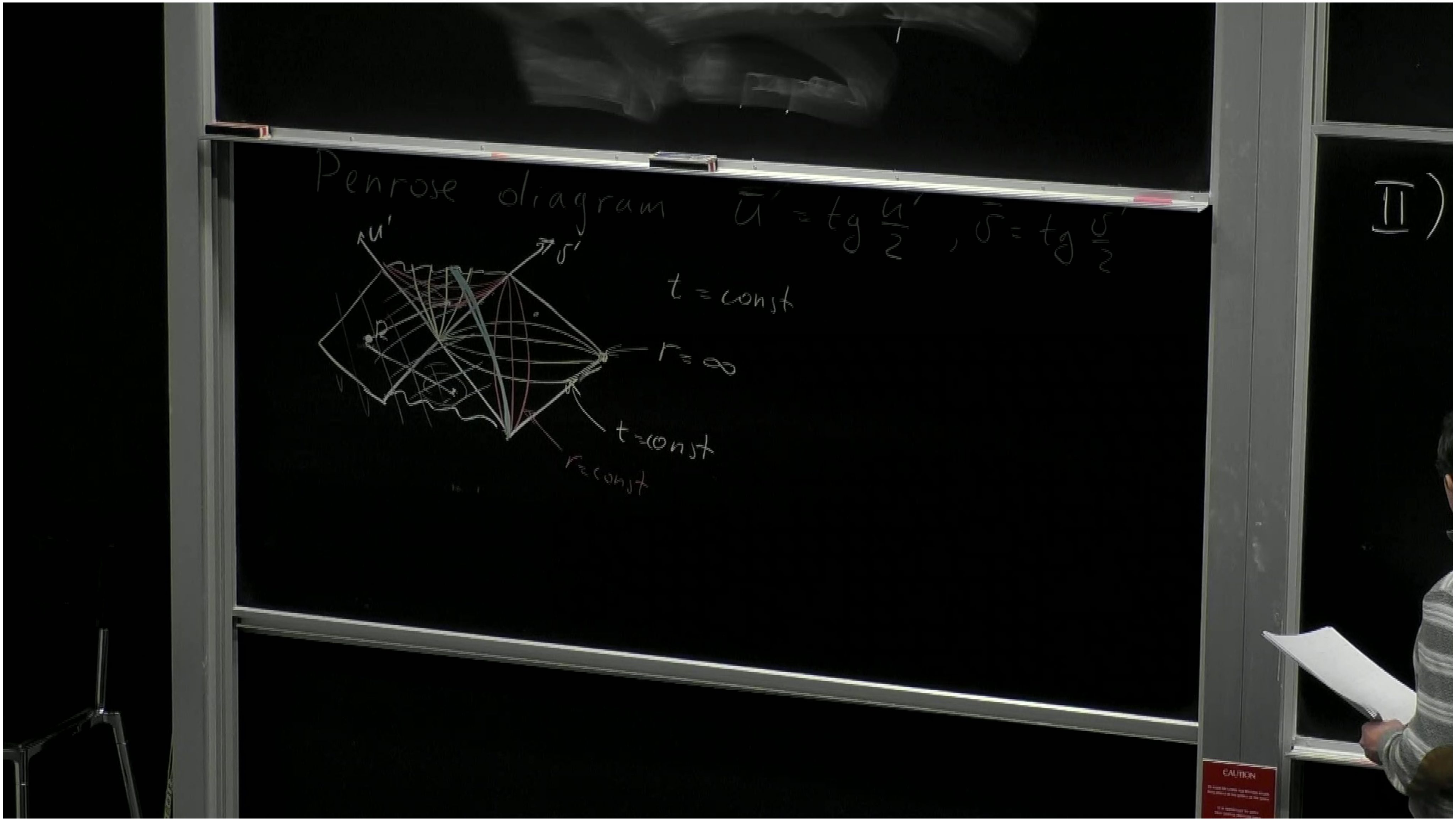


$\bar{u}\bar{v} = (4M)^2$
$r = 0$
$\bar{u}$
$\bar{v}$
$\bar{u} > 0$
$\bar{v} > 0$
$r = 2M$
$\bar{u} > 0$
$\bar{v} < 0$
$\bar{u} < 0$
$\bar{v} > 0$
$r = \infty$
$\bar{u} < 0$
$\bar{v} < 0$
$r = 2M$
$r = 0$


r=2M
$\bar{u}\bar{v}=(4M)^2$
r=0
$\bar{u}>0$
$\bar{v}>0$
r=2M
r=∞
$\bar{u}>0$
$\bar{v}<0$
$\bar{u}<0$
$\bar{v}>0$
r=∞
$\bar{u}<0$
$\bar{v}<0$
r=2M
r=0


Penrose diagram $\bar{u}' = tg\,\frac{\bar{u}'}{2}$, $\bar{v} = tg\,\frac{v'}{2}$


Penrose diagram ū' = tg u'/2 , v̄ = tg v'/2
u'
v'
t = const
r = ∞
t = const
II)


Penrose diagram $\bar{u}' = tg\frac{u'}{2}$, $\bar{v}' = tg\frac{v'}{2}$
u'
v'
t = const
r = ∞
t = const
r = const
II)

Ex 1. Draw Penrose diagram

Minkowski space

a) 4d

b) 2d

2. $M, J \left(\left(Q_1, Q_2 \ldots \right) \right)$

Proposal : $S_{BH} = \alpha \cdot A_{horizon} \overset{Sch.}{=} \alpha \cdot 16\pi M^2$

qubit $S_p = \ln 2$