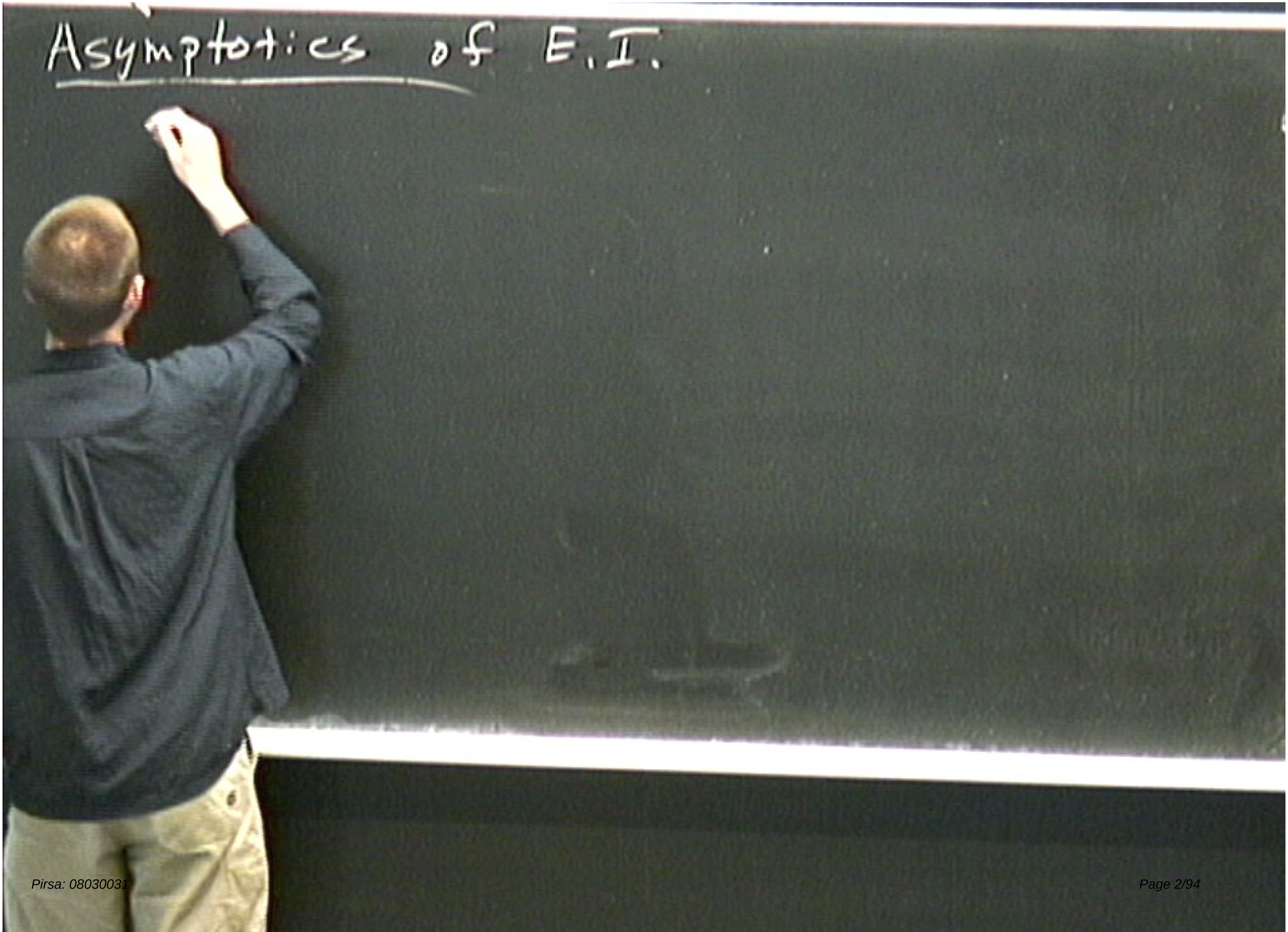
Title: Asymptotics of Eternal Inflation

Date: Mar 31, 2008 11:00 AM

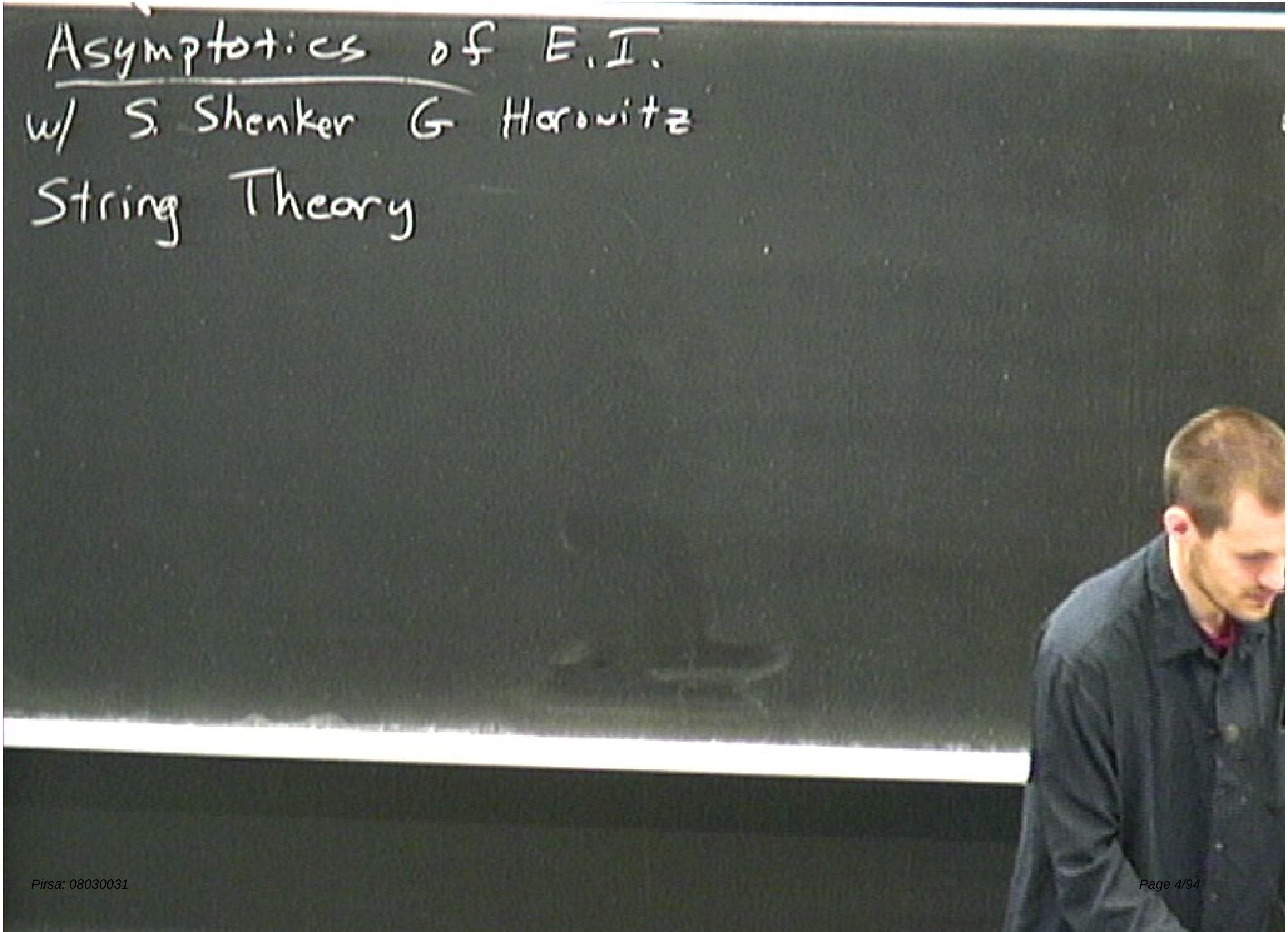
URL: http://pirsa.org/08030031

Abstract: TBA


Asymptotics of E.I.

Asymptotics of E. I.

w/ S. Shenker G. Horowitz


Asymptotics of E.I.
w/ S. Shenker G Horowitz
String Theory

Asymptotics of E.I.

w/ S. Shenker G. Horowitz

String Theory has lots of vacua

Mechanism for producing large spacetime regims of each vacuum: eternal inflation

Asymptotics of E.I.

w/ S. Shenker G Horowitz

String Theory has lots of vacua

Mechanism for producing large spacetime regions of each vacuum: eternal inflation

just cont

Asymptotics of E.I.

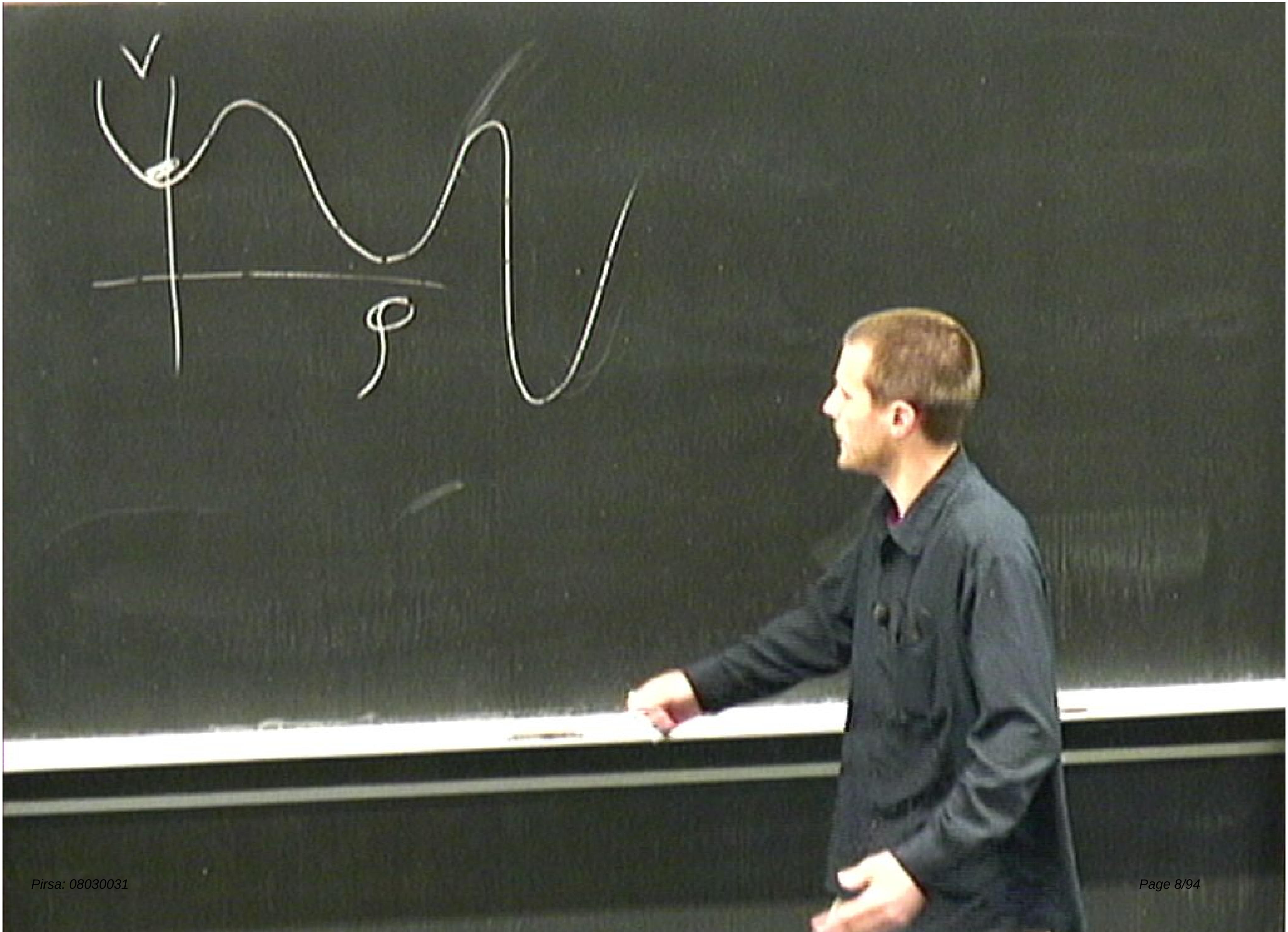
w/ S. Shenker G Horowitz

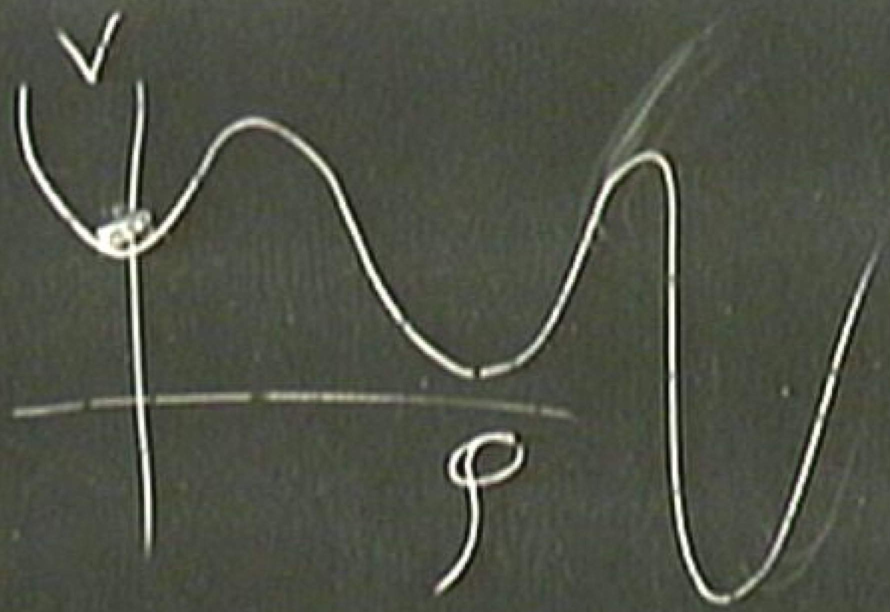
String Theory has lots of vacua

Mechanism for producing large spacetime regims of each vacuum: eternal inflation

just cant

Problem: infinities


V
φ


V
φ

Asymptotics of E.I.

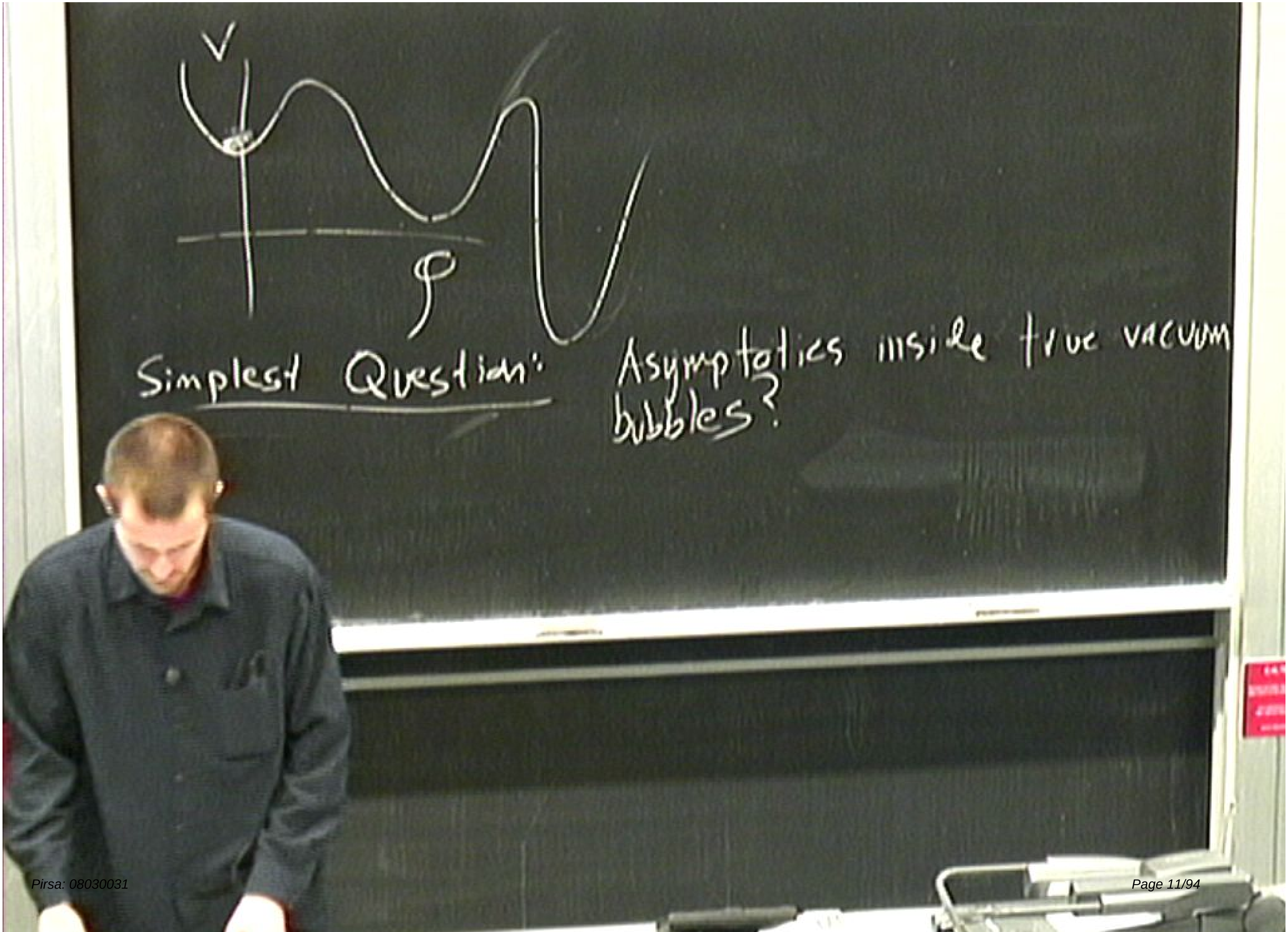
w/ S. Shenker G. Horowitz

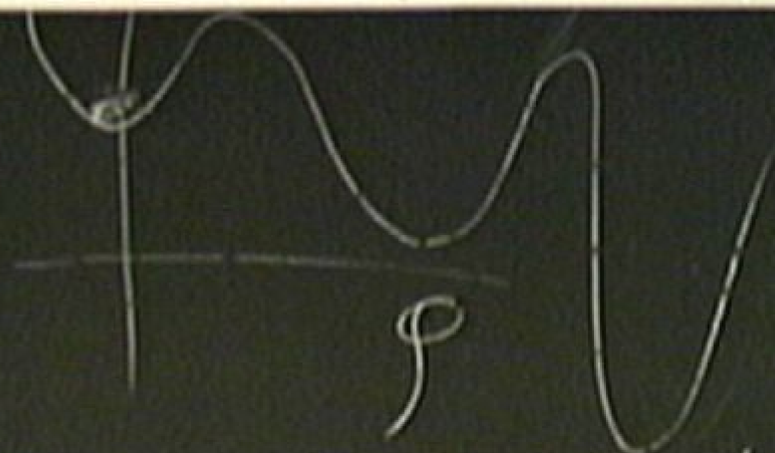
String Theory has lots of vacua

Mechanism for producing large spacetime regims of each vacuum: eternal inflation

just cant

Problem: infinities → # of bubbles
→ volume inside each bubble

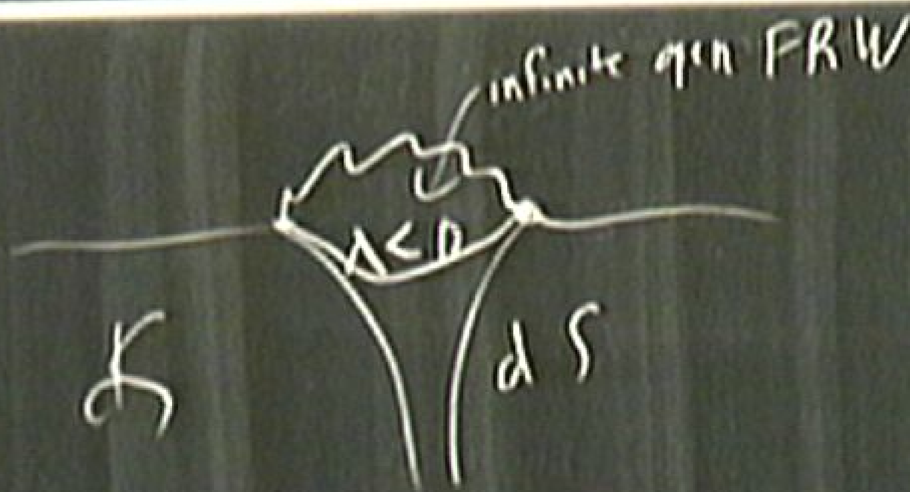

V
φ
Simplest Question:
Asymptotics inside true vacuum bubbles?

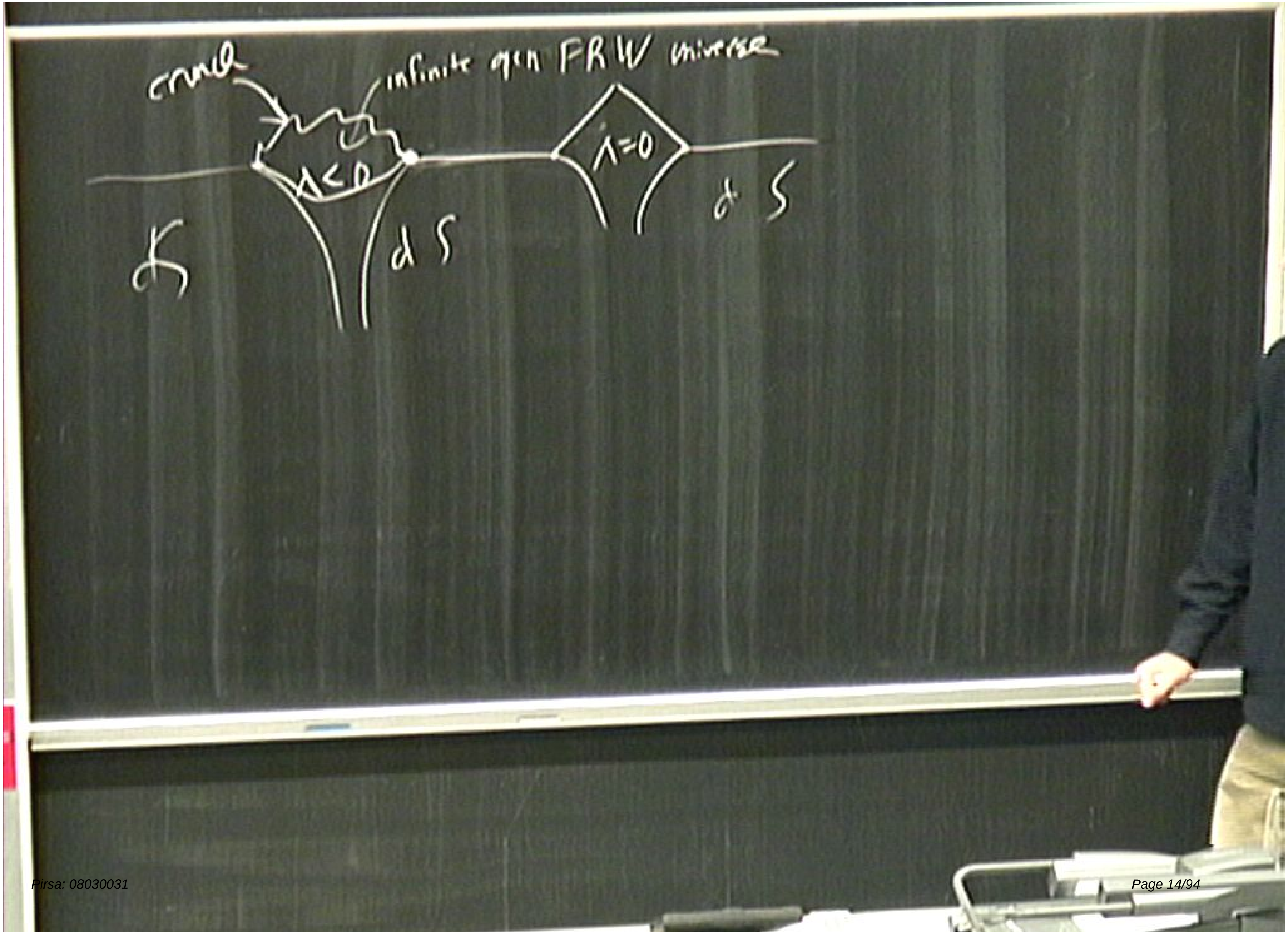


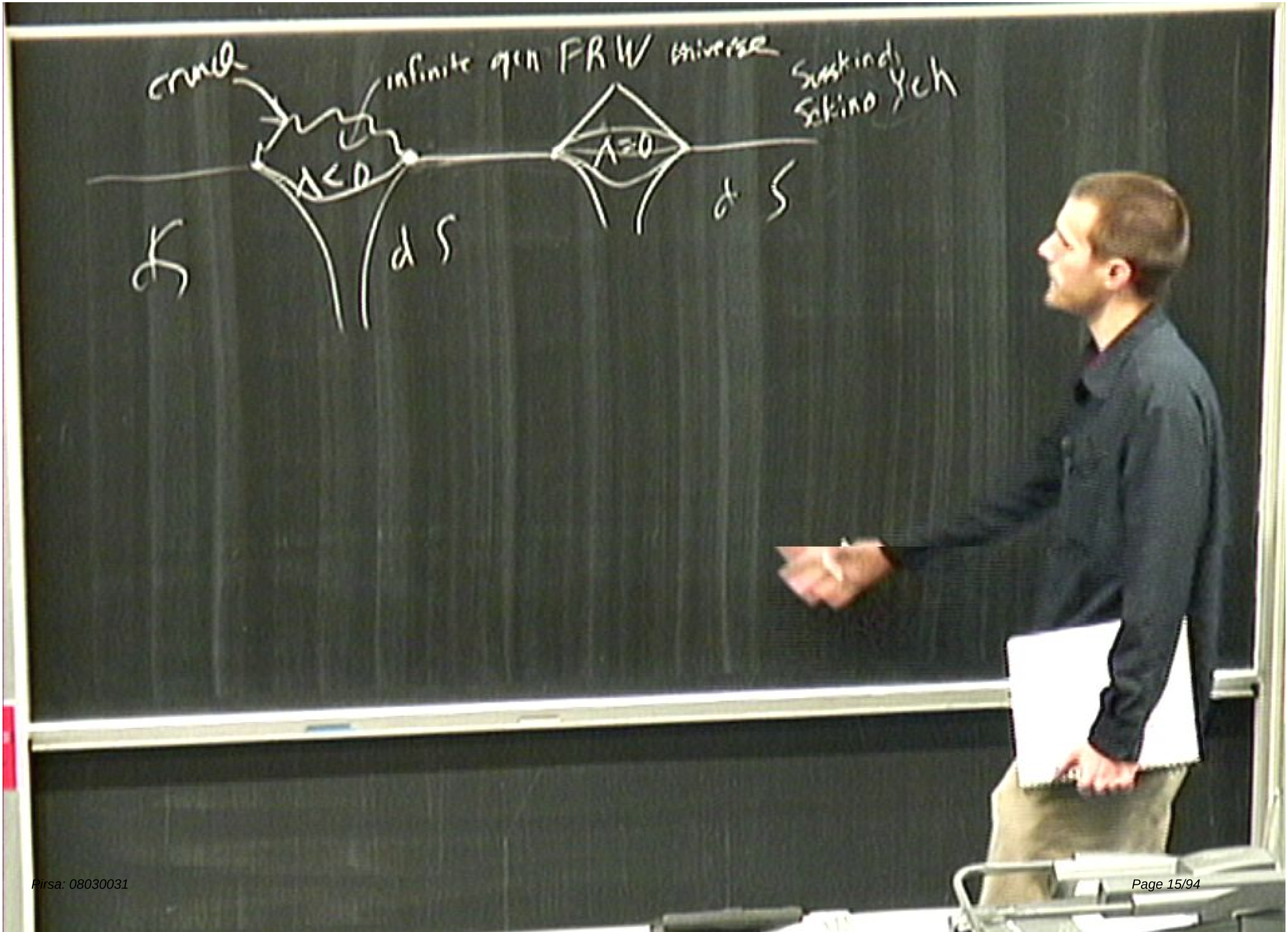
Simplest Question: Asymptotics inside true vacuum bubbles?

