Title: Explorations in String Theory (PHYS 647) - Lecture 15

Date: Mar 04, 2010 11:20 AM

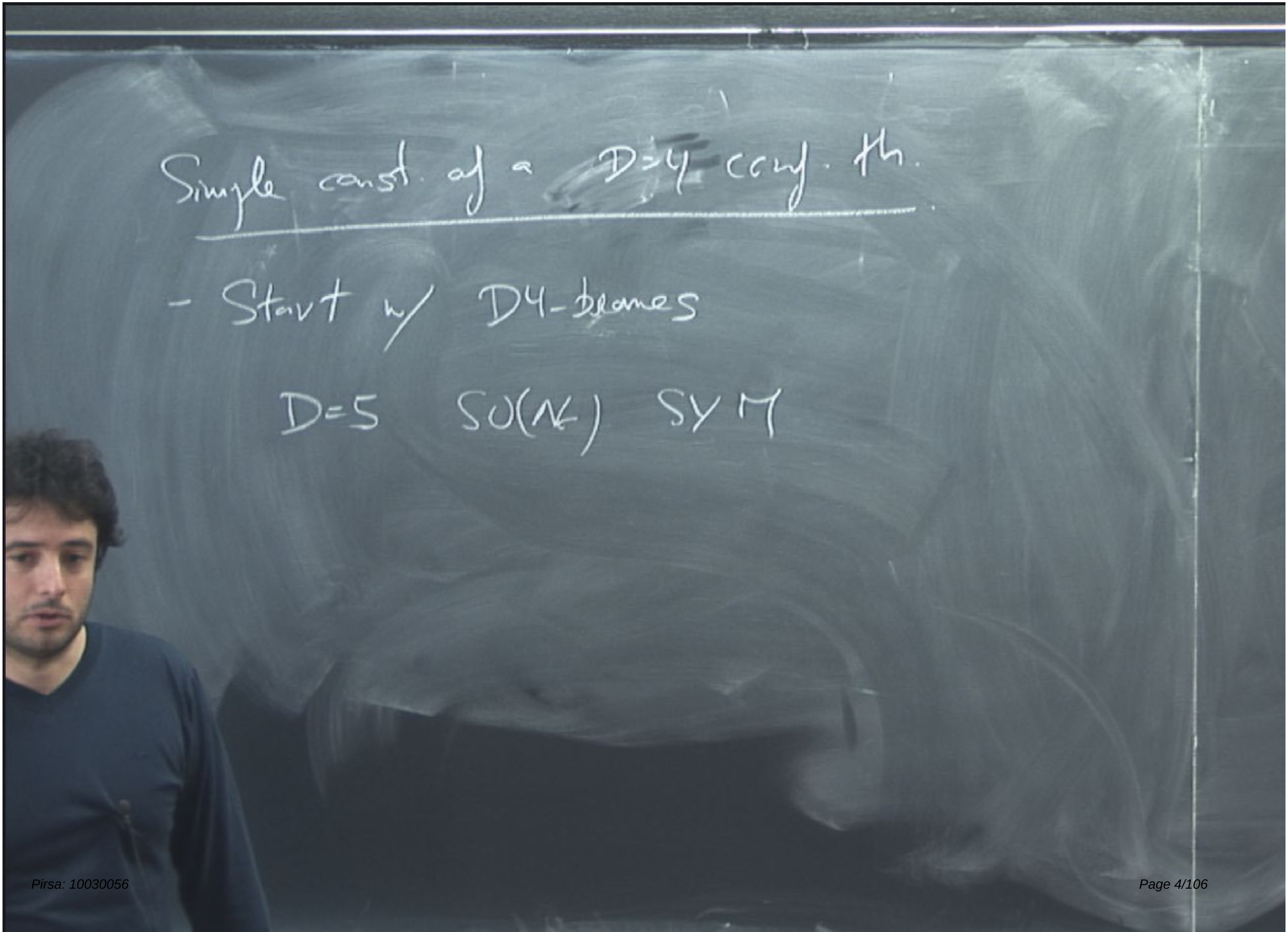
URL: http://pirsa.org/10030056

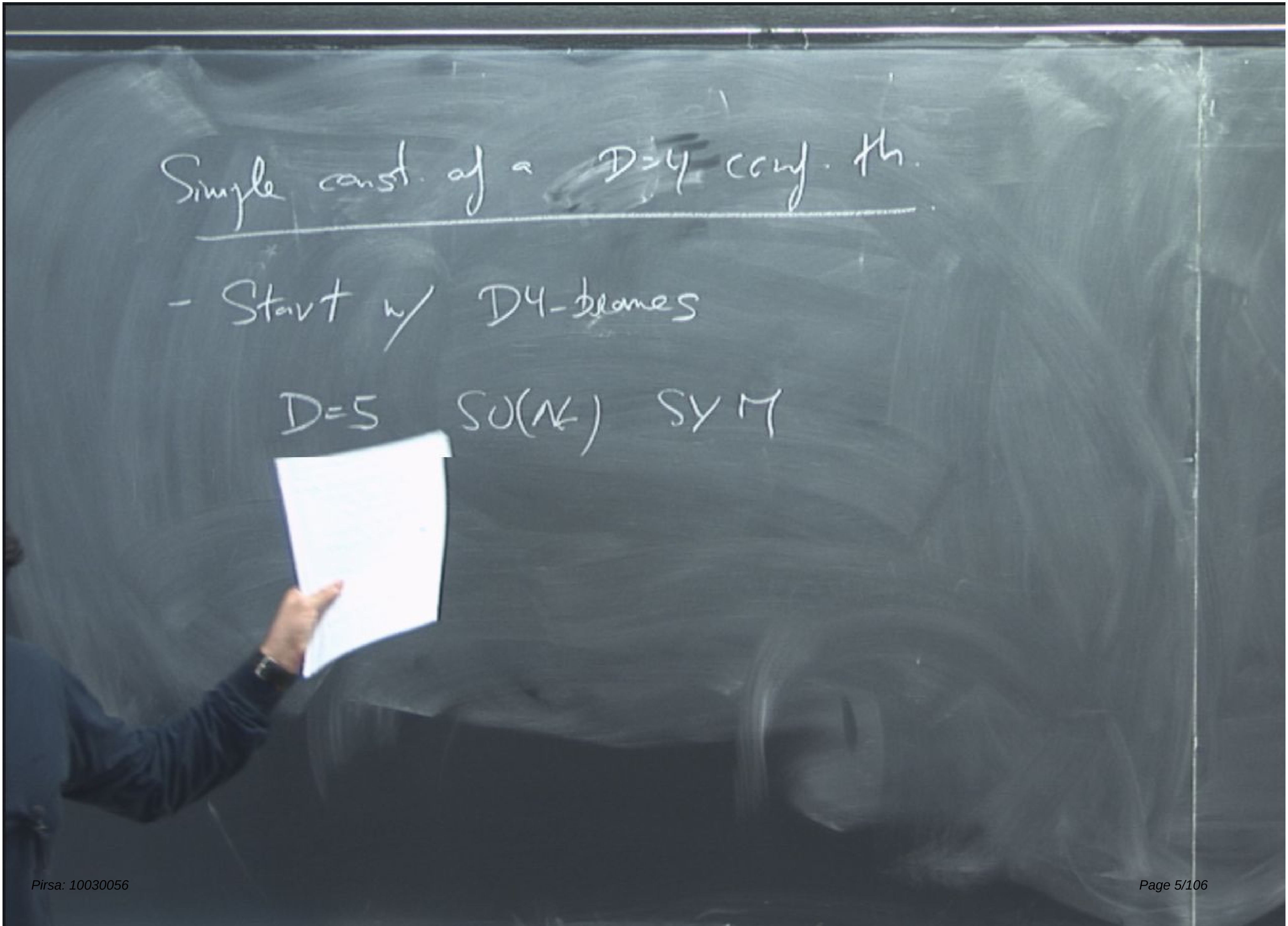
Abstract:

4) Conf./Deconf. Phase transition

Simple const. of a $D=4$ conf. th.

- Start w/ D4-branes


Simple const. of a D=4 conf. th.
- Start w/ D4-branes
D=5 SU(N_c) SYM


Simple const. of a D=4 conf. th.
- Start w/ D4-branes
D=5 SU(Nc) SYM

Simple const. of a D=4 conf. th.

- Start w/ D4-branes

$D=5 \quad SU(N) \quad SYM$

$$\Big\{ \underset{1}{A_\mu} + \underset{1/2}{\text{fermions}} + \underset{0}{\text{scalars}} \Big\}$$

Simple const. of a $D=4$ conf. th.

- Start w/ D4-branes

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- 

Simple const. of a D=4 conf. th.

- Start w/ D4-branes

$$D=5 \quad SU(N) \quad SYM$$

$$\left\{ \underset{1}{A_\mu} + \underset{1/2}{\text{fermions}} + \underset{0}{\text{scalars}} \right\}$$

- S^1_L Antiperiod. for fermions around S^1_L $\Rightarrow$ ~~Fermion Zero Mode~~

Simple const. of a $D=4$ conf. th.

- Start w/ D4-branes

$D=5$ $SU(N_c)$ SYM

$$\left\{ \underset{1}{A_\mu} + \underset{1/2}{\text{fermions}} + \underset{0}{\text{scalars}} \right\}$$

- S^1_L

Antiperiod. for fermions around S^1_L $\Rightarrow$ ~~Fermion Zero Modes~~

Simple const. of a D=4 conf. th.

- Start w/ D4-branes

$$D=5 \quad SU(N_c) \quad SYM$$

$$\Phi(x,y) = \sum \phi_n(x)\, e^{iny/L}$$

$$\left.\begin{array}{ccc} A_\mu + & \text{fermions} + & \text{scalars} \\ 1 & \tfrac{1}{2} & 0 \end{array}\right\}$$

$$M^2_{4D} = M^2_{5D} + n^2/L^2$$

S^1_L

Antiperiod. for fermions around S^1_L $\Rightarrow$ ~~Fermion Zero Mode~~

const. of a $D=4$ conf. th.

t w/ D4-branes

$D=5$ $SU(N_c)$ SYM

$\left.\begin{array}{ccccc} A_\mu & + \text{ fermions} & + & \text{scalars} \\ 1 & \tfrac{1}{2} & & 0 \end{array}\right\}$

S^1_L

Antiperiod. for fermions around S^1_L $\Rightarrow$ ~~Fermion Zero Mode~~ $\Rightarrow M_F^2 \sim 1/L^2$

- Scalars 1-loop

-Scalars 1-loop mass

$\Rightarrow M_F^2 \sim 1/L^2$

$\Rightarrow$ F, S become massive

$M \sim 1/L$

Simple const. of a D=4 conf. th.

- Start w/ D4-branes

D=5 $SU(N)$ SYM

[A_μ + fermions + scalars]

S^1

Antiperio…

fermions ar…

Simple const. of a $D=4$ conf. th.

- Start w/ D4-branes

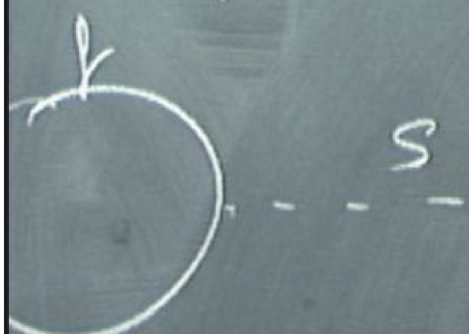
$D=5$ $SU(N_c)$ SYM

$$\left\{ \underset{1}{A_\mu} + \underset{1/2}{\text{fermions}} + \underset{0}{\text{scalars}} \right\}$$

S^1_L

Antiperiod. for fermions around S^1_L $\Rightarrow$ ~~Fermion zero mod.~~ $\Rightarrow$