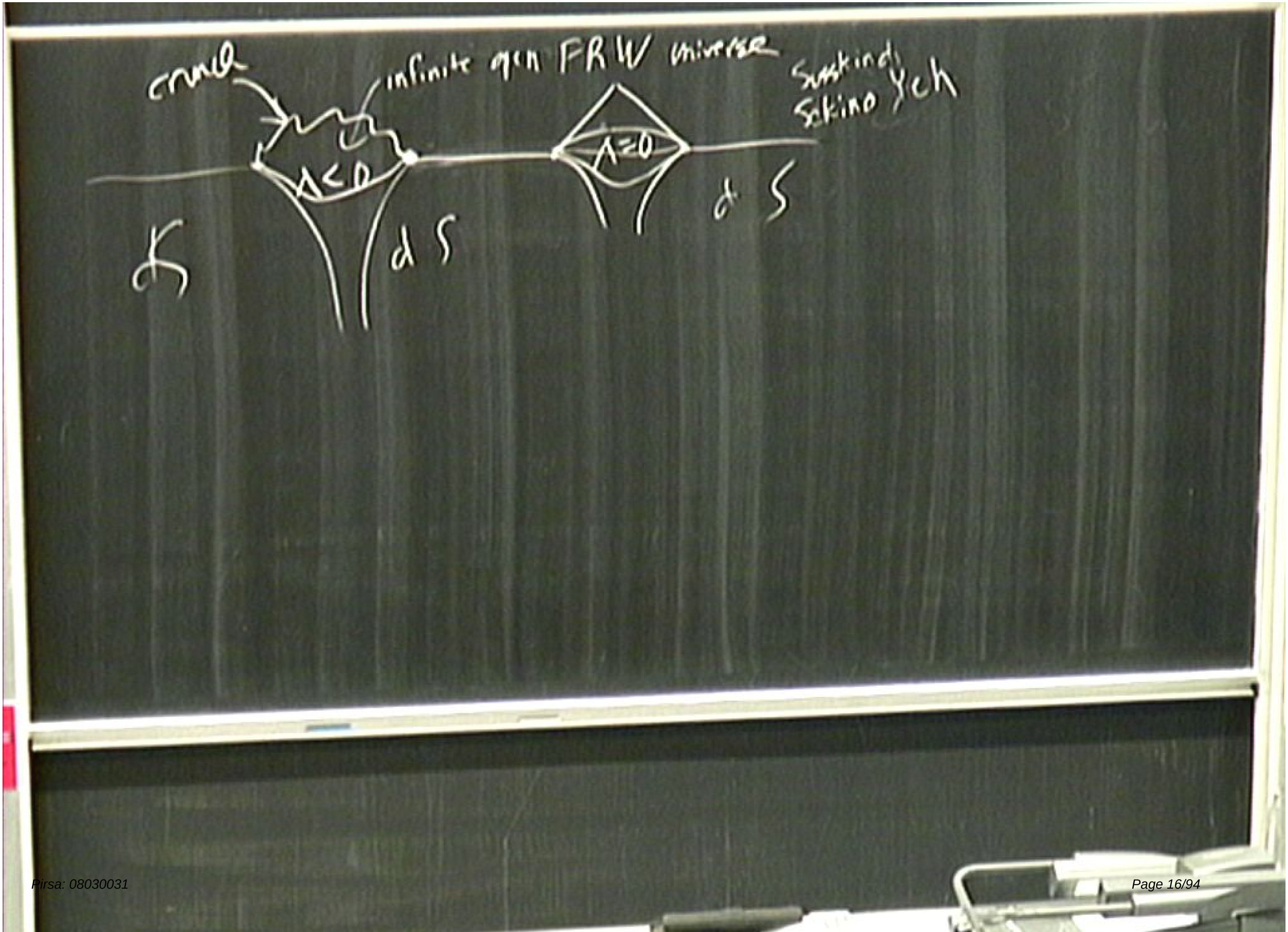
2 types: $\Lambda = 0$

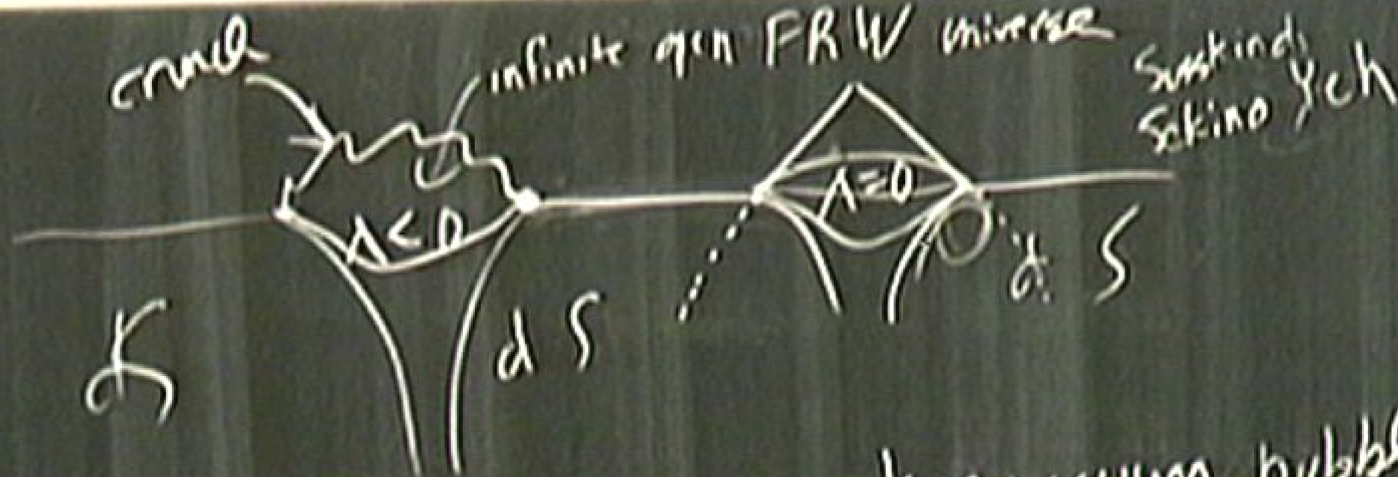
$\Lambda < 0$


infinite open FRW
Λ<0
dS
dS

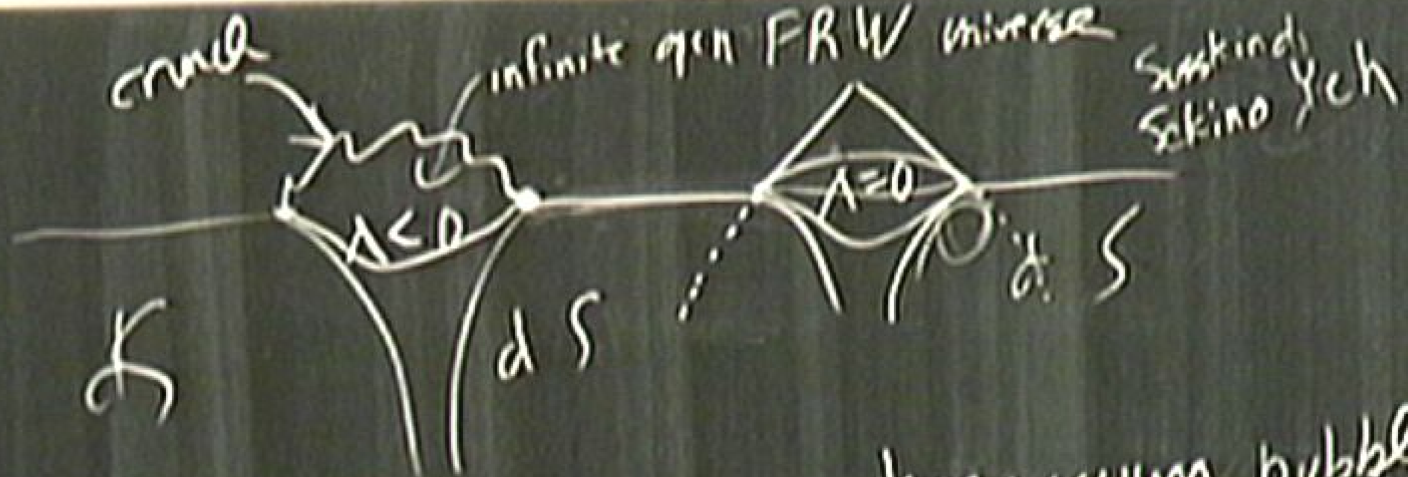

crunch
infinite open FRW universe
Λ<0
Λ=0
dS
dS
dS


crunch
infinite open FRW universe
Susskind, Sekino Yeh
Λ<0
Λ=0
dS
dS
dS

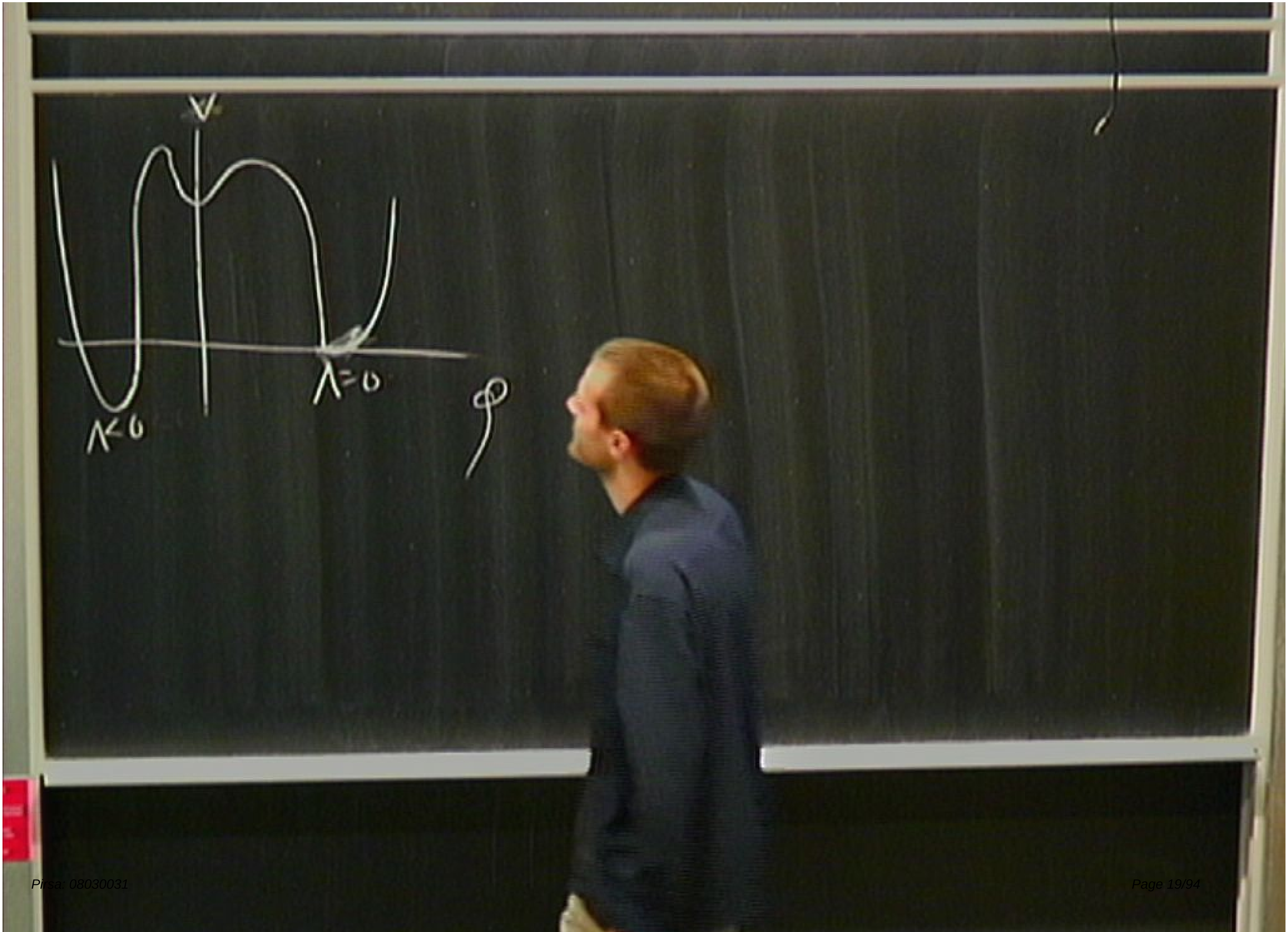

FRW universe
$\Lambda < 0$
$\Lambda = 0$
dS
dS
dS

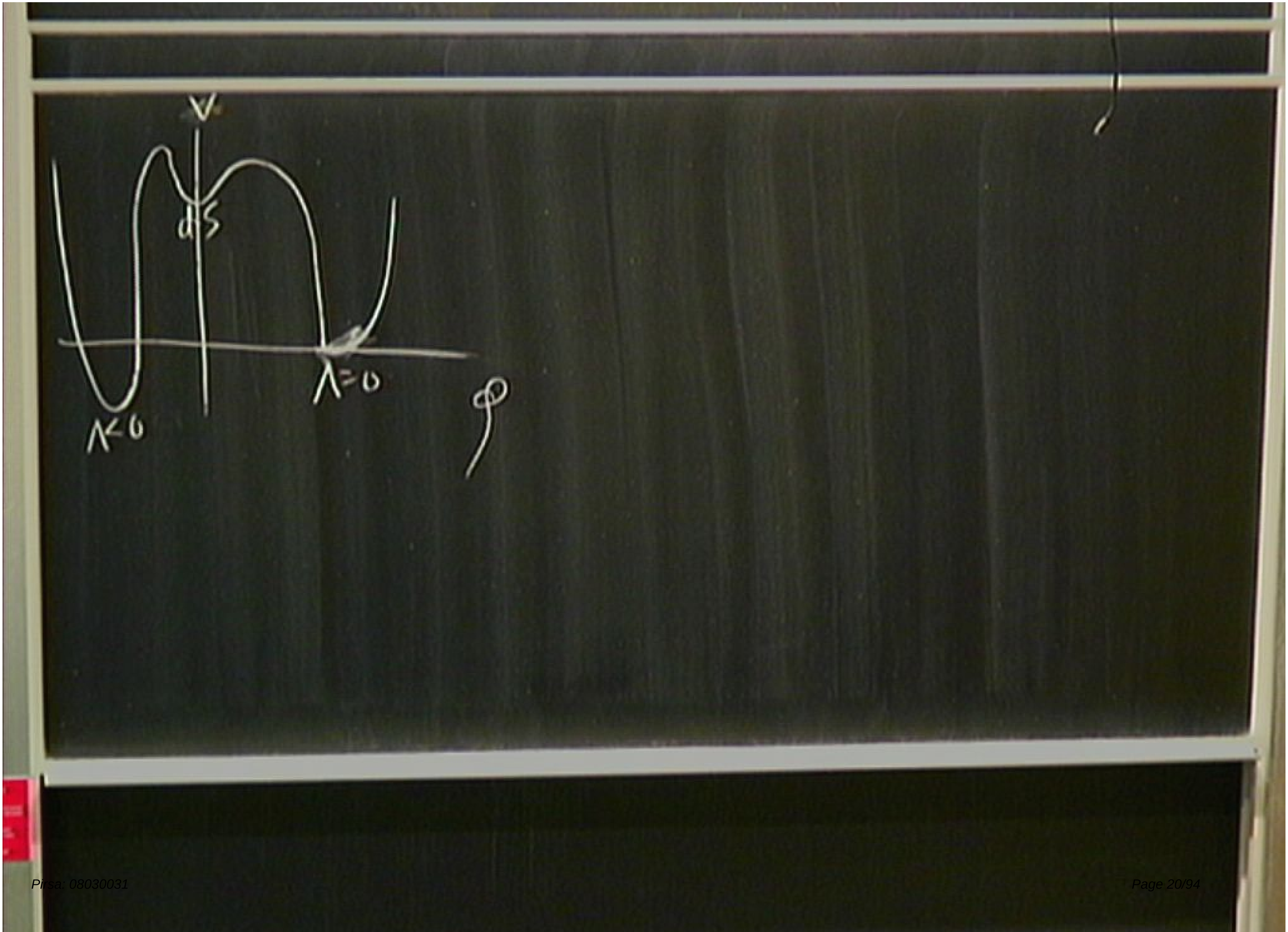


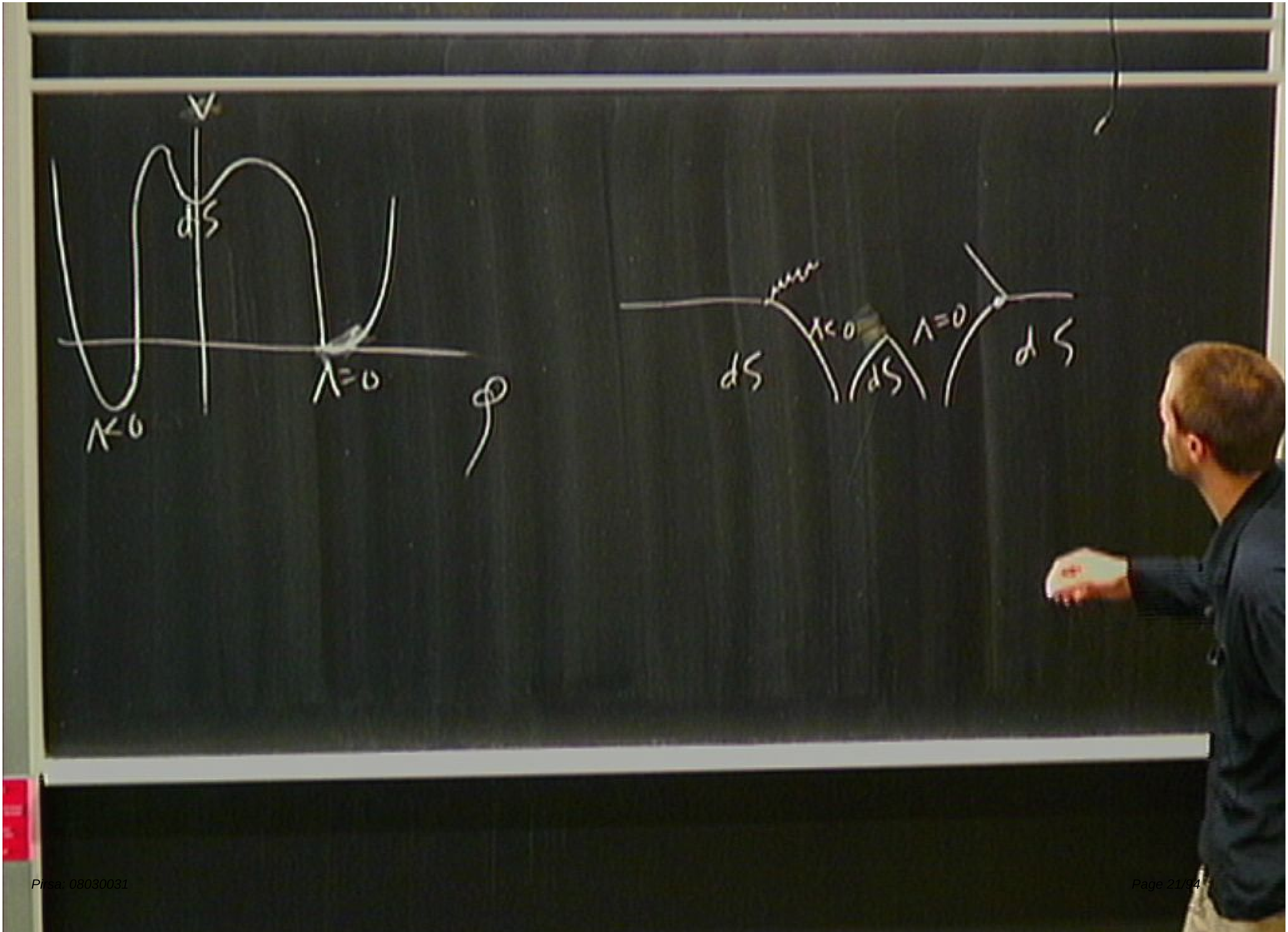
Danger to asymptotics: any true vacuum bubble collides

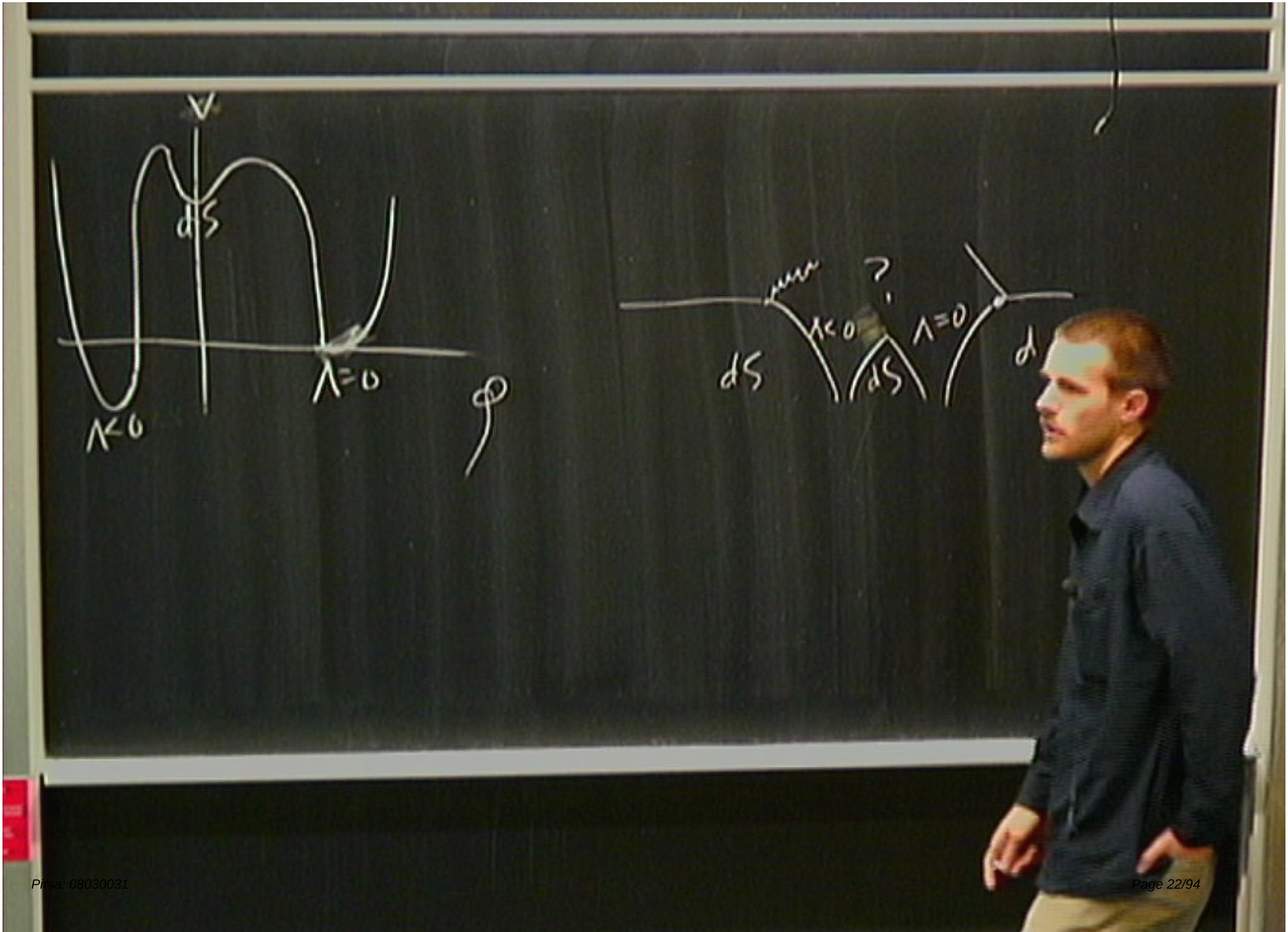


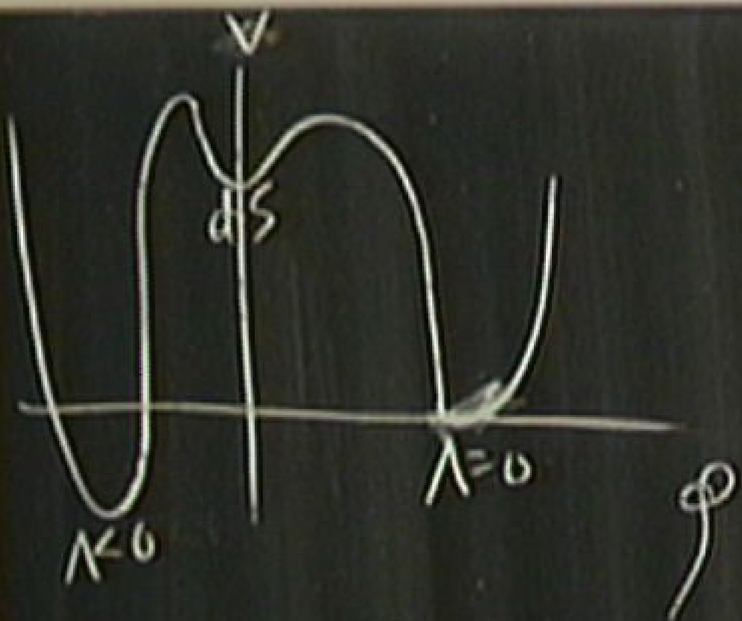
Danger to asymptotics: any true vacuum bubble collides with infinite # of others

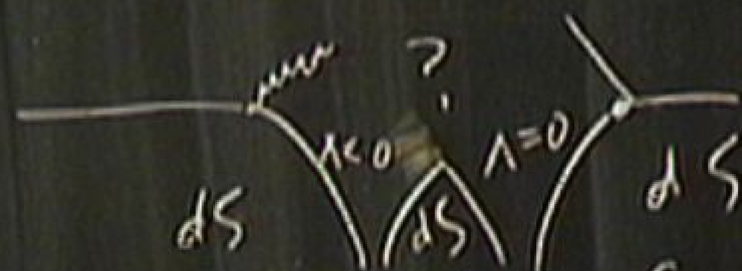

V
Λ<0
Λ=0
φ


V
dS
Λ<0
Λ=0
φ

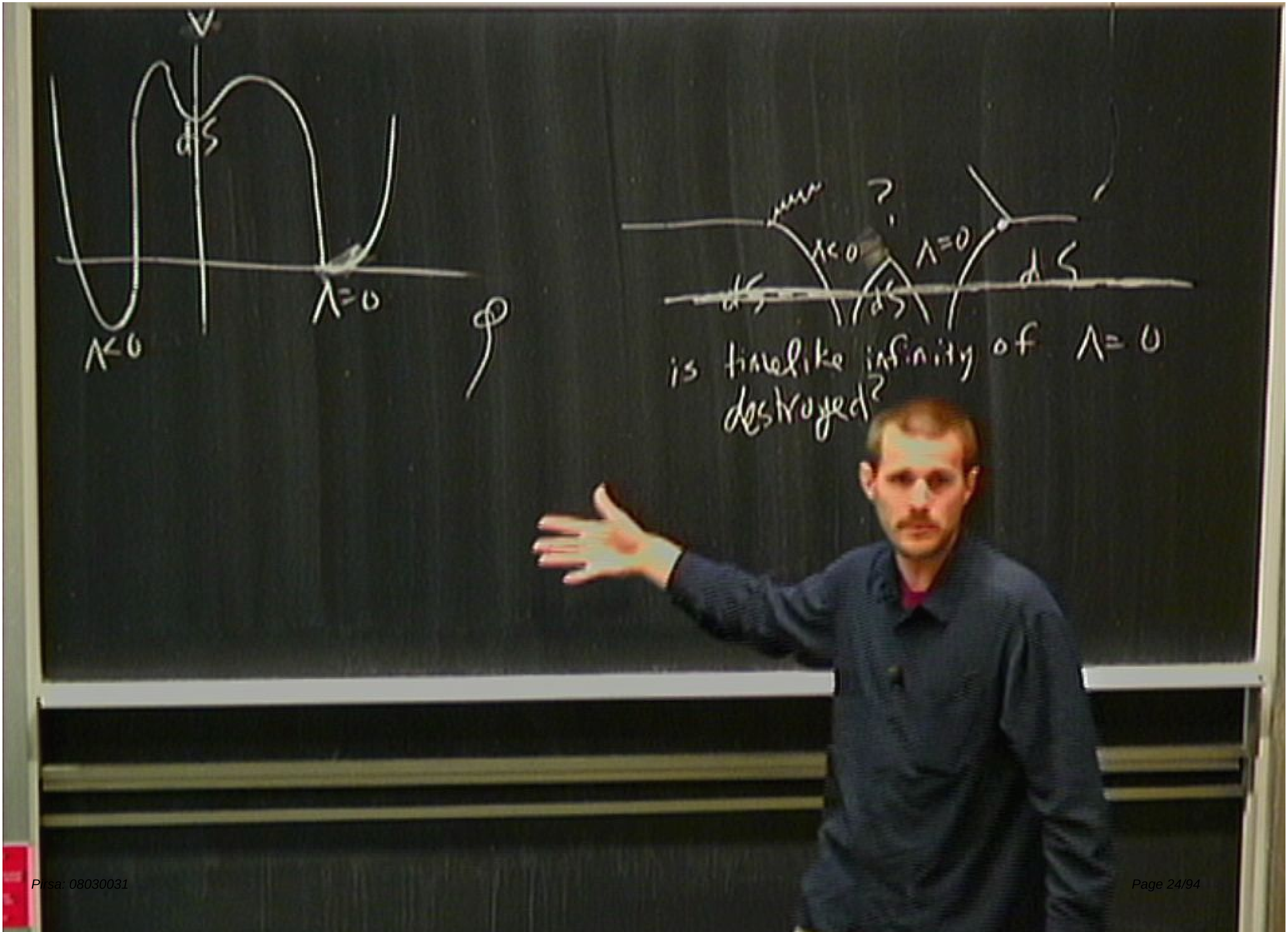

V
dS
Λ<0
Λ=0
φ
dS
Λ<0
dS
Λ=0
dS

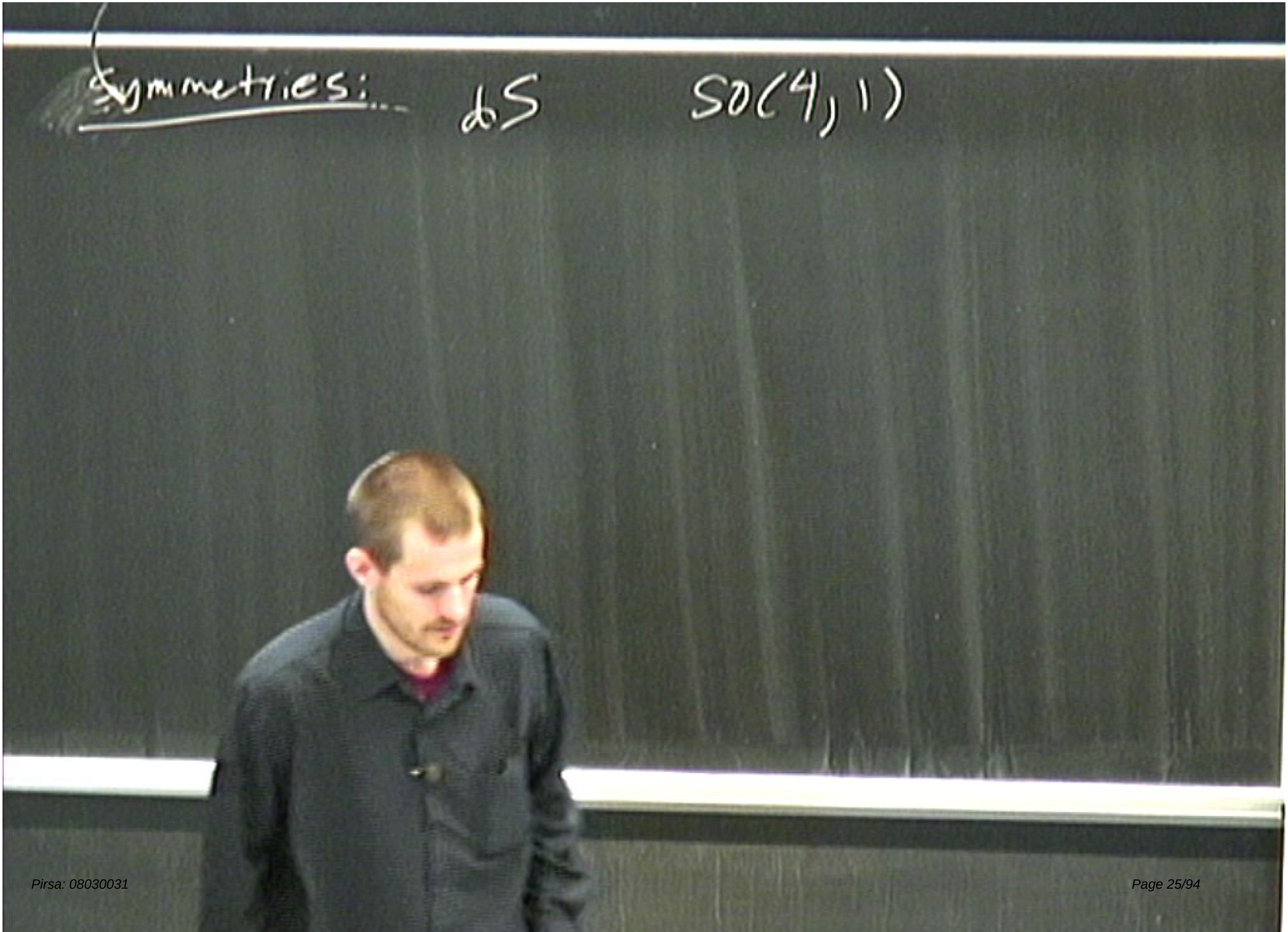

V
dS
Λ<0
Λ=0
φ
dS
Λ<0
?
dS
Λ=0

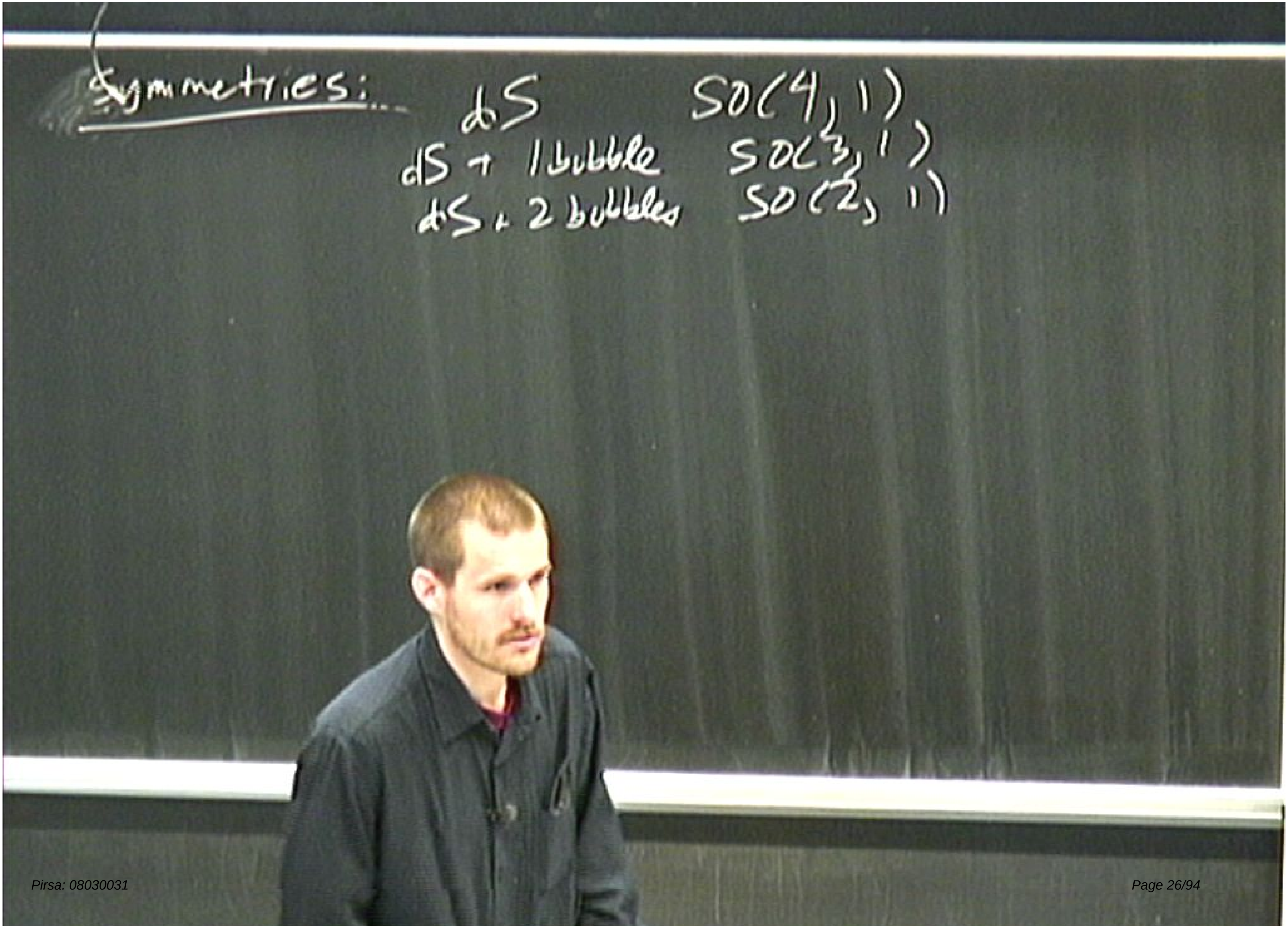


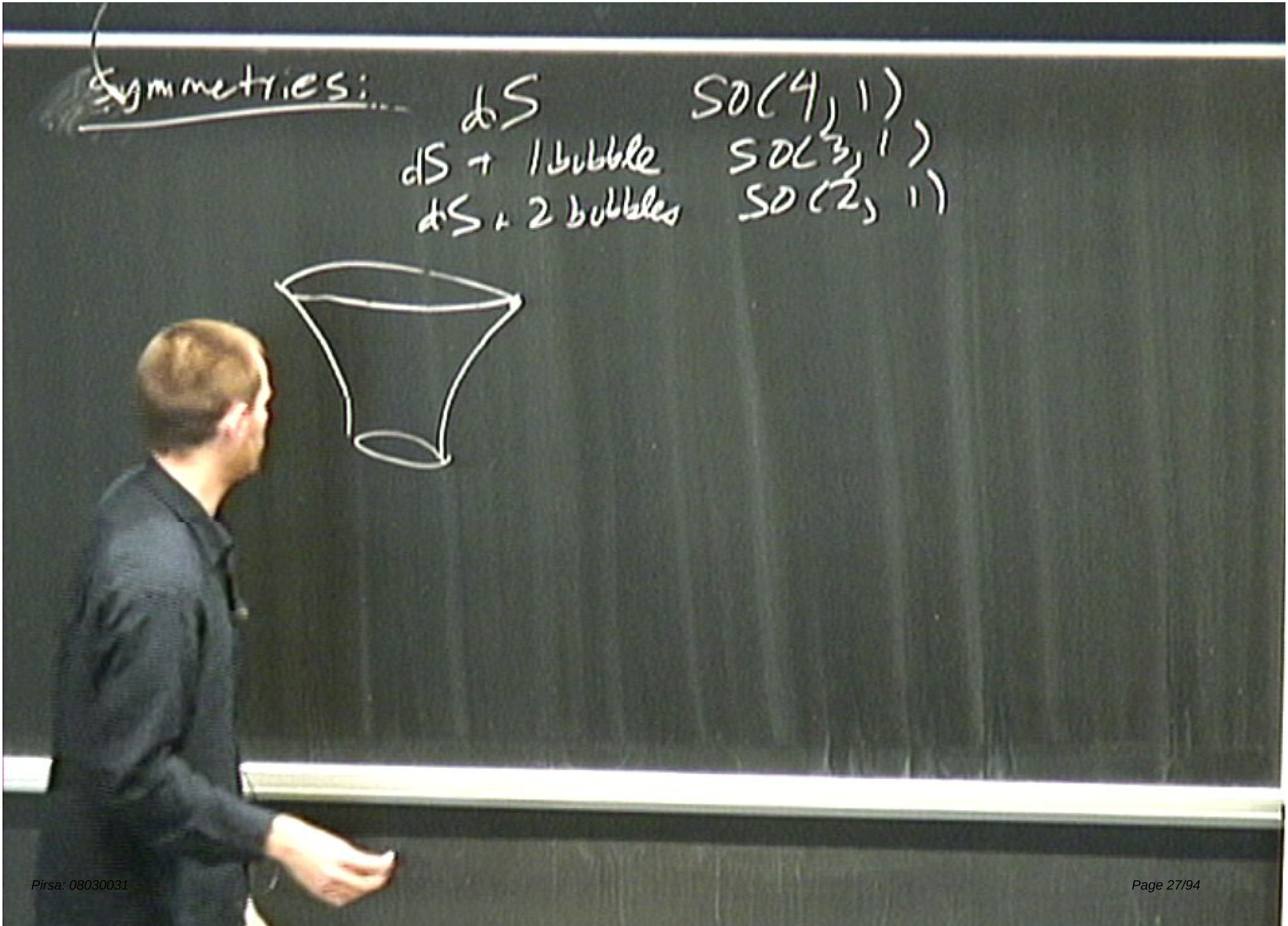


is timelike infinity of $\Lambda = 0$ destroyed?


V
dS
Λ<0
Λ=0
φ
?
Λ<0
Λ=0
dS
dS
dS
is timelike infinity of Λ=0
destroyed?


Symmetries:
dS
SO(4,1)


Symmetries:
dS SO(4,1)
dS + 1 bubble SO(3,1)
dS + 2 bubbles SO(2,1)

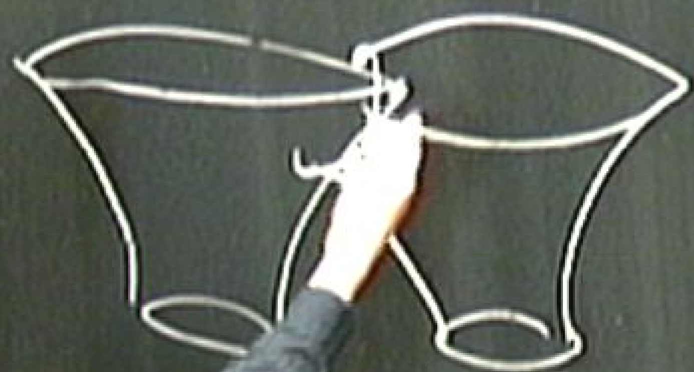

Symmetries:
dS SO(4,1)
dS + 1 bubble SO(3,1)
dS + 2 bubbles SO(2,1)

Symmetries:

dS $SO(4,1)$

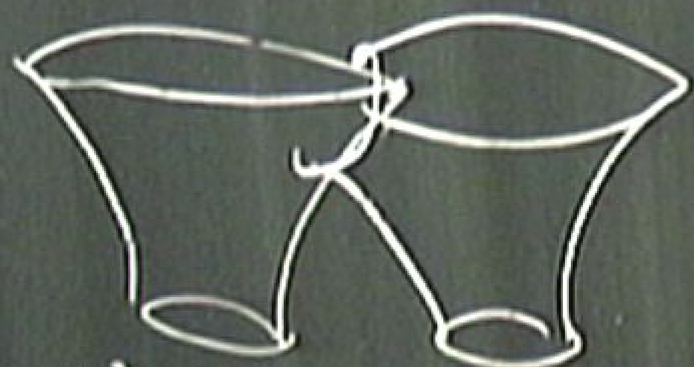
dS + 1 bubble $SO(3,1)$

dS + 2 bubbles $SO(2,1)$



Symmetries:

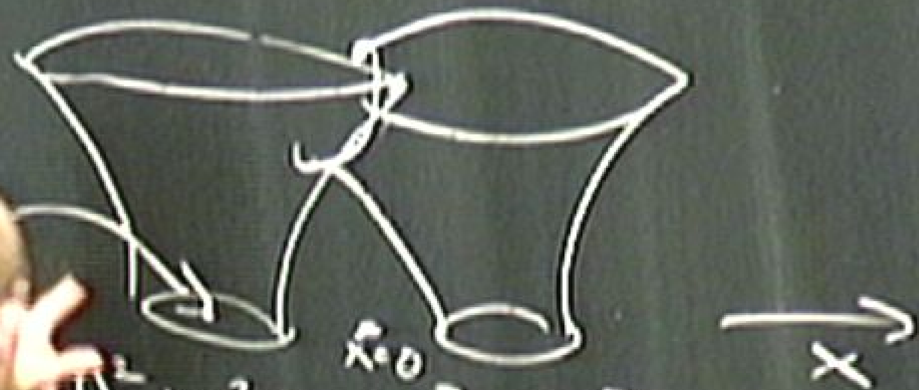
dS	SO(4, 1)
dS + 1 bubble	SO(3, 1)
dS + 2 bubbles	SO(2, 1)



$$(x+d)^2+y^2+z-t^2=r_0^2$$

Symmetries:

dS	$SO(4,1)$
dS + 1 bubble	$SO(3,1)$
dS + 2 bubbles	$SO(2,1)$



$$\ldots d)^2 + y^2 + z - t^2 = r_0^2$$

Symmetries:

dS $SO(4,1)$

dS + 1 bubble $SO(3,1)$

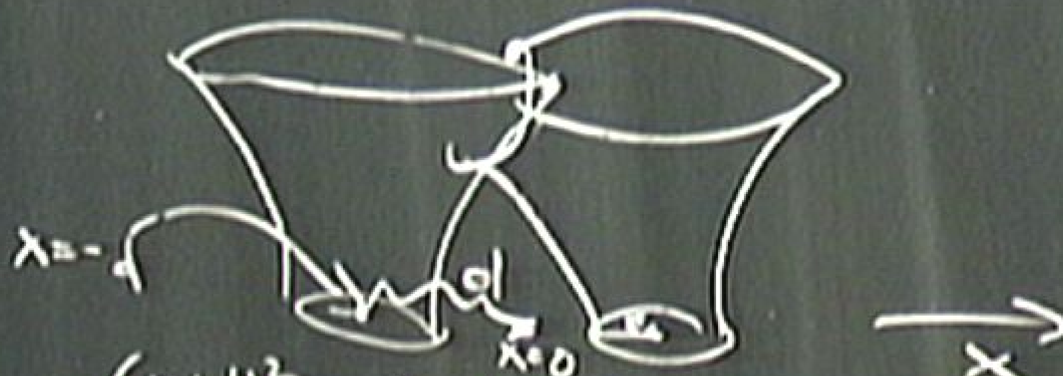
dS + 2 bubbles $SO(2,1)$

$$(x+d)^2+y^2+z-t^2=r_0^2 \qquad (x-d)+y^2+z^2-t^2=r_0^2$$

Collision: $x=0$

Symmetries:

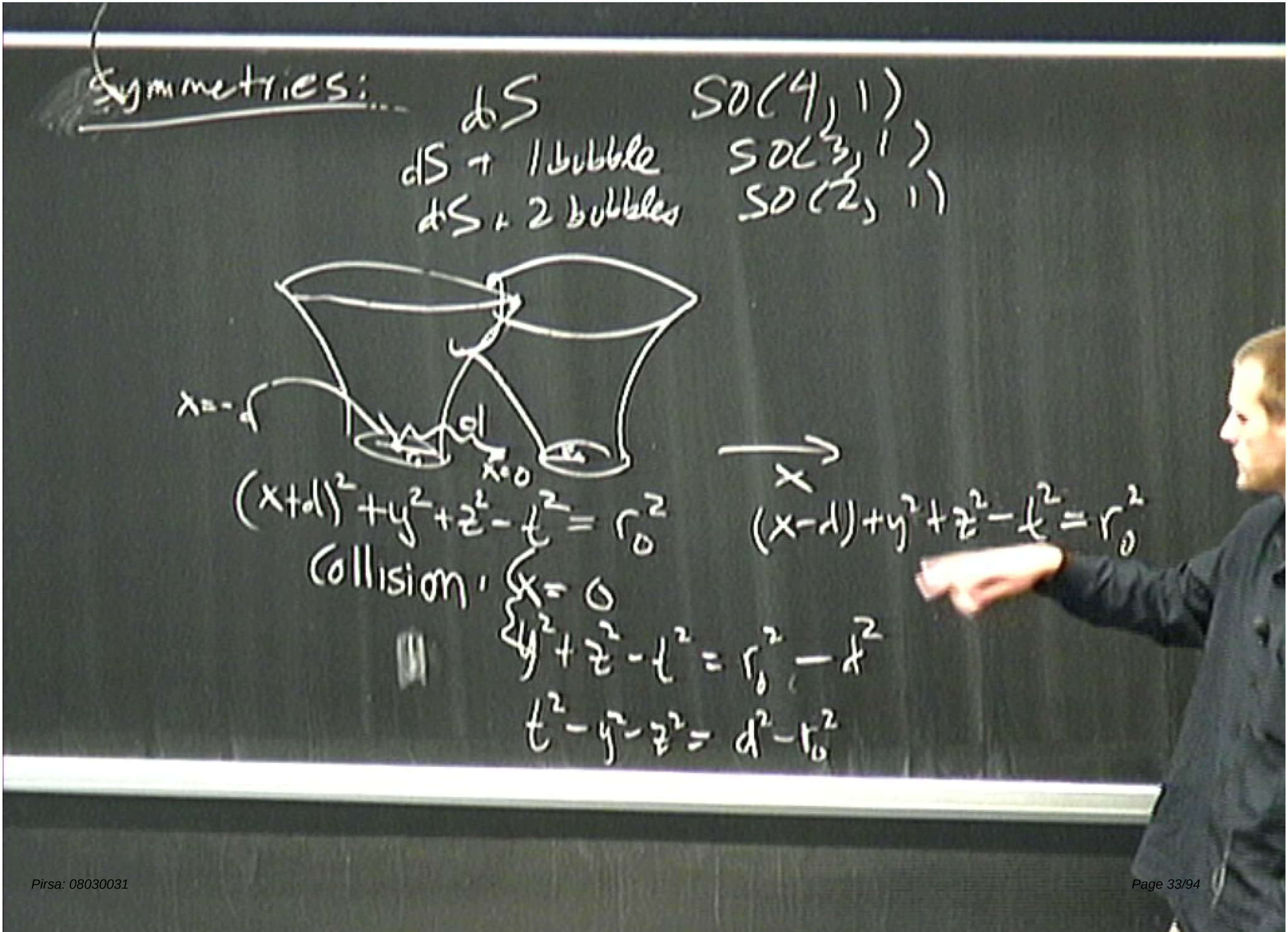
dS	$SO(4,1)$
dS + 1 bubble	$SO(3,1)$
dS + 2 bubbles	$SO(2,1)$



$(x+d)^2+y^2+z^2-t^2=r_0^2$ $\qquad$ $(x-d)+y^2+z^2-t^2=r_0^2$

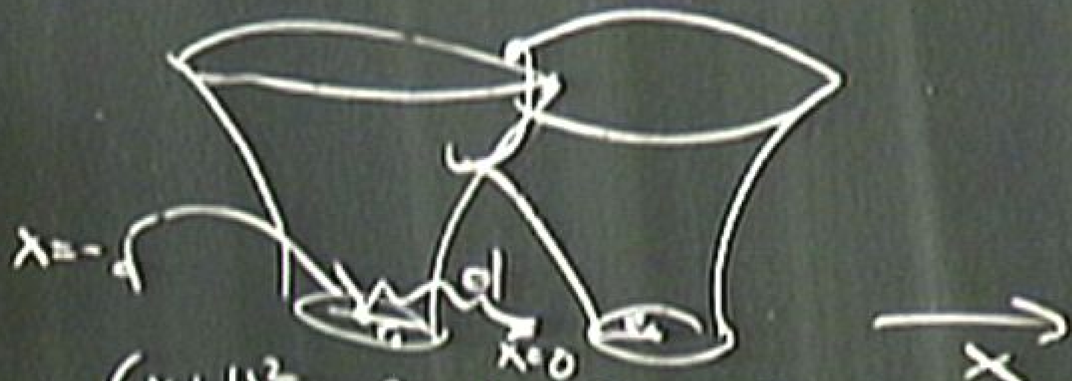
Collision: $x=0$

$y^2+z^2-t^2=r_0^2-d^2$


Symmetries:
dS SO(4,1)
dS + 1 bubble SO(3,1)
dS + 2 bubbles SO(2,1)
x = -d
d
x = 0
x
$(x+d)^2 + y^2 + z^2 - t^2 = r_0^2$
$(x-d) + y^2 + z^2 - t^2 = r_0^2$
Collision:
$x = 0$
$y^2 + z^2 - t^2 = r_0^2 - d^2$
$t^2 - y^2 - z^2 = d^2 - r_0^2$

Symmetries:

dS	$SO(4,1)$
dS + 1 bubble	$SO(3,1)$
dS + 2 bubbles	$SO(2,1)$



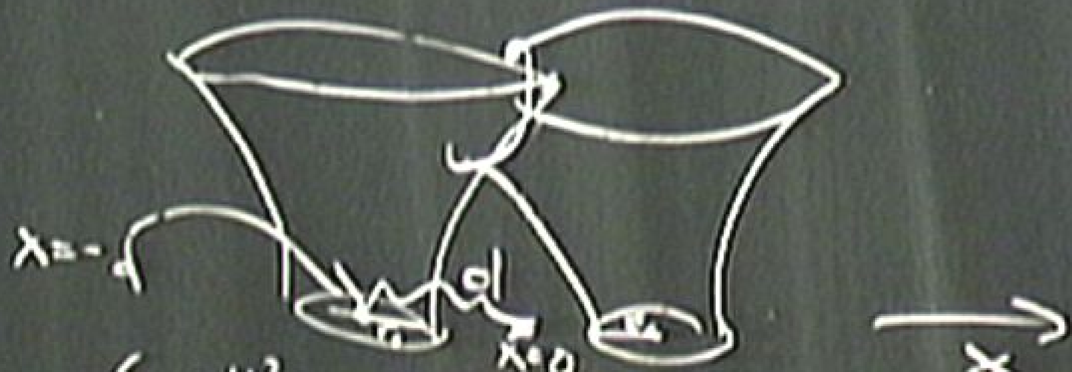
$$(x+d)^2+y^2+z^2-t^2=r_0^2 \qquad (x-d)+y^2+z^2-t^2=r_0^2$$

Collision: $\begin{cases} x=0 \\ y^2+z^2-t^2=r_0^2-d^2 \end{cases}$

$$t^2-y^2-z^2=d^2-r_0^2 \qquad H_2$$

Symmetries:

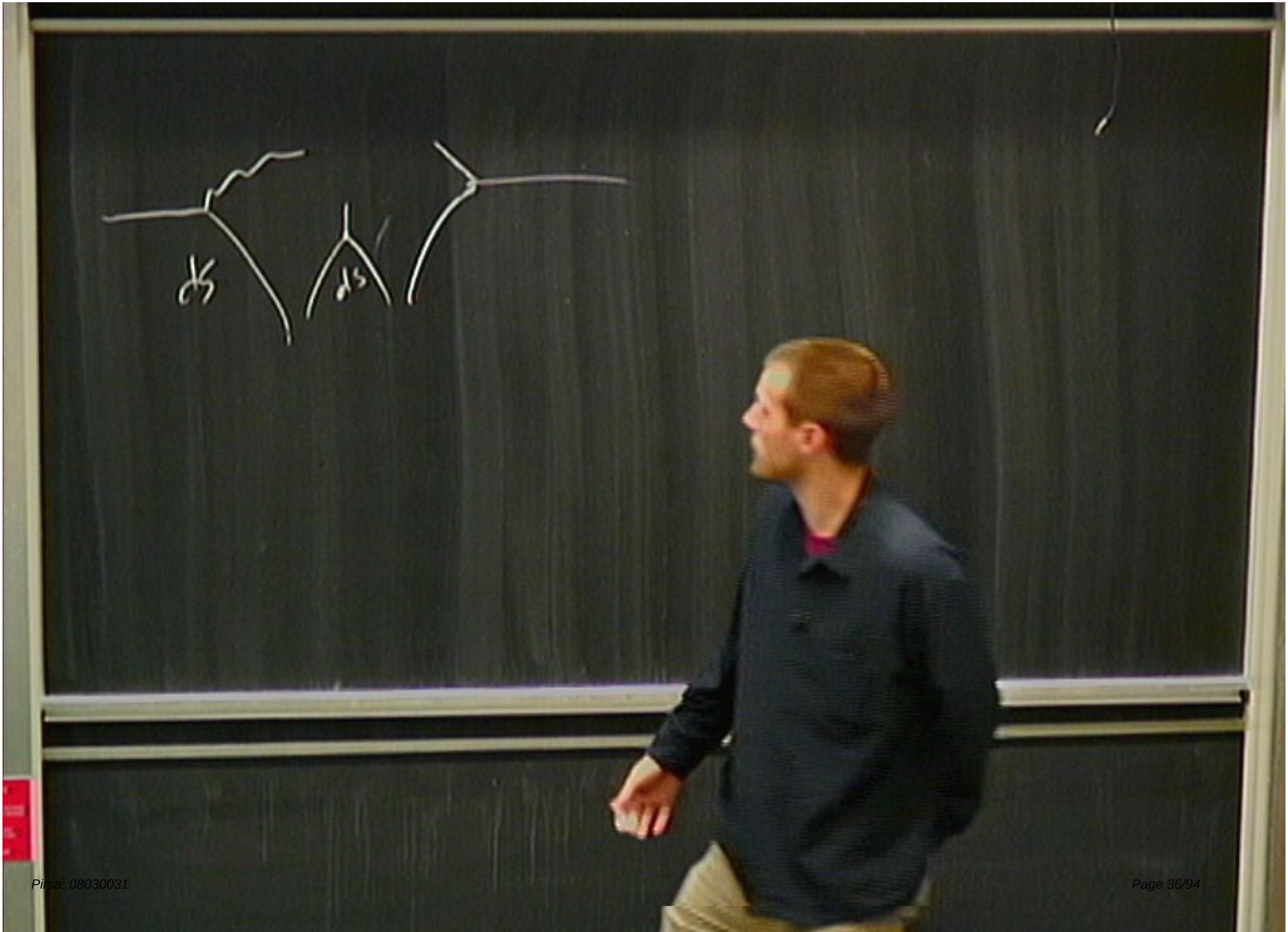
dS	SO(4,1)
dS + 1 bubble	SO(3,1)
dS + 2 bubbles	SO(2,1)

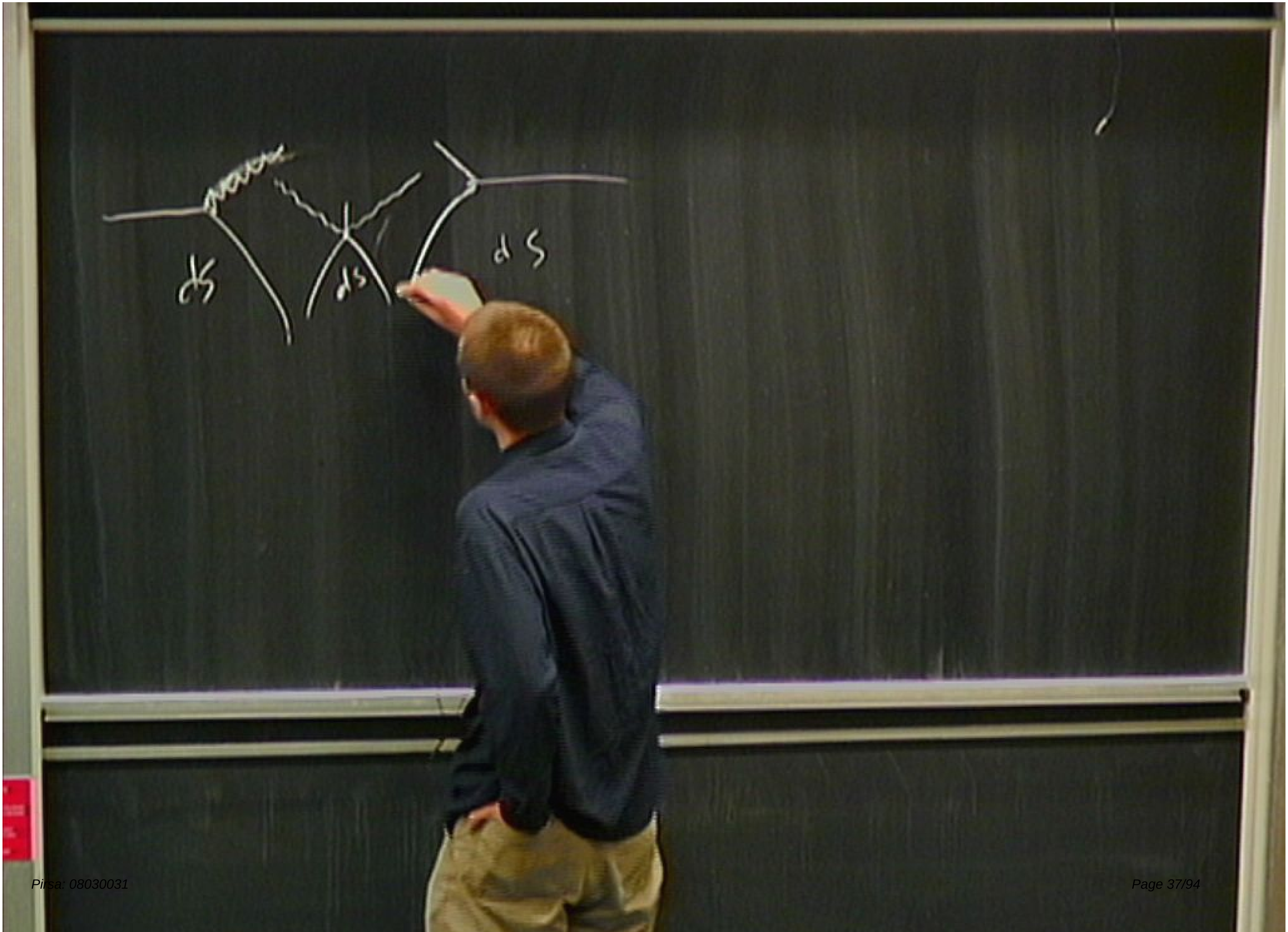


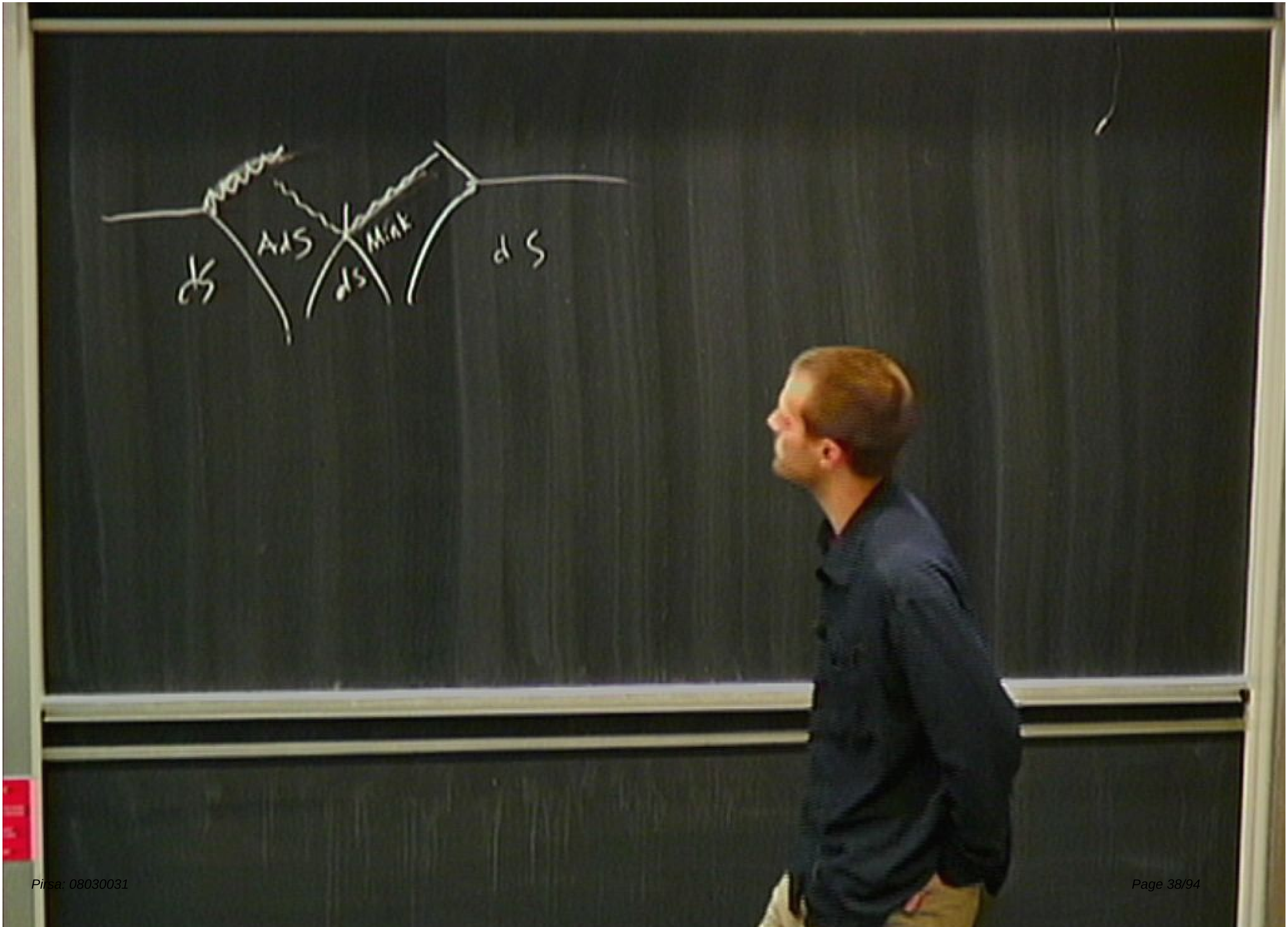
$$(x+d)^2+y^2+z^2-t^2=r_0^2 \qquad (x-d)+y^2+z^2-t^2=r_0^2$$