L loop mass



$\Rightarrow$ F, S become massive

$M \sim 1/L$

$\Rightarrow E \ll M$

$1/L^2$

loop mass

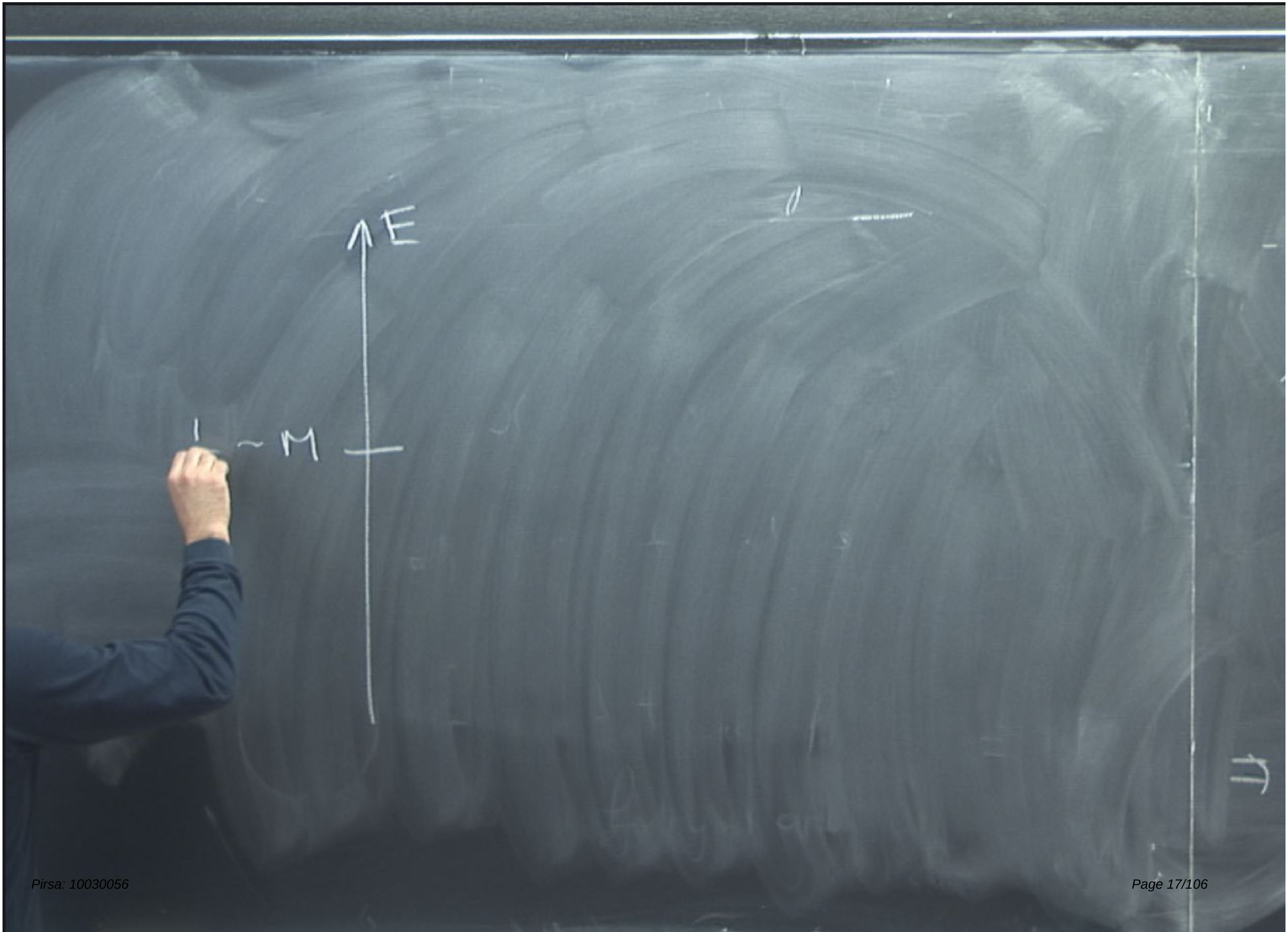
$\Rightarrow$ F, S become massive

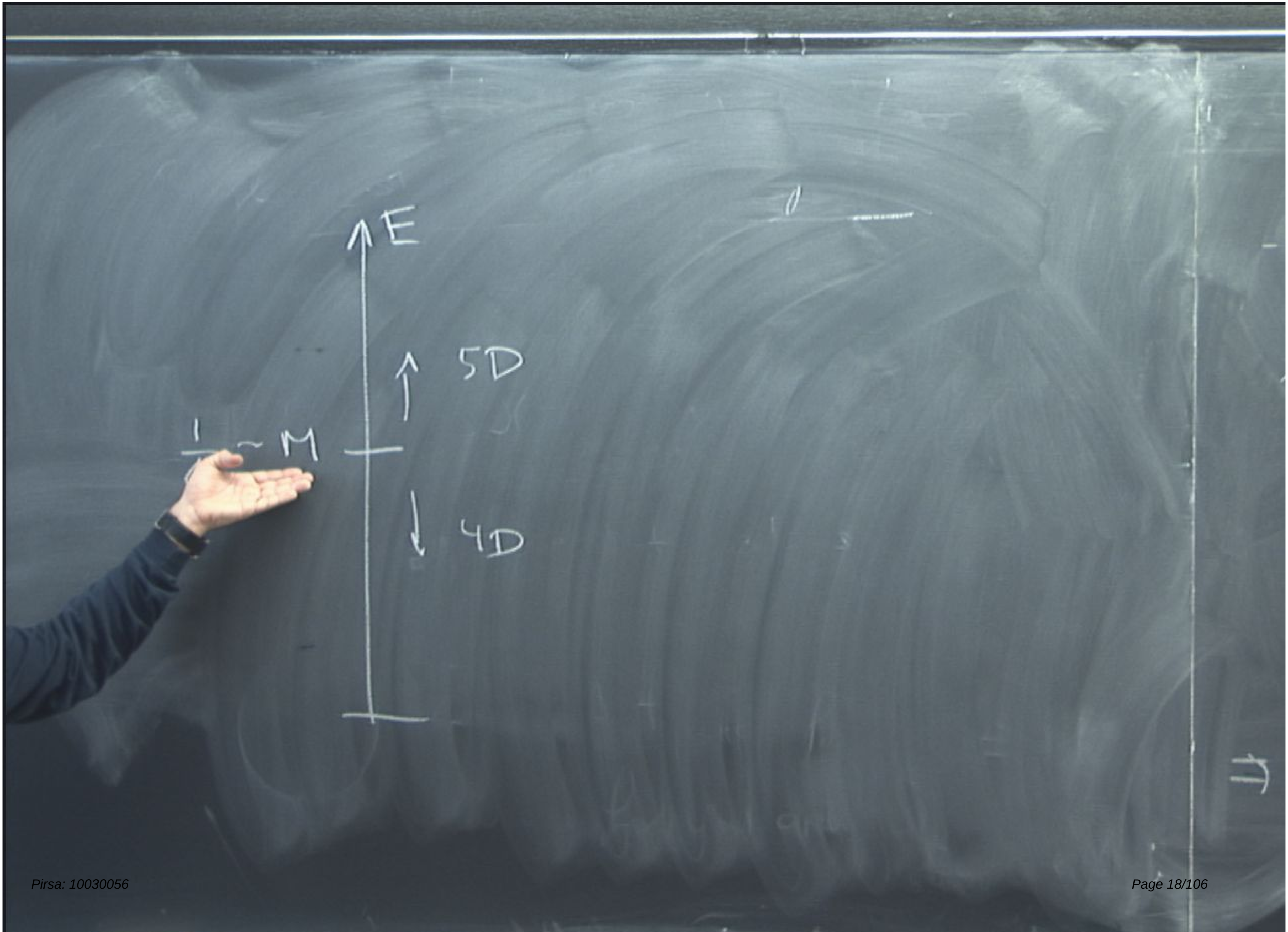
$M \sim 1/L$

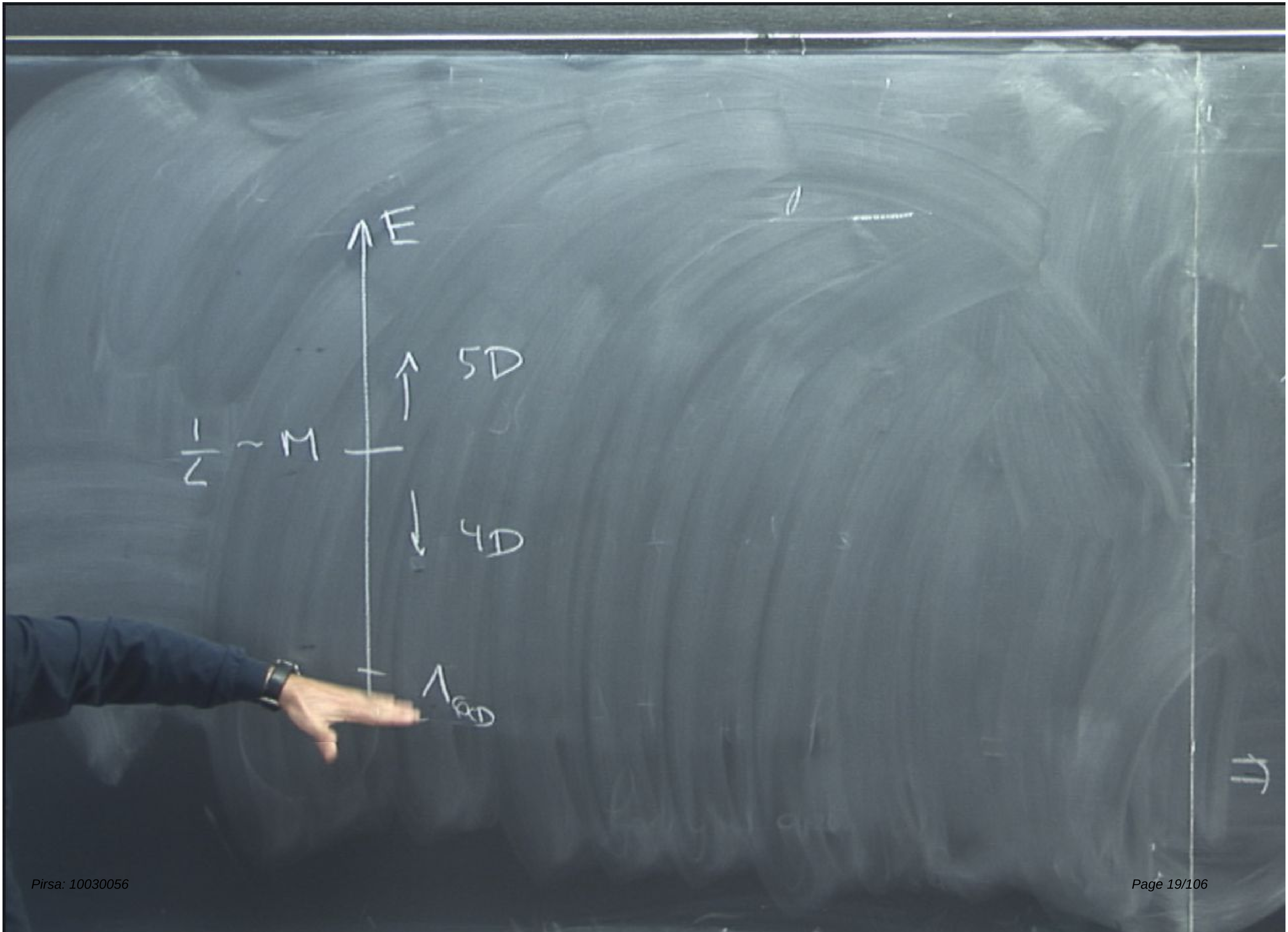
$\Rightarrow E \ll M$

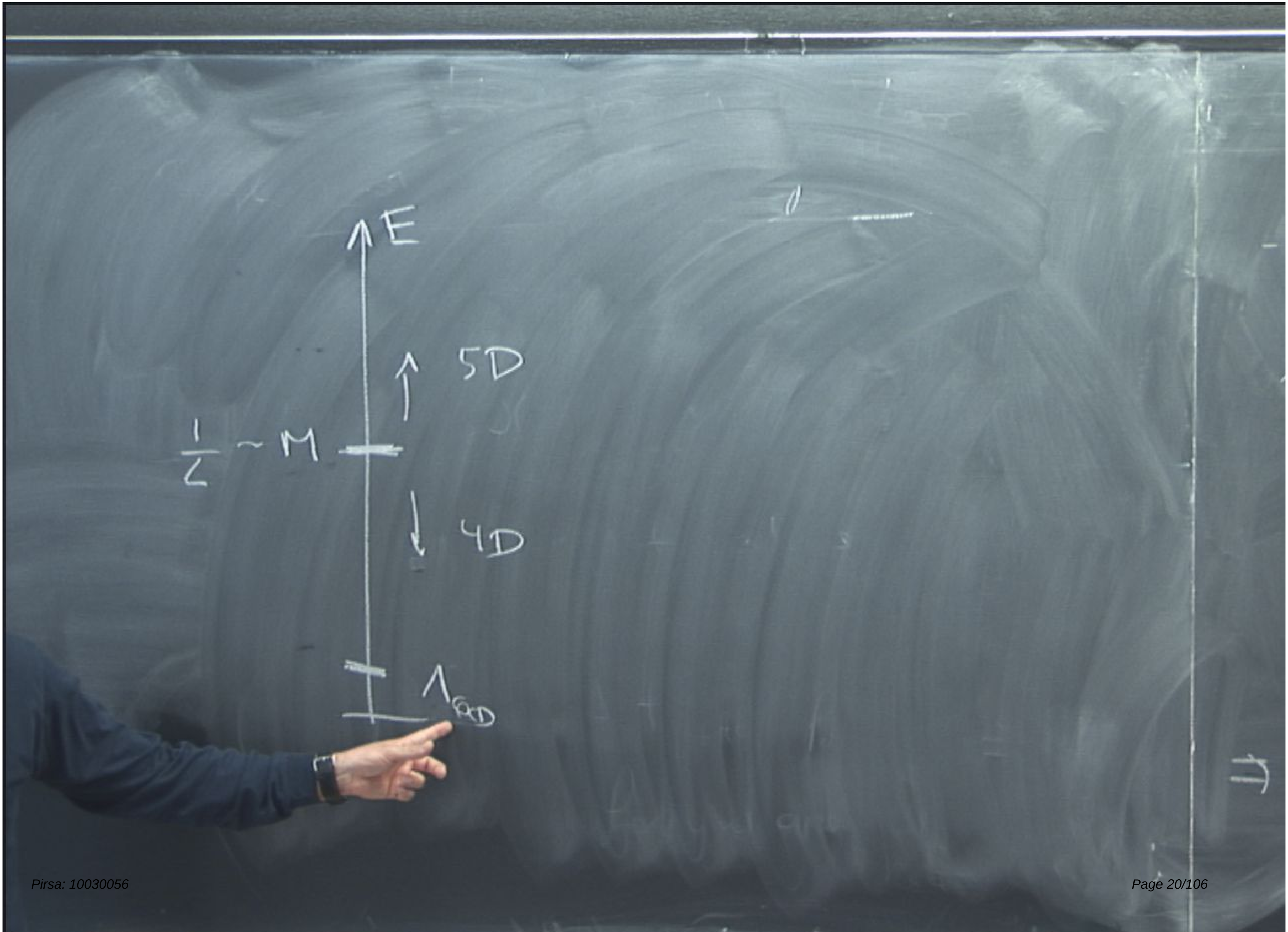
$\boxed{\text{Massless } A_\mu^a}$

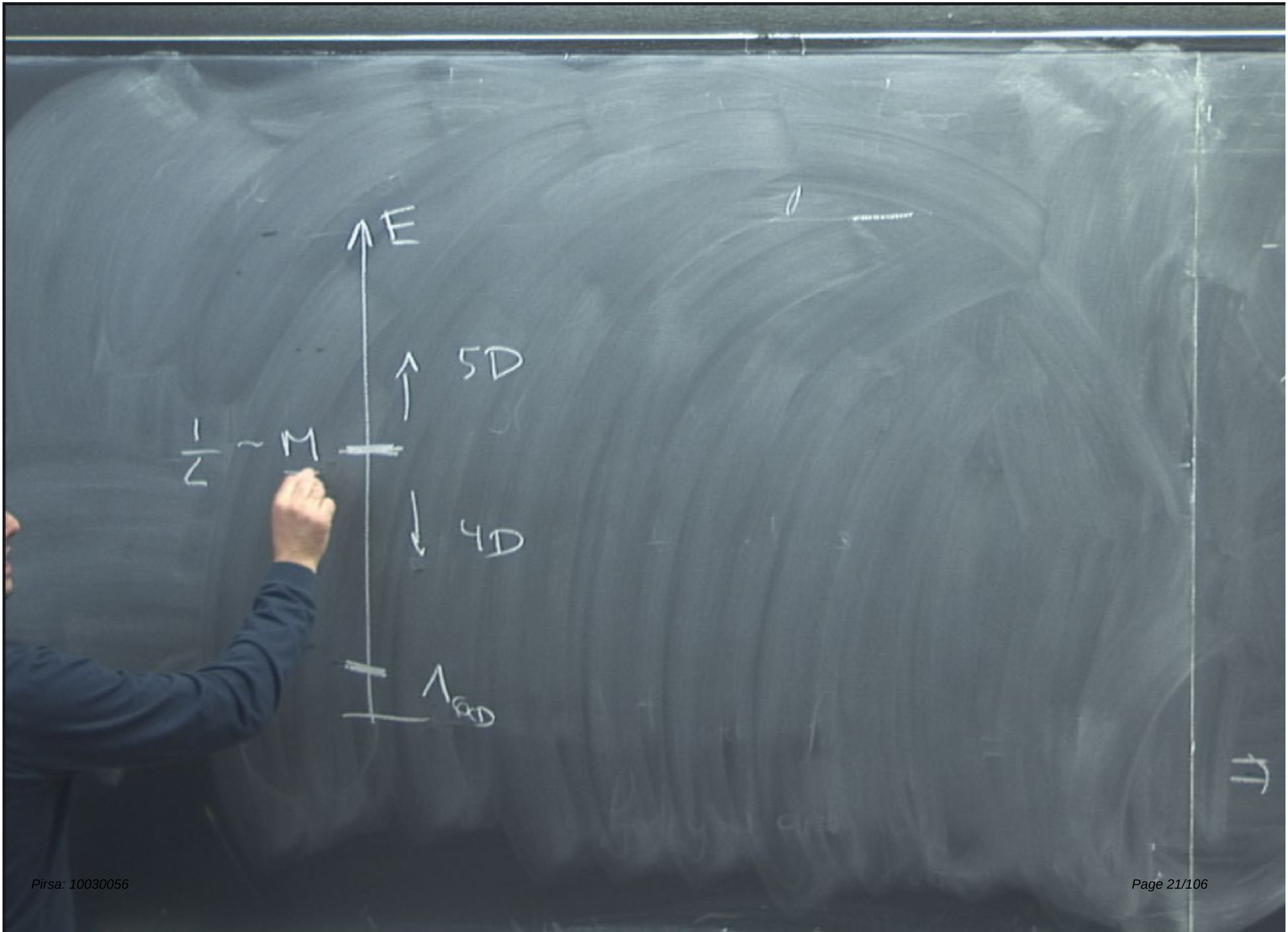
L^2

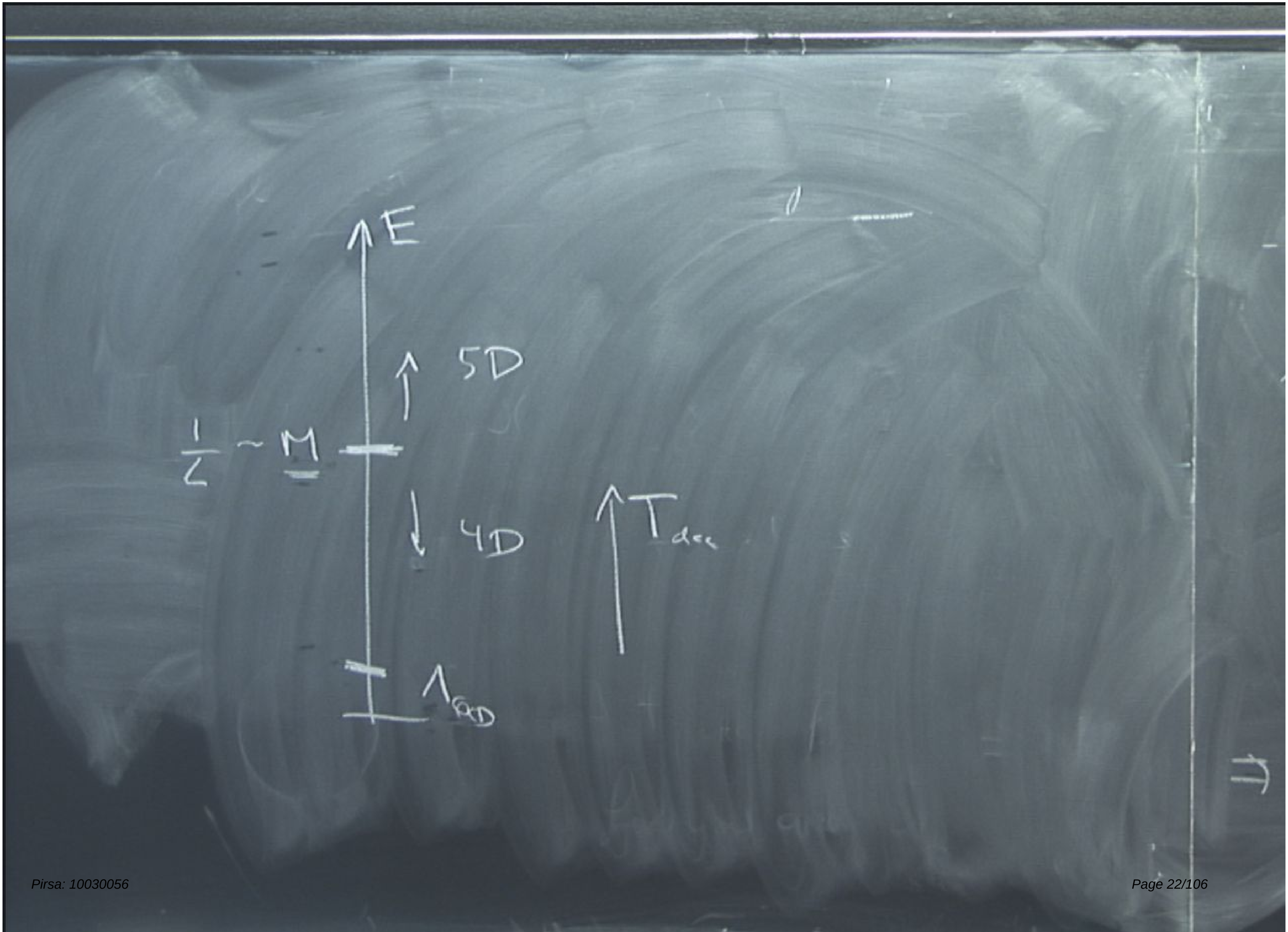

E
~ M

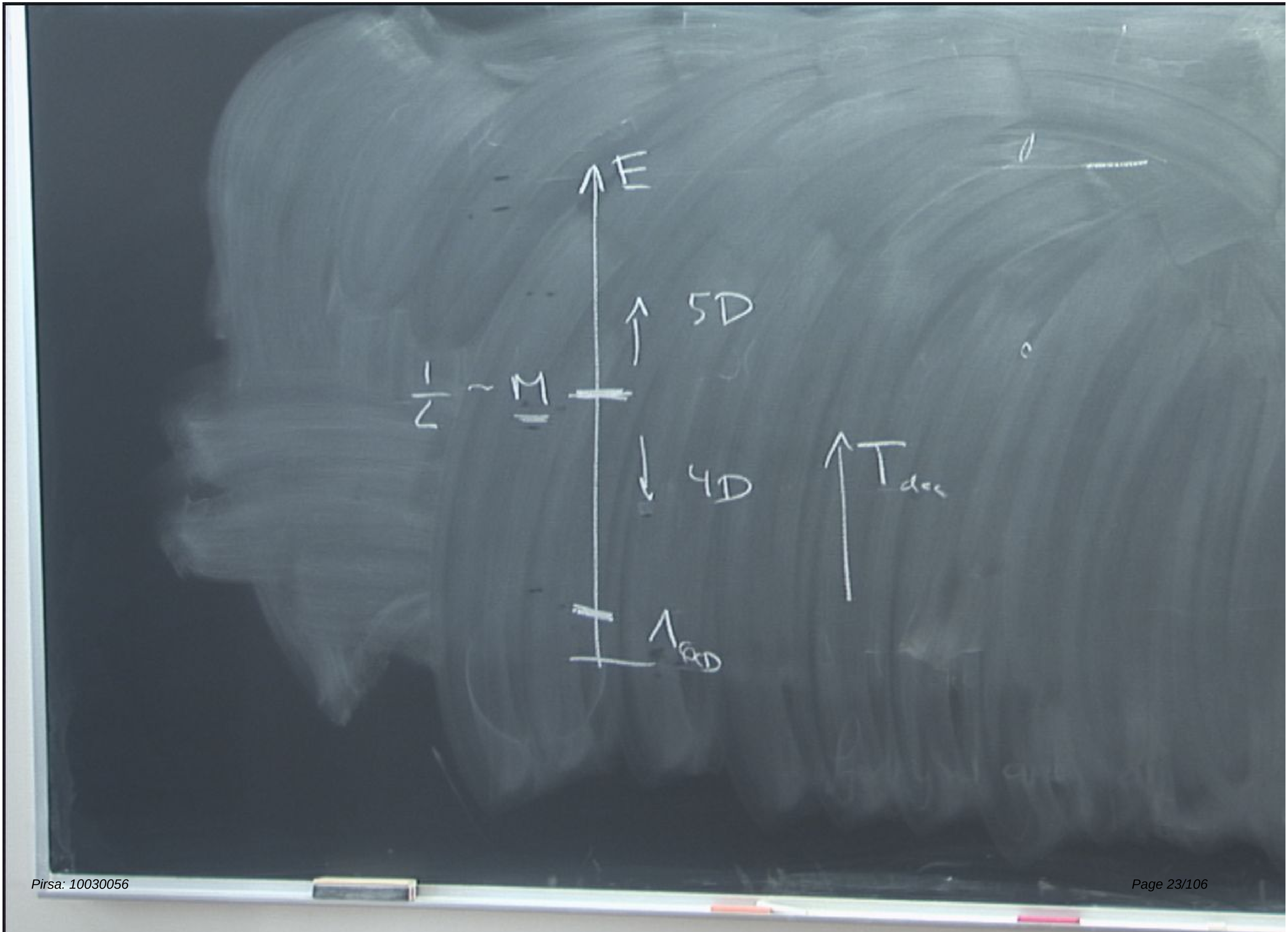

E
5D
4D
~ M


E
5D
1/L ~ M
4D
Λ_QCD


E
5D
1/L ~ M
4D
Λ_QCD

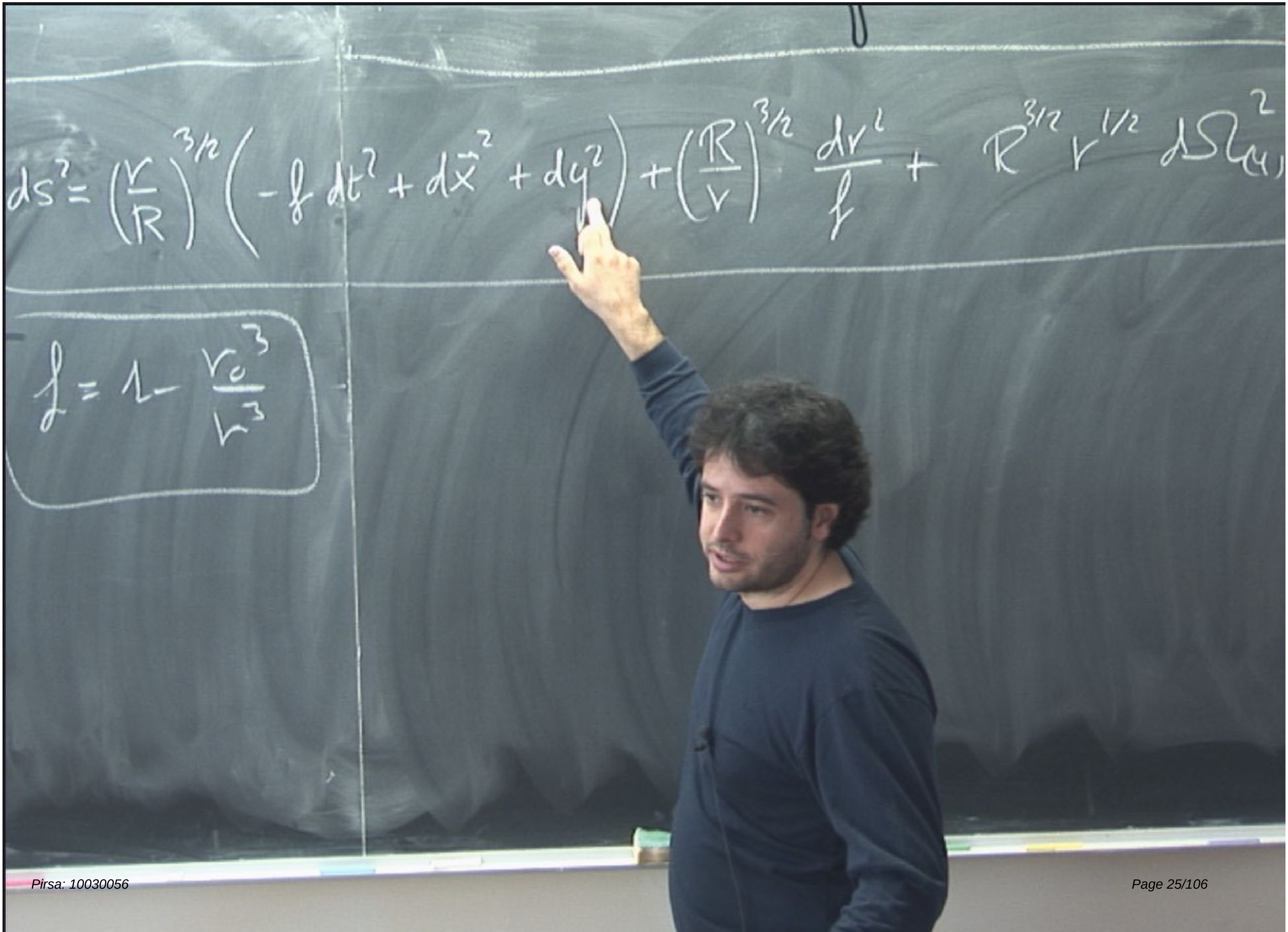

E
5D
1/L ~ M
4D
Λ_QCD


E
5D
$\frac{1}{L} \sim M$
4D
T_{dec}
Λ_{QCD}


E
5D
1/L ~ M
4D
T_dec
Λ_QCD

$$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + d\vec{x}^{\,2} + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f} + R^{3/2}\, r^{1/2}\, d\Omega$$

f


$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + d\vec{x}^2 + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f} + R^{3/2} r^{1/2} d\Omega_{(4)}^2$
$f = 1 - \frac{r_0^3}{r^3}$

$$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + d\vec{x}^{\,2} + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f} + R^{3/2}\, r^{1/2}\, d\Omega_{(4)}^2$$

$$\boxed{f = 1 - \frac{r_0^3}{r^3}}$$

Horizon $r = r_0$

$$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + d\vec{x}^2 + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f} + R^{3/2}\, r^{1/2}\, d\Omega_{(4)}^2$$