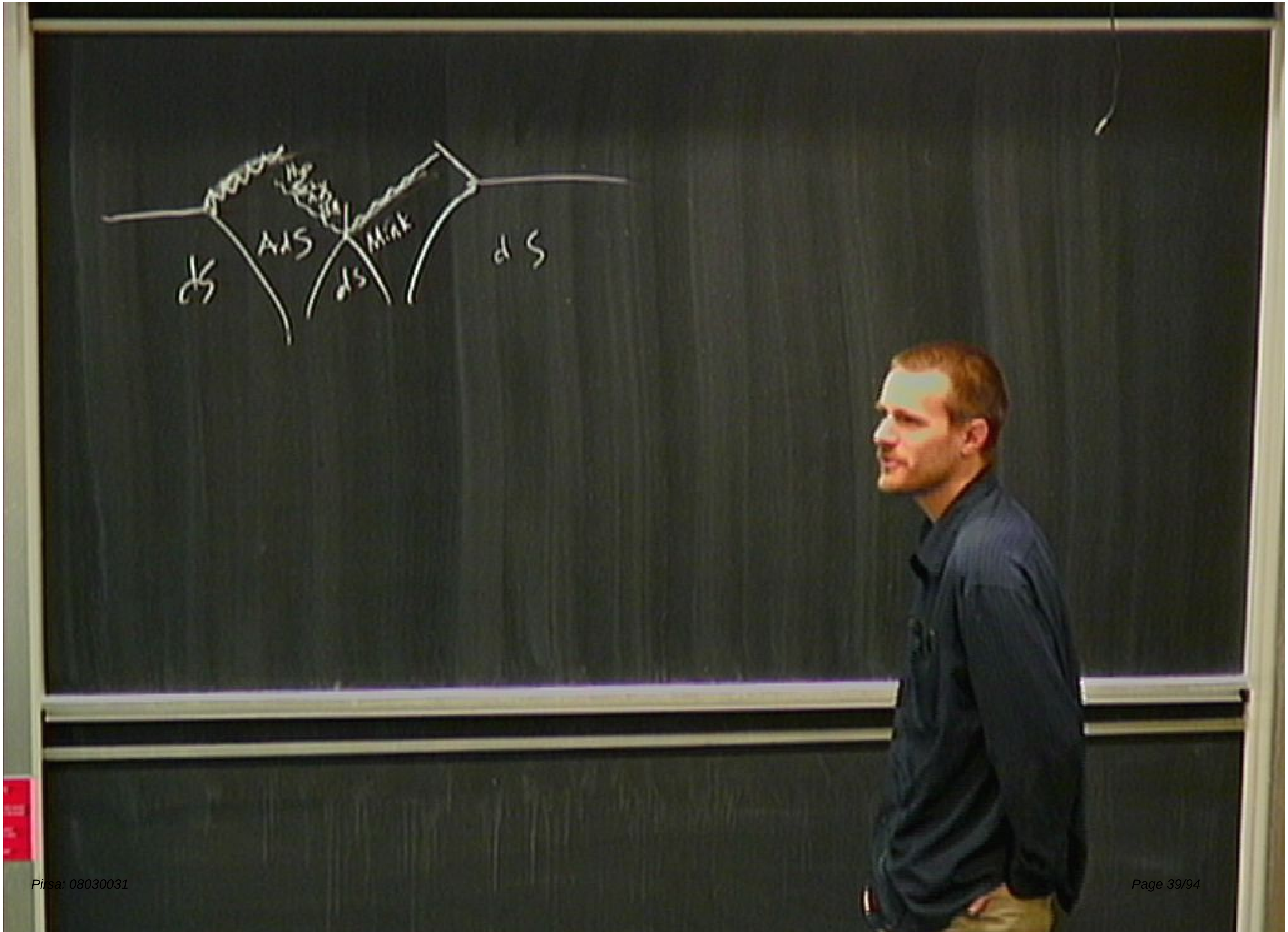
Collision: $\begin{cases} x=0 \\ y^2+z^2-t^2=r_0^2-d^2 \end{cases}$

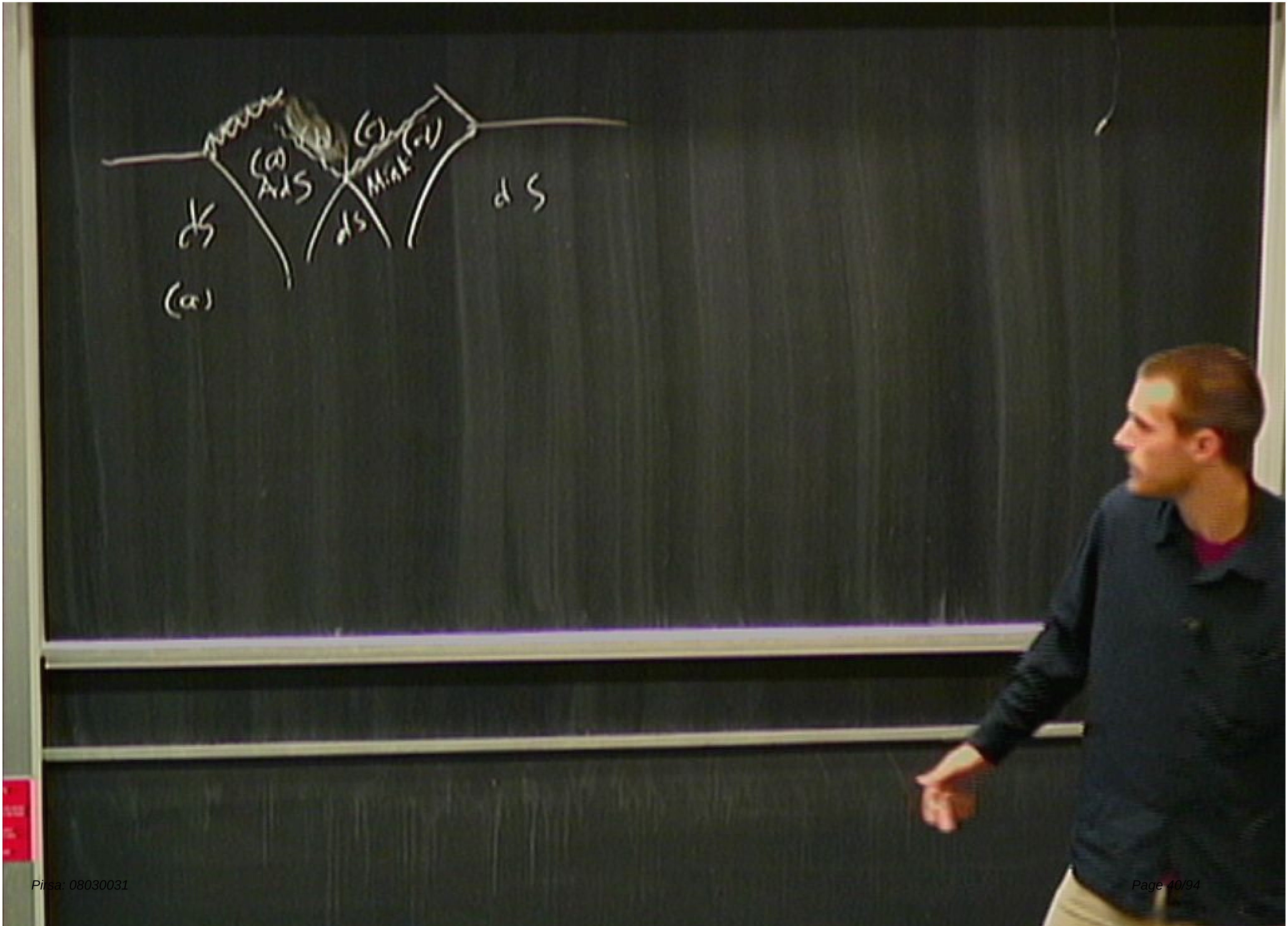
$$t^2-y^2-z^2=d^2-r_0^2 \qquad H_2$$

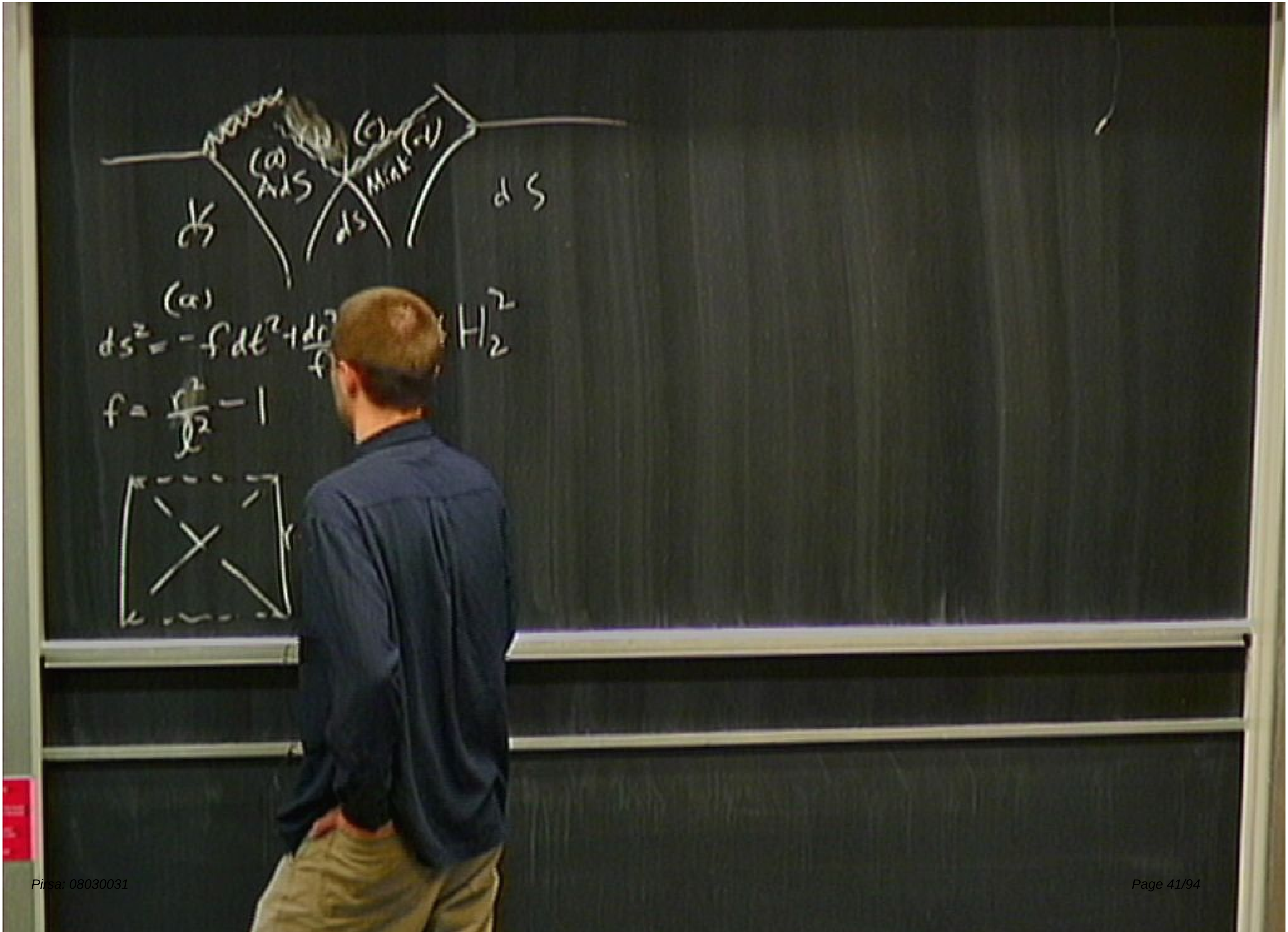

dS
dS

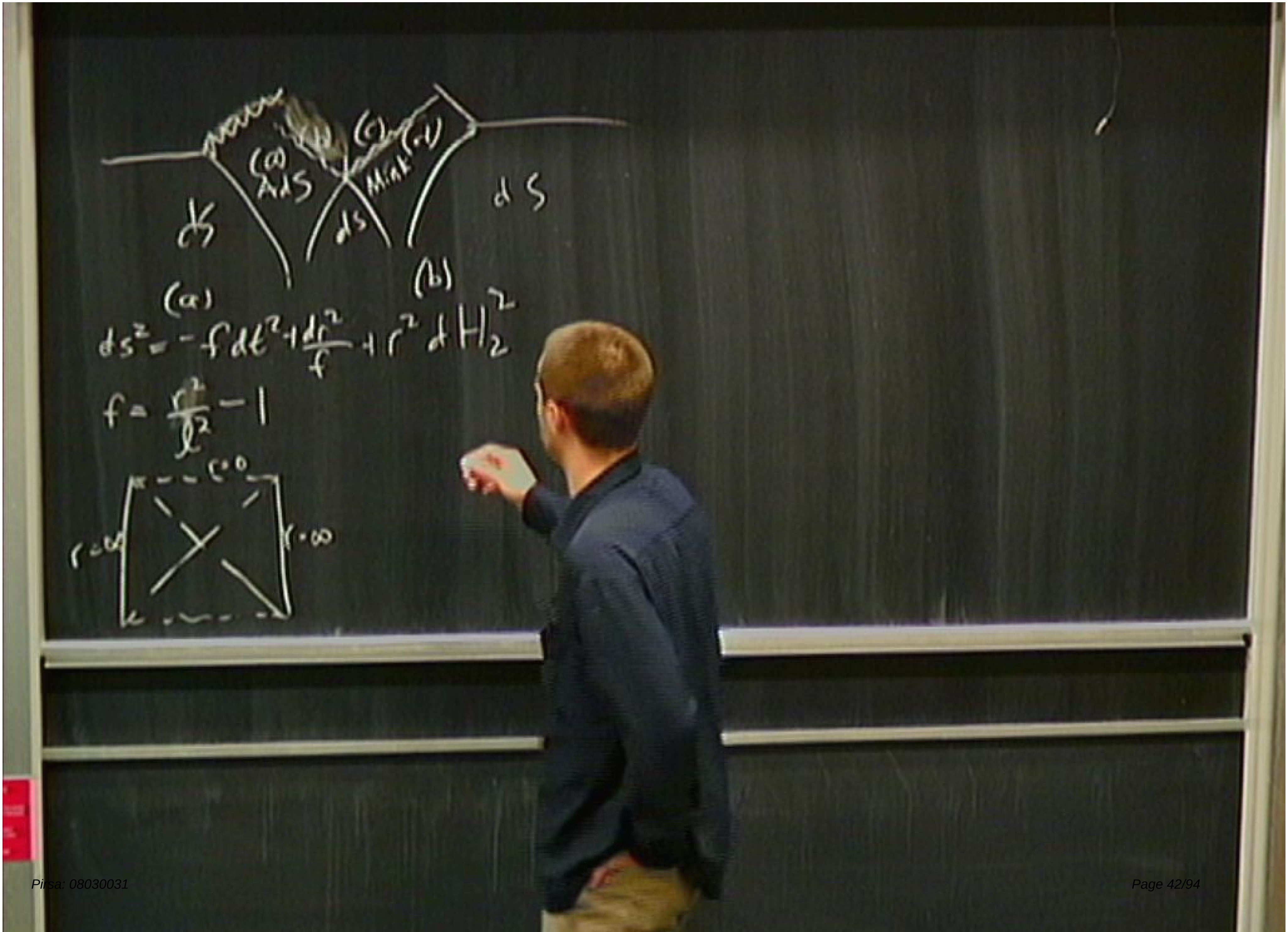

dS
dS
dS

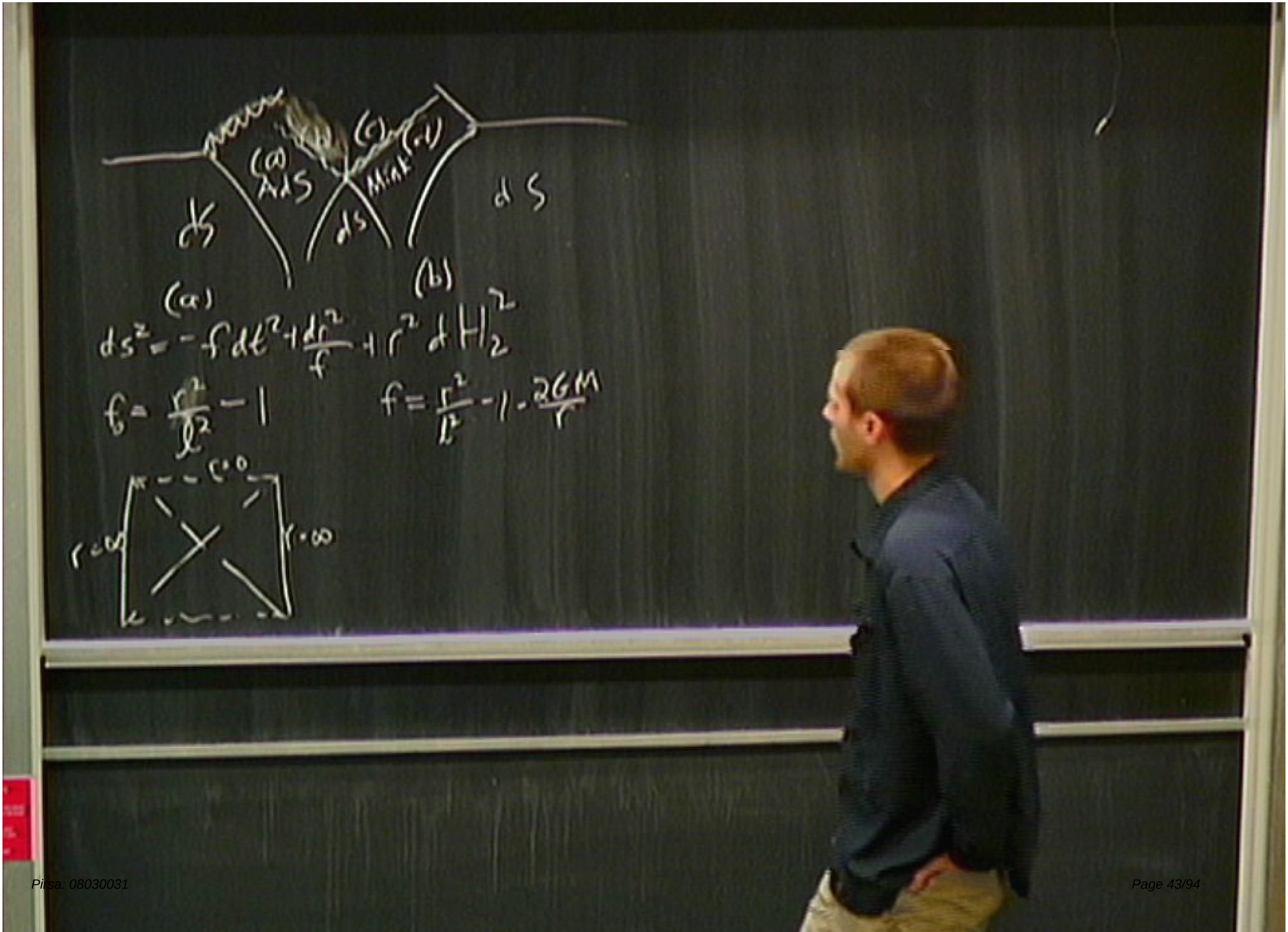

dS
AdS
dS
Mink
dS

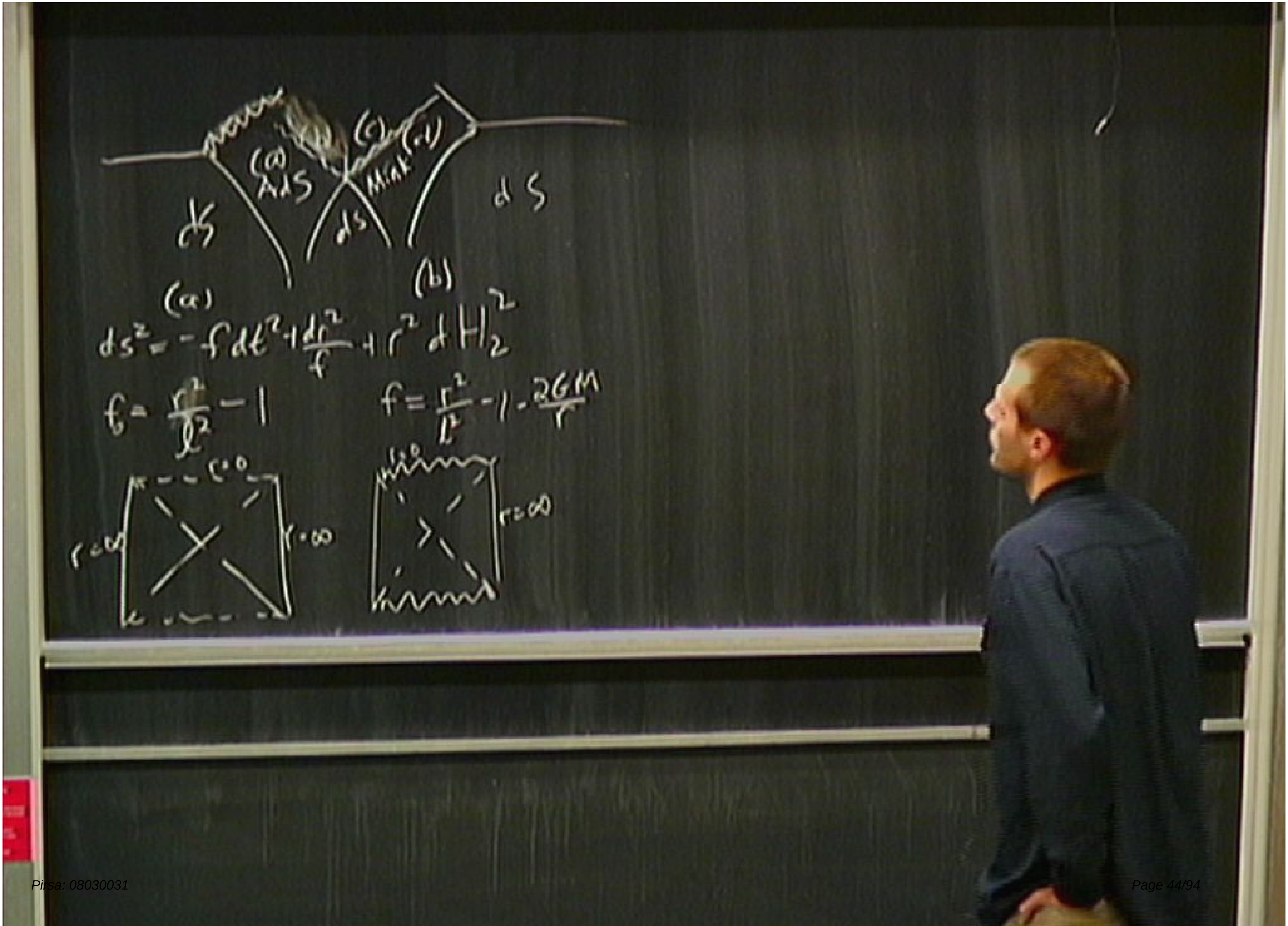

dS
AdS
dS
Mink
dS

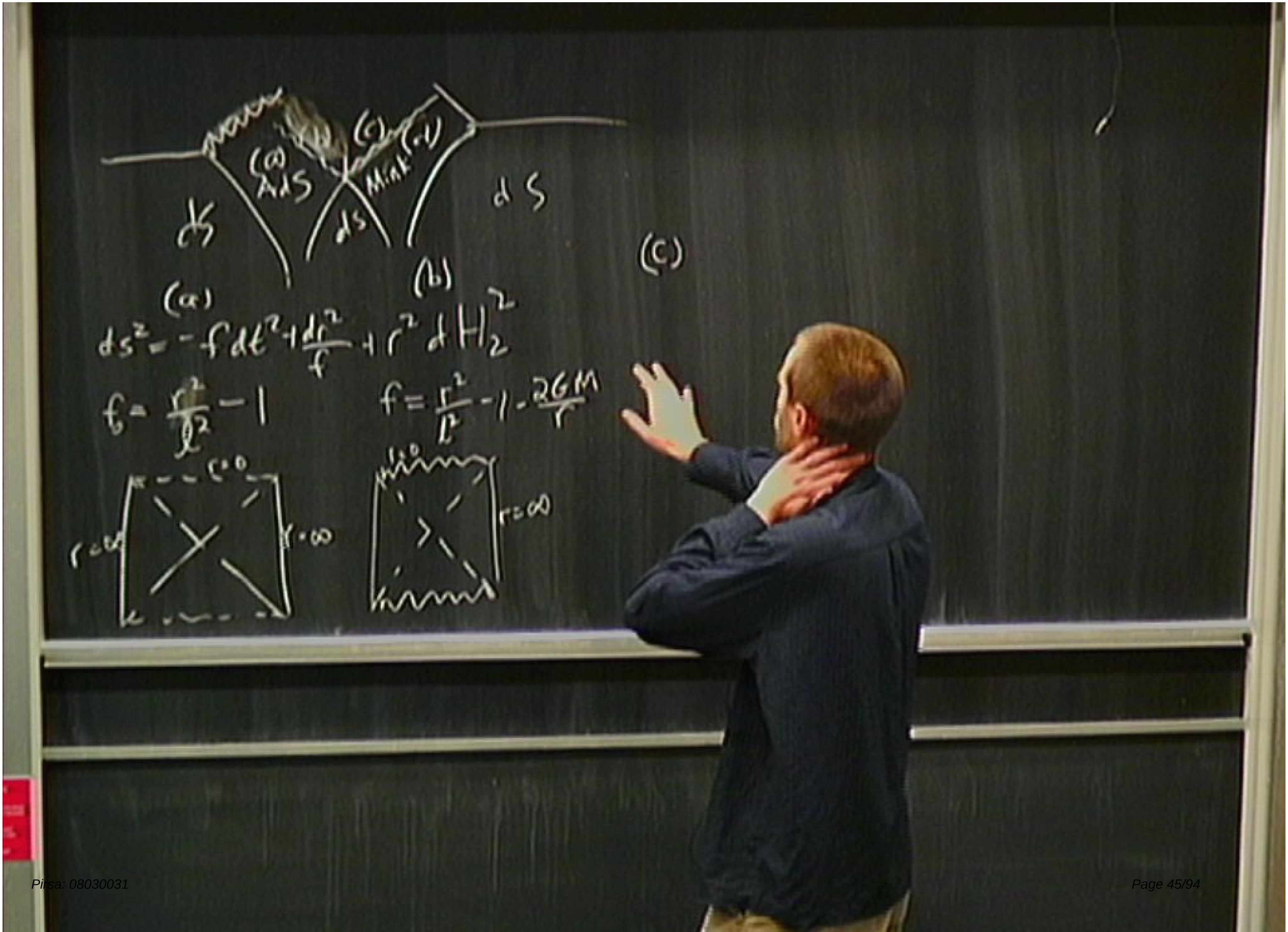

(a)
AdS
(c)
Mink
dS
dS
dS
(a)

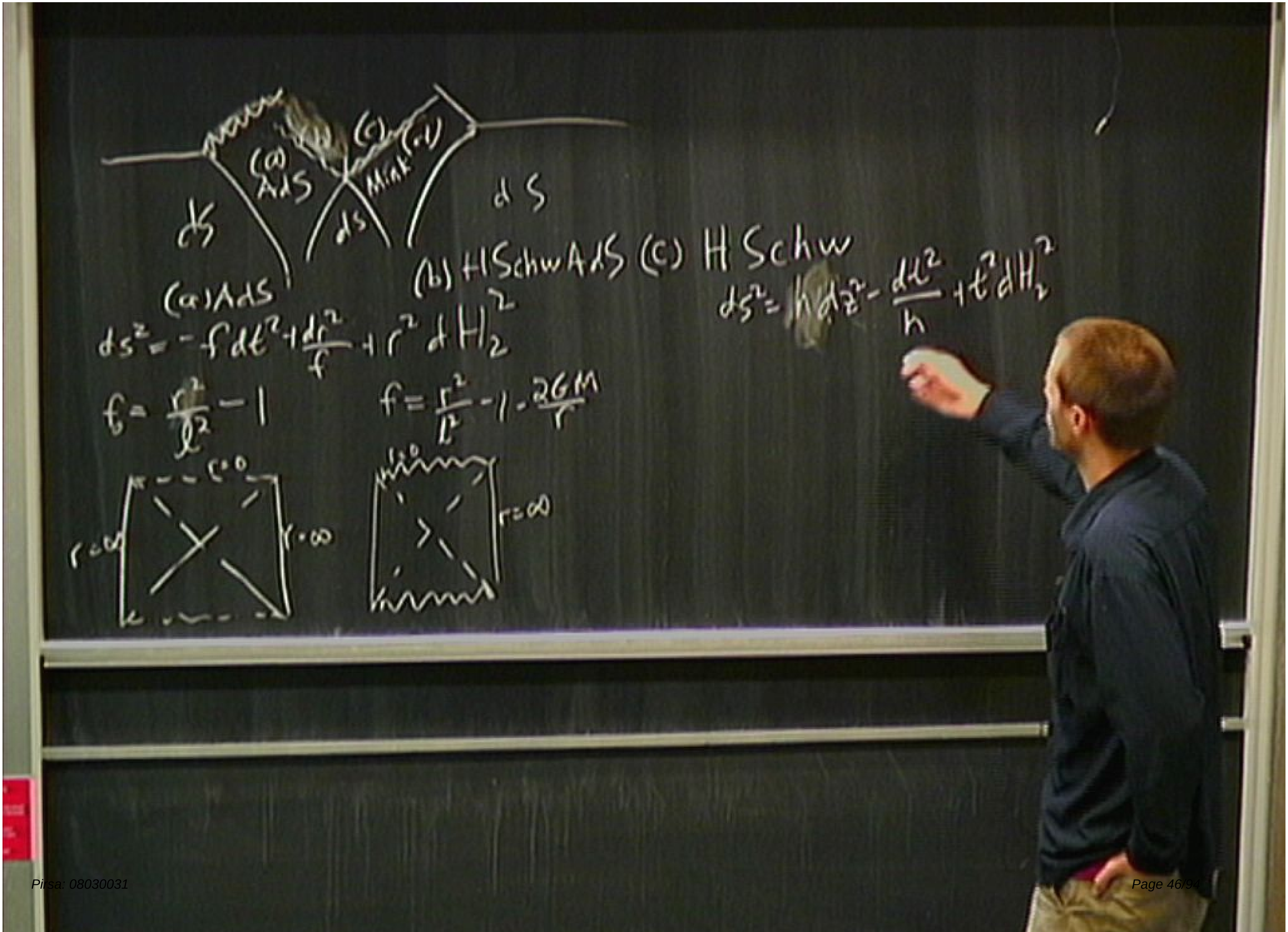

(a)
AdS
(c)
Mink
dS
dS
d S
(a)
f = r²/ℓ² − 1

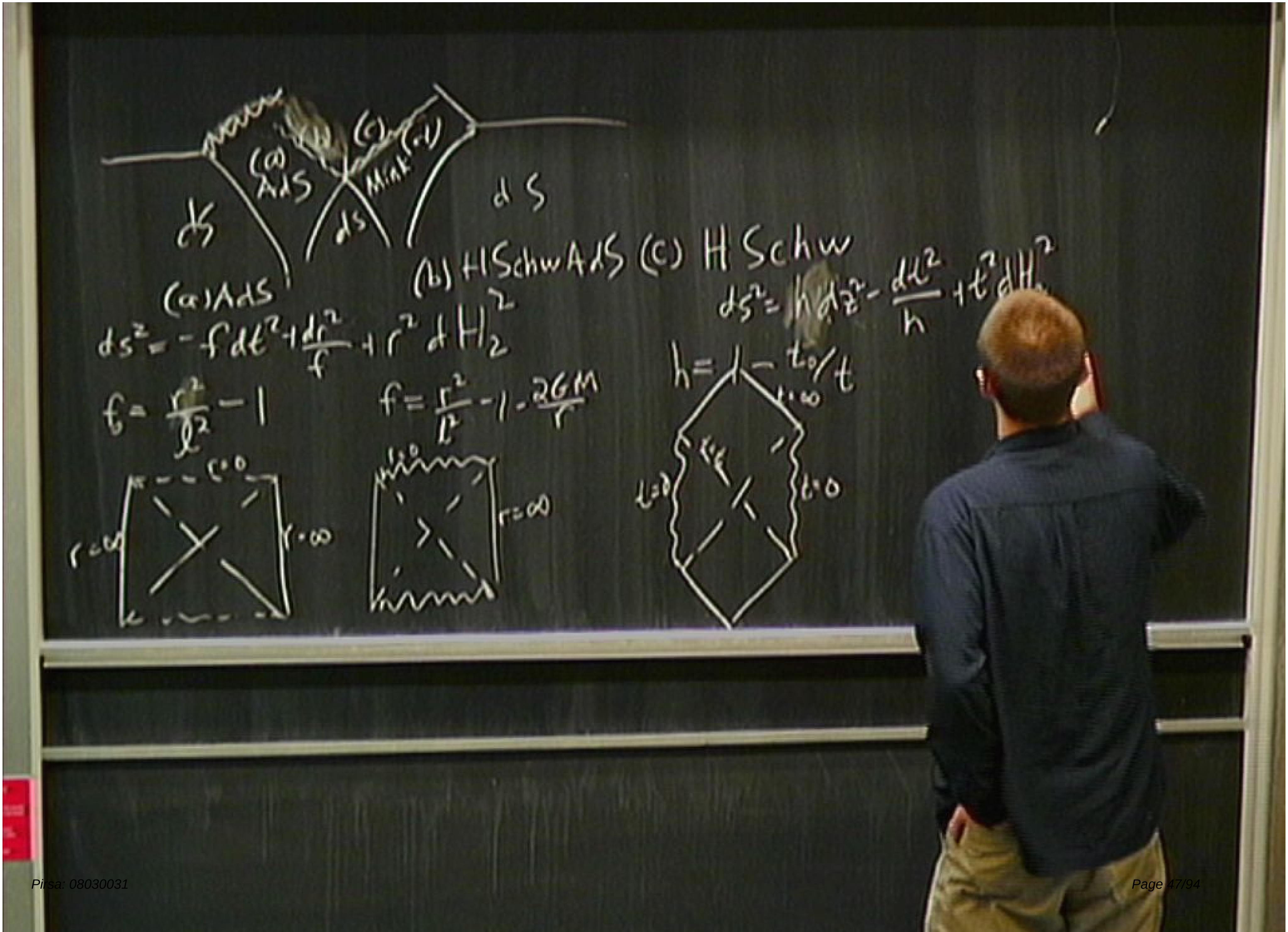

(a) AdS
(c) Mink
dS
dS
d S
(b)
(a)
ds² = - f dt² + dr²/f + r² dH₂²
f = r²/ℓ² - 1
r=0
r=∞
r=∞

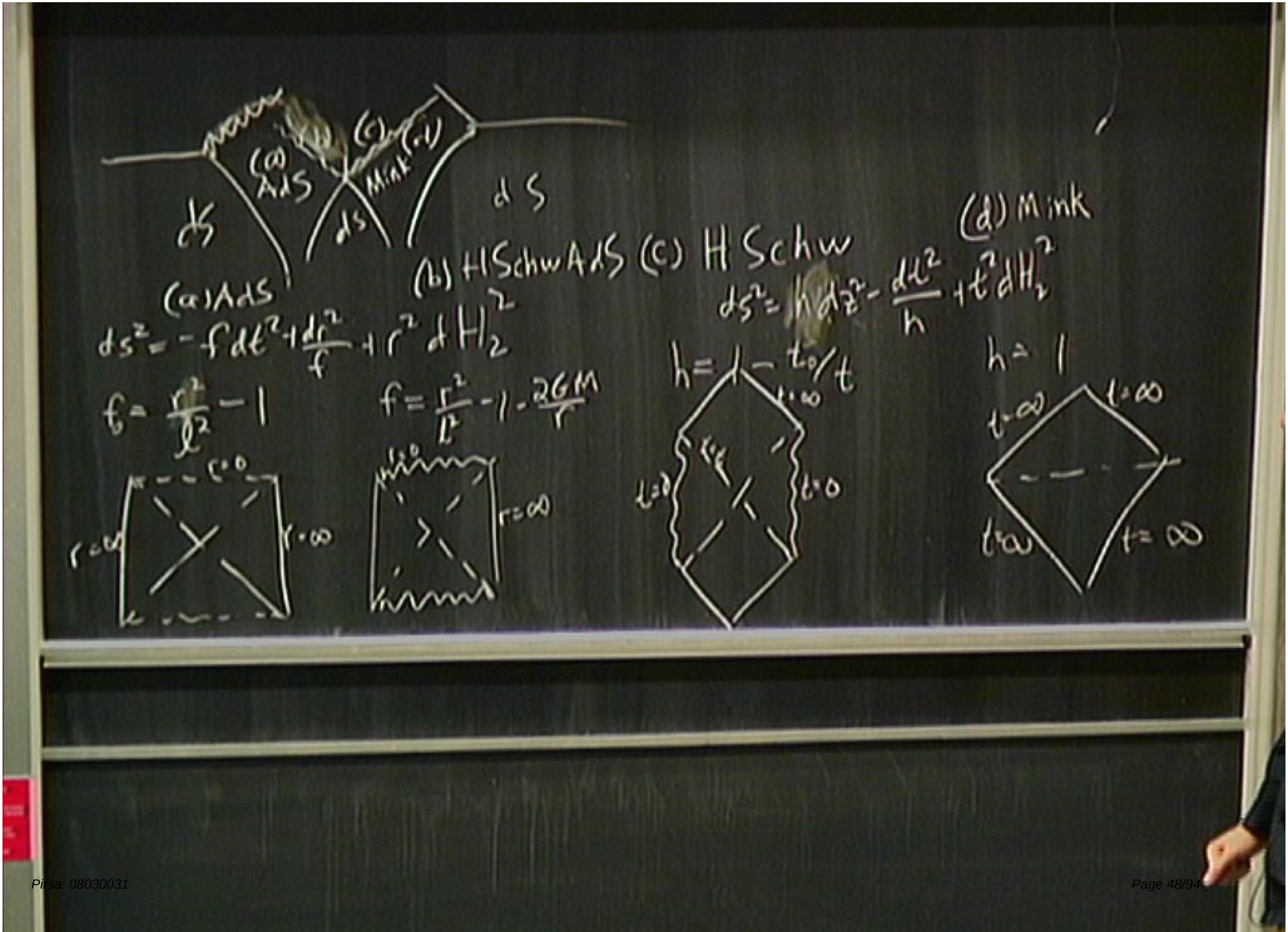

(a)
AdS
(c)
Mink
dS
dS
dS
(b)
(a)
ds^2 = -f dt^2 + dr^2/f + r^2 dH_2^2
f = r^2/l^2 - 1
f = r^2/l^2 - 1 - 2GM/r
r=0
r=∞
r=∞


(c)
(a)
AdS
Mink (+1)
dS
dS
dS
(b)
(a)
ds² = −f dt² + dr²/f + r² dH₂²
f = r²/ℓ² − 1
f = r²/ℓ² − 1 − 2GM/r
r=0
r=∞
r=∞
r=0
r=∞

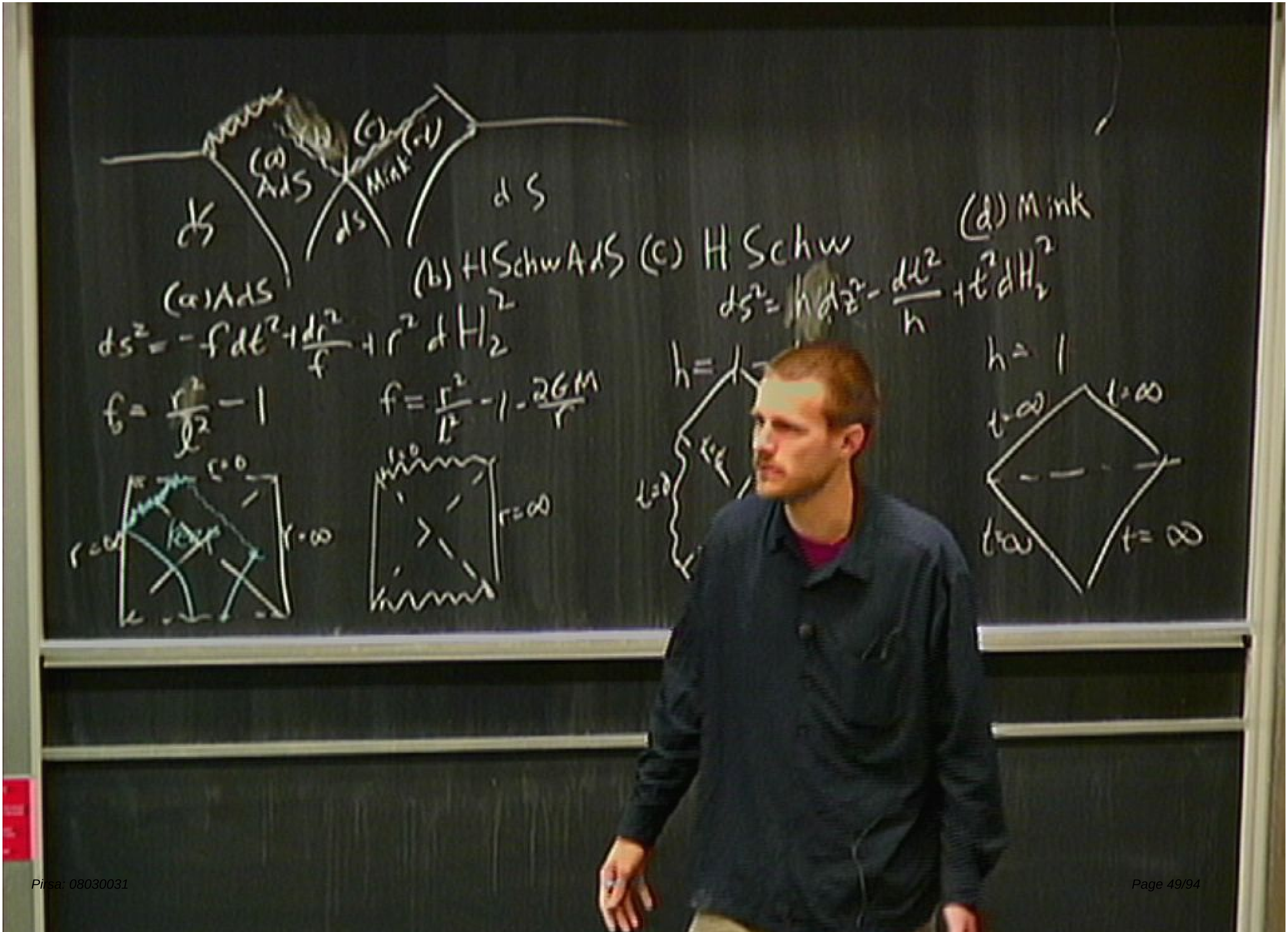

(a) AdS
(c)
Mink (-1)
dS
dS
dS
(b)
(C)
(a)
ds² = -f dt² + dr²/f + r² dH₂²
f = r²/ℓ² - 1
f = r²/ℓ² - 1 - 2GM/r
r=0
r=∞
r=∞
r=0
r=∞


(a) AdS
(c) Mink (-1)
dS
dS
d S
(b) H Schw AdS (c) H Schw
ds² = h dz² - dt²/h + t² dH₂²
(a) AdS
ds² = -f dt² + dr²/f + r² dH₂²
f = r²/ℓ² - 1
f = r²/ℓ² - 1 - 2GM/r
r=0
r=∞
r=∞
r=0
r=∞

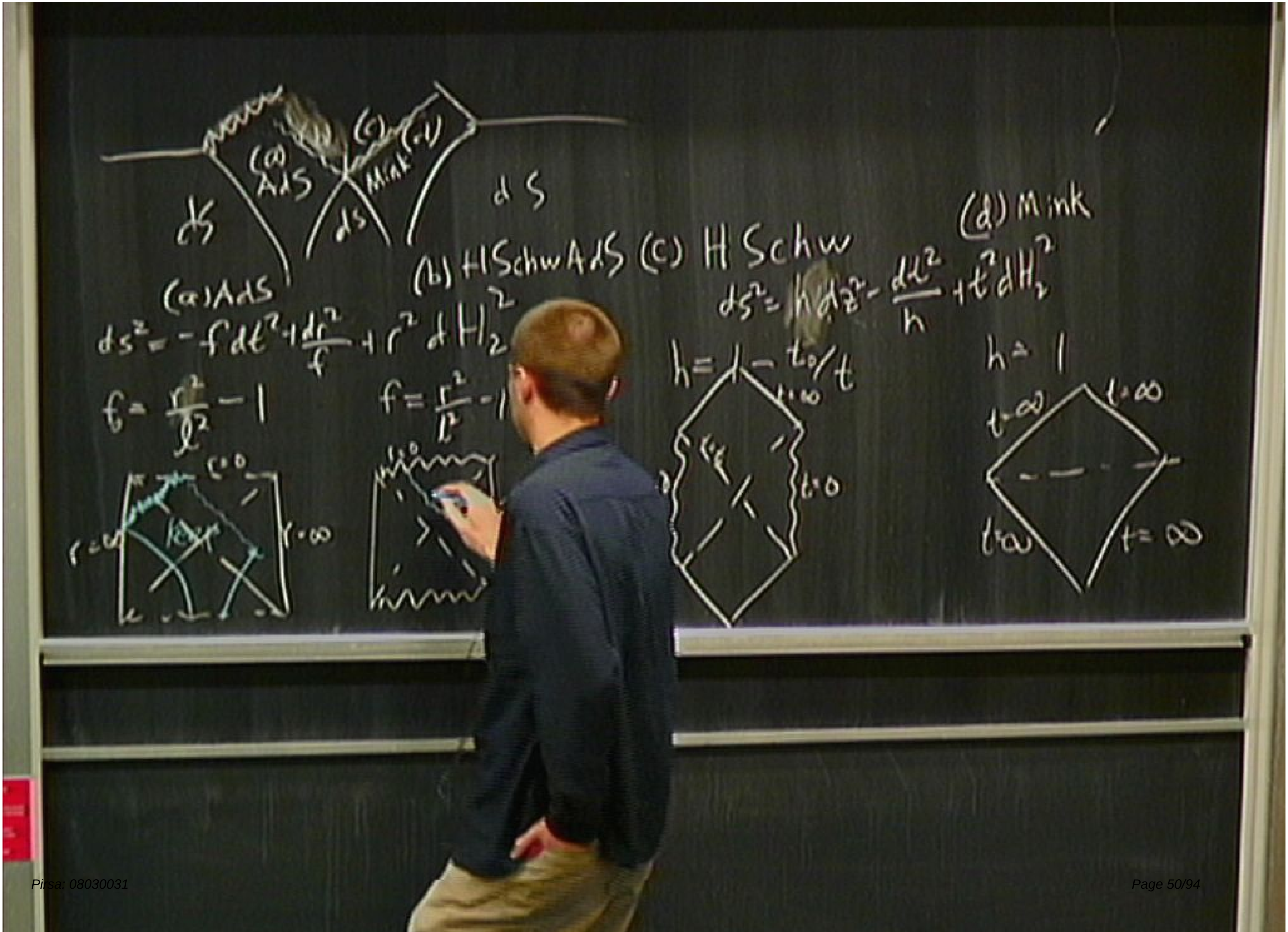

(a) AdS
(c)
Mink
dS
dS
dS
(b) H Schw AdS (c) H Schw
(a) AdS
ds² = -f dt² + dr²/f + r² dH₂²
f = r²/ℓ² - 1
f = r²/ℓ² - 1 - 2GM/r
ds² = h dz² - dt²/h + t² dH₂²
h = 1 - t₀/t
r=0
r=∞
r=∞
r=0
r=∞
t=∞
t=t₀
t=0
t=0

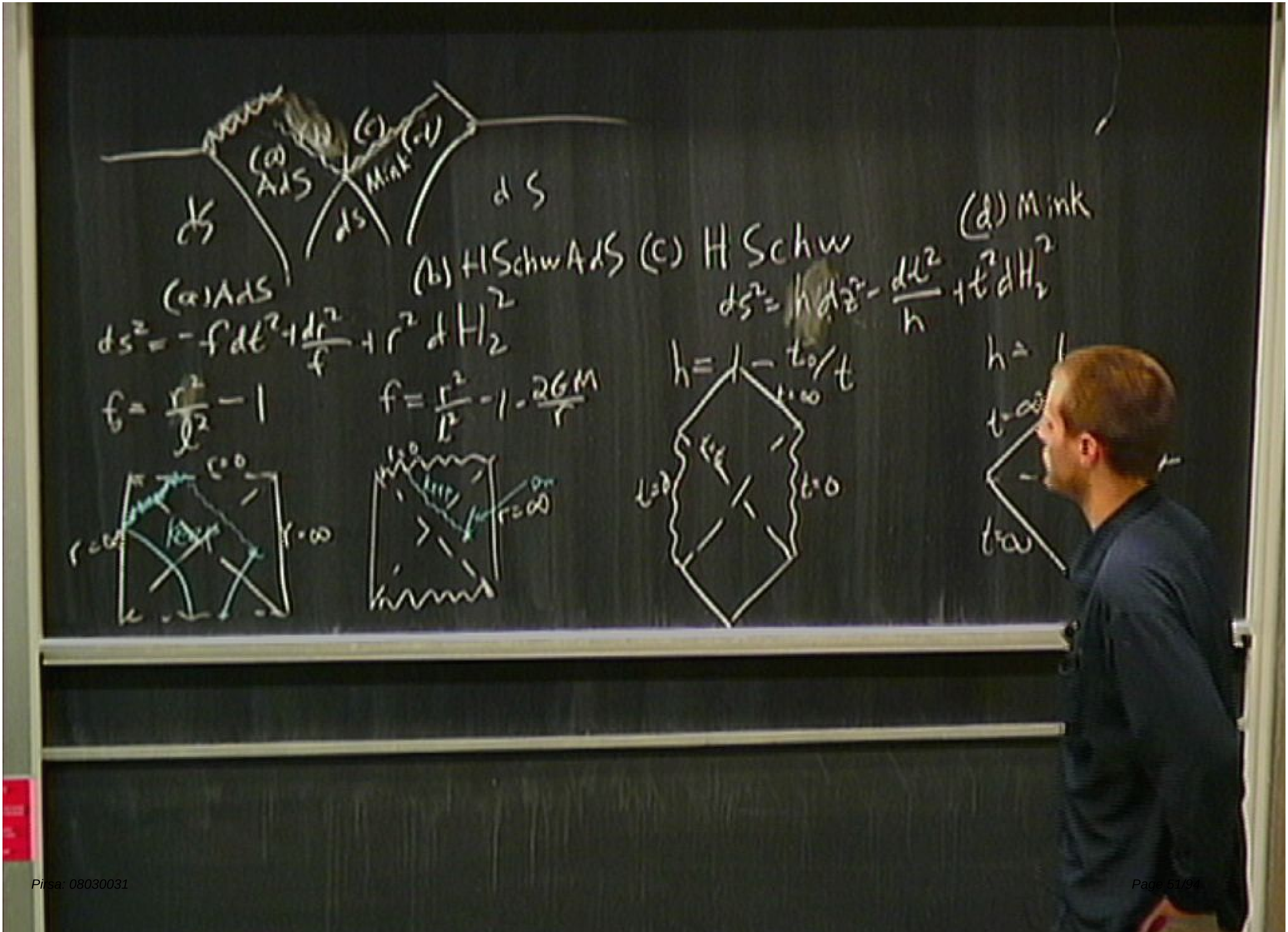


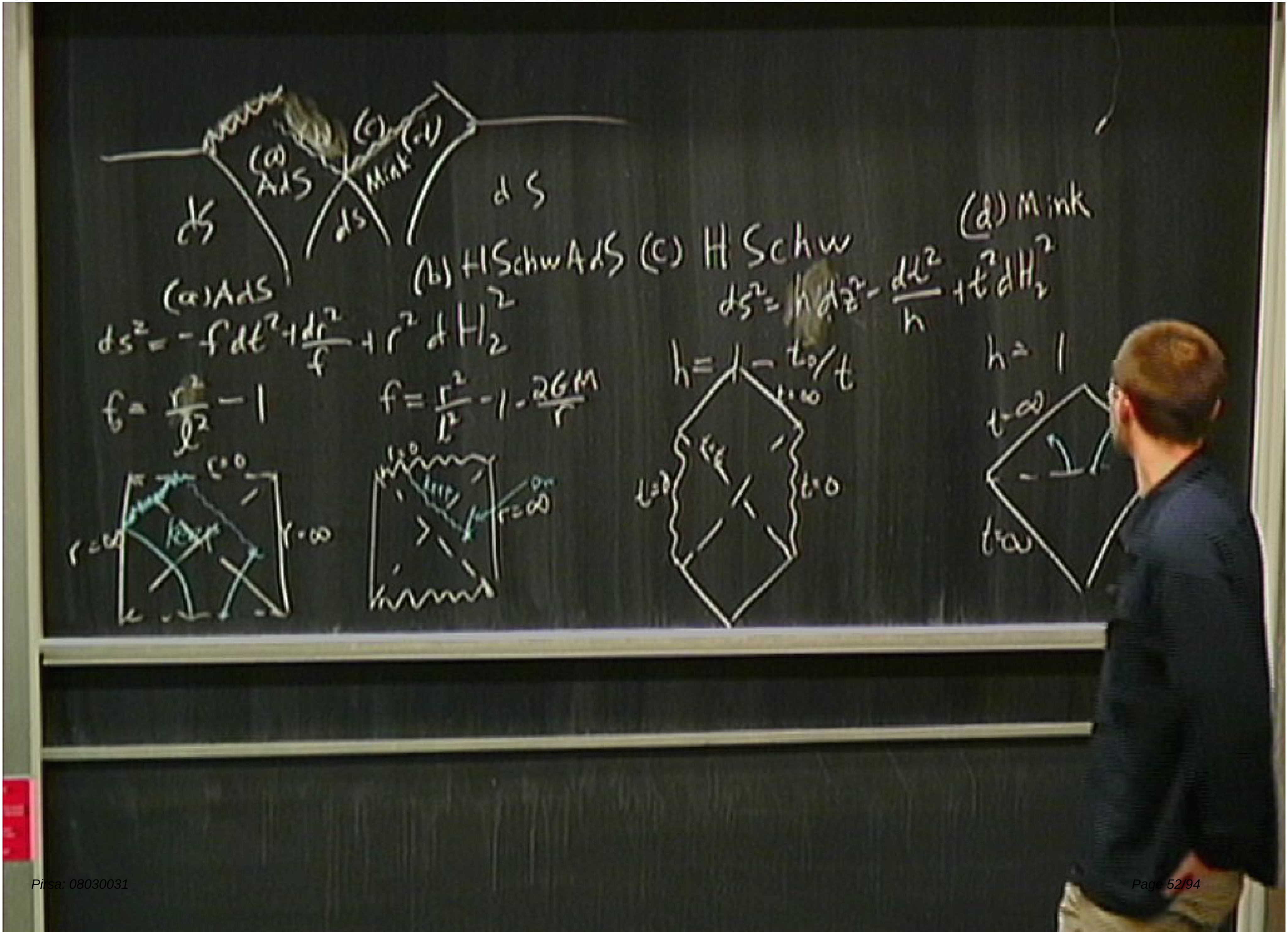
(a) AdS
(c)
Mink (-1)
dS
dS
dS
(d) Mink
(b) HSchwAdS
(c) H Schw
(a) AdS
$ds^2 = -f\,dt^2 + \frac{dr^2}{f} + r^2\,dH_2^2$
$f = \frac{r^2}{\ell^2} - 1$
$f = \frac{r^2}{\ell^2} - 1 - \frac{2GM}{r}$
$ds^2 = h\,dz^2 - \frac{dt^2}{h} + t^2\,dH_2^2$
$h = 1 - t_0/t$
$h = 1$
t=0
r=∞
t=∞
r=∞
t=0
t=∞
t=t₀
t=0
t=0
t=∞
t=∞
t=∞
t=∞



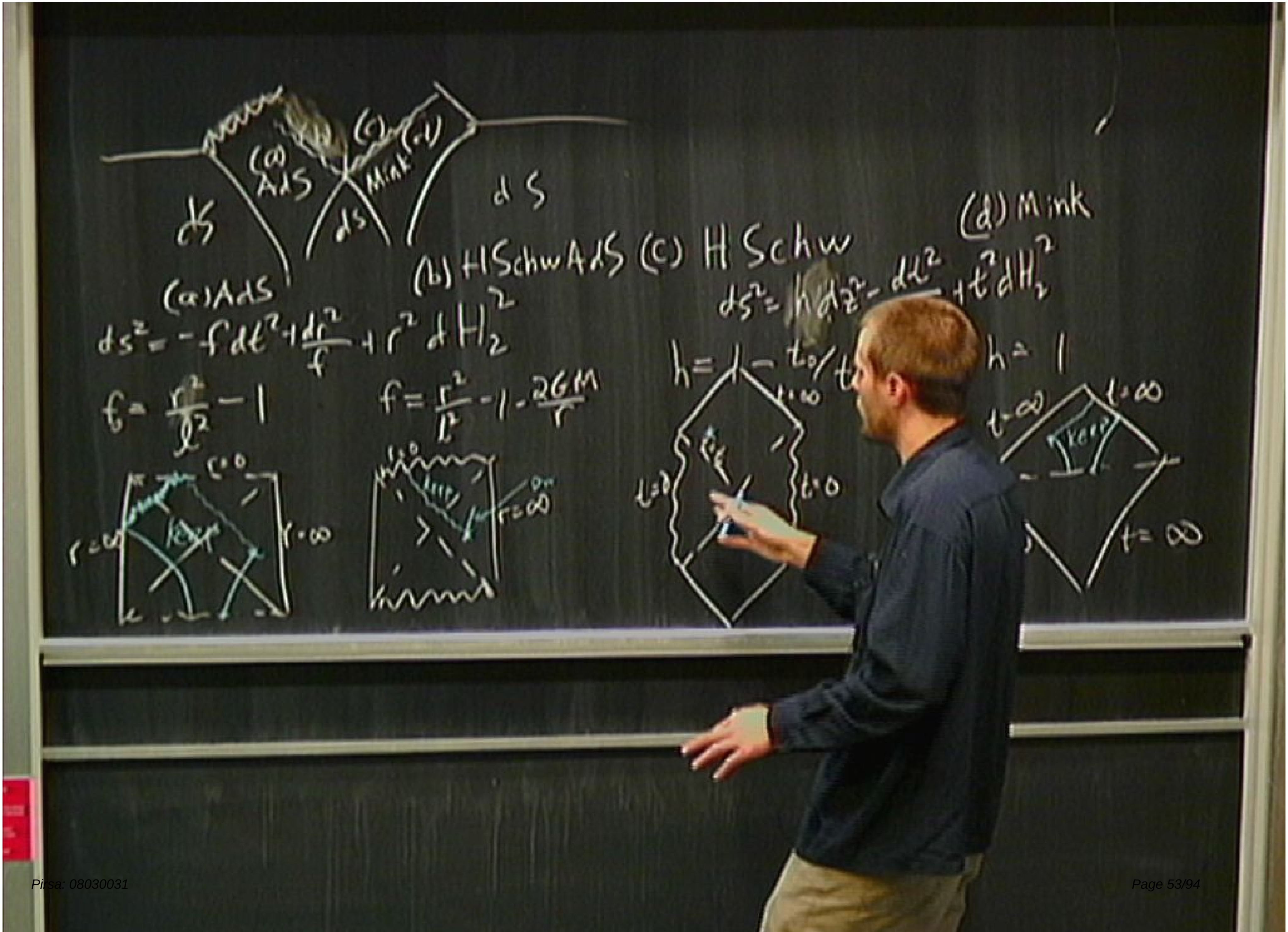
(a) AdS
(b) H Schw AdS
(c) H Schw
(d) Mink
dS
$ds^2 = -f dt^2 + \frac{dr^2}{f} + r^2 dH_2^2$
$f = \frac{r^2}{\ell^2} - 1$
$f = \frac{r^2}{\ell^2} - 1 - \frac{2GM}{r}$
$ds^2 = h dz^2 - \frac{dt^2}{h} + t^2 dH_2^2$
$h = 1$