$$\boxed{f = 1 - \frac{r_0^3}{r^3}}$$

$$\boxed{e^{\Phi} = \left(\frac{r}{R}\right)^{3/4}}$$

Horizon $r = r_0$

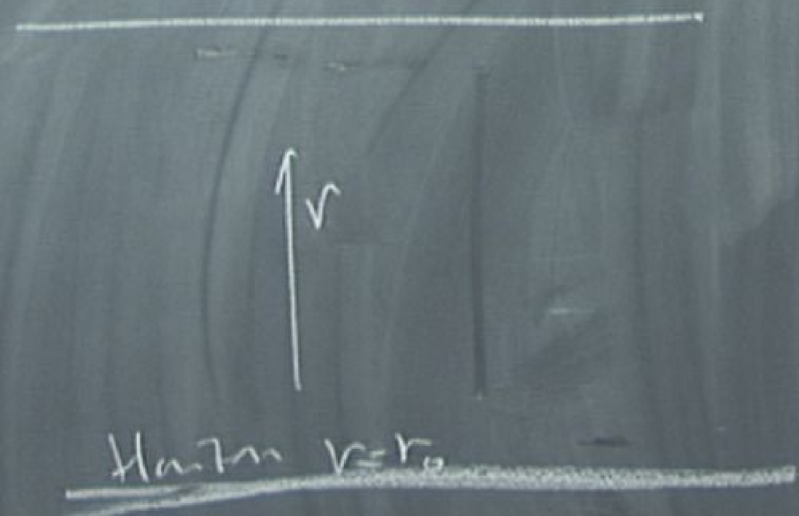
$R \neq$

$e^{\Phi} \neq$

e^{Φ}

$g_{eff} \sim e$

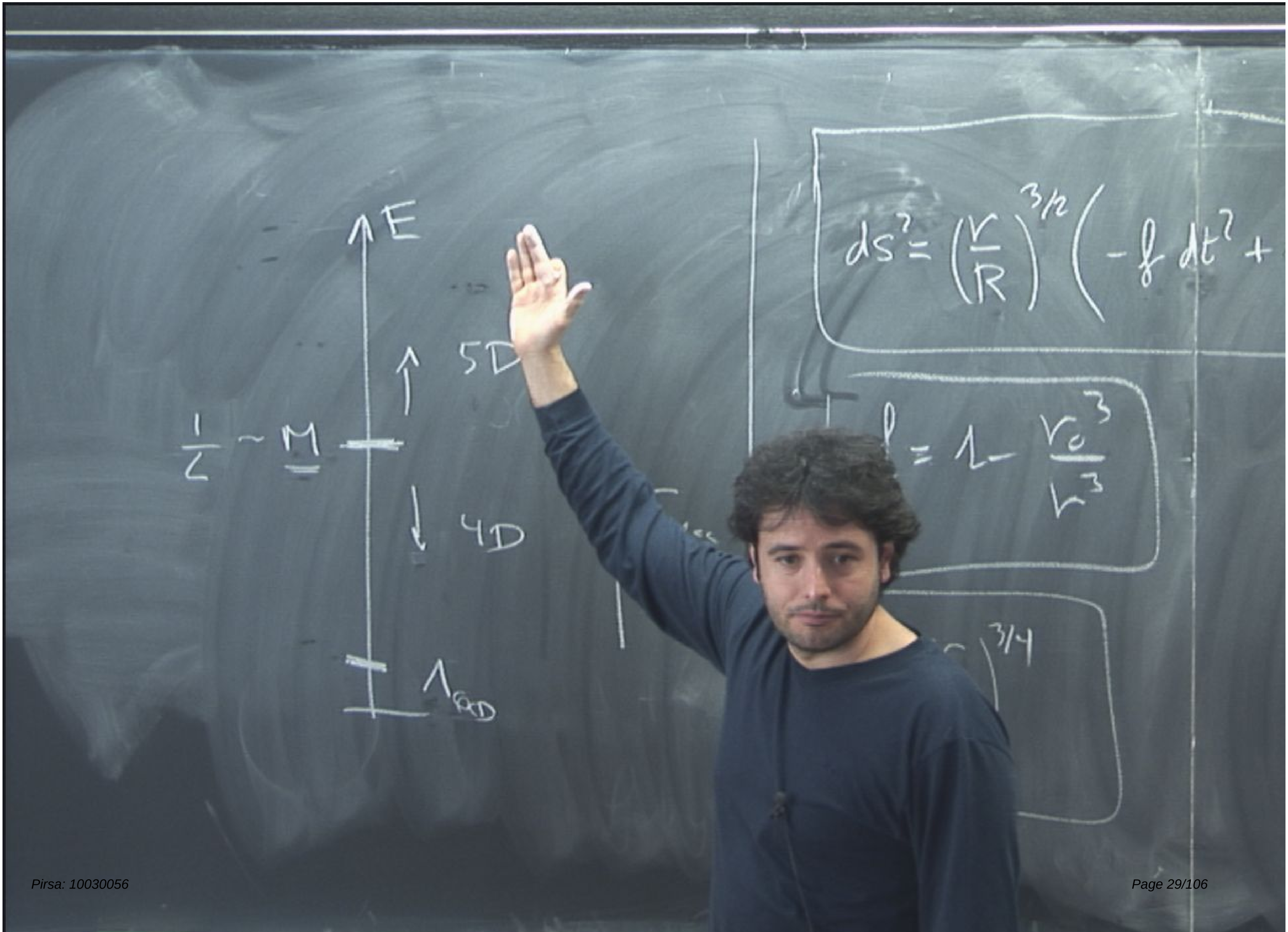
$$f\,dt^2 + d\vec{x}^2 + dy^2\Big) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f} + R^{3/2} r^{1/2}\, d\Omega_{(4)}^2$$

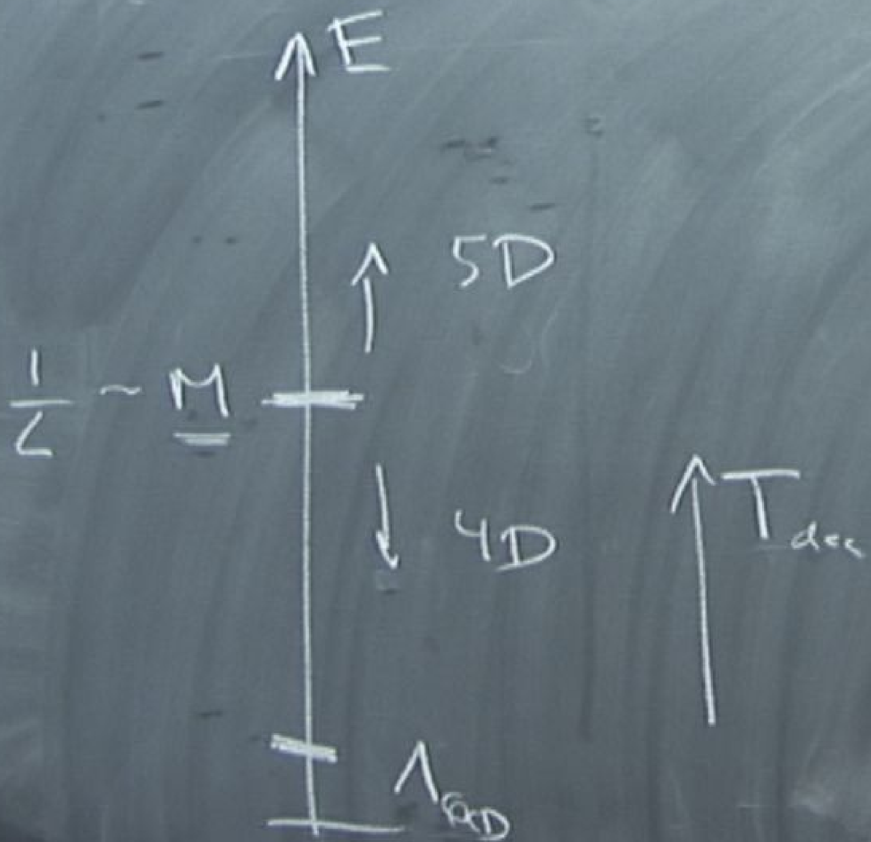


$$R \neq \text{const}$$

$$e^{\Phi} \neq \text{const}$$

$$g_{eff} \sim e^{\Phi} \sim g_{YM}^2$$


E
5D
1/L ~ M
4D
Λ_QCD
ds² = (r/R)^{3/2} (−f dt² +
f = 1 − r_0³/r³
3/4



$$\boxed{ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + \right.}$$

$$\boxed{f = 1 - \frac{r_0^3}{r^3}}$$

$$\boxed{e^{\Phi} = \left(\frac{r}{R}\right)^{3/4}}$$

$$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}+R^{3/2}\,r^{1/2}\,d\Omega^2_{(4)}$$

$$R \neq \text{const.}$$

$$e^{\Phi} \neq \text{const.}$$

$$g_{eff} \sim e^{\Phi} \sim g^2_{YM}$$

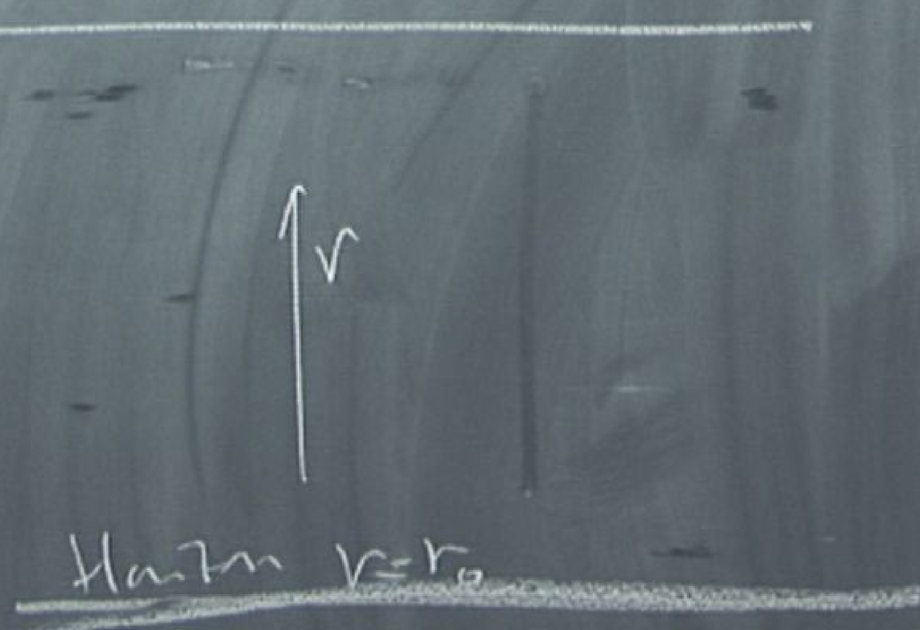
r

$r = r_0$

$$\ldots\Big)^{3/2}\left(-f\,dt^2 + d\vec{x}^{\,2} + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f} + R^{3/2}\,r^{1/2}\,d\ldots$$

$$\ldots - \frac{r_0^{\,3}}{r^3}$$

$$\ldots\Big)^{3/4}$$



R

e

g_{eff}

E

$g^2_{5D}\, E$

5D

$\frac{1}{L} \sim M$

4D

T_{dec}

Λ_{QCD}

$$\boxed{ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + \right.}$$

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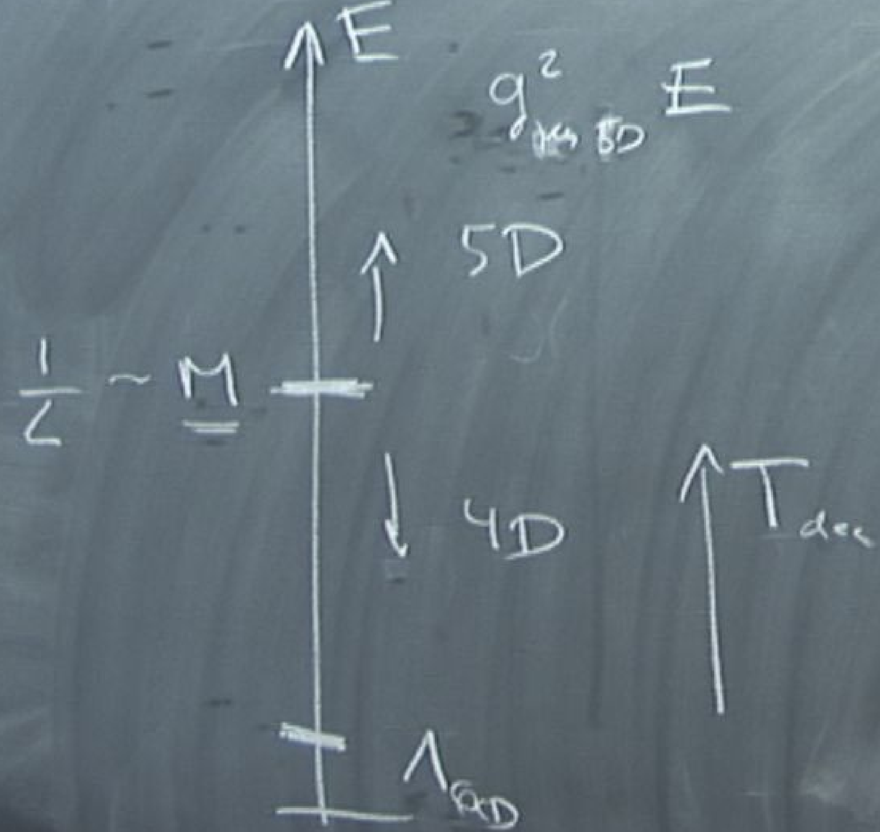

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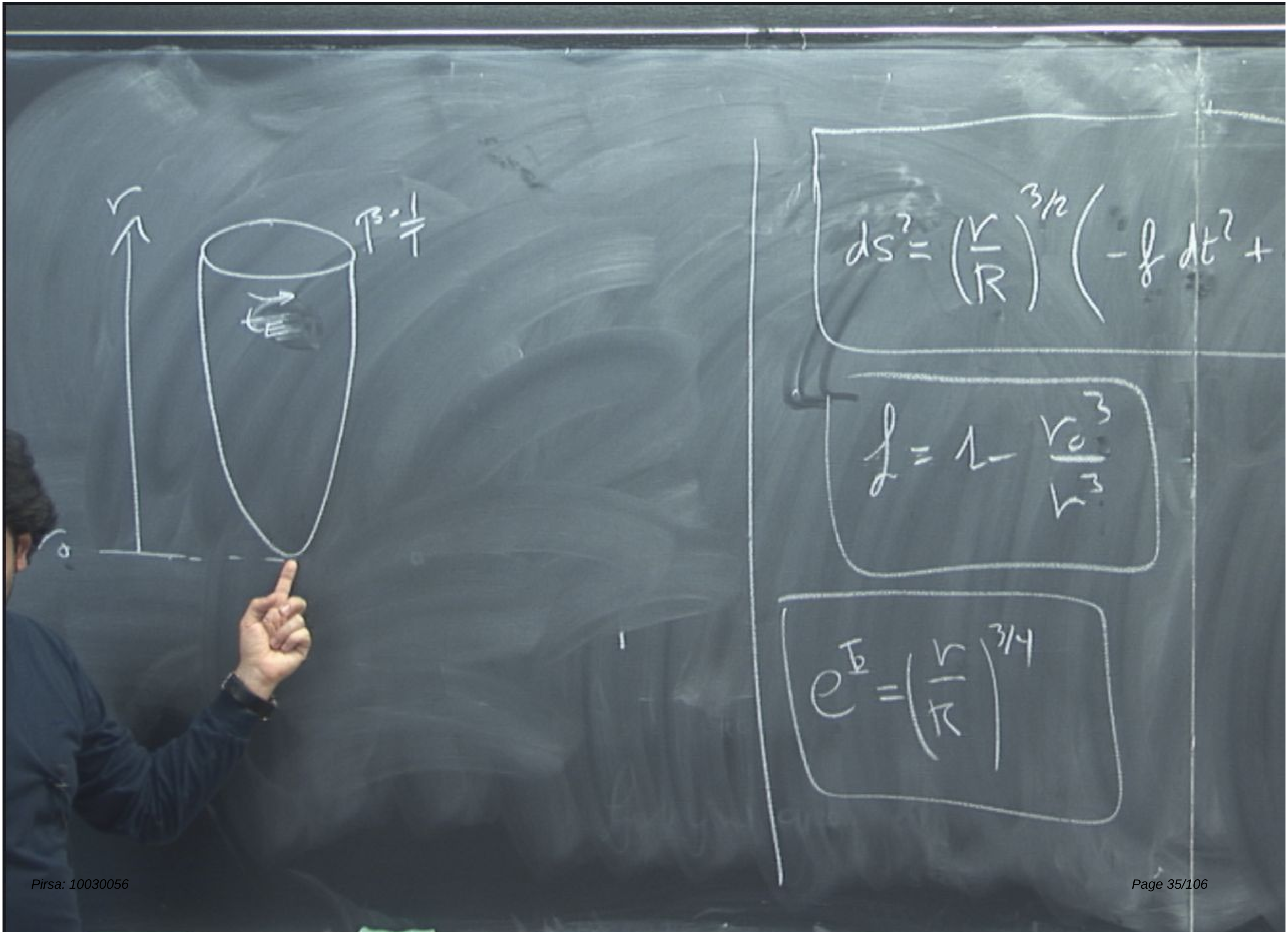
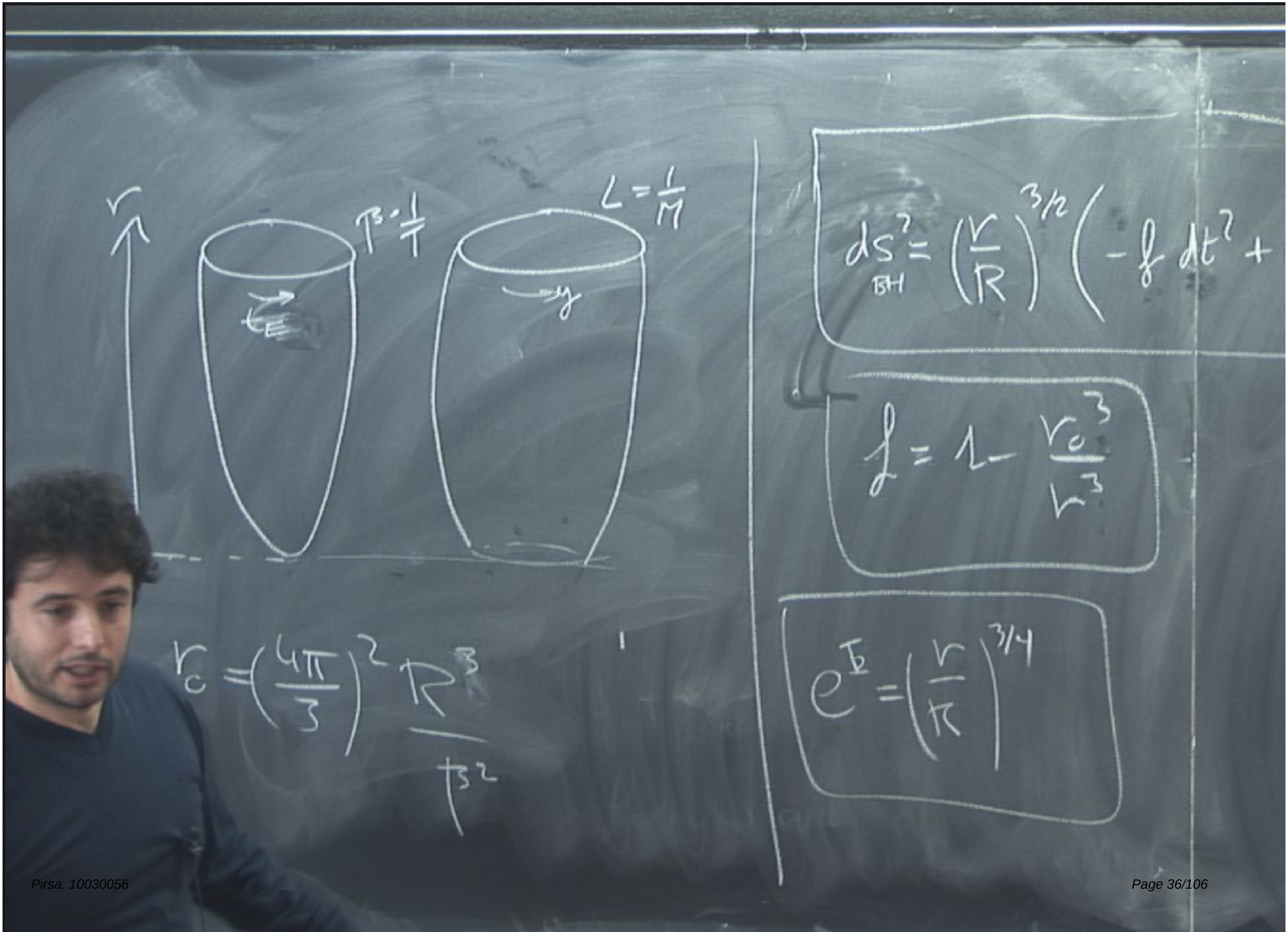

r
$\beta = \frac{1}{T}$
t_E
0
$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 +\right.$
$f = 1 - \frac{r_0^3}{r^3}$
$e^{\Phi} = \left(\frac{r}{R}\right)^{3/4}$