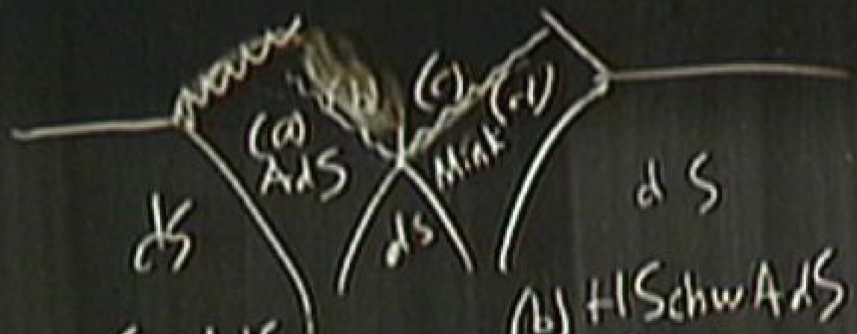

(a) AdS
(b) HSchwAdS
(c) H Schw
(d) Mink
dS
Mink
$ds^2 = -f\,dt^2 + \frac{dr^2}{f} + r^2\,dH_2^2$
$f = \frac{r^2}{\ell^2} - 1$
$ds^2 = h\,dz^2 - \frac{dt^2}{h} + t^2\,dH_2^2$
$h = 1 - t_0/t$
$h = 1$
$t=0$
$t=\infty$


(a) AdS
Mink
dS
d S
(d) Mink
(b) H Schw AdS (C) H Schw
(a) AdS
ds² = −f dt² + dr²/f + r² dH₂²
f = r²/ℓ² − 1
f = r²/ℓ² − 1 − 2GM/r
ds² = h dz² − dt²/h + t² dH₂²
h = 1 − t₀/t
h = 1
r = ∞
t = 0
t = ∞



dS
(a) AdS
(c)
Mink
d S
(d) Mink
(b) H Schw AdS
(c) H Schw
ds² = h dz² − dt²/h + t² dH₂²
ds² = −f dt² + dr²/f + r² dH₂²
h = 1 − t₀/t
h = 1
f = r²/ℓ² − 1
f = r²/ℓ² − 1 − 2GM/r
t=0
t=∞
r=∞


(a) AdS
(b) H Schw AdS
(c) H Schw
(d) Mink
dS
(a) AdS
(c) Mink (r=1)
$ds^2 = -f dt^2 + \frac{dr^2}{f} + r^2 dH_2^2$
$f = \frac{r^2}{l^2} - 1$
$f = \frac{r^2}{l^2} - 1 - \frac{2GM}{r}$
$ds^2 = h dz^2 - dt^2 + t^2 dH_2^2$
$h = 1 - t_0/t$
$h = 1$
t=0
t=∞
r=∞
kerr



(d) Mink

(a) AdS

(b) H Schw AdS

(c) H Schw

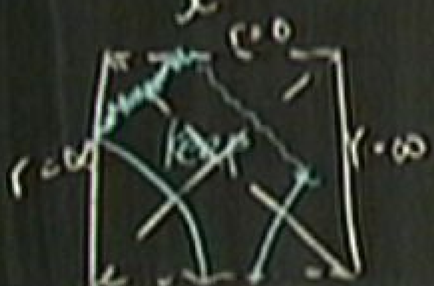
$$ds^2 = -f\,dt^2 + \frac{dr^2}{f} + r^2\, dH_2^2$$

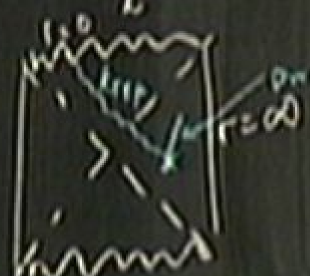
$$f = \frac{r^2}{\ell^2} - 1$$

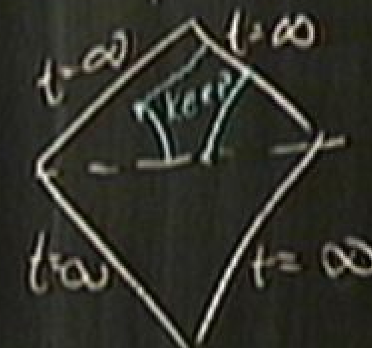
$$f = \frac{r^2}{\ell^2} - 1 - \frac{2GM}{r}$$

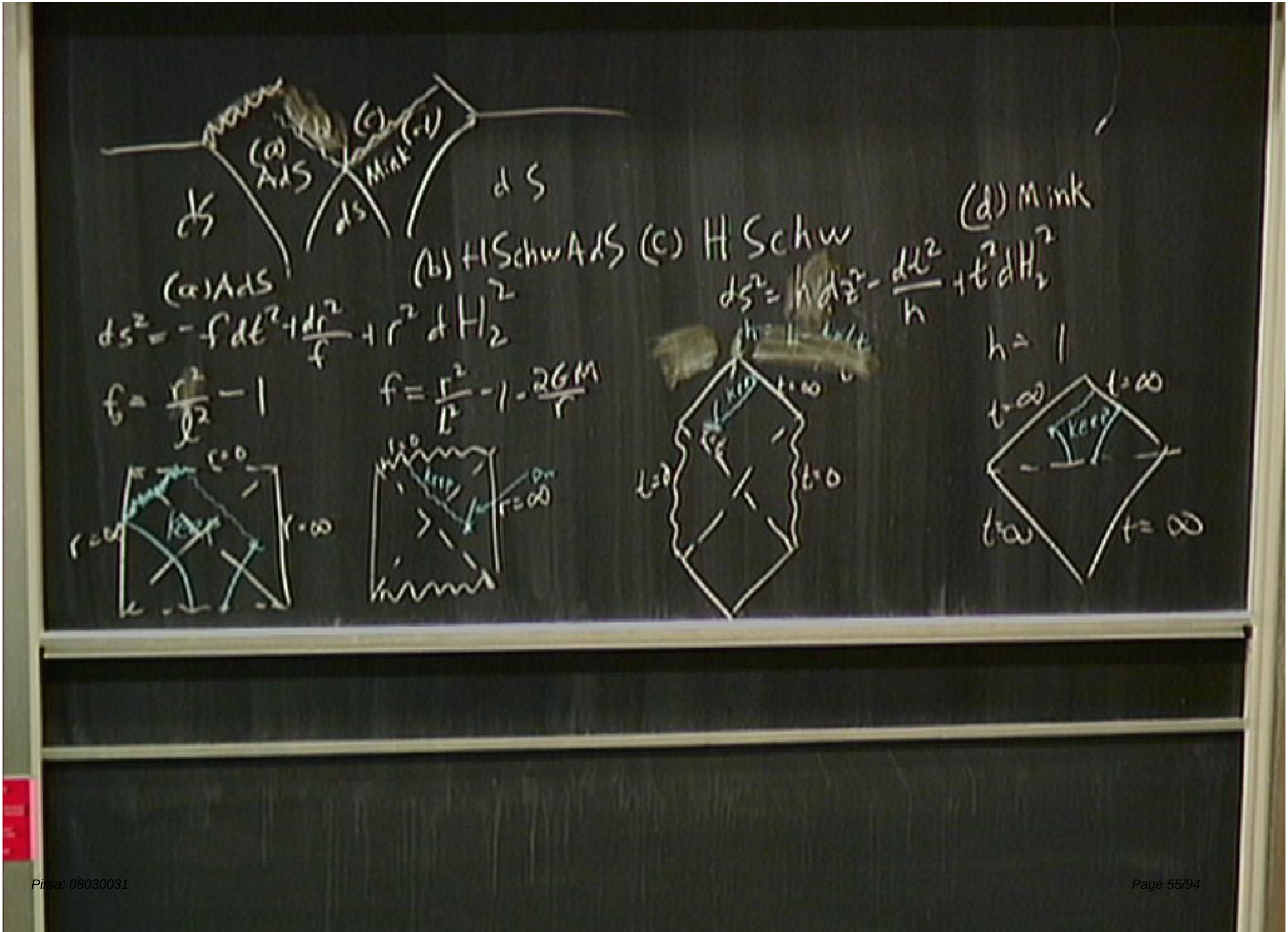
$$ds^2 = h\, dz^2 - \frac{dt^2}{h} + t^2\, dH_2^2$$

$$h = 1$$








(a) AdS
(c)
Mink
dS
dS
dS
d S
(d) Mink
(b) HSchwAdS (c) H Schw
(a) AdS
$ds^2 = -f dt^2 + \frac{dr^2}{f} + r^2 dH_2^2$
$f = \frac{r^2}{\ell^2} - 1$
$f = \frac{r^2}{\ell^2} - 1 - \frac{2GM}{r}$
$ds^2 = h dz^2 - \frac{dt^2}{h} + t^2 dH_2^2$
$h = 1$
keep
t=0
t=∞
r=∞
t=∞
t=0
t=∞
t=∞
t=∞

Israel junction conditions:

(1) Induced metric agrees

$-d\tau^2 +$

Israel junction conditions:

① Induced metric agrees

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

Israel junction conditions:

(1) Induced metric agrees

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

$$R \to \infty \quad \text{as} \quad \tau \to \infty$$

Israel junction conditions:

① Induced metric agrees

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

$$R \to \infty \quad \text{as} \quad \tau \to \infty$$

② Jump in extrinsic curvature related to $T_{\mu\nu}^{DW}$

$$\sqrt{\dot{R}^2 + f(R)}$$

Israel junction conditions:

① Induced metric agrees

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

$R \to \infty$ as $\tau \to \infty$

② Jump in extrinsic curvature related to $T_{\mu\nu}^{DW}$

$$\frac{\sqrt{\dot{R}^2 + f(R)}}{R} \pm \frac{\sqrt{\dot{R}^2 - h(R)}}{R} = G\sigma$$

Israel junction conditions:

① Induced metric agrees $\qquad T_{\mu\nu} = \sigma g_{\mu\nu}$

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

$R \to \infty$ as $\tau \to \infty$

② Jump in extrinsic curvature related to $T_{\mu\nu}^{DW}$

$$\frac{\sqrt{\dot{R}^2 + f(R)}}{R} \pm \frac{\sqrt{\dot{R}^2 - h(R)}}{R} = G\sigma$$

Israel junction conditions:

$$\boxed{T_{\mu\nu} = \sigma g_{\mu\nu}}$$

(1) Induced metric agrees

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

$$R \to \infty \quad \text{as} \quad \tau \to \infty$$

(2) in extrinsic curvature related to $T_{\mu\nu}^{DW}$

$$\frac{\sqrt{\dot{R}^2 + f(R)}}{R} \pm \frac{\sqrt{\dot{R}^2 - h(R)}}{R} = G\sigma$$

Israel junction conditions:

① Induced metric agrees

$$\boxed{T_{\mu\nu} = \sigma g_{\mu\nu}}$$

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

$$R \to \infty \quad \text{as} \quad \tau \to \infty$$

② Jump in extrinsic curvature related to $T_{\mu\nu}^{DW}$

$$\frac{\sqrt{\dot{R}^2 + f(R)}}{R} \pm \frac{\sqrt{\dot{R}^2 - h(R)}}{R} = G\sigma$$

± negative

Israel junction conditions:

$$\boxed{T_{\mu\nu} = \sigma g_{\mu\nu}}$$

① Induced metric agrees

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

$$R \to \infty \quad \text{as} \quad \tau \to \infty$$

② Jump in extrinsic curvature related to $T_{\mu\nu}^{DW}$

$$\frac{\sqrt{\dot{R}^2 + f(R)}}{R} \pm \frac{\sqrt{\dot{R}^2 - h(R)}}{R} = G\sigma$$

- negative (DW moving left on $\Lambda = 0$ side

Israel junction conditions:

$$\boxed{T_{\mu\nu} = \sigma g_{\mu\nu}}$$

① Induced metric agrees

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

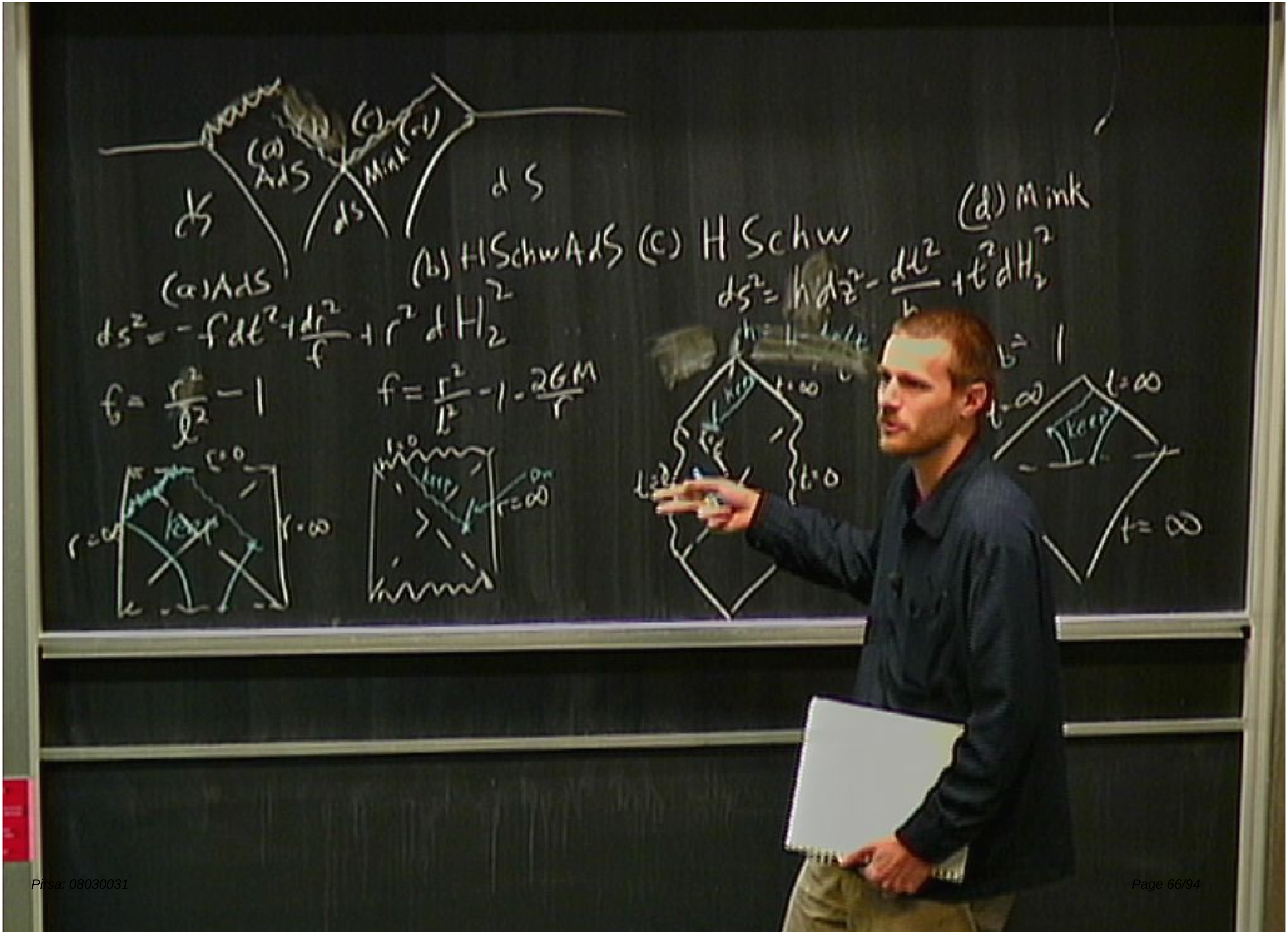
$R \to \infty$ as $\tau \to \infty$

② Jump in extrinsic curvature related to $T_{\mu\nu}^{DW}$

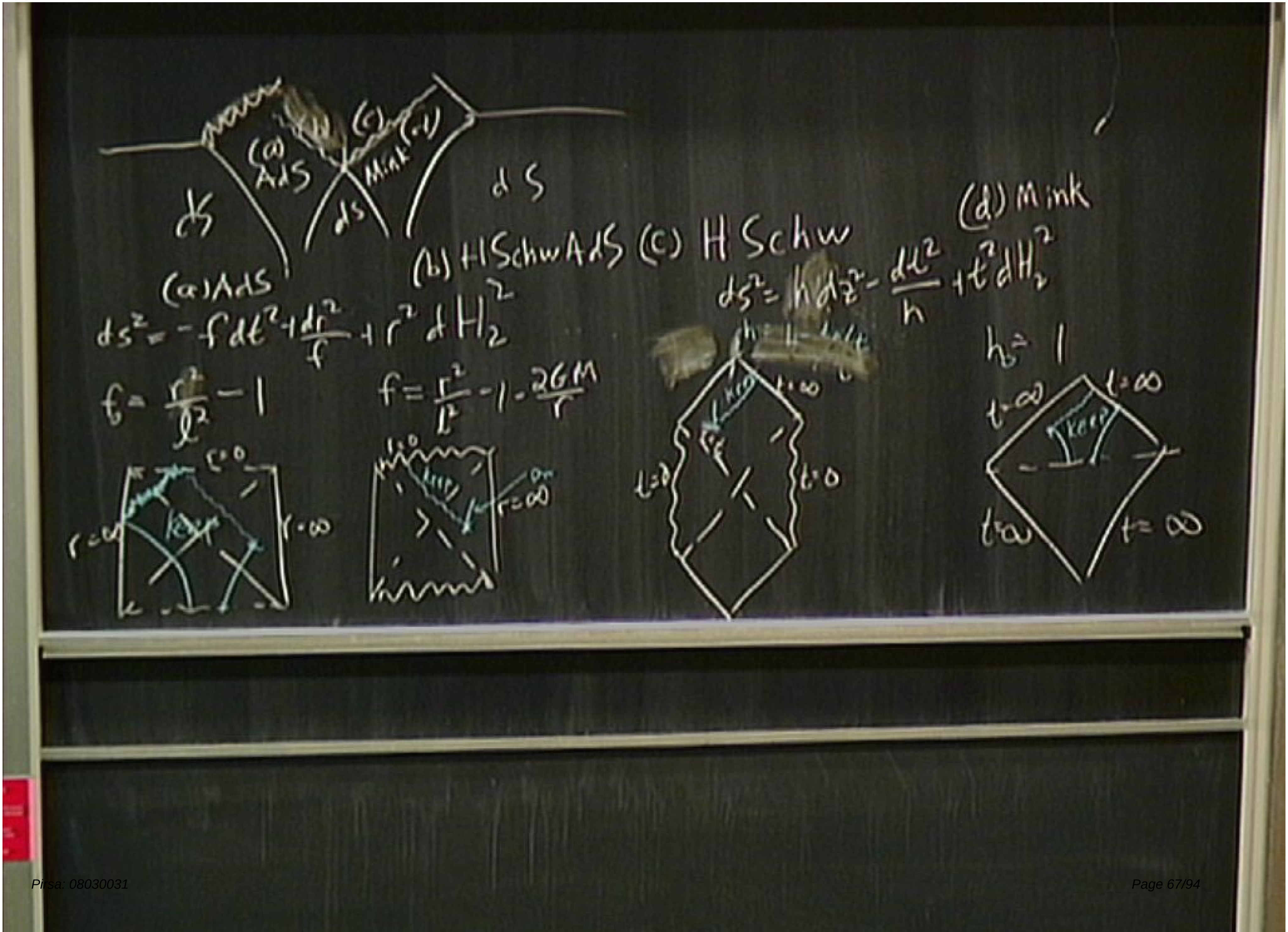
$$\frac{\sqrt{\dot{R}^2 + f(R)}}{R} \pm \frac{\sqrt{\dot{R}^2 - h(R)}}{R} = G\sigma$$

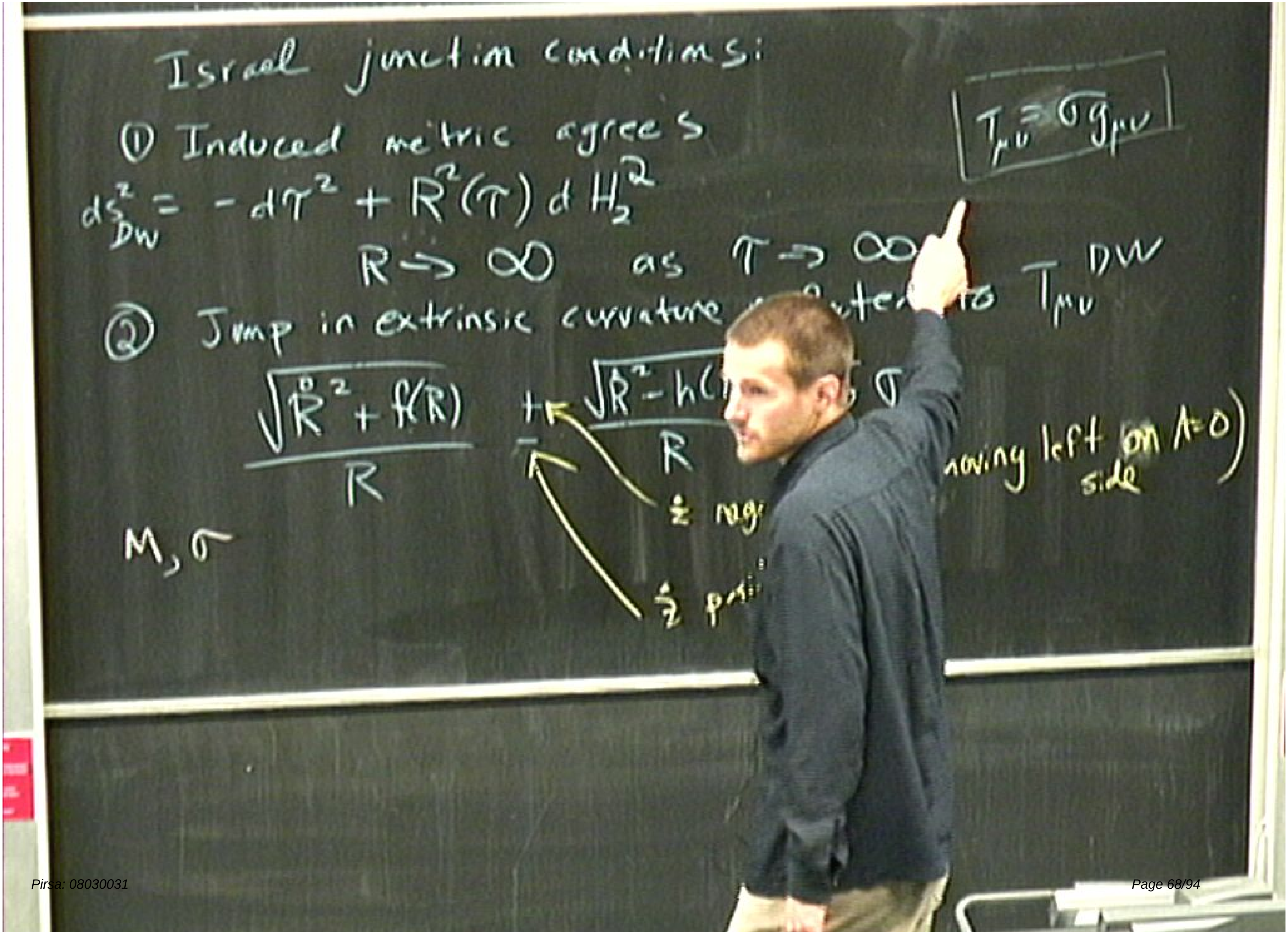
$\dot{z}$ negative (DW moving left on $\Lambda = 0$ side)

$\dot{z}$ positive



(a) AdS
(c) Mink (=1)
dS
dS
dS
(d) Mink
(b) H Schw AdS (c) H Schw
(a) AdS
ds² = −f dt² + dr²/f + r² dH₂²
f = r²/ℓ² − 1
f = r²/ℓ² − 1 − 2GM/r
ds² = h dz² − dt²/h + t² dH₂²
keep
t = ∞
t = 0
r = ∞
t = ∞


(a) AdS
(b) H Schw AdS
(c) H Schw
(d) Mink
dS
$ds^2 = -f dt^2 + \frac{dr^2}{f} + r^2 dH_2^2$
$f = \frac{r^2}{\ell^2} - 1$
$f = \frac{r^2}{\ell^2} - 1 - \frac{2GM}{r}$
$ds^2 = h dz^2 - \frac{dt^2}{h} + t^2 dH_2^2$
$h = 1$
keep
$t = \infty$
$t = 0$
$r = \infty$


Israel junction conditions:
① Induced metric agrees
$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$
$R \to \infty$ as $\tau \to \infty$
$T_{\mu\nu} = \sigma g_{\mu\nu}$
② Jump in extrinsic curvature
to $T_{\mu\nu}^{DW}$
$\frac{\sqrt{\dot{R}^2 + f(R)}}{R}$
$\pm$
R
σ
moving left on $\Lambda = 0$ side)
M, σ

Israel junction conditions:

$$\boxed{T_{\mu\nu} = \sigma g_{\mu\nu}}$$

① Induced metric agrees

$$ds^2_{DW} = -d\tau^2 + R^2(\tau)\, dH_2^2$$

$$R \to \infty \quad \text{as} \quad \tau \to \infty$$

② Jump in extrinsic curvature related to $T_{\mu\nu}^{DW}$

$$\frac{\sqrt{\dot{R}^2 + f(R)}}{R} \pm \frac{\sqrt{\dot{R}^2 - h(R)}}{R} = G\sigma$$

$\dot{z}$ negative (DW moving left on $\Lambda = 0$ side)

$\dot{z}$ positive

M, σ, t_0, ℓ

micro

$$\sqrt{\dot{R}^2 + \frac{R^2}{\ell^2} - 1 - \frac{2GM}{R}} \pm \sqrt{\dot{R}^2 - 1 + t\,a/_R} = G\sigma R$$

$$\sqrt{\dot{R}^2 + \frac{R^2}{\ell^2} - 1 - \frac{2GM}{R}} \pm \sqrt{\dot{R}^2 - 1 + t\,d_R} = G\sigma R$$

<u>large R</u>:

$$\sqrt{\frac{R^2}{\ell^2} + \dot{R}^2 - 1} \pm \sqrt{\dot{R}^2 - 1} = G\sigma R$$

$$\sqrt{\dot{R}^2 + \frac{R^2}{\ell^2} - 1 - \frac{2GM}{R}} \pm \sqrt{\dot{R}^2 - 1 + t\,d_R} = G\sigma R$$

large R:

$$\sqrt{\frac{R^2}{\ell^2} + \dot{R}^2 - 1} \pm \sqrt{\dot{R}^2 - 1} = G\sigma R$$

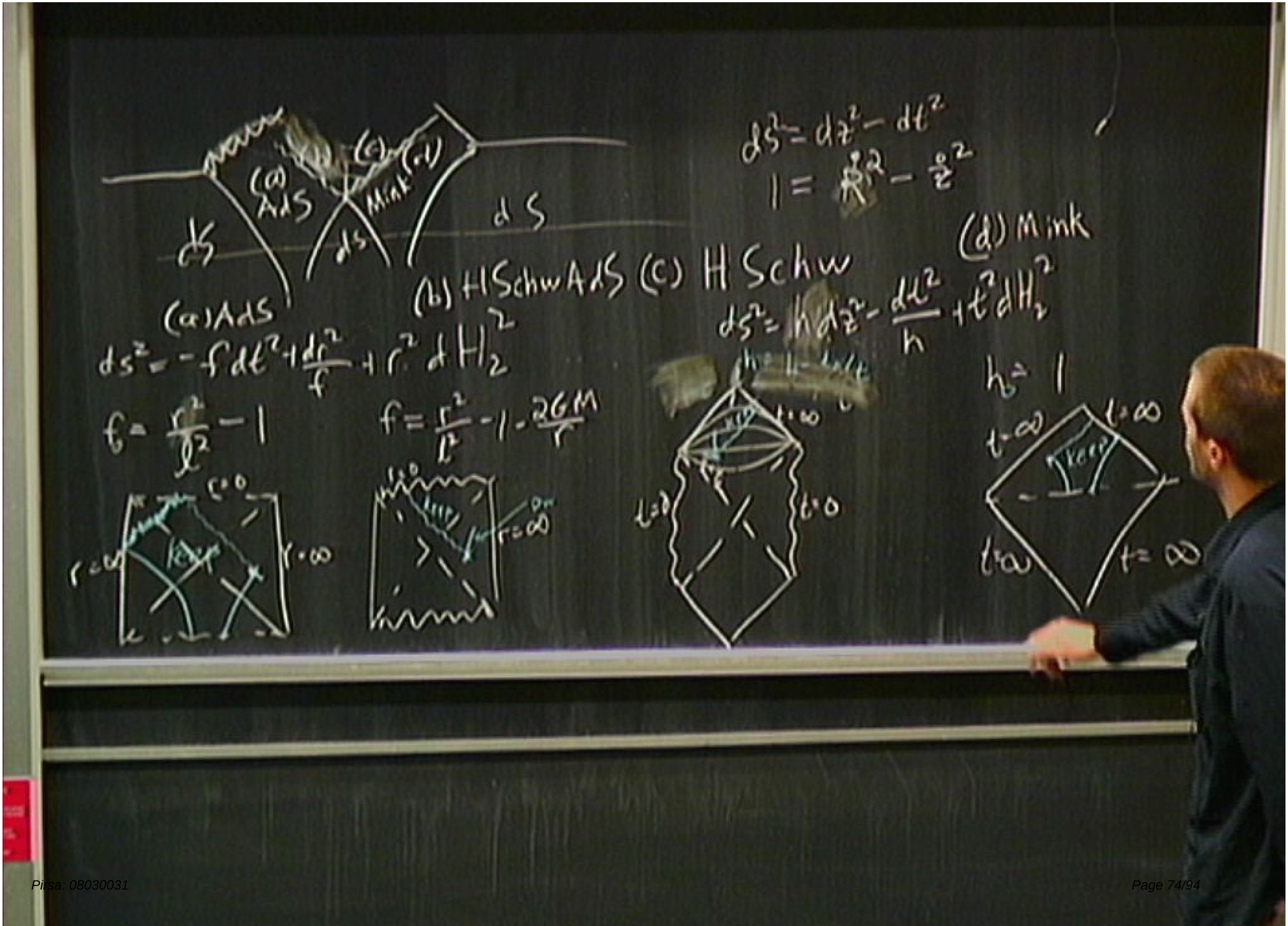
− sign:

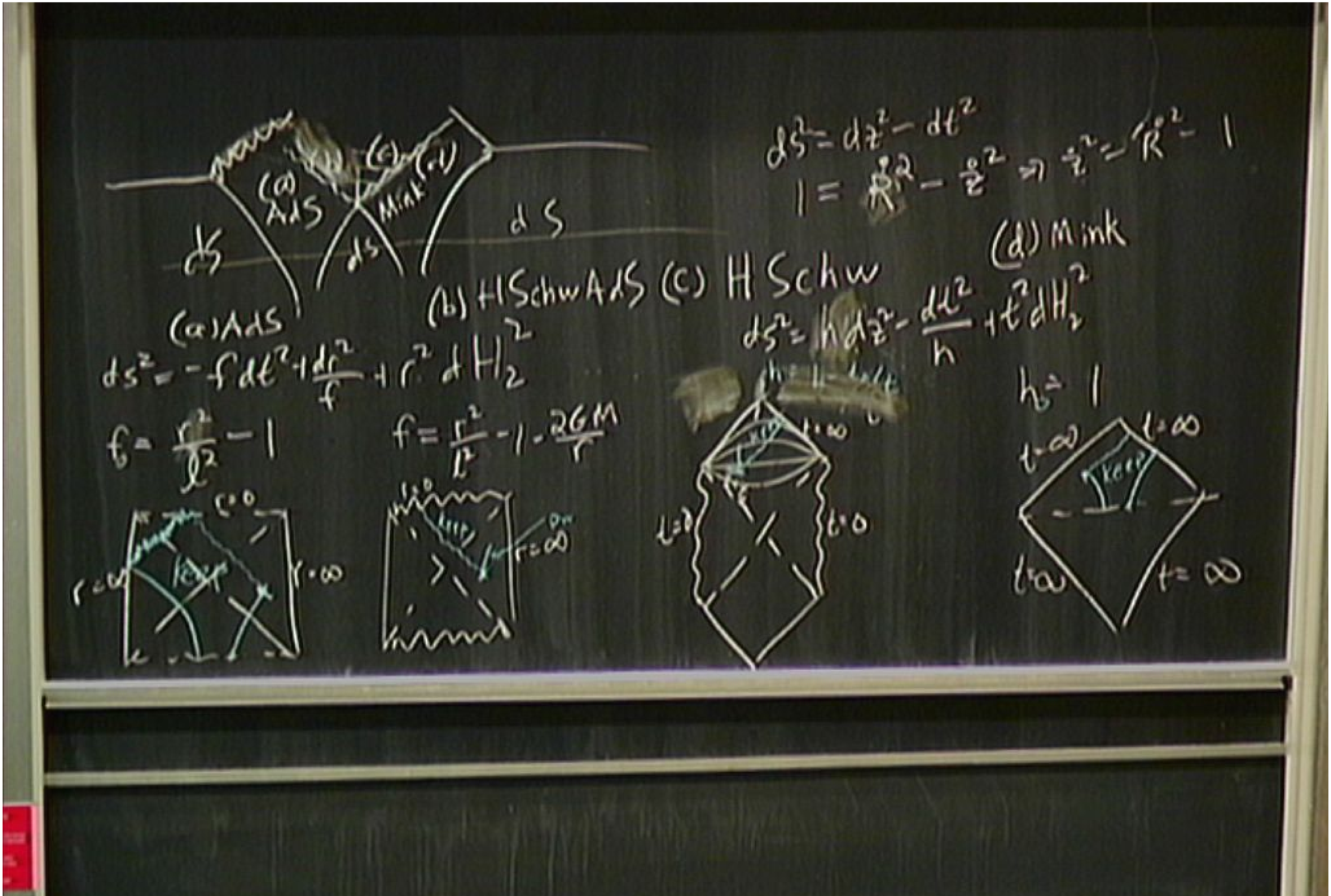
$$\sqrt{\dot{R}^2 + \frac{R^2}{\ell^2} - 1 - \frac{2GM}{R}} \pm \sqrt{\dot{R}^2 - 1 + t\,d_R} = G\sigma R$$

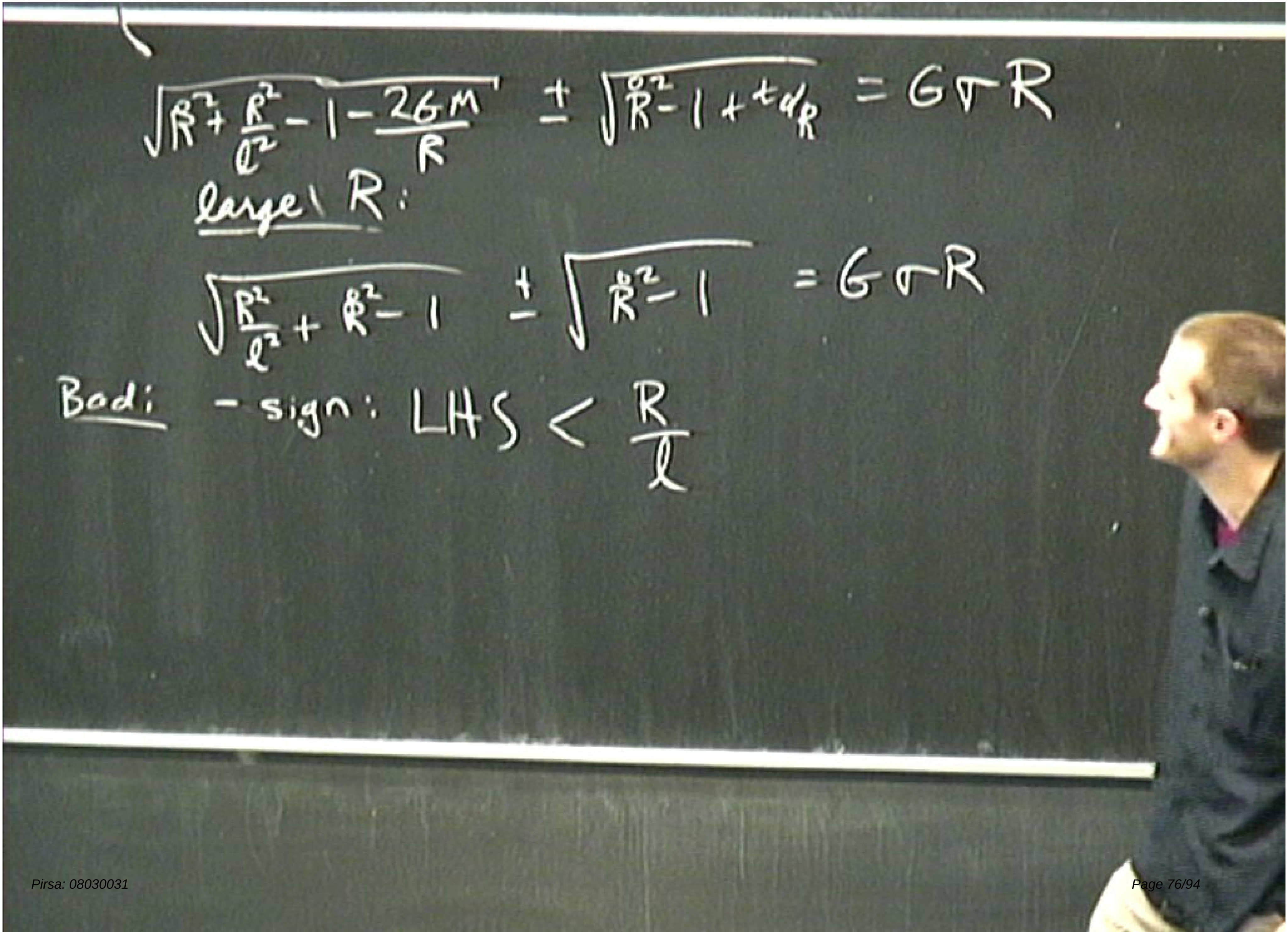
large R:

$$\sqrt{\frac{R^2}{\ell^2} + \dot{R}^2 - 1} \pm \sqrt{\dot{R}^2 - 1} = G\sigma R$$

Bodi: − sign: LHS


(a) AdS
Mink
dS
(c)
d S
ds² = dz² − dt²
(d) Mink
(b) H Schw AdS
(c) H Schw
(a) AdS
ds² = − f dt² + dr²/f + r² dH₂²
ds² = h dz² − dt²/h + t² dH₂²
h = 1
f = r²/ℓ² − 1
f = r²/ℓ² − 1 − 2GM/r
t = 0
t = ∞
r = ∞
keep


(a) AdS
Mink (c)
dS
(b) H Schw AdS (c) H Schw
(d) Mink
(a) AdS
$ds^2 = dz^2 - dt^2$
$1 = \dot{R}^2 - \dot{z}^2 \Rightarrow \dot{z}^2 = \dot{R}^2 - 1$
$ds^2 = -f\,dt^2 + \frac{dr^2}{f} + r^2\,dH_2^2$
$f = \frac{r^2}{\ell^2} - 1$
$f = \frac{r^2}{\ell^2} - 1 - \frac{2GM}{r}$
$ds^2 = h\,dz^2 - \frac{dt^2}{h} + t^2\,dH_2^2$
$h = 1$
keep
$t=0$
$t=\infty$
$r=\infty$



$\sqrt{\dot{R}^2 + \frac{R^2}{\ell^2} - 1 - \frac{2GM}{R}} \pm \sqrt{\dot{R}^2 - 1 + t\, d_R} = G\sigma R$
large R:
$\sqrt{\frac{R^2}{\ell^2} + \dot{R}^2 - 1} \pm \sqrt{\dot{R}^2 - 1} = G\sigma R$
Bad: − sign: LHS $< \frac{R}{\ell}$

$$\sqrt{\dot{R}^2 + \frac{R^2}{\ell^2} - 1 - \frac{2GM}{R}} \pm \sqrt{\dot{R}^2 - 1 + t\,\alpha_R} = G\sigma R$$

large R:

$$\sqrt{\frac{R^2}{\ell^2} + \dot{R}^2 - 1} \pm \sqrt{\dot{R}^2 - 1} = G\sigma R$$

Bad: $-$ sign: $\text{LHS} < \frac{R}{\ell} \Leftrightarrow G\sigma < \frac{1}{\ell}$

Good: $+$ sign: $\text{LHS} > R/\ell$

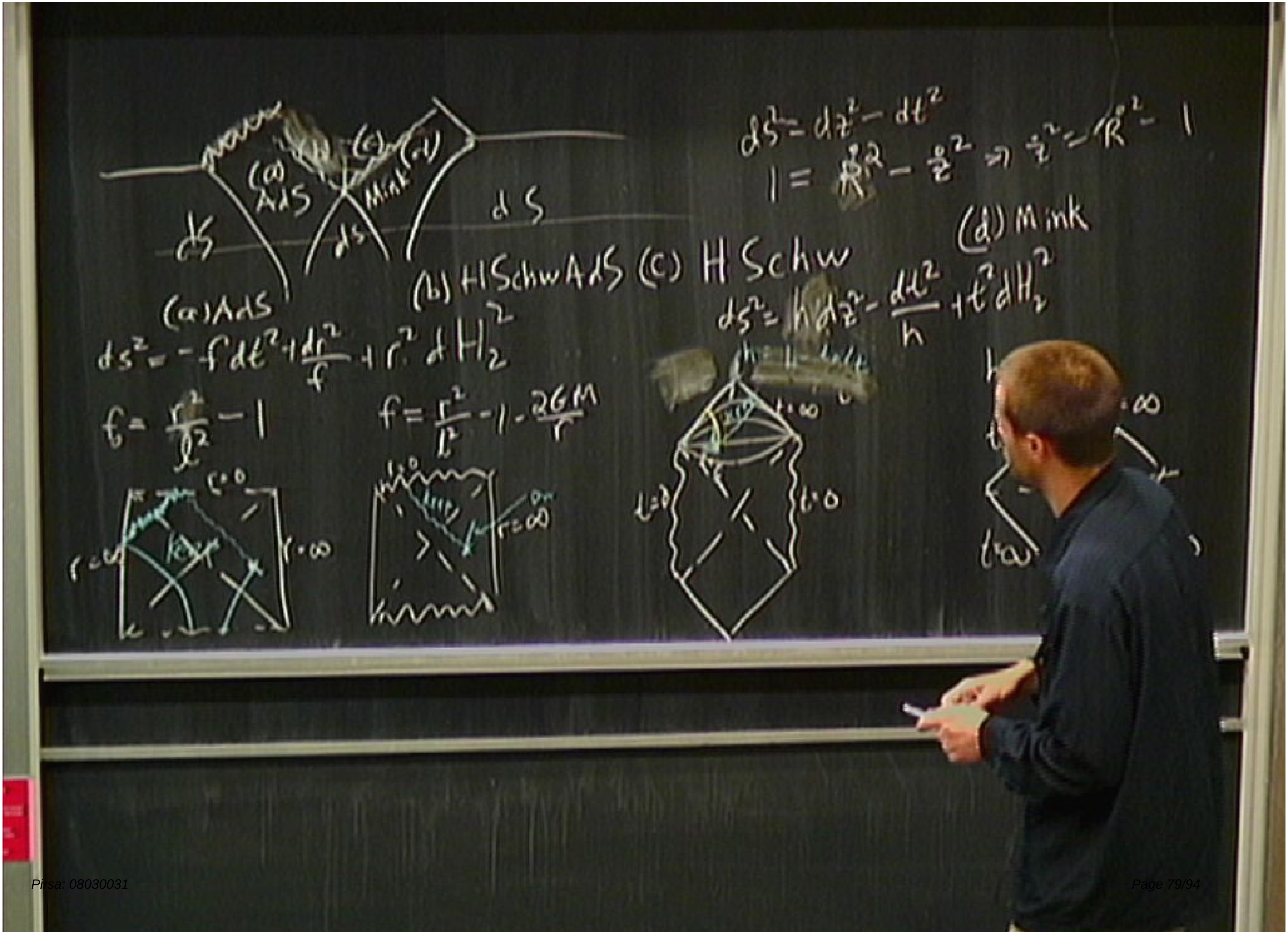
$$\sqrt{\dot{R}^2 + \frac{R^2}{\ell^2} - 1 - \frac{2GM}{R}} \pm \sqrt{\dot{R}^2 - 1 + {}^{t}d_{R}} = G\sigma R$$

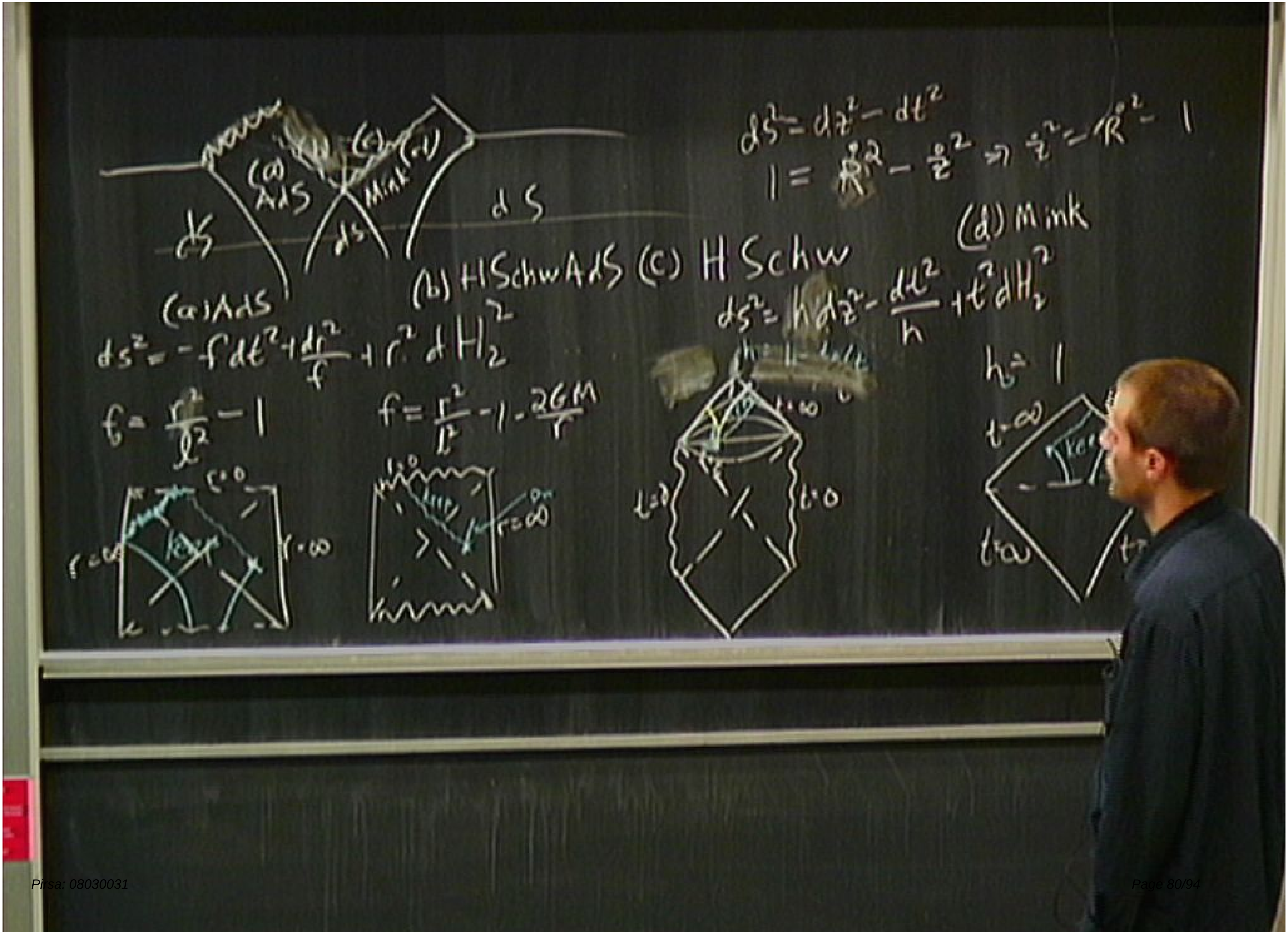
large R:

$$\sqrt{\frac{R^2}{\ell^2} + \dot{R}^2 - 1} \pm \sqrt{\dot{R}^2 - 1} = G\sigma R$$

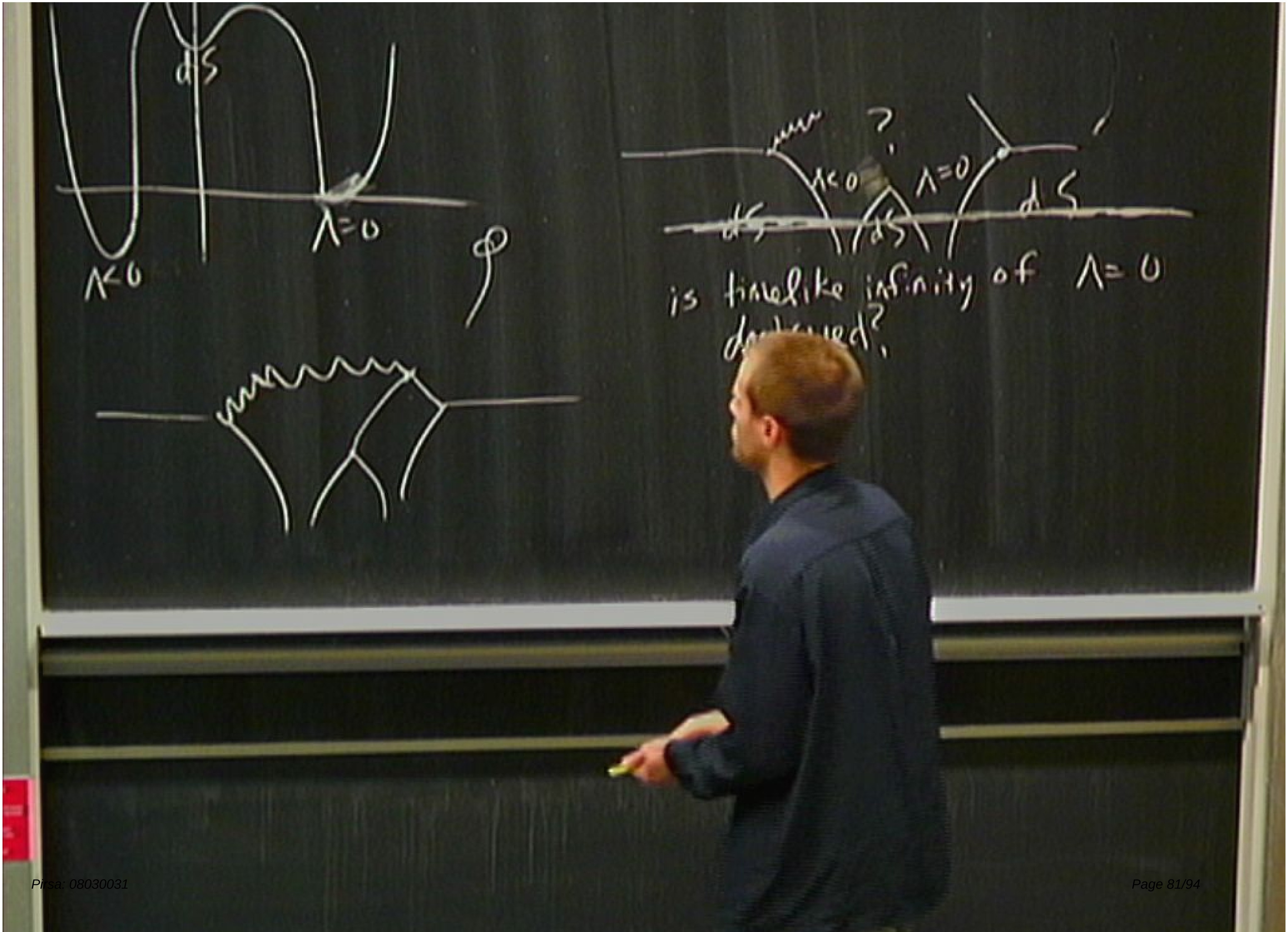
Bad: $-$ sign: $\text{LHS} < \frac{R}{\ell} \Leftrightarrow G\sigma < \frac{1}{\ell}$ BAD

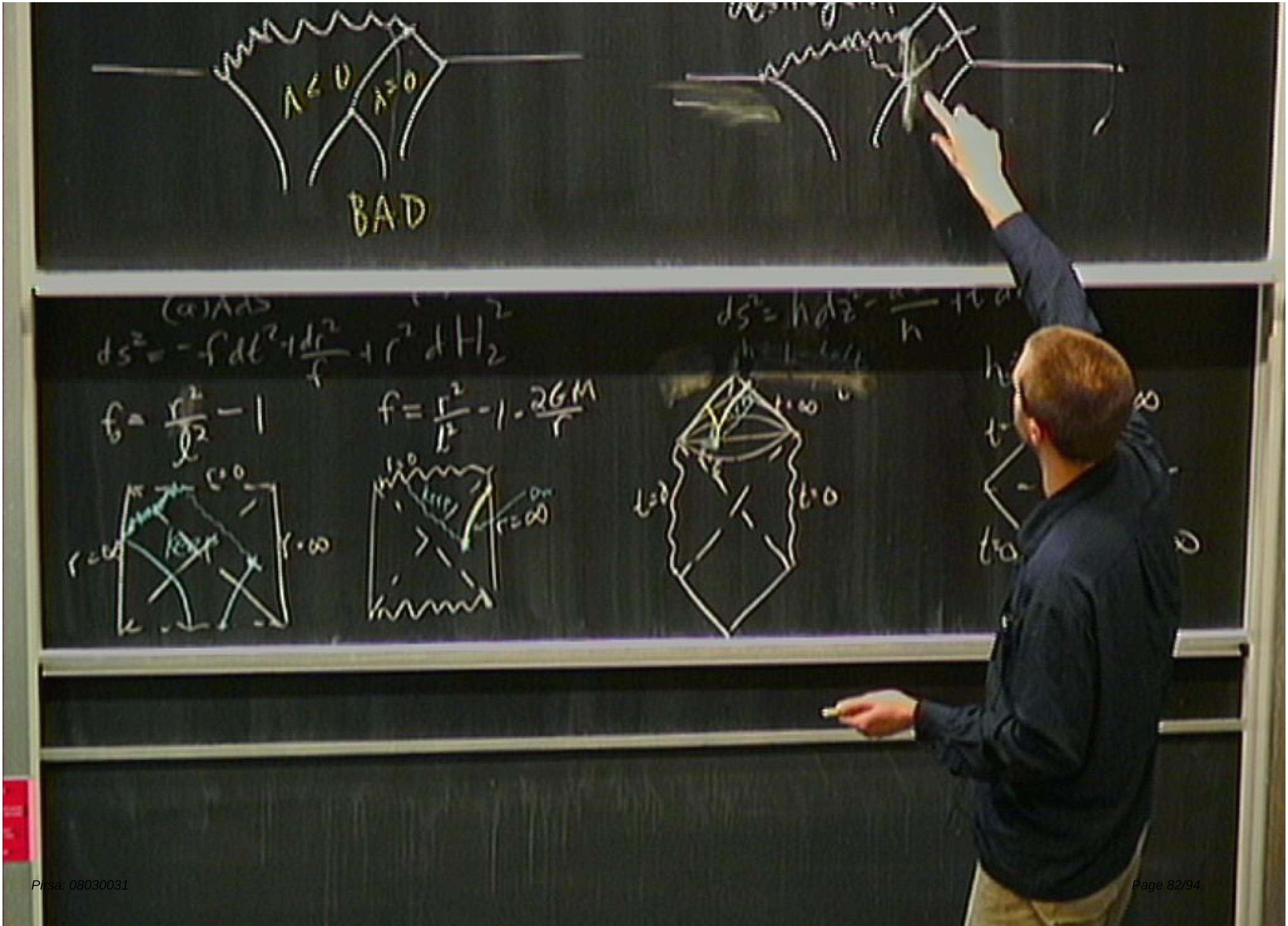
Good: $+$ sign: $\text{LHS} > R/\ell \Leftrightarrow G\sigma > 1/\ell$ GOOD


(a) AdS
(b) H Schw AdS
(c) H Schw
(d) Mink
dS
$ds^2 = dz^2 - dt^2$
$1 = R^2 - z^2$
$ds^2 = -f\,dt^2 + \frac{dr^2}{f} + r^2\,dH_2^2$
$f = \frac{r^2}{\ell^2} - 1$
$f = \frac{r^2}{\ell^2} - 1 - \frac{2GM}{r}$
$ds^2 = h\,dz^2 - \frac{dt^2}{h} + t^2\,dH_2^2$

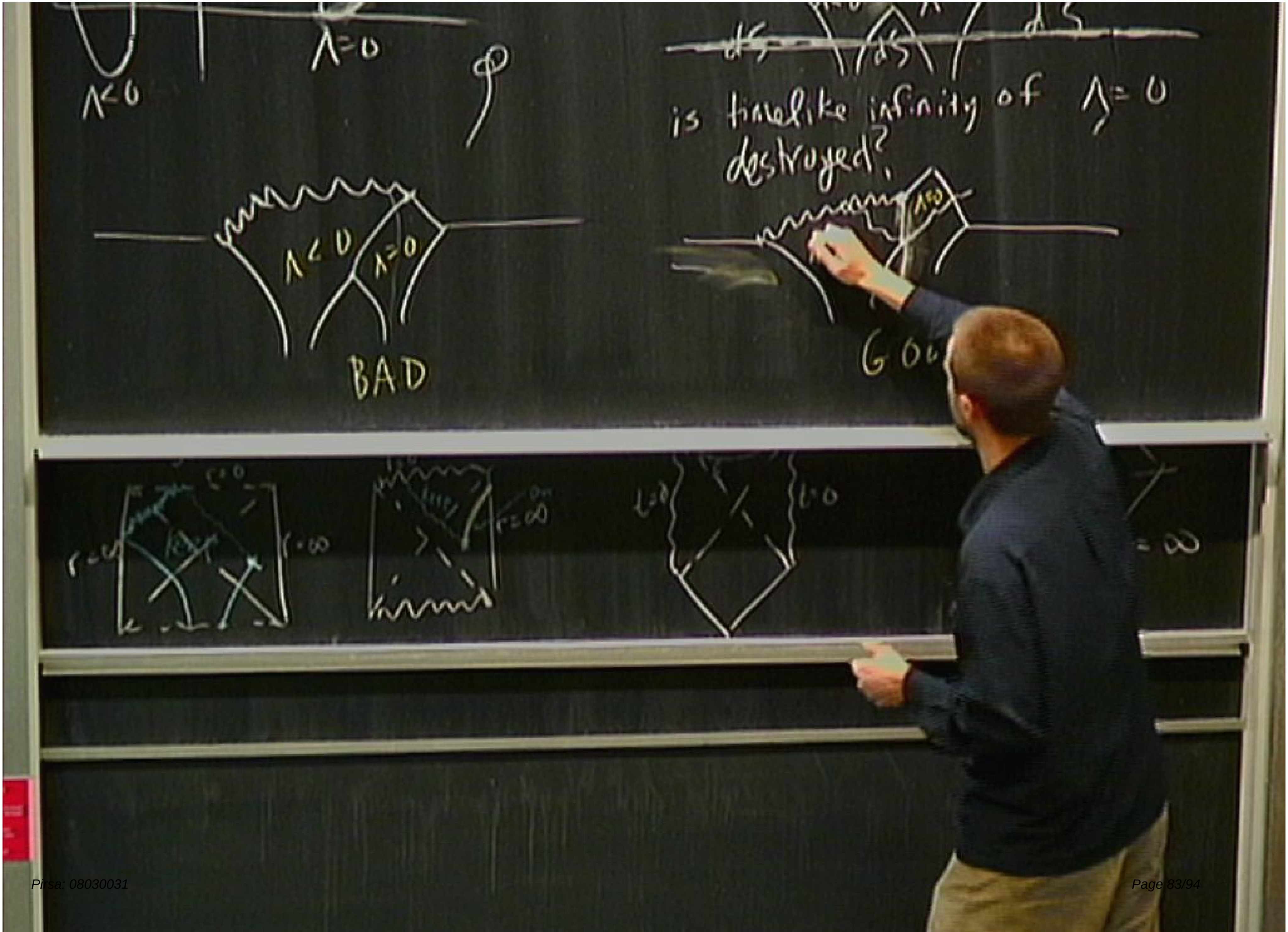


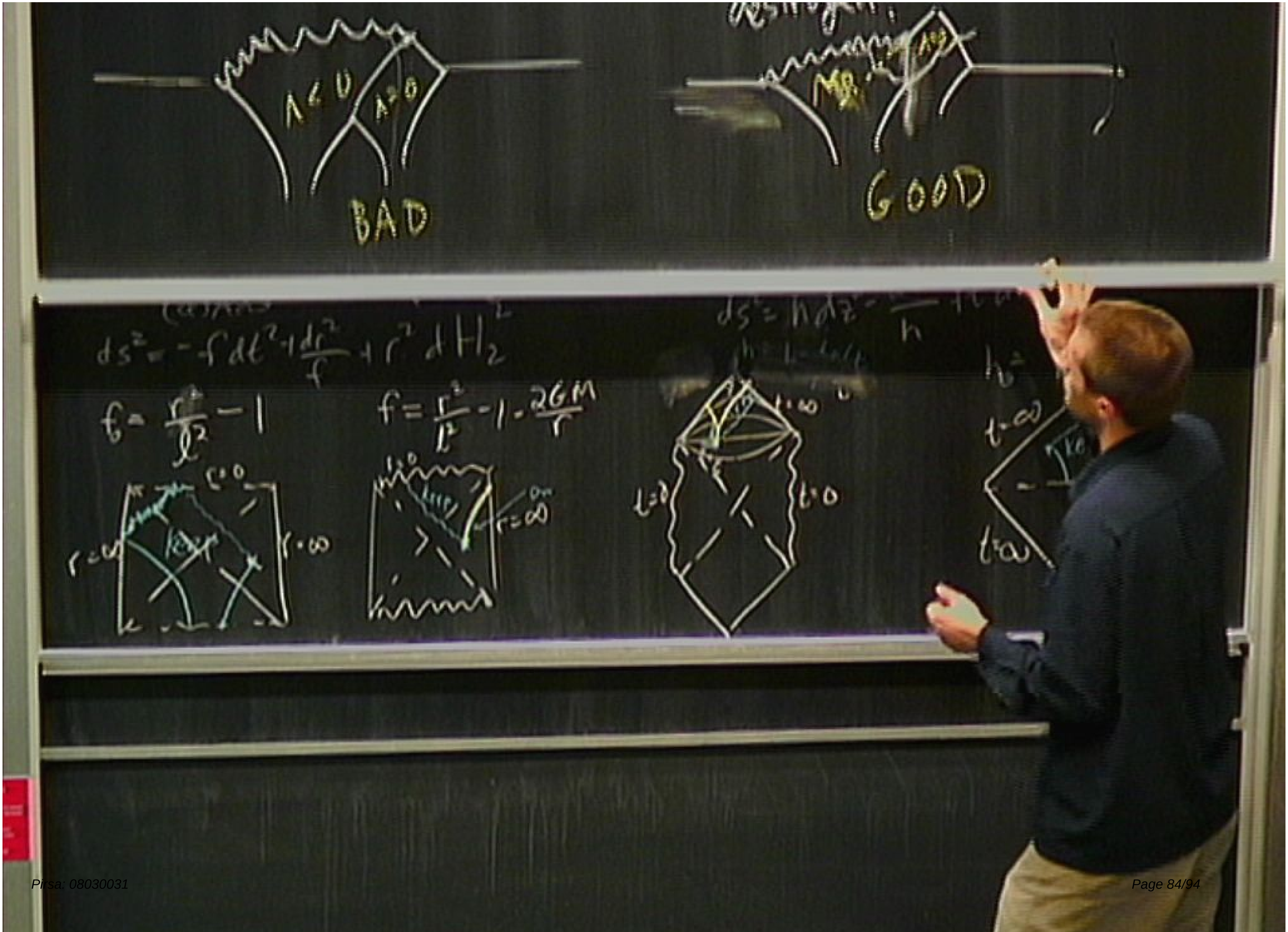
(a) AdS
(b) H Schw AdS
(c) H Schw
(d) Mink
dS
Mink
ds^2 = dz^2 - dt^2
ds^2 = -f dt^2 + dr^2/f + r^2 dH_2^2
f = r^2/l^2 - 1
f = r^2/l^2 - 1 - 2GM/r
ds^2 = h dz^2 - dt^2/h + t^2 dH_2^2
h = 1


dS
Λ<0
Λ=0
?
Λ<0
Λ=0
dS
dS
dS
is timelike infinity of Λ= 0



BAD
Λ<0
Λ>0
ds² = -f dt² + dr²/f + r² dH₂
f = r²/ℓ² - 1
f = r²/ℓ² - 1 - 2GM/r
r=∞
t=0