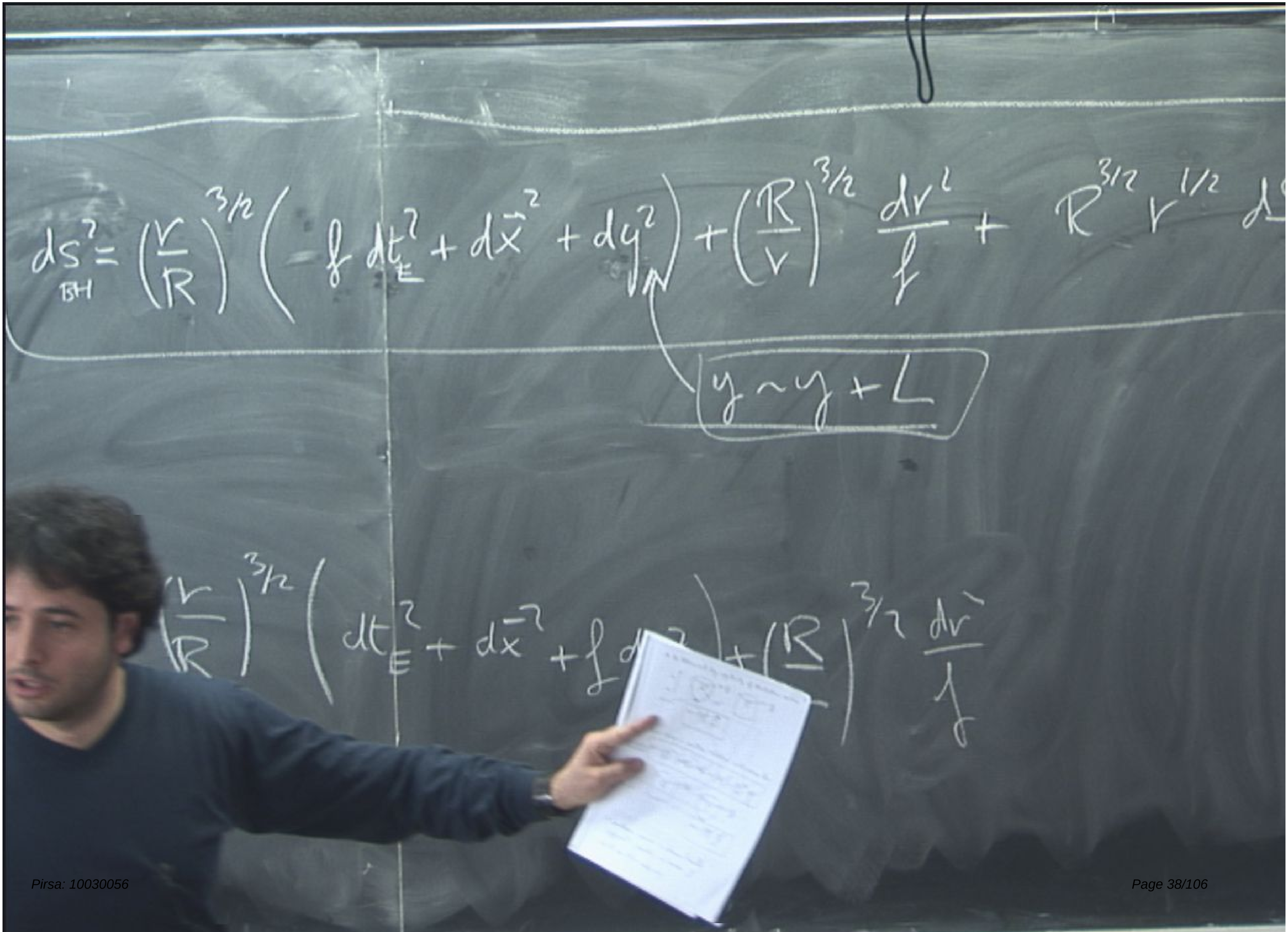

r
$\beta = \frac{1}{T}$
$L = \frac{1}{M}$
t_E
y
$r_c = \left(\frac{4\pi}{3}\right)^2 \frac{R^3}{\beta^2}$
$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 +\right.$
$f = 1 - \frac{r_c^3}{r^3}$
$e^{\Phi} = \left(\frac{r}{R}\right)^{3/4}$

$L = \frac{1}{M}$

$$\boxed{ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt_E^2 + d\vec{x}^{\,2} + dy^2\right) + \left(\frac{R}{r}\right)^{3/2} \frac{d}{f}}$$

$$\boxed{y \sim y + L}$$

$$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(dt_E^2 + d\vec{x}^{\,2} + f\,dy^2\right) + \left(\frac{R}{r}\right)^{3/2}$$



$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt_E^2 + d\vec{x}^2 + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f} + R^{3/2} r^{1/2} d$
$y \sim y + L$
$\left(\frac{r}{R}\right)^{3/2}\left(dt_E^2 + d\vec{x}^2 + f\,d\right) + \left(\frac{R}{\ }\right)^{3/2}\frac{dr^2}{f}$

$$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt_E^2 + d\vec{x}^2 + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

$$\boxed{y \sim y + L}$$

$$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(dt_E^2 + d\vec{x}^2 + f\,dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

r

r_0

$$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt_E^2 + d\vec{x}^2 + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

$$\boxed{y \sim y + L}$$

$$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(dt_E^2 + d\vec{x}^2 + f\,dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

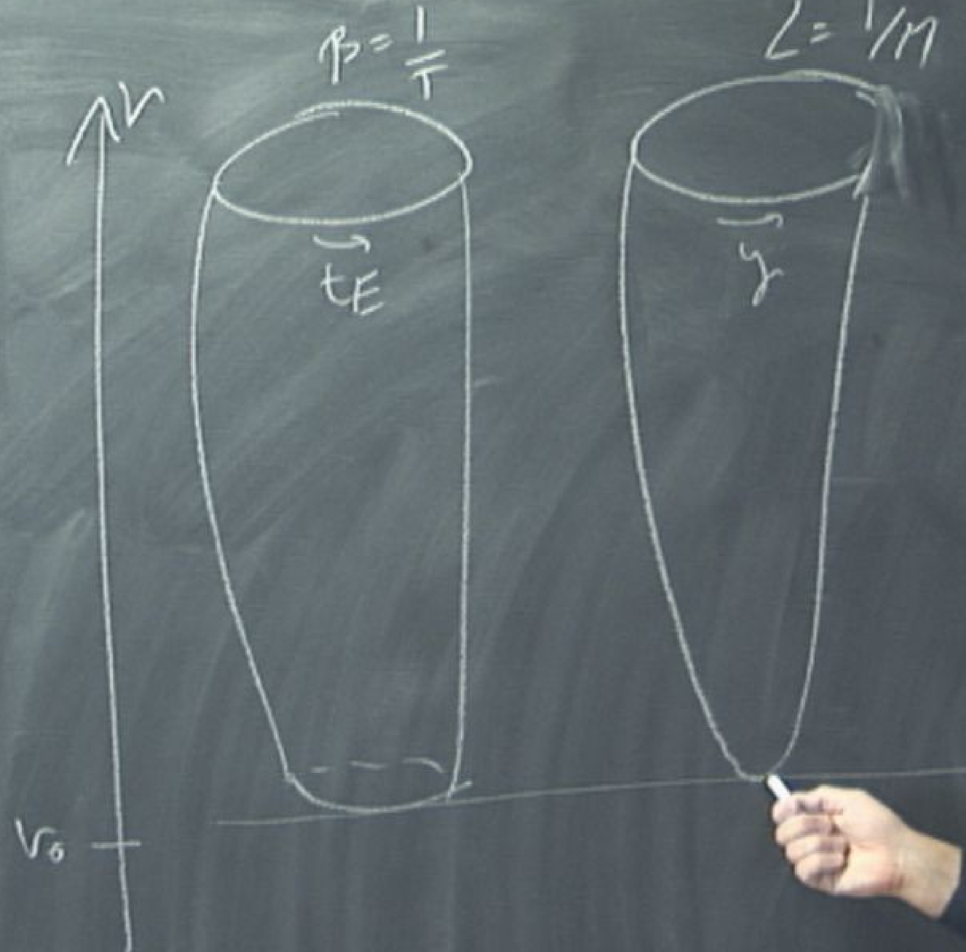
r

r_0

$$d\vec{x}^2 + dy^2\Big) + \left(\frac{R}{r}\right)^{3/2} \frac{dr^2}{f}$$

$$\boxed{y \sim y + L}$$

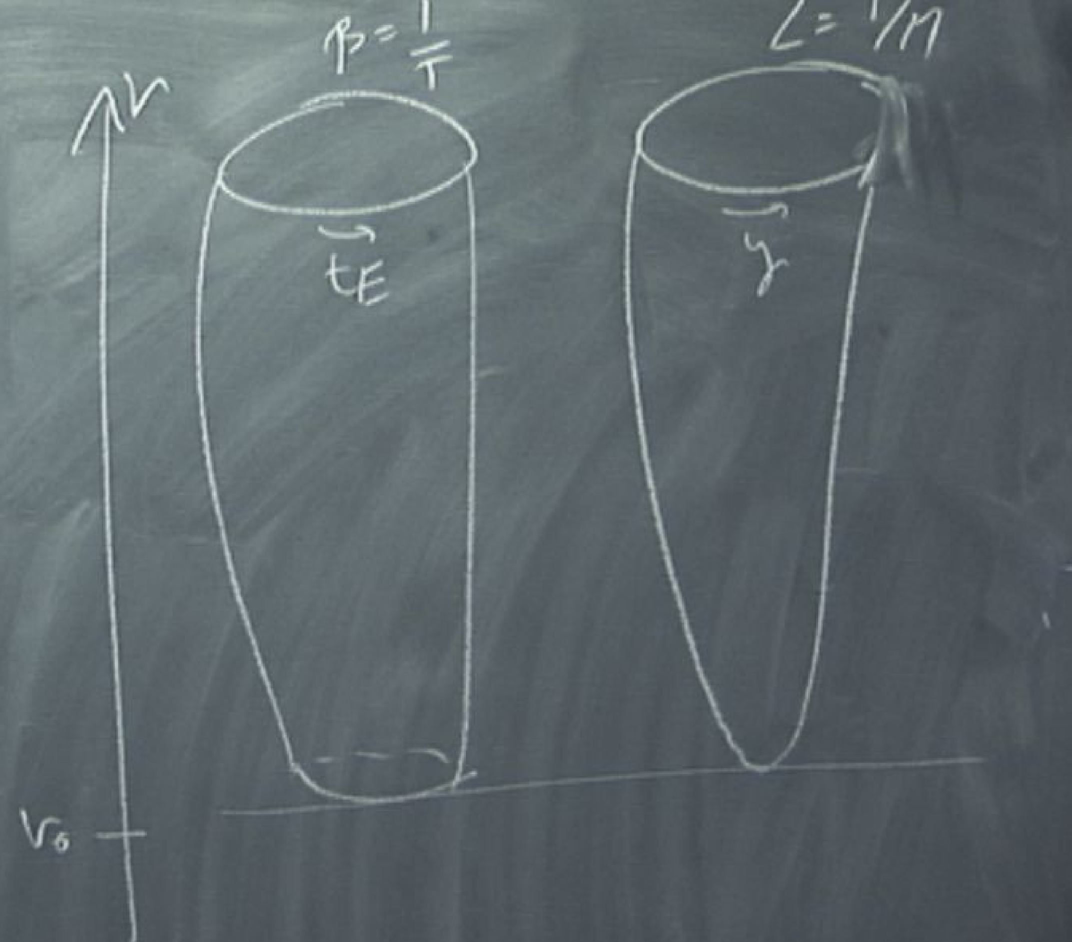
$$d\vec{x}^2 + f\,dy^2\Big) + \left(\frac{R}{r}\right)^{3/2} \frac{dr^2}{f}$$



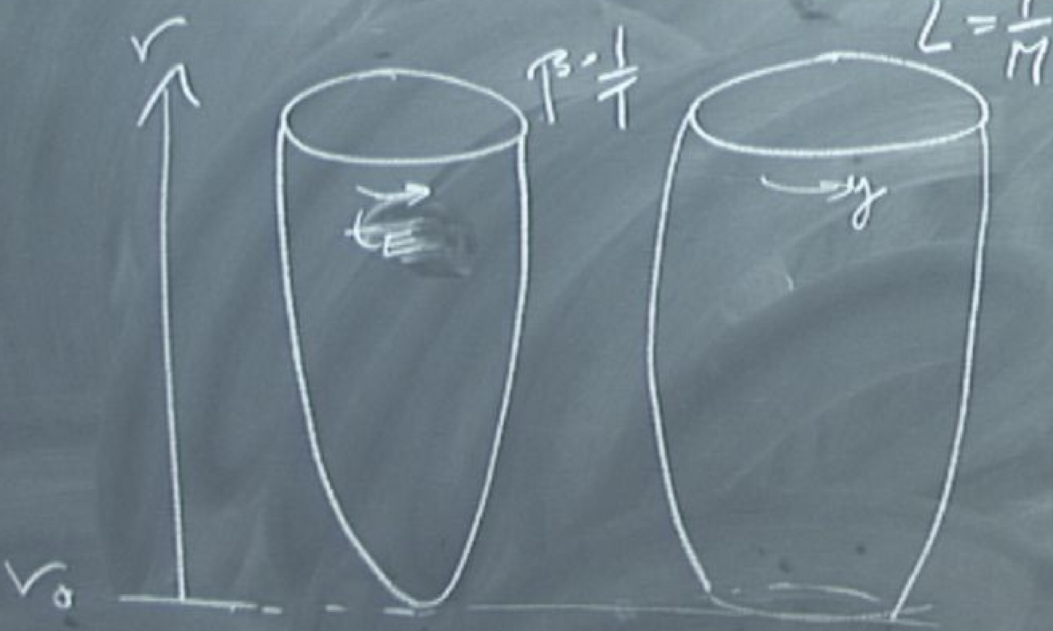
$$\ldots d\vec{x}^2 + dy^2\Big) + \left(\frac{R}{r}\right)^{3/2} \frac{dr^2}{f}$$

$$\boxed{y \sim y + L}$$

$$d\ldots\Big) + \left(\frac{R}{r}\right)^{3/2} \frac{dr^2}{f}$$



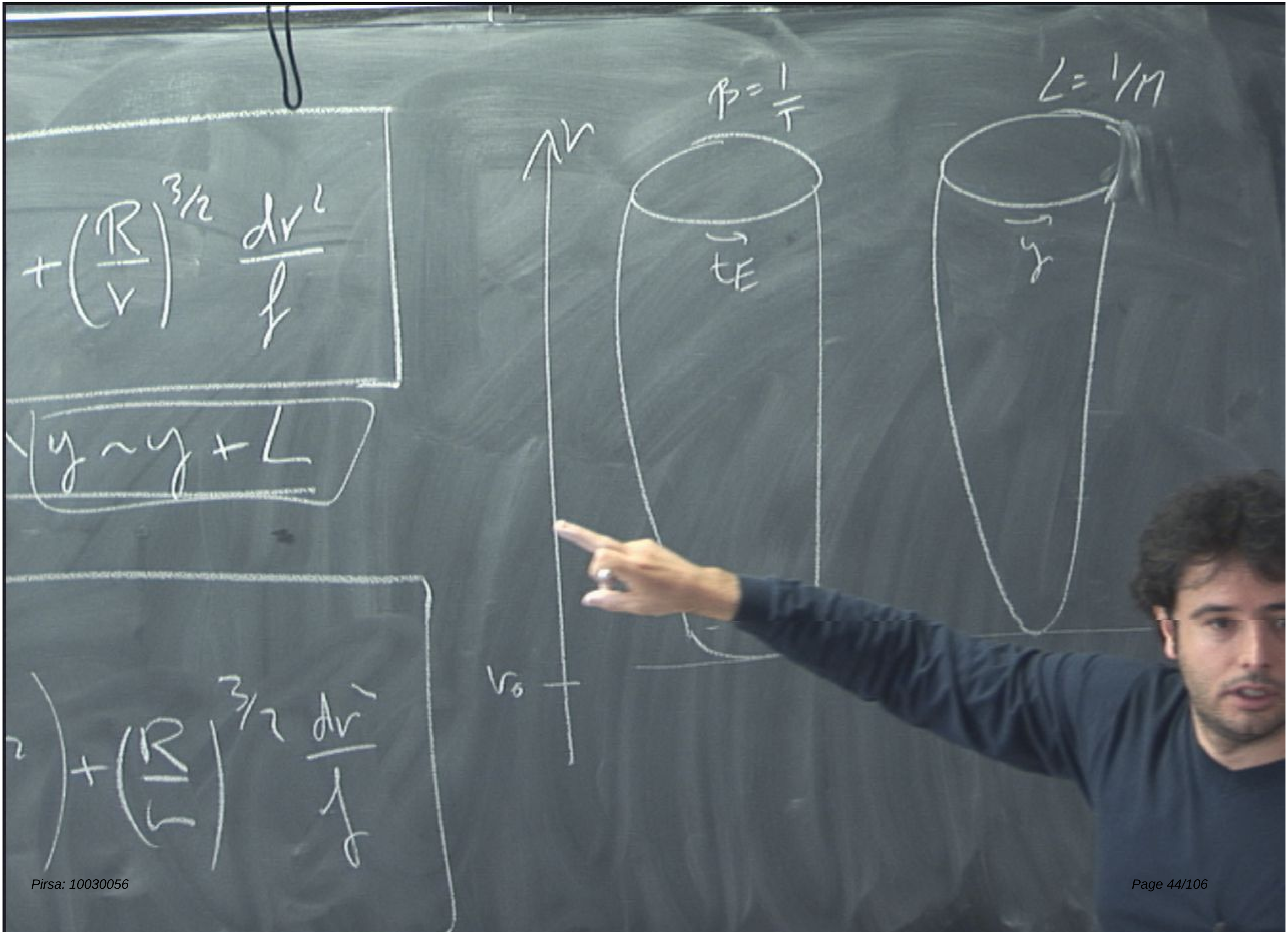
BH



$$r_c = \left(\frac{4\pi}{3}\right)^2 \frac{R^3}{\beta^2}$$

$$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\, dt_E^2 + \right.$$

$$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(dt_E^2 + \right.$$

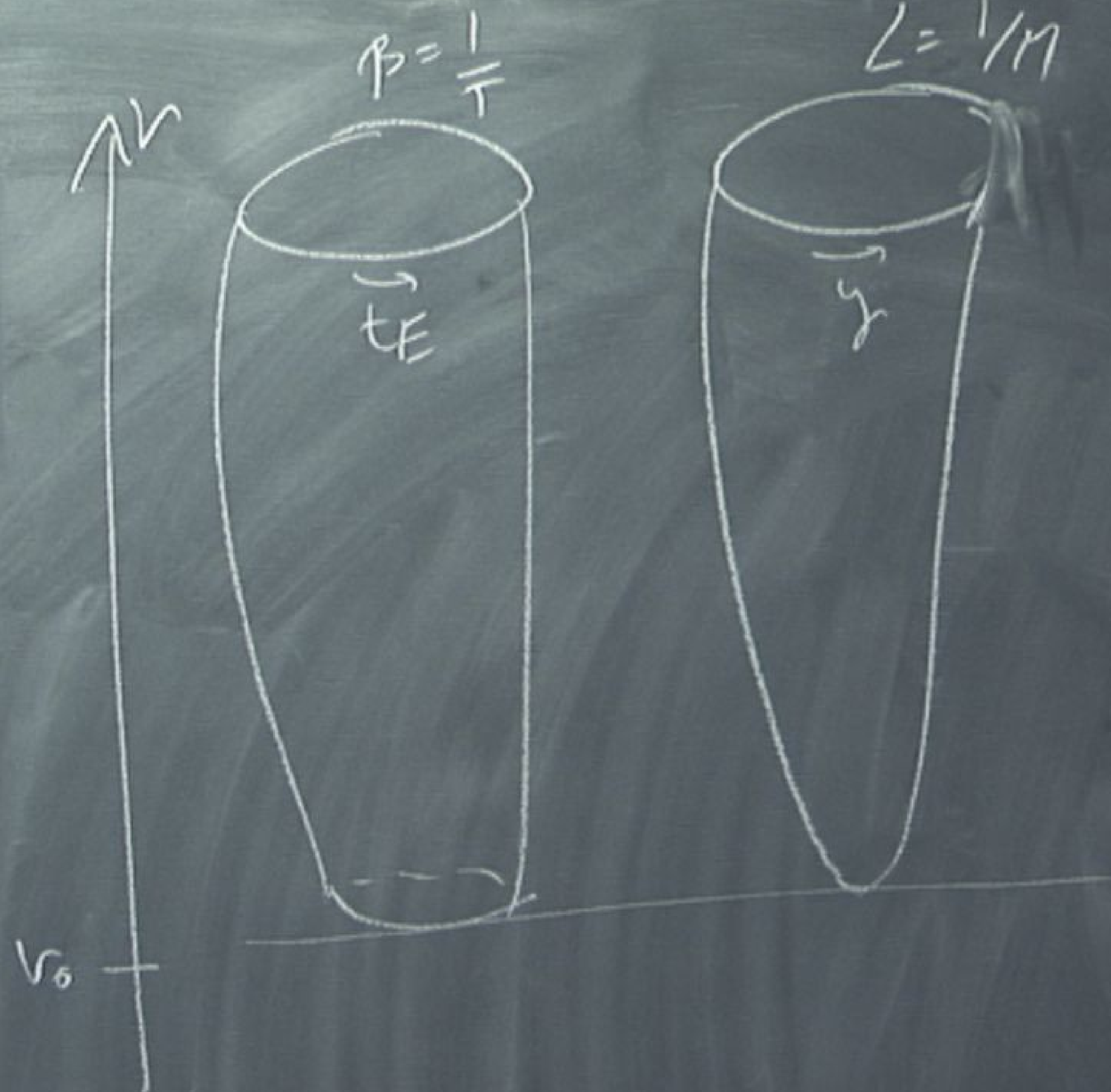


+(R/r)^{3/2} dr^2/f
y ~ y + L
β = 1/T
L = 1/M
t_E
y
r
r_0
+(R/r)^{3/2} dr^2/f

$$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

$$y \sim y + L$$

$$\Big) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

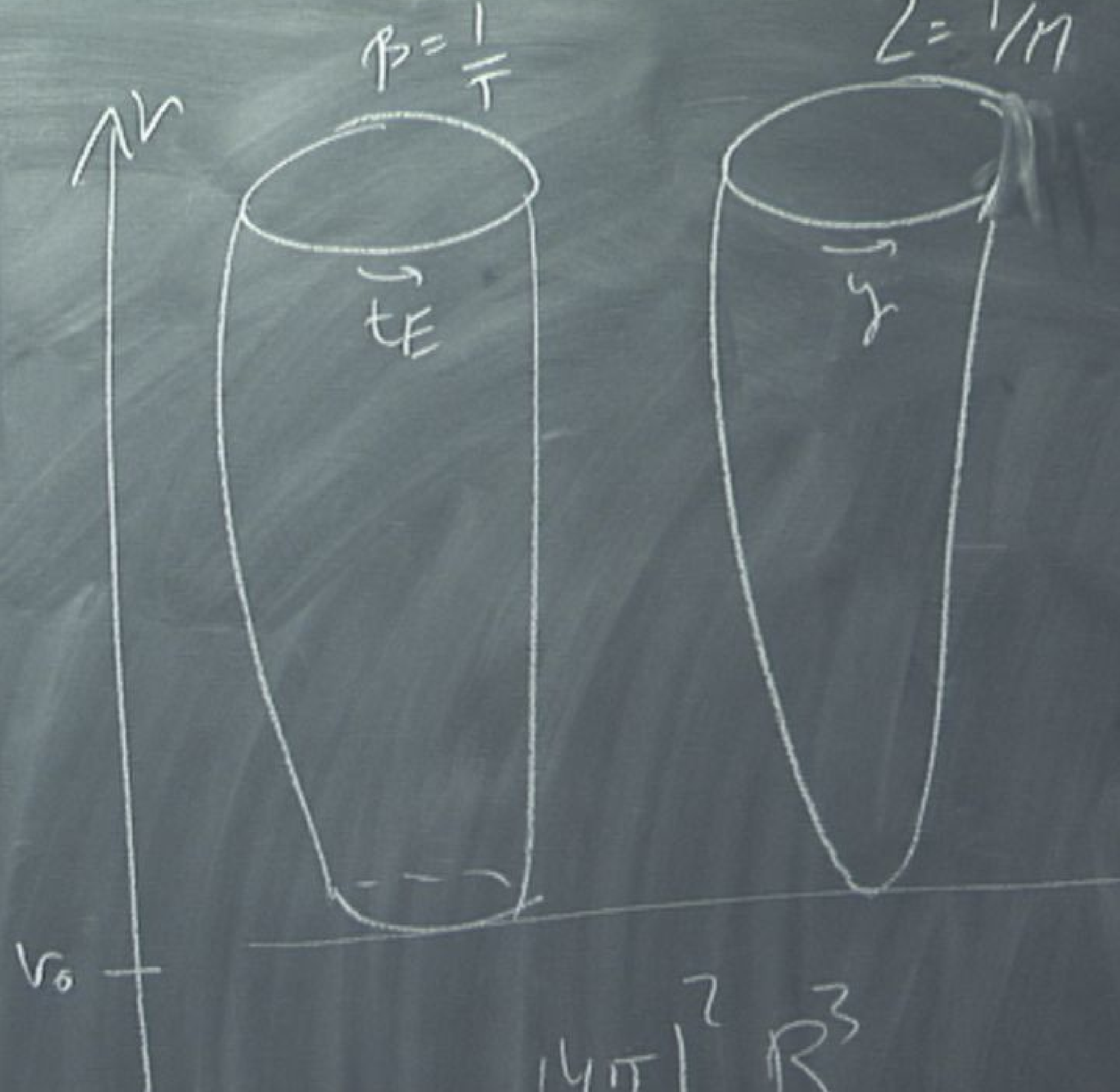


$r_0 =$

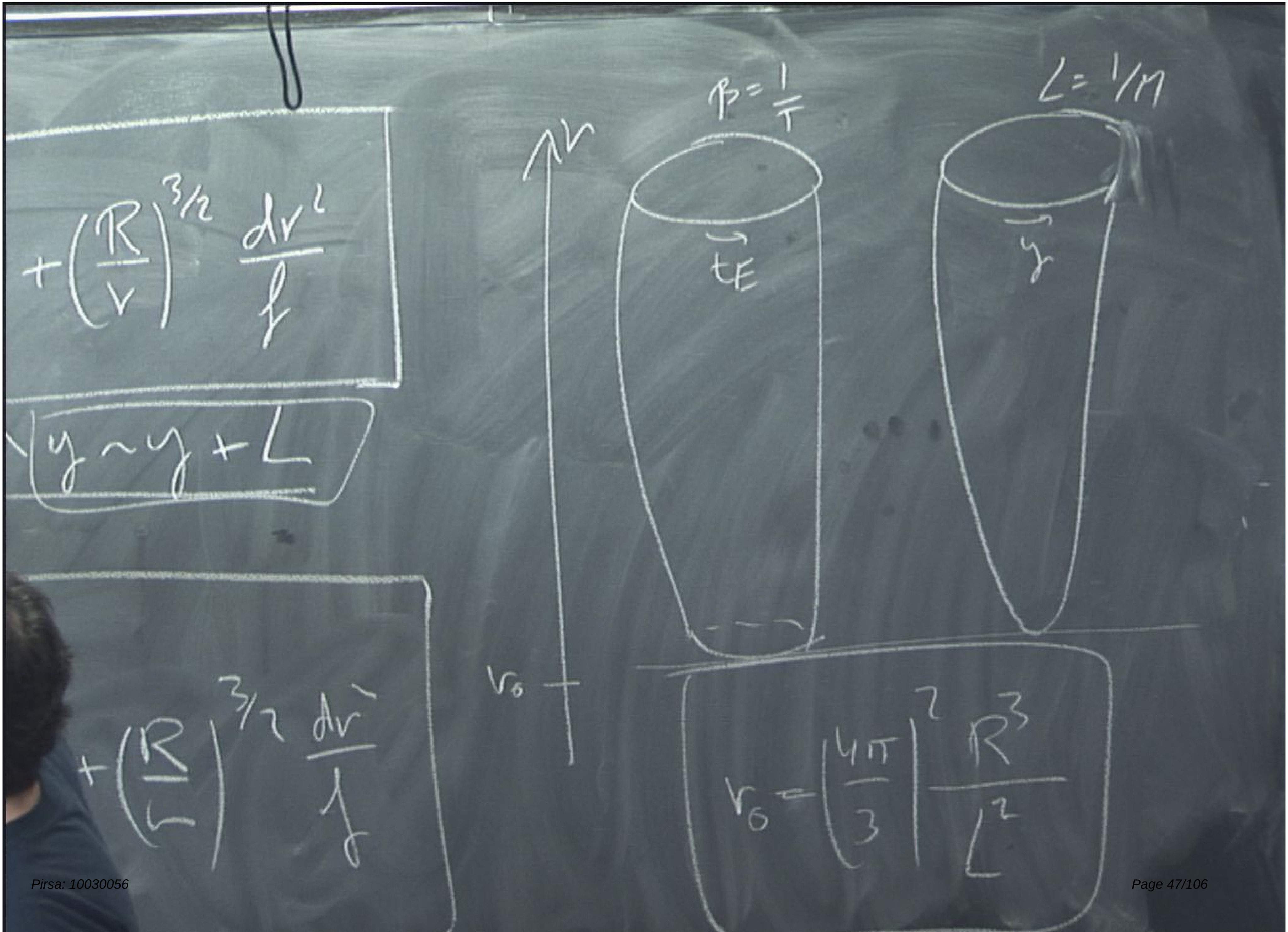
$$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

$$y \sim y + L$$

$$)+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$



$$r_0 = \left(\frac{4\pi}{3}\right)^2 \frac{R^3}{L^2}$$

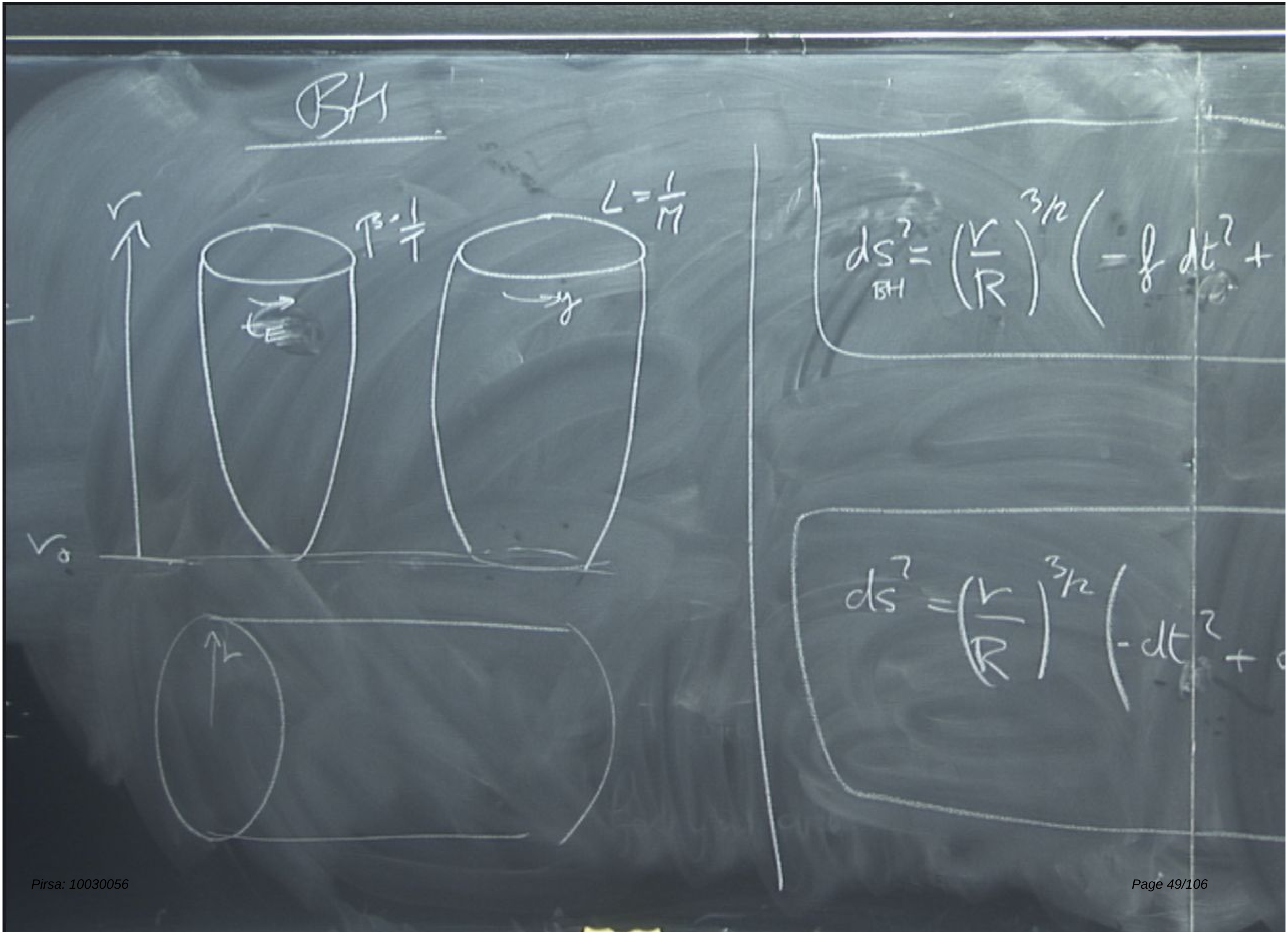


$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$
$y \sim y + L$
$\beta = \frac{1}{T}$
$L = 1/M$
t_E
y
r
r_0
$r_0 = \left(\frac{4\pi}{3}\right)^2 \frac{R^3}{L^2}$
$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$

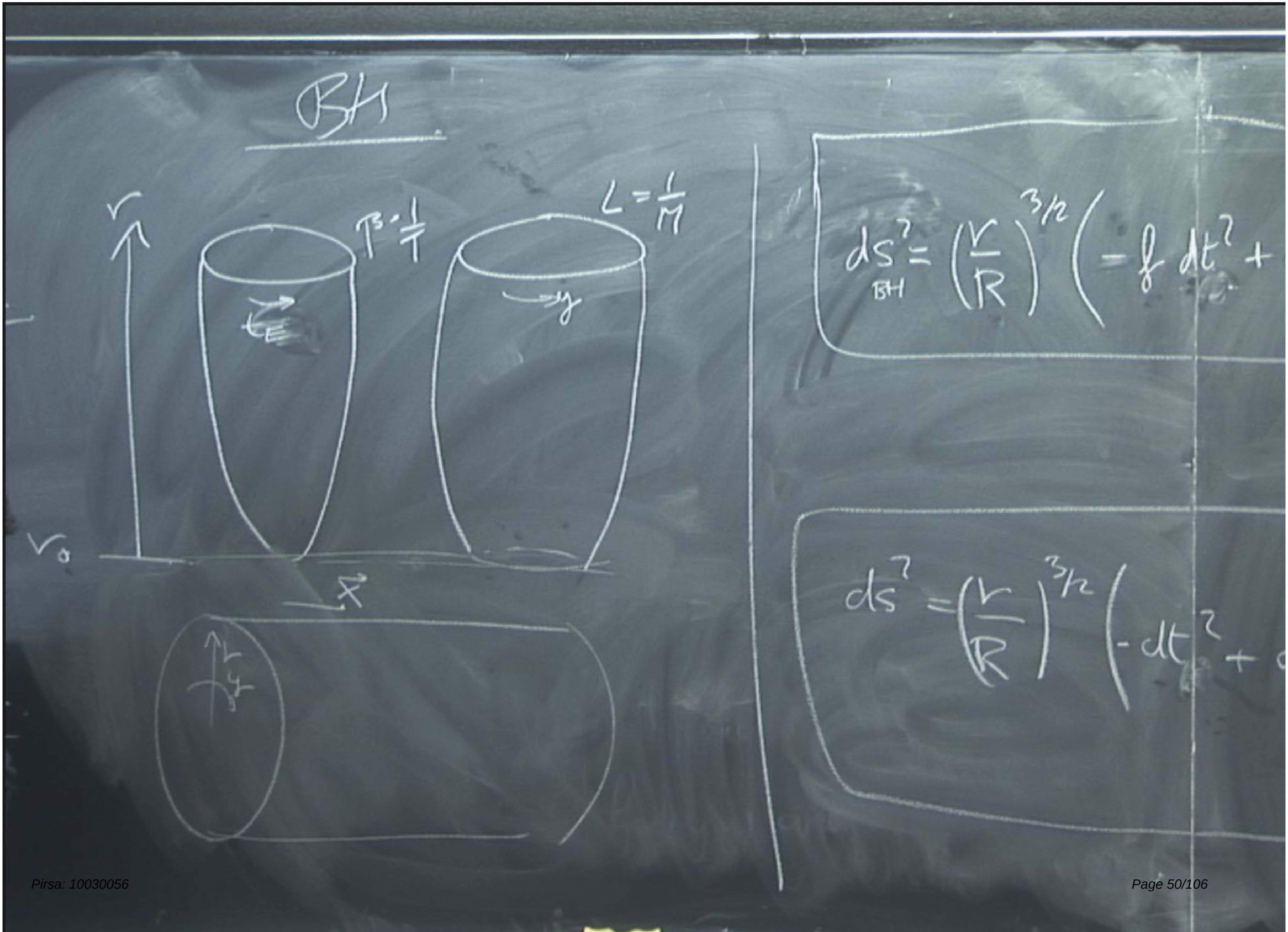
$$\boxed{ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + d\vec{x}^{\,2} + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}}$$

$$\boxed{y \sim y + L}$$

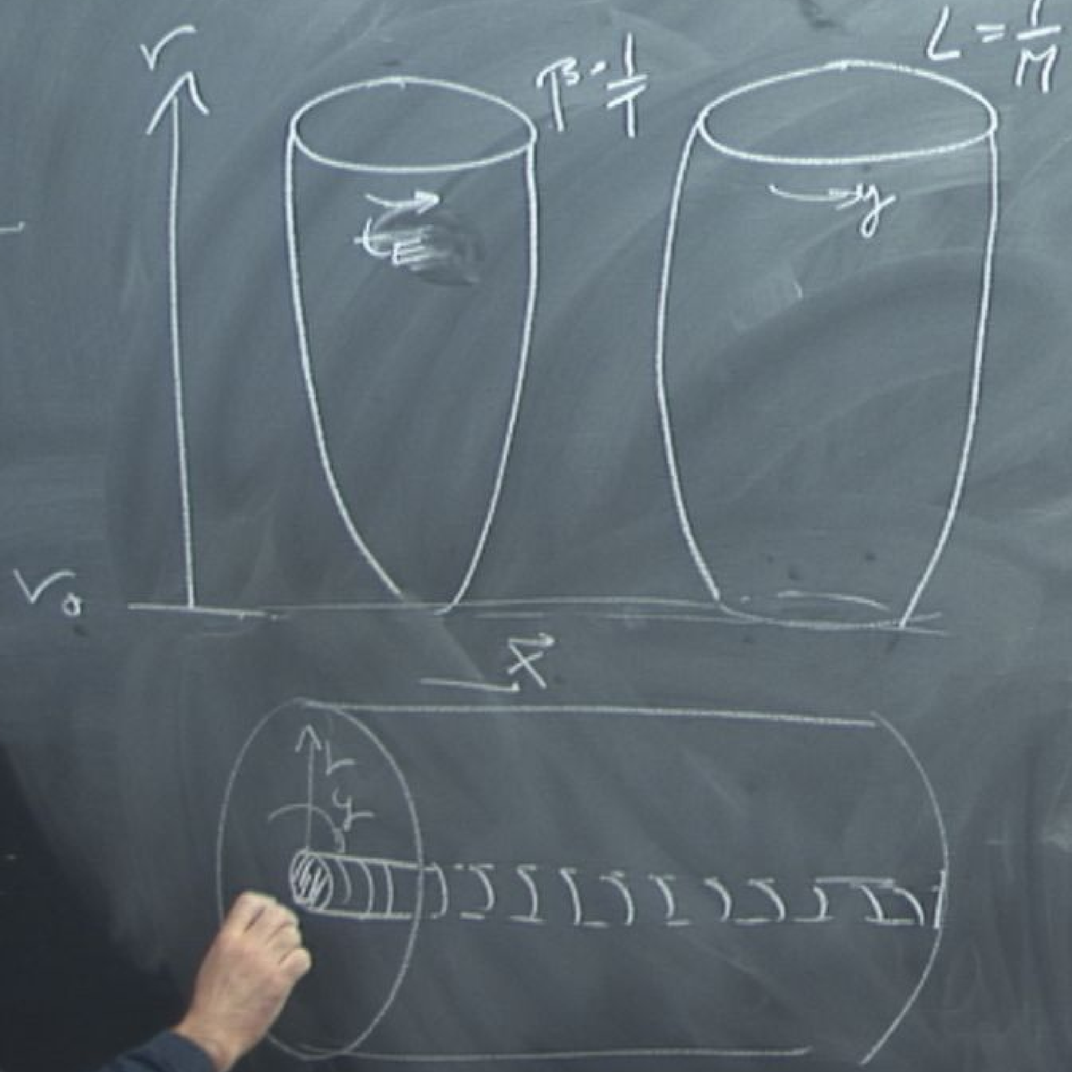
$$\boxed{ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-dt^2 + d\vec{x}^{\,2} + f\,dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}}$$



BH
r
$\beta = \frac{1}{T}$
$L = \frac{1}{M}$
t_E
y
r_0
$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 +\right.$
$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-dt^2 +\right.$


BH
r
β = 1/T
L = 1/M
t_E
y
r_0
x
y
ds²_BH = (r/R)^{3/2} (−f dt² +
ds² = (r/R)^{3/2} (−dt² +