Λ<0
Λ=0
is timelike infinity of Λ=0
destroyed?
Λ<0
Λ=0
BAD


BAD
GOOD
Λ<0
Λ>0
ds² = -f dt² + dr²/f + r² dH₂
f = r²/ℓ² − 1
f = r²/ℓ² − 1 − 2GM/r
t=0
t=∞
r=∞

$$\sqrt{\dot{R}^2 + \frac{R^2}{\ell^2} - 1 - \frac{2GM}{R}} \pm \sqrt{\dot{R}^2 - 1 + {}^t d_R} = G\sigma R$$

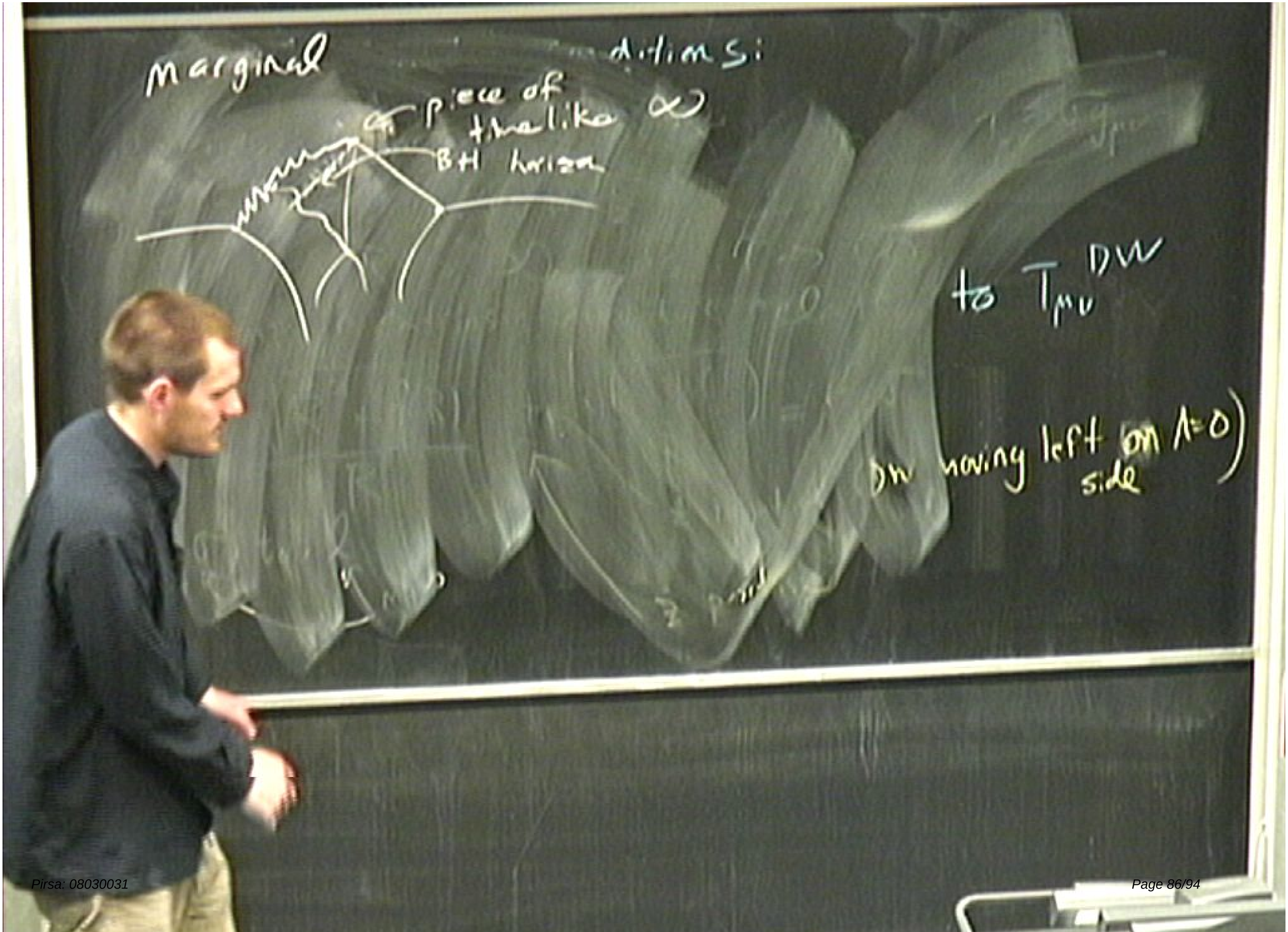
large R:

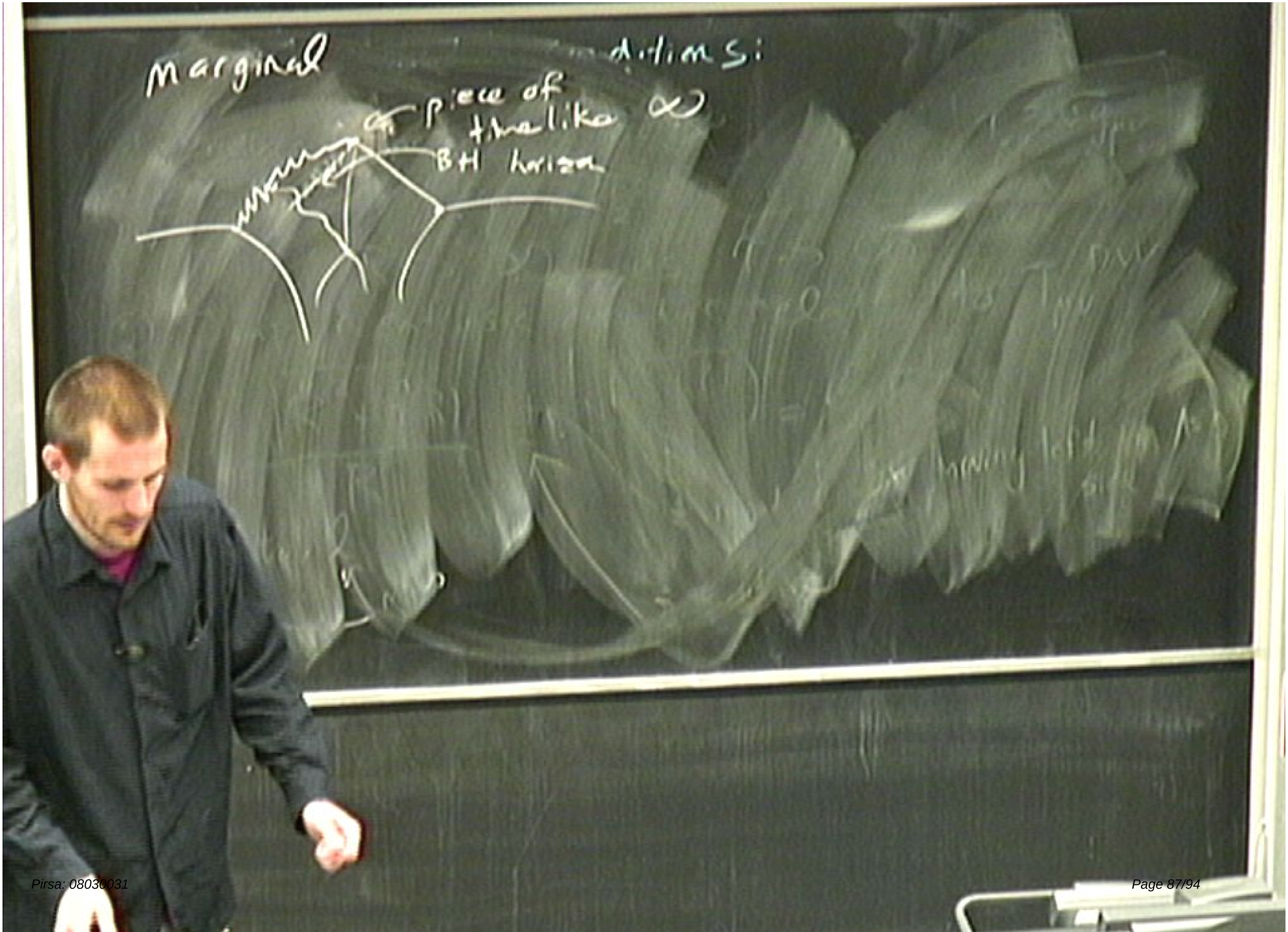
$$\sqrt{\frac{R^2}{\ell^2} + \dot{R}^2 - 1} \pm \sqrt{\dot{R}^2 - 1} = G\sigma R$$

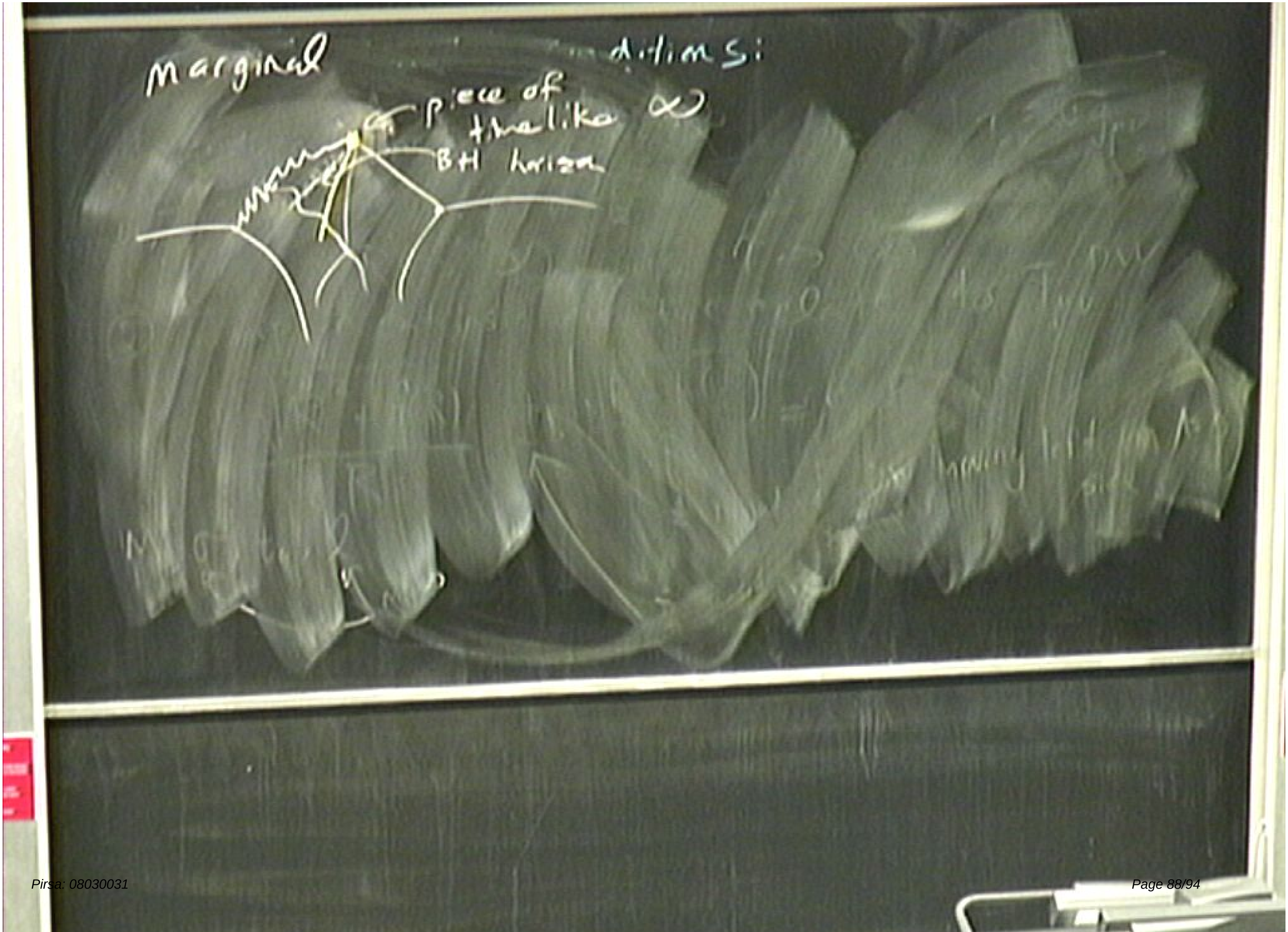
Bad: $-$ sign: LHS $< \frac{R}{\ell} \Leftrightarrow G\sigma < \frac{1}{\ell}$ BAD

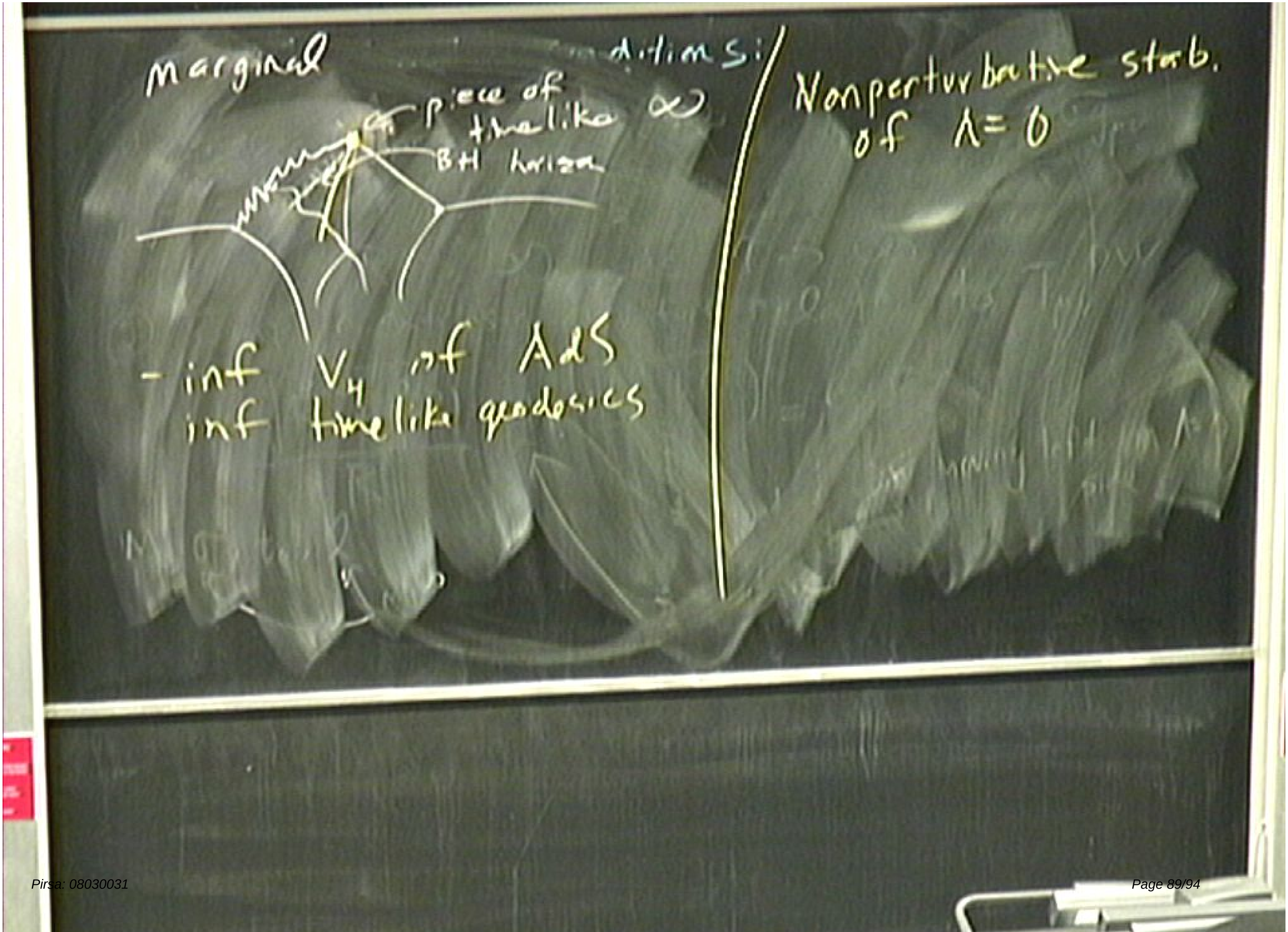
Good: $+$ sign: LHS $> R/\ell \Leftrightarrow G\sigma > 1/\ell$ GOOD

$$\dot{R} = 1 \quad \ddot{R} = 0 \Leftrightarrow G\sigma = 1/\ell$$

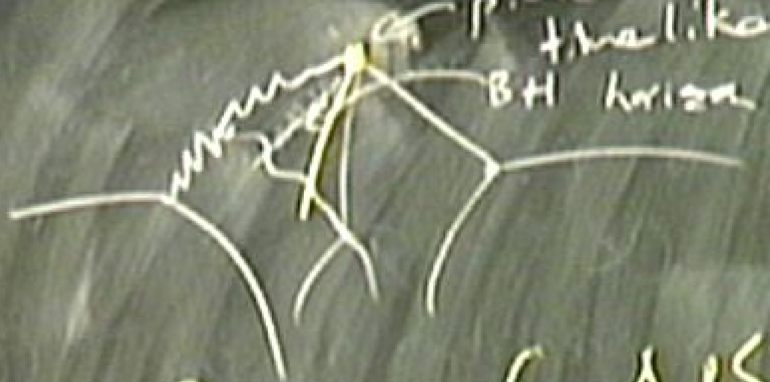

marginal
ditions:
piece of timelike ∞
BH horizon
to T_μν^DW
DW moving left on Λ=0 side)


marginal
piece of
timelike ∞
BH horizon


marginal
piece of
timelike ∞
BH horizon


marginal
piece of timelike ∞
BH horizon
- inf V_4 of AdS
inf timelike geodesics
Nonperturbative stab. of $\Lambda = 0$

marginal ... dims:

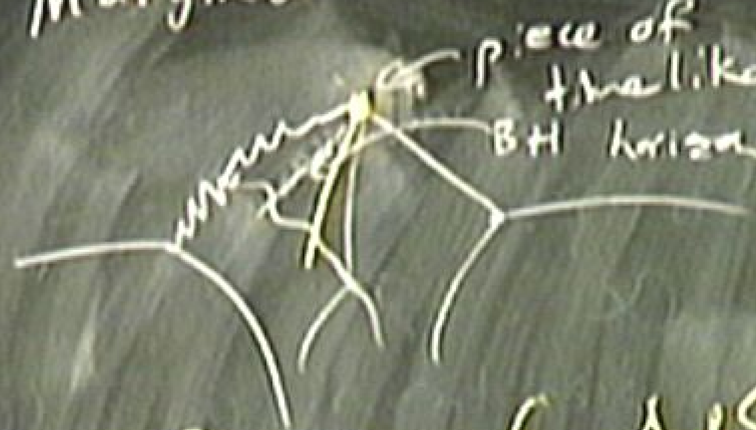


- inf V_4 of AdS
  inf timelike geodesics

Nonperturbative stab. of $\Lambda = 0$

$$G\sigma \geq \frac{1}{\ell}$$

marginal ... d dims:



- inf V_4 of AdS

inf timelike geodesics

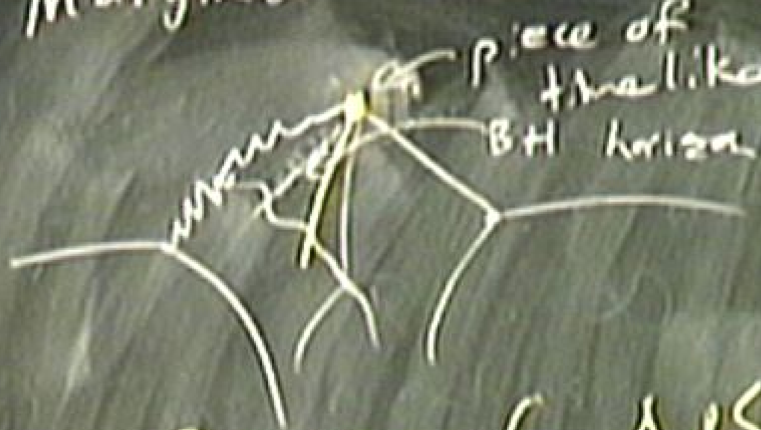
Nonperturbative stab. of $\Lambda = 0$

$$G\sigma \geq \frac{1}{\ell}$$

BPS bound on σ

$$G\sigma \geq \frac{1}{\ell}$$

marginal ...ditions:



- inf V_4 of AdS
inf timelike geodesics

Nonperturbative stab.
of $\Lambda = 0$

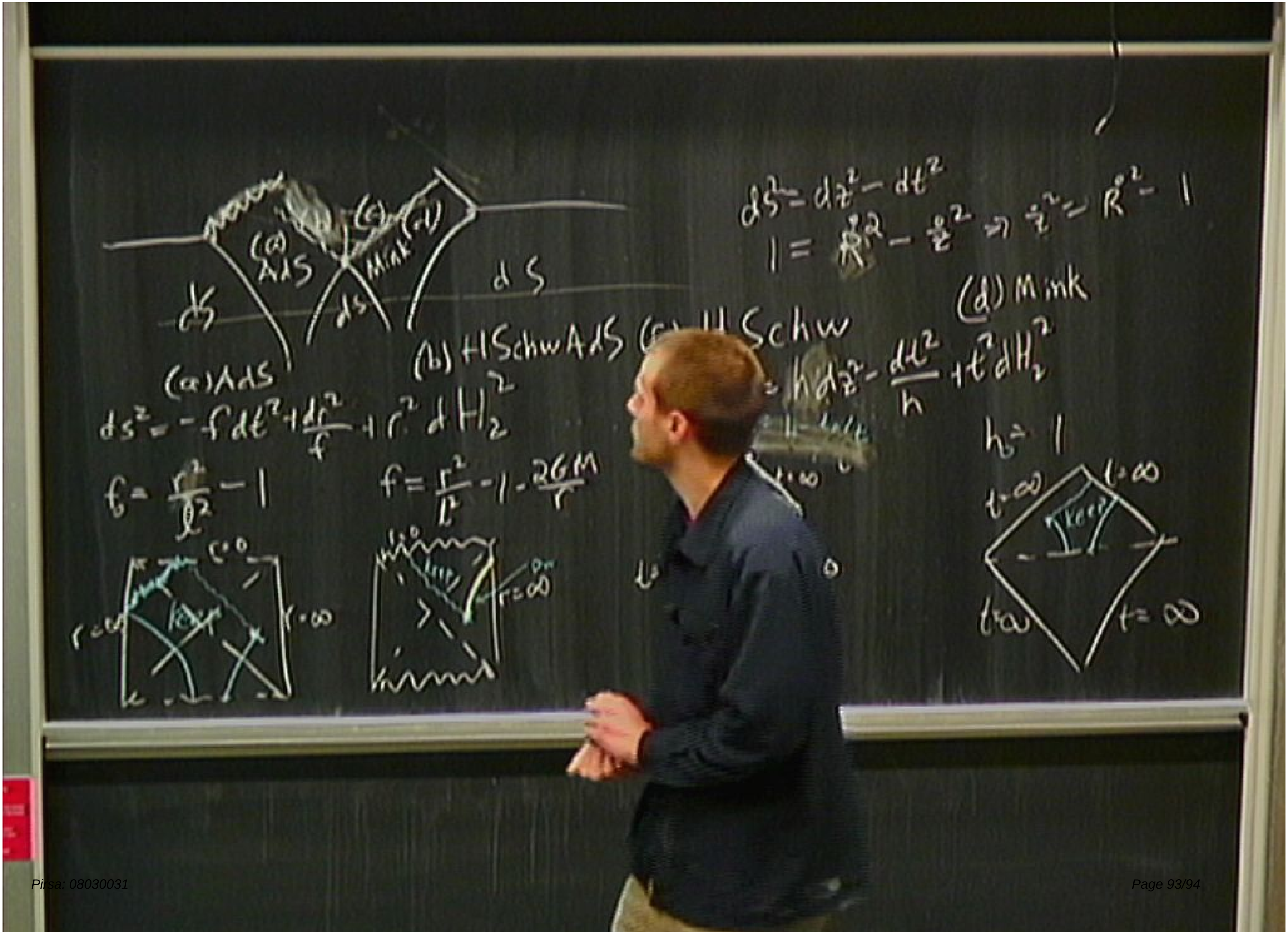
$$G\sigma \geq \frac{1}{\ell}$$

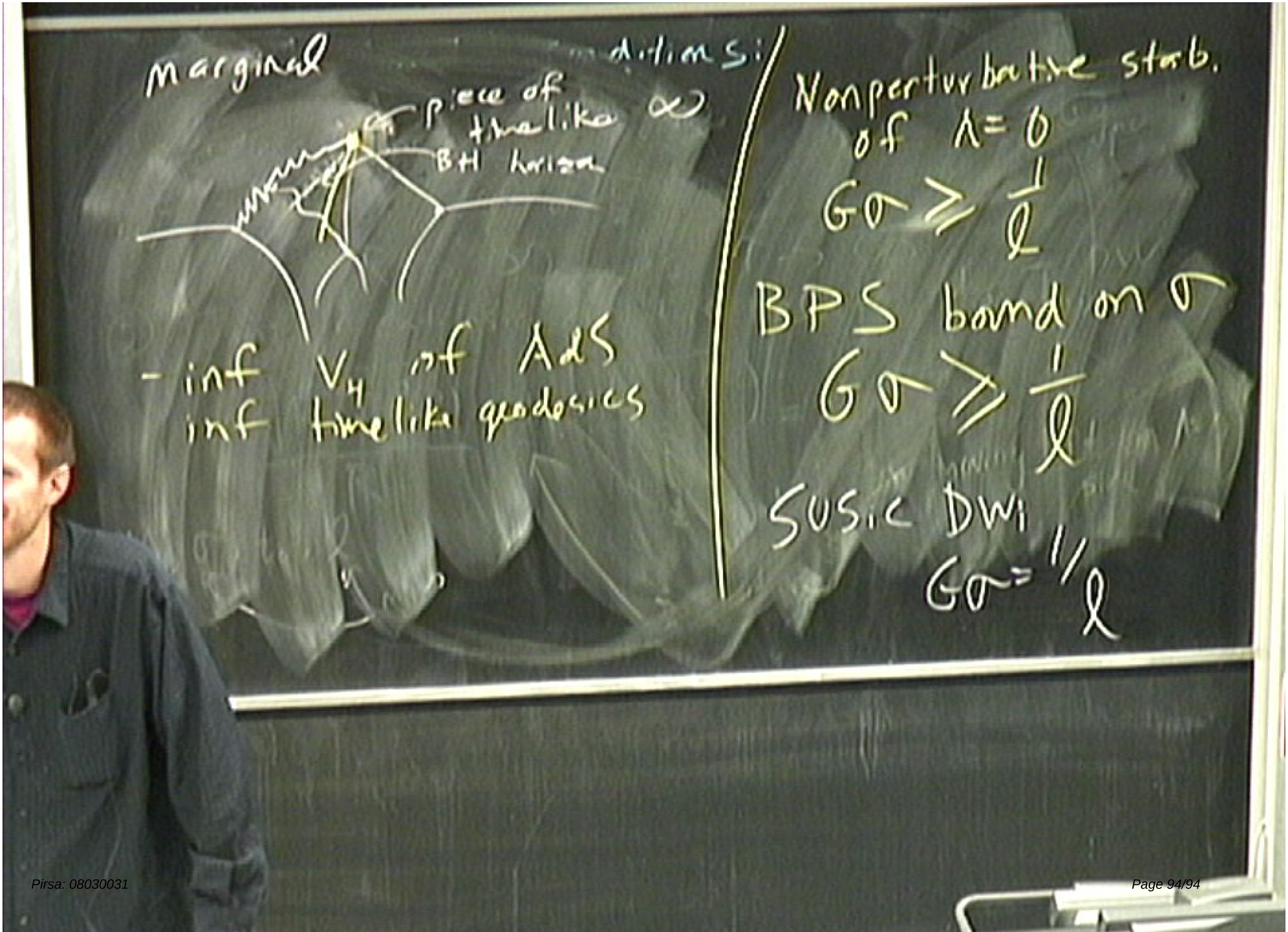
BPS bound on σ

$$G\sigma \geq \frac{1}{\ell}$$

SUSic DWi

$$G\sigma = 1/\ell$$


(a) AdS
(b) H! Schw AdS
(c) H Schw
(d) Mink
dS
$ds^2 = -f\,dt^2 + \frac{dr^2}{f} + r^2\,dH_2^2$
$f = \frac{r^2}{l^2} - 1$
$f = \frac{r^2}{l^2} - 1 - \frac{2GM}{r}$
$ds^2 = dz^2 - dt^2$
$1 = \dot{R}^2 - \dot{z}^2 \Rightarrow \dot{z}^2 = \dot{R}^2 - 1$
(d) Mink
$h\,dz^2 - \frac{dt^2}{h} + t^2\,dH_2^2$
$h = 1$
$t = \infty$
$r = \infty$
keep


marginal
piece of timelike ∞
BH horizon
- inf V4 of AdS
inf timelike geodesics
Nonperturbative stab.
of Λ = 0
Gσ ≥ 1/ℓ
BPS bound on σ
Gσ ≥ 1/ℓ
SUSic DWs
Gσ = 1/ℓ