BH



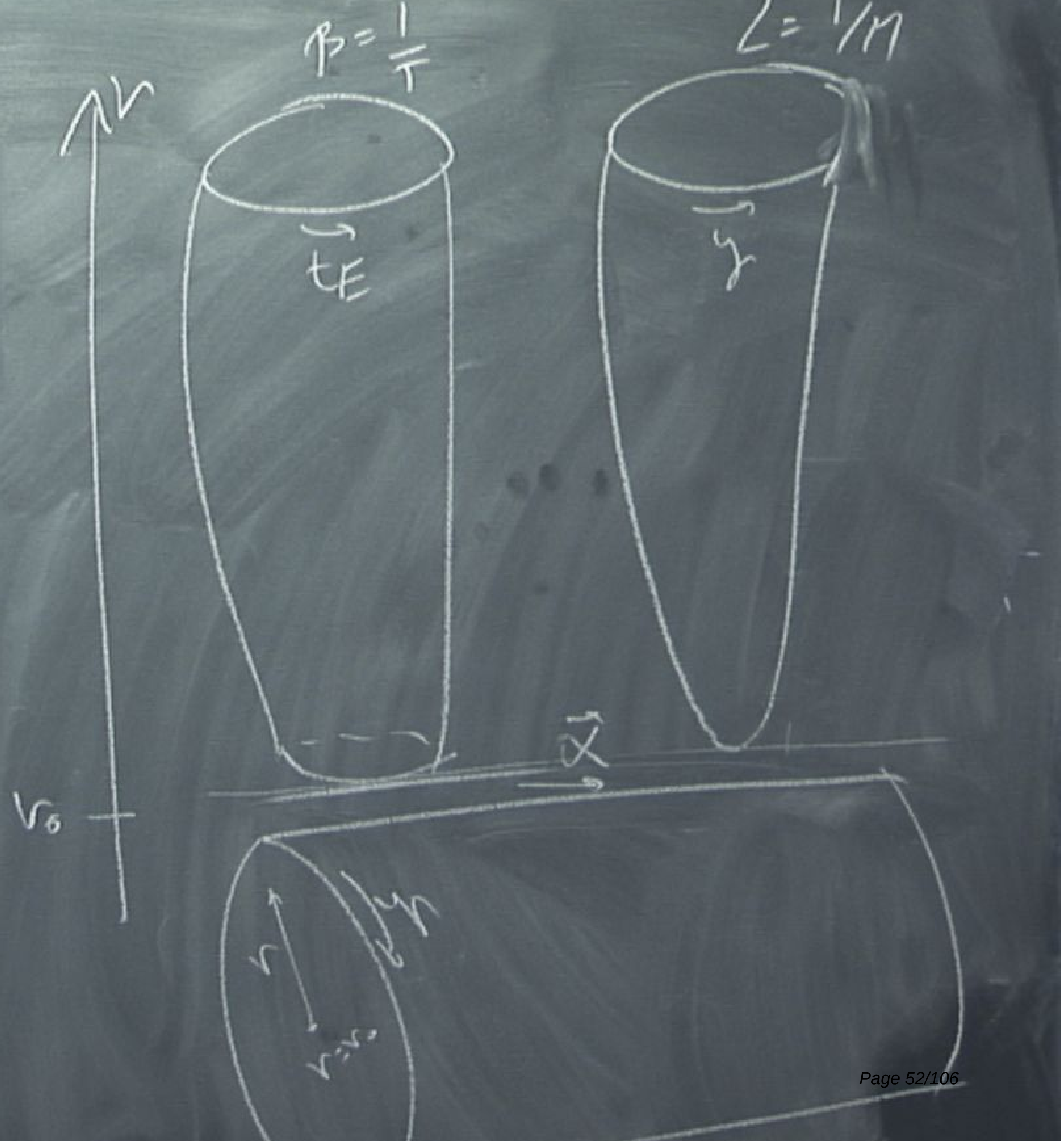
$$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + \right.$$

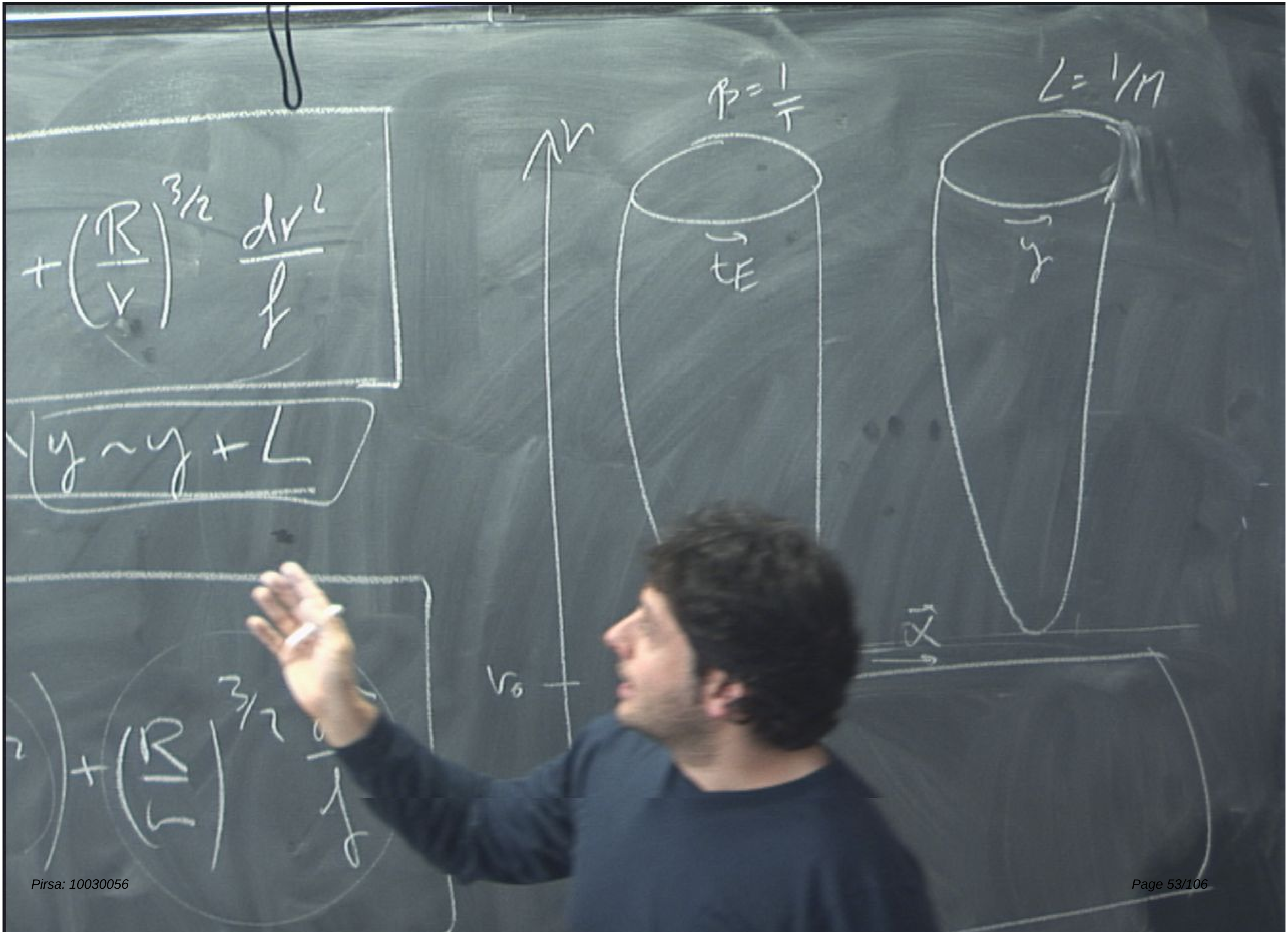
$$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-dt^2 + \right.$$

$$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

$$\boxed{y \sim y + L}$$

$$\Big) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

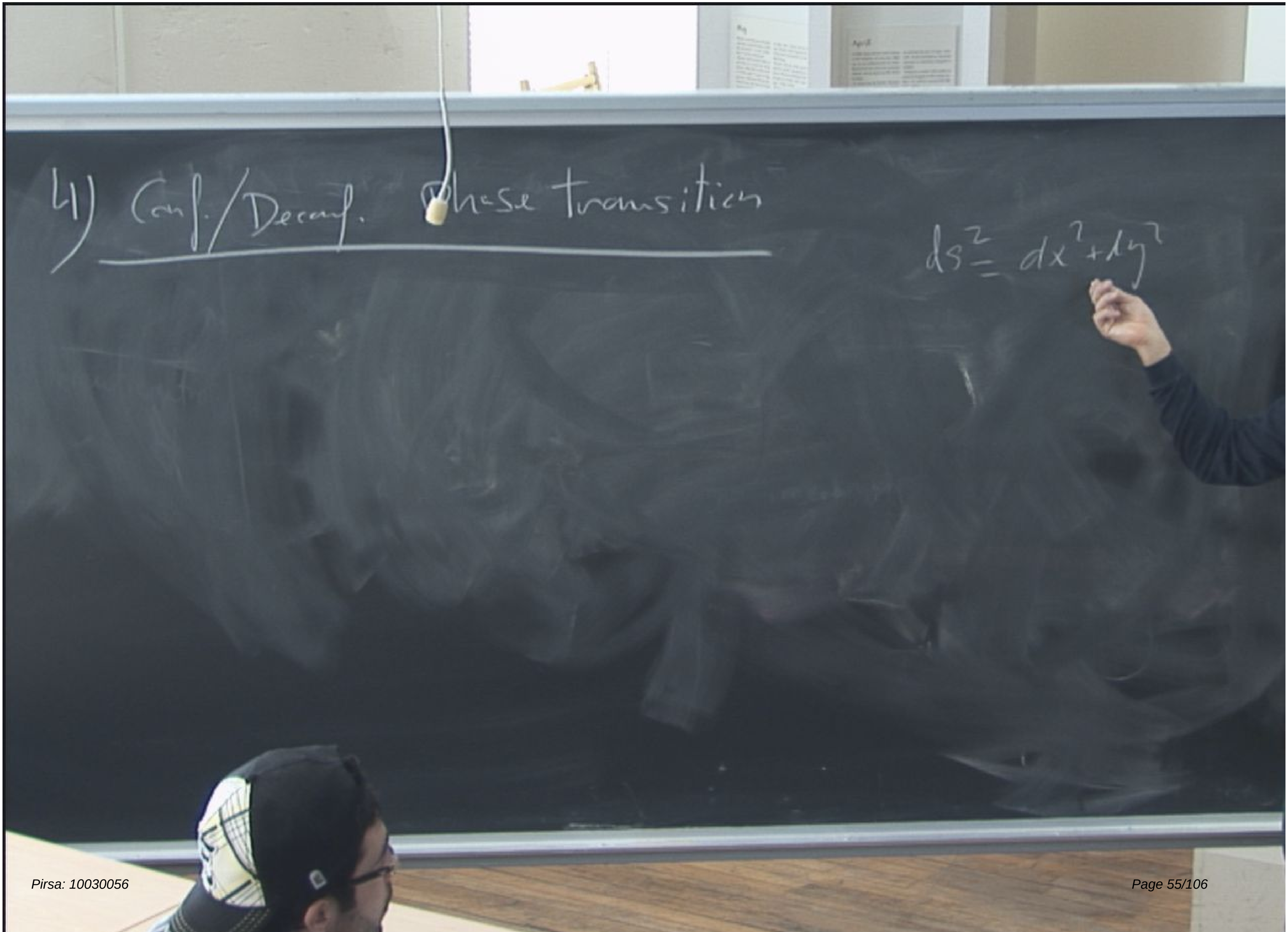


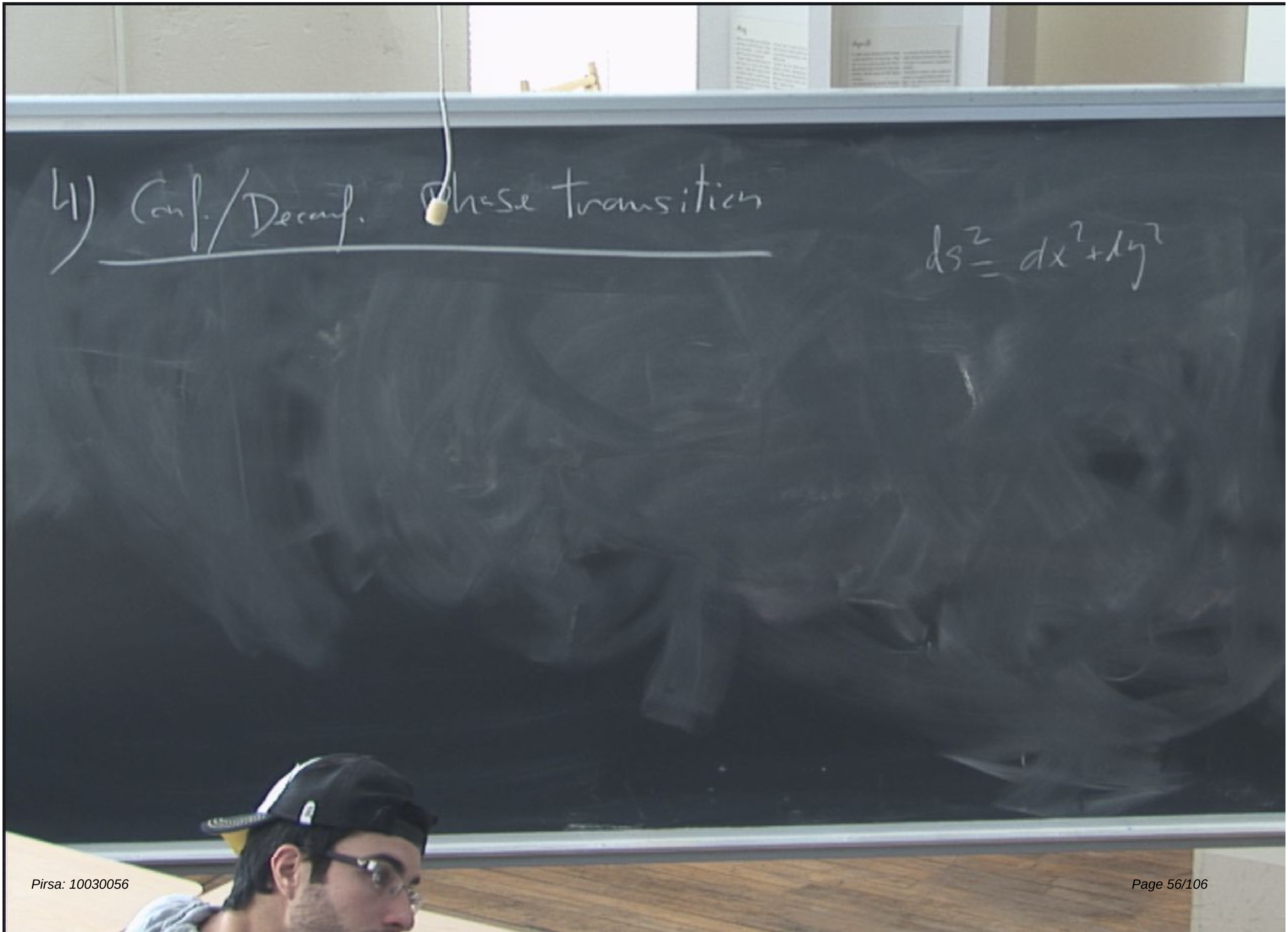

β = 1/T
L = 1/M
r
t_E
y
y ~ y + L
r_0
x

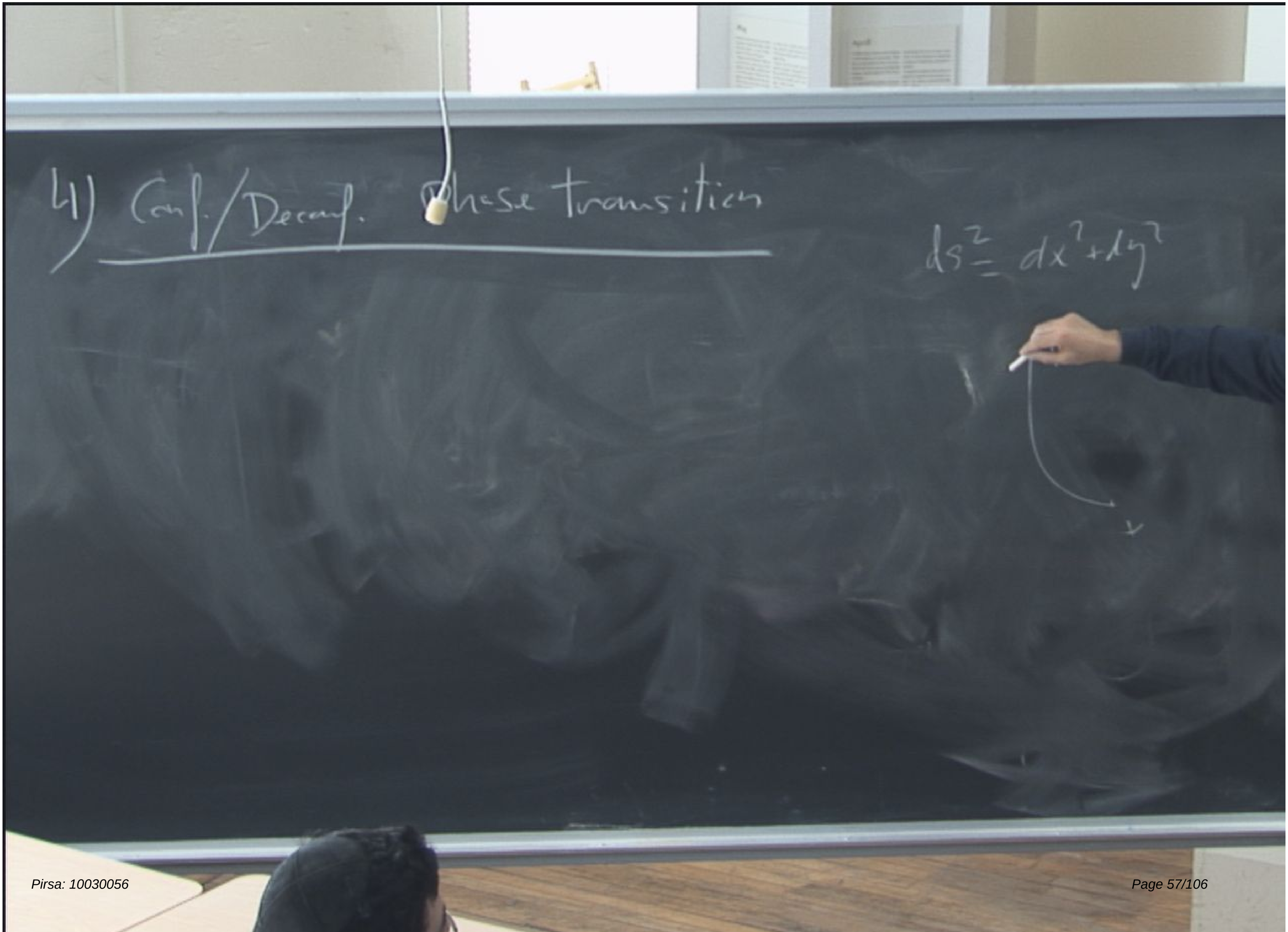
$$\boxed{ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + d\vec{x}^2 + dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}}$$

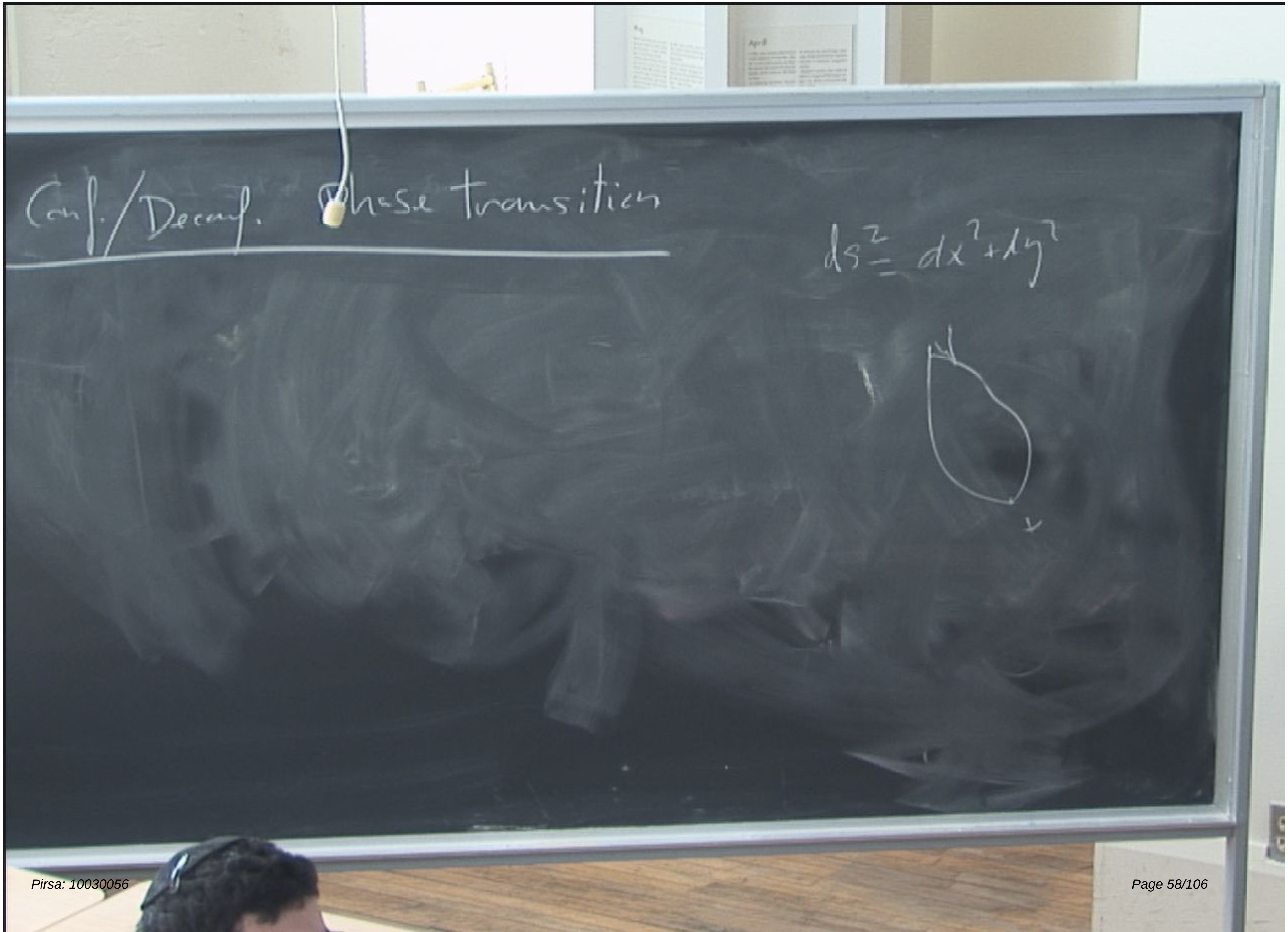
$$\boxed{y \sim y + L}$$

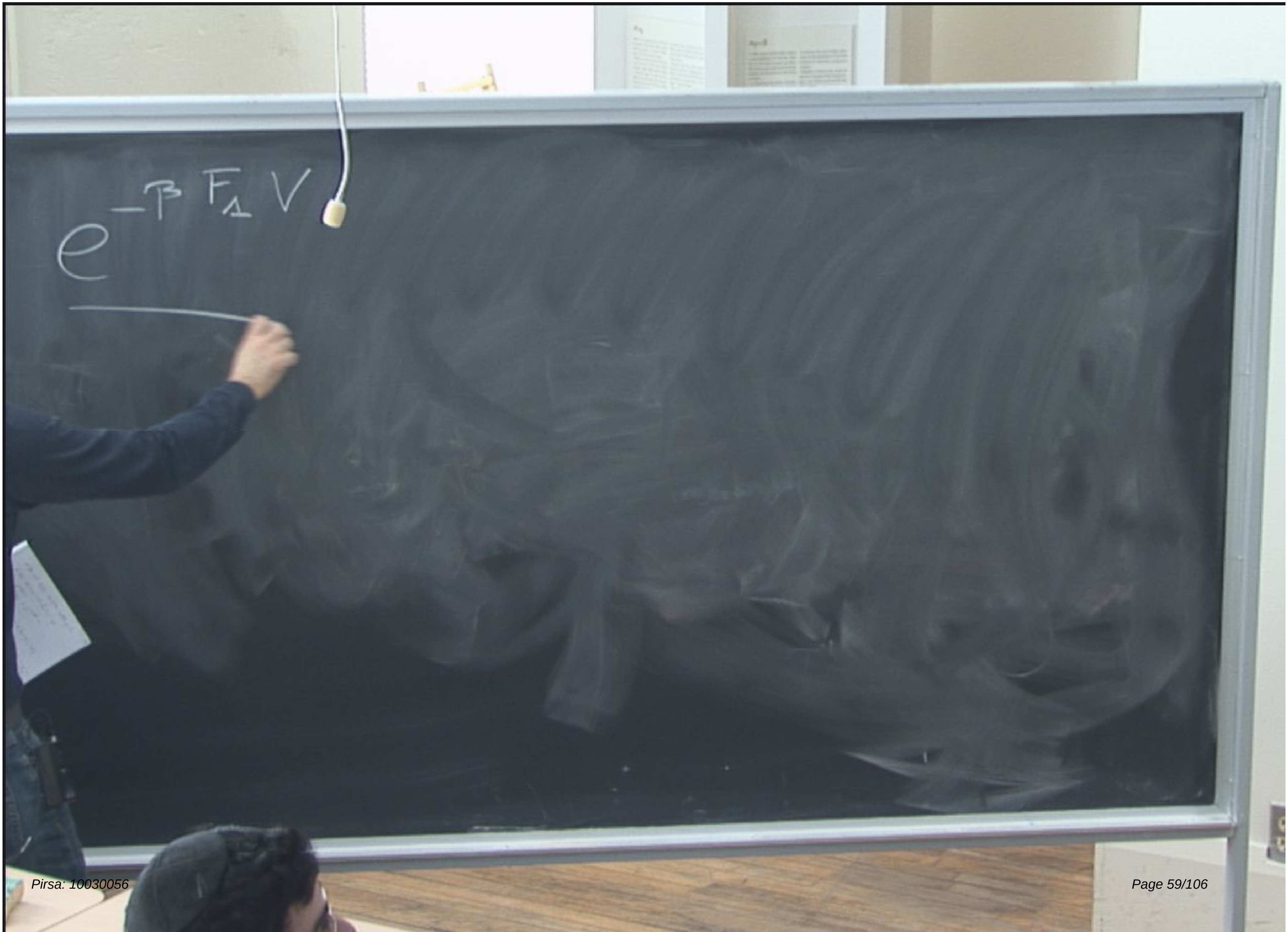
$$\boxed{ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-dt^2 + d\vec{x}^2 + f\,dy^2\right) + \left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}}$$

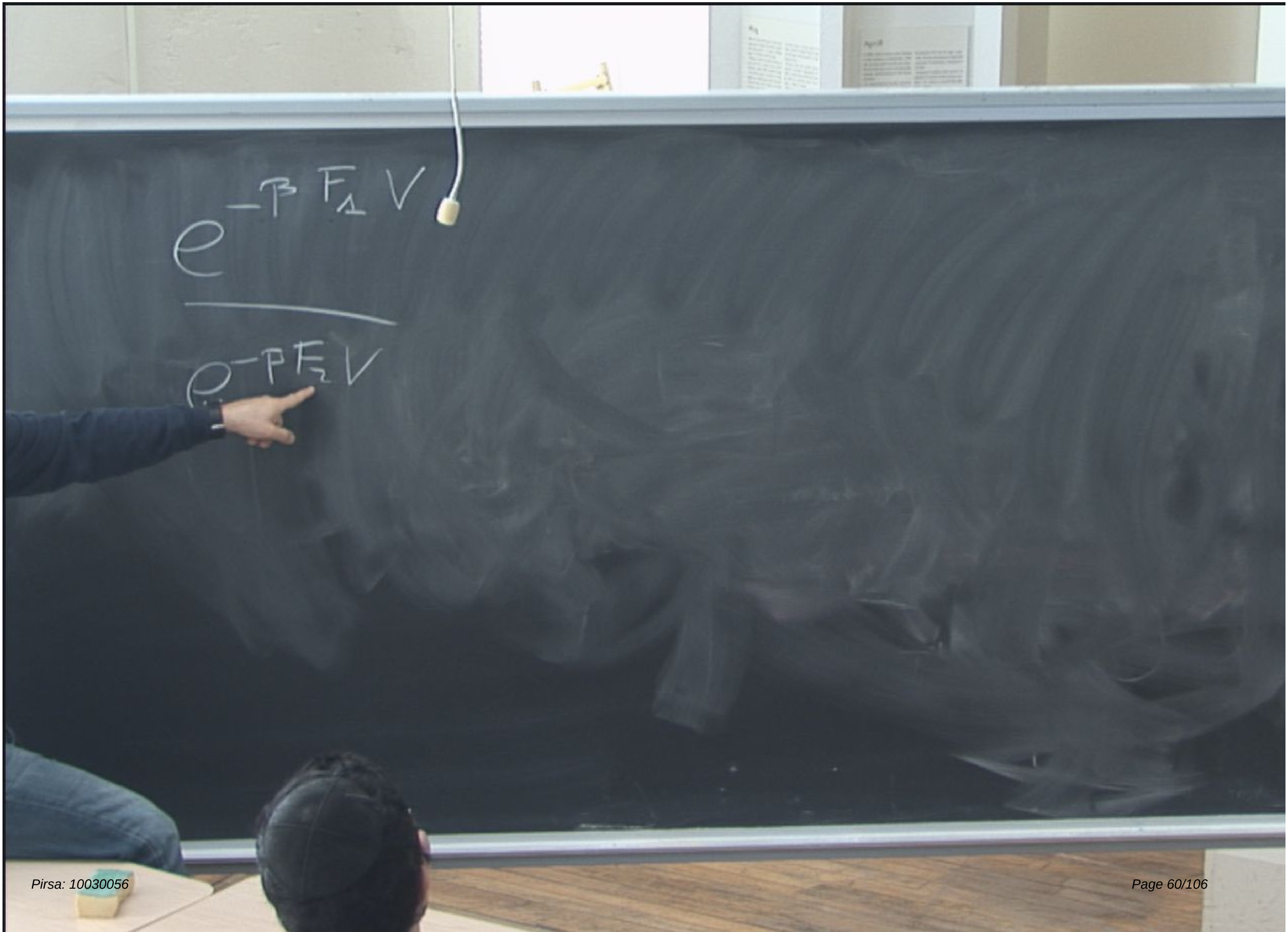

4) Conf./Deconf. Phase transition
ds² = dx² + dy²

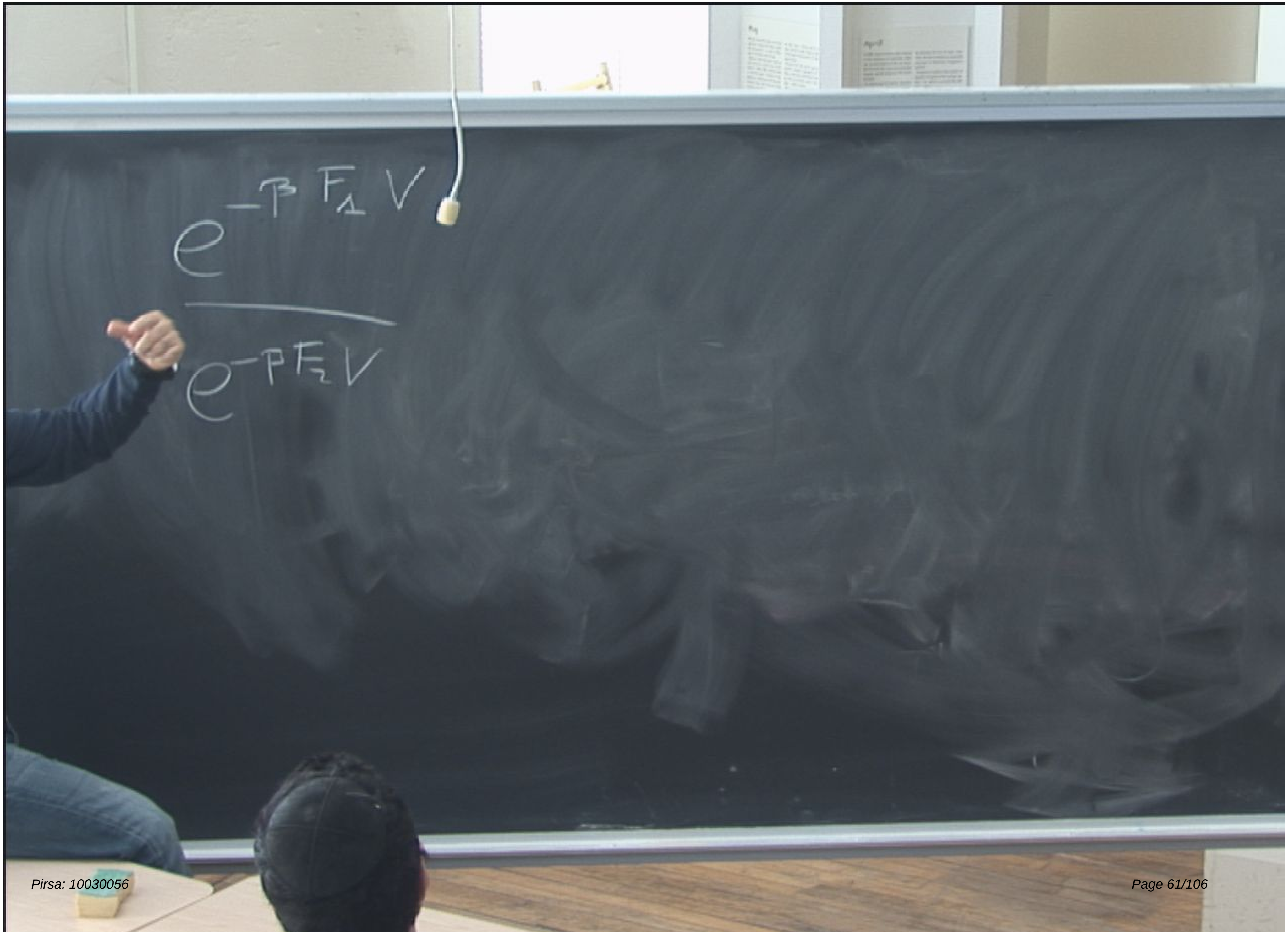

4) Conf./Deconf. Phase transition
ds² = dx² + dy²

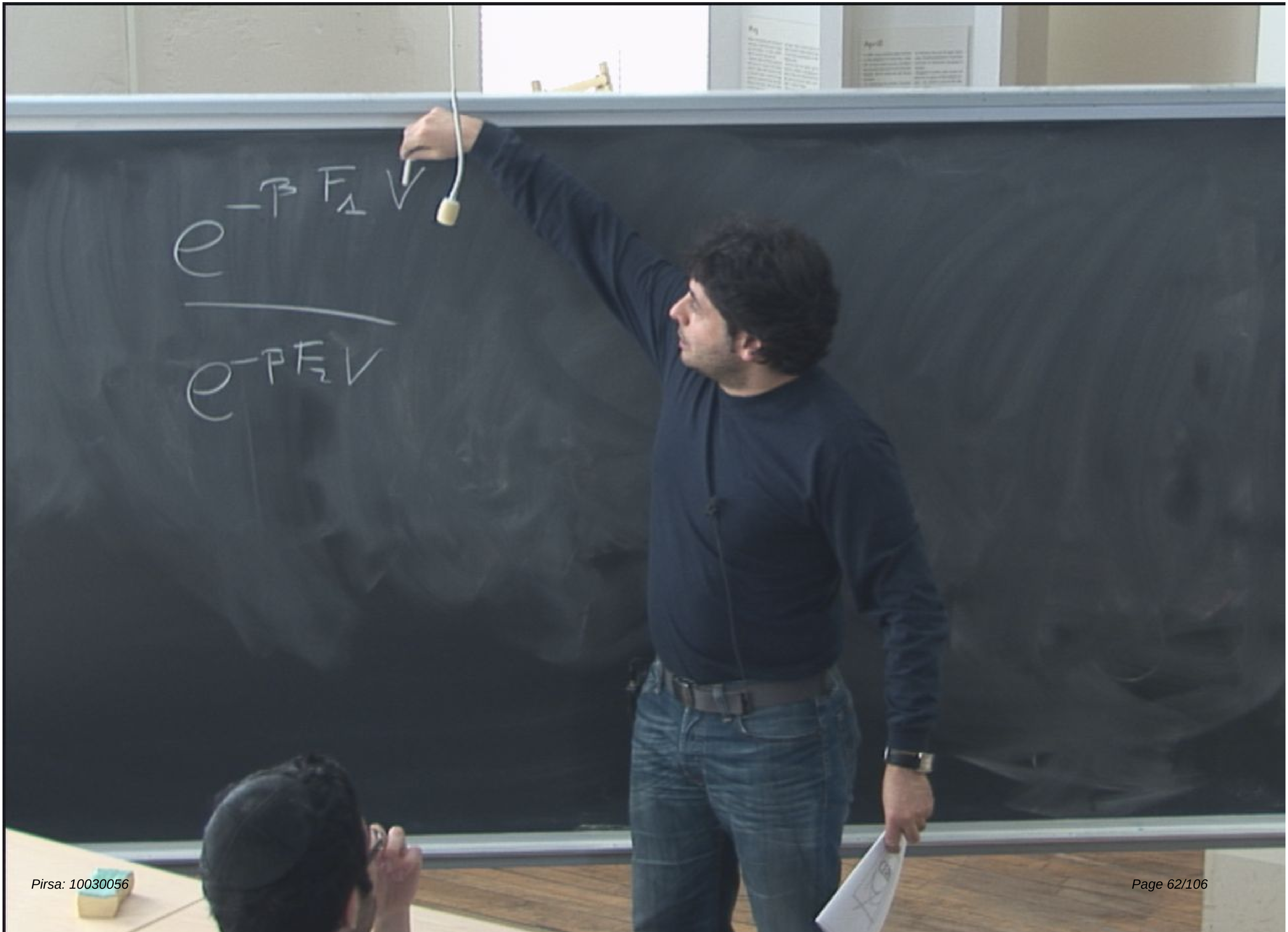

4) Conf./Deconf. Phase transition
ds² = dx² + dy²

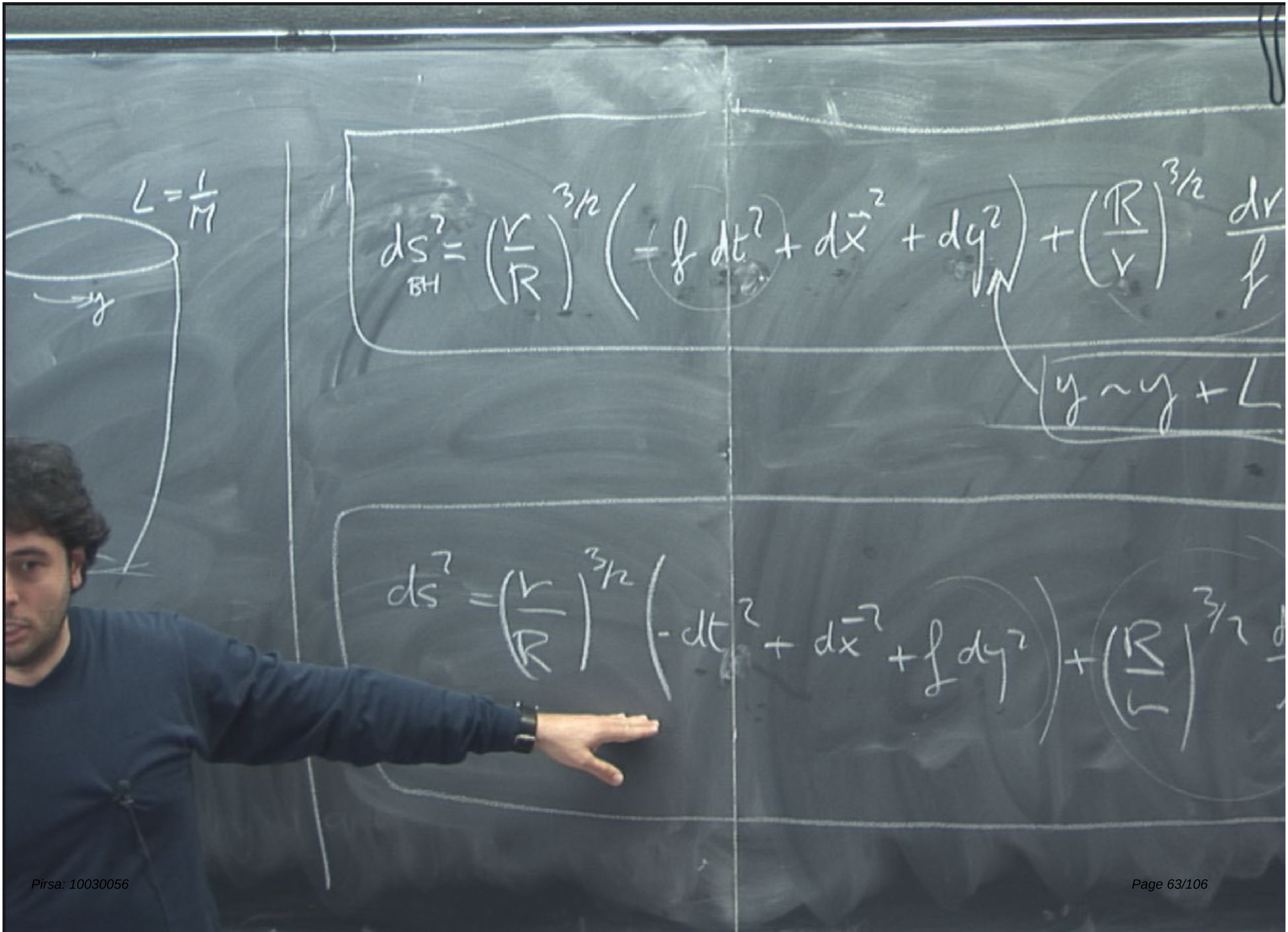

Conf./Deconf. Phase transition
ds² = dx² + dy²

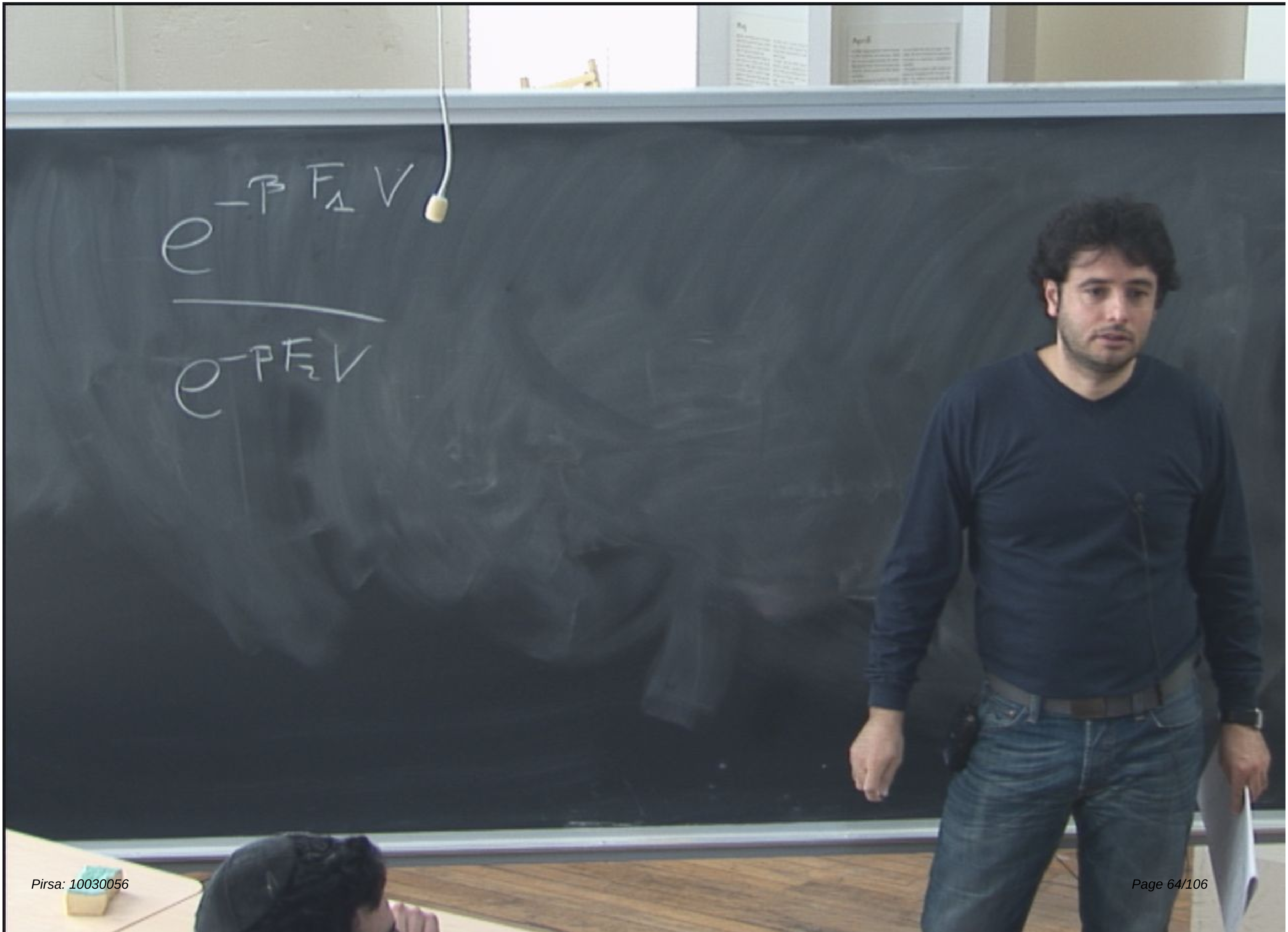

$e^{-\beta F_1 V}$


$\frac{e^{-\beta F_1 V}}{e^{-\beta F_2 V}}$


$\frac{e^{-\beta F_1 V}}{e^{-\beta F_2 V}}$


$\frac{e^{-\beta F_1 V}}{e^{-\beta F_2 V}}$

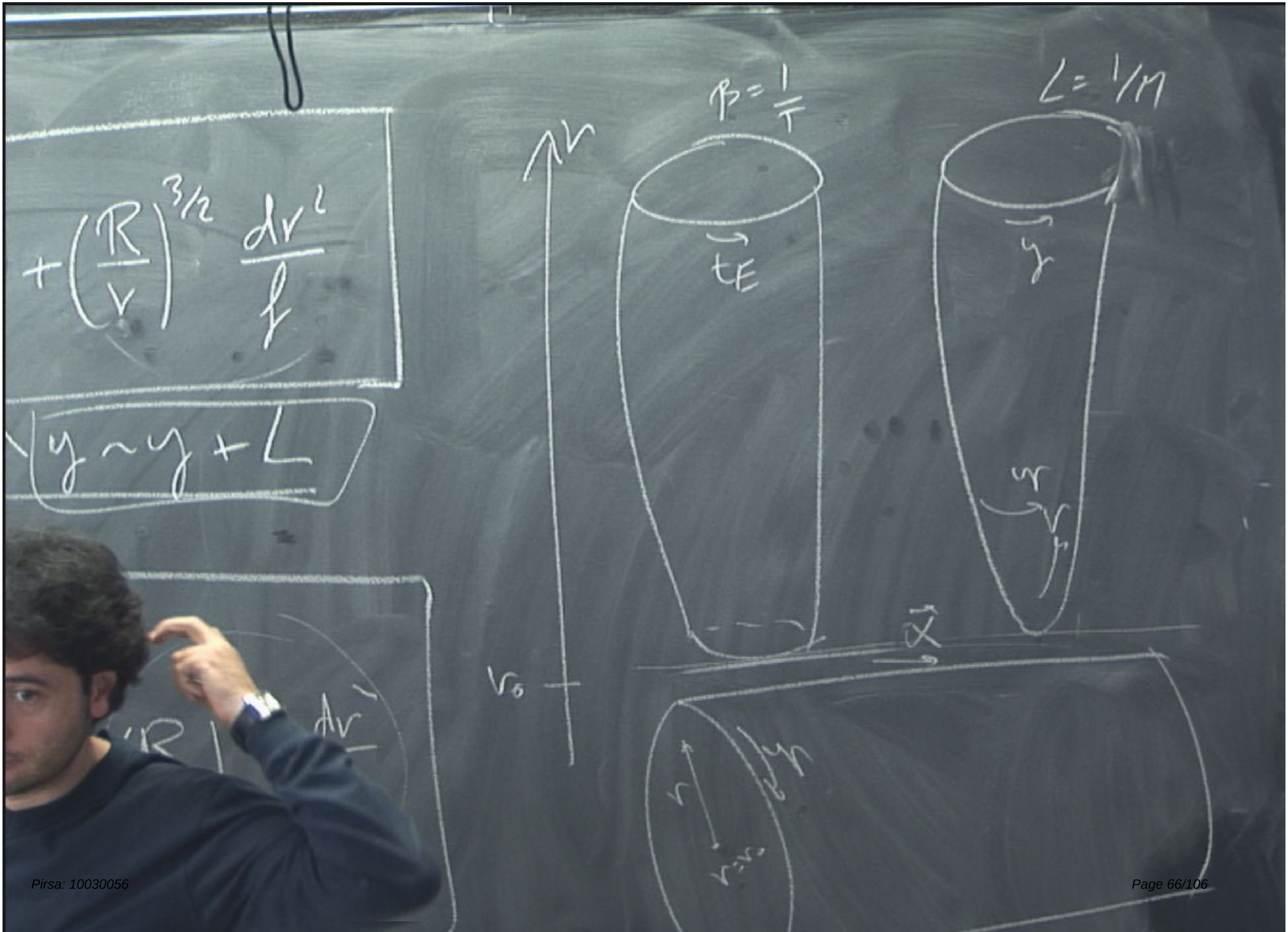

$L = \frac{1}{M}$
y
$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + d\vec{x}^2 + dy^2\right) + \left(\frac{R}{r}\right)^{3/2} \frac{dr}{f}$
$y \sim y + L$
$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-dt^2 + d\vec{x}^2 + f\,dy^2\right) + \left(\frac{R}{r}\right)^{3/2}$


$$\frac{e^{-\beta F_1 V}}{e^{-\beta F_2 V}}$$

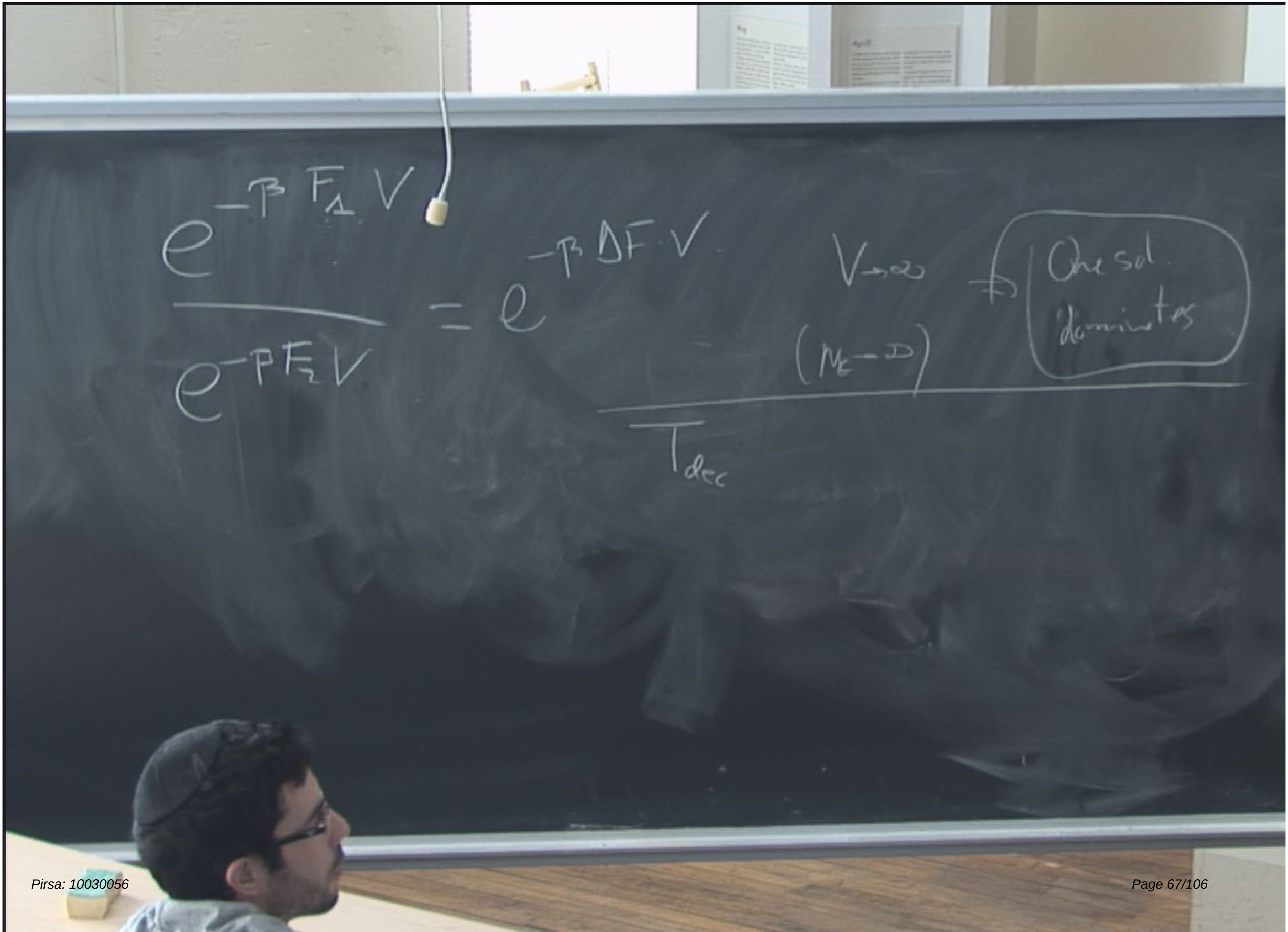
$$\frac{e^{-\beta F_1 V}}{e^{-\beta F_2 V}} = e^{-\beta \Delta F \cdot V}$$

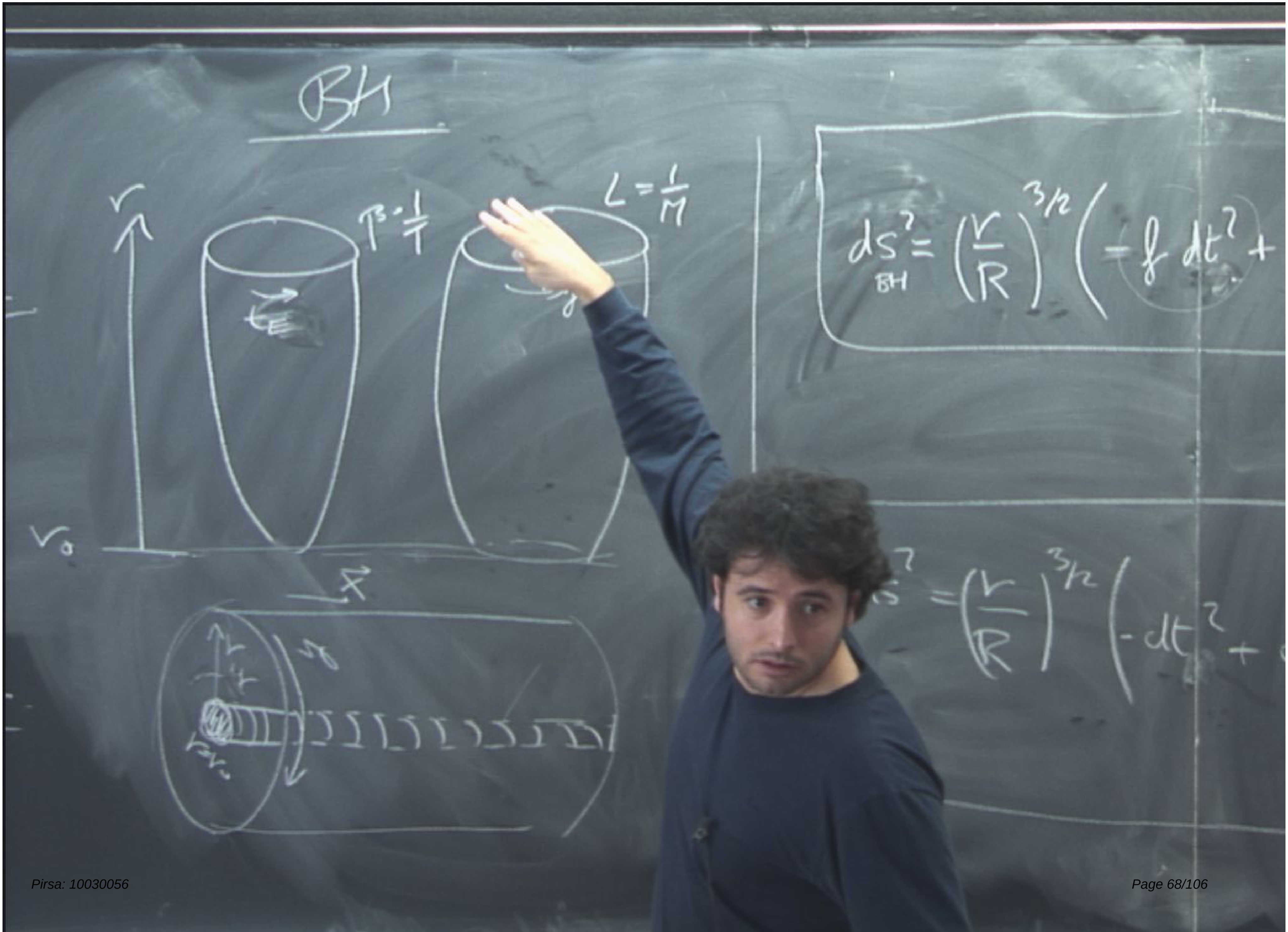
$V \to \infty$ $\Rightarrow$ $\boxed{\text{One sol. dominates}}$

$(N_c \to \infty)$

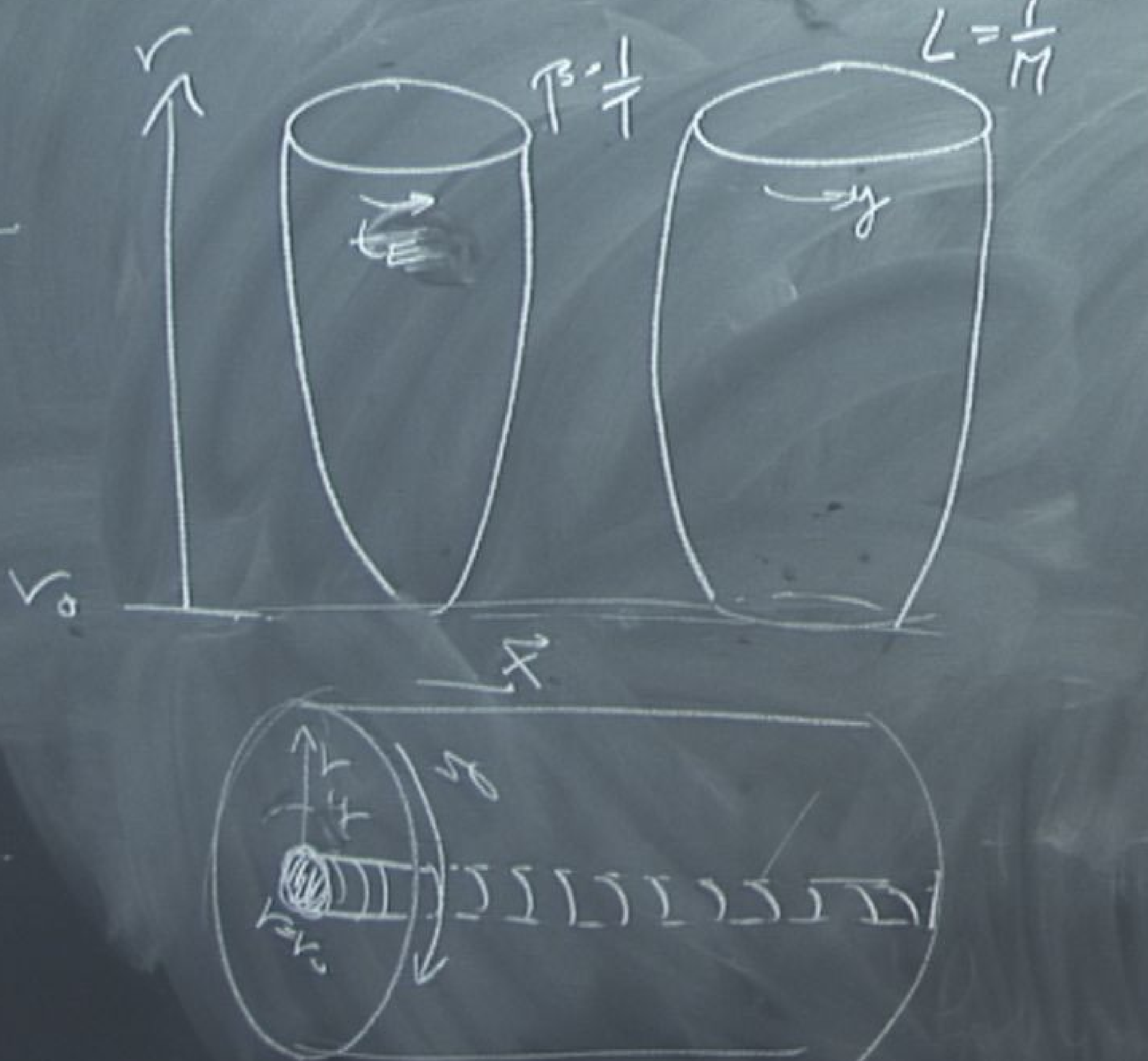


β = 1/T
L = 1/M
+(R/r)^{3/2} dr²/f
y ~ y + L
t_E
y
r
r₀
x


$\frac{e^{-\beta F_1 V}}{e^{-\beta F_2 V}} = e^{-\beta \Delta F \cdot V}$
$V \to \infty$
$(N_c \to \infty)$
$\Rightarrow$ One sol. dominates
T_{dec}

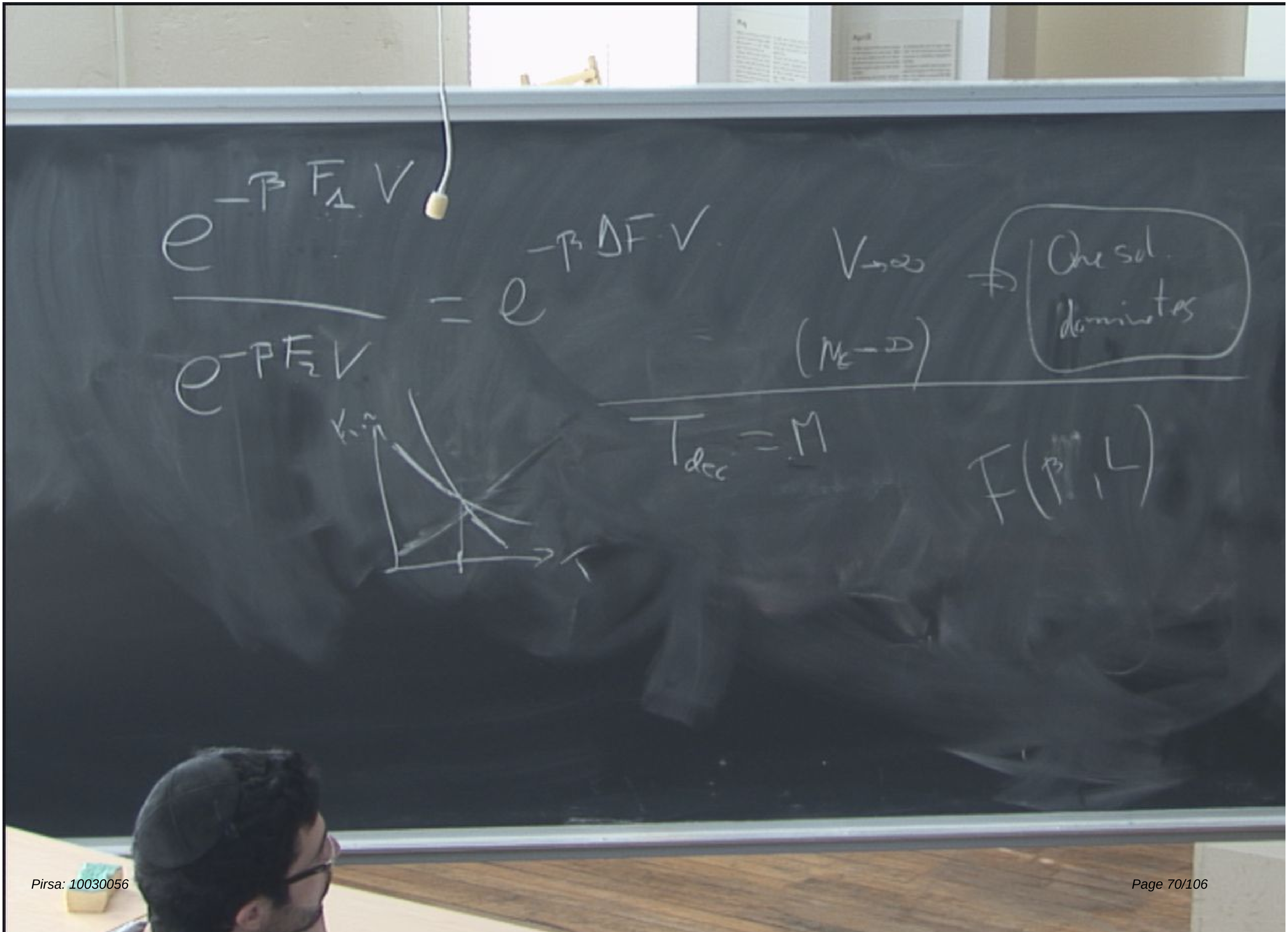

BH
r
β = 1/T
L = 1/M
r₀
x
ds²_BH = (r/R)^{3/2} (-f dt² +
= (r/R)^{3/2} (-dt² +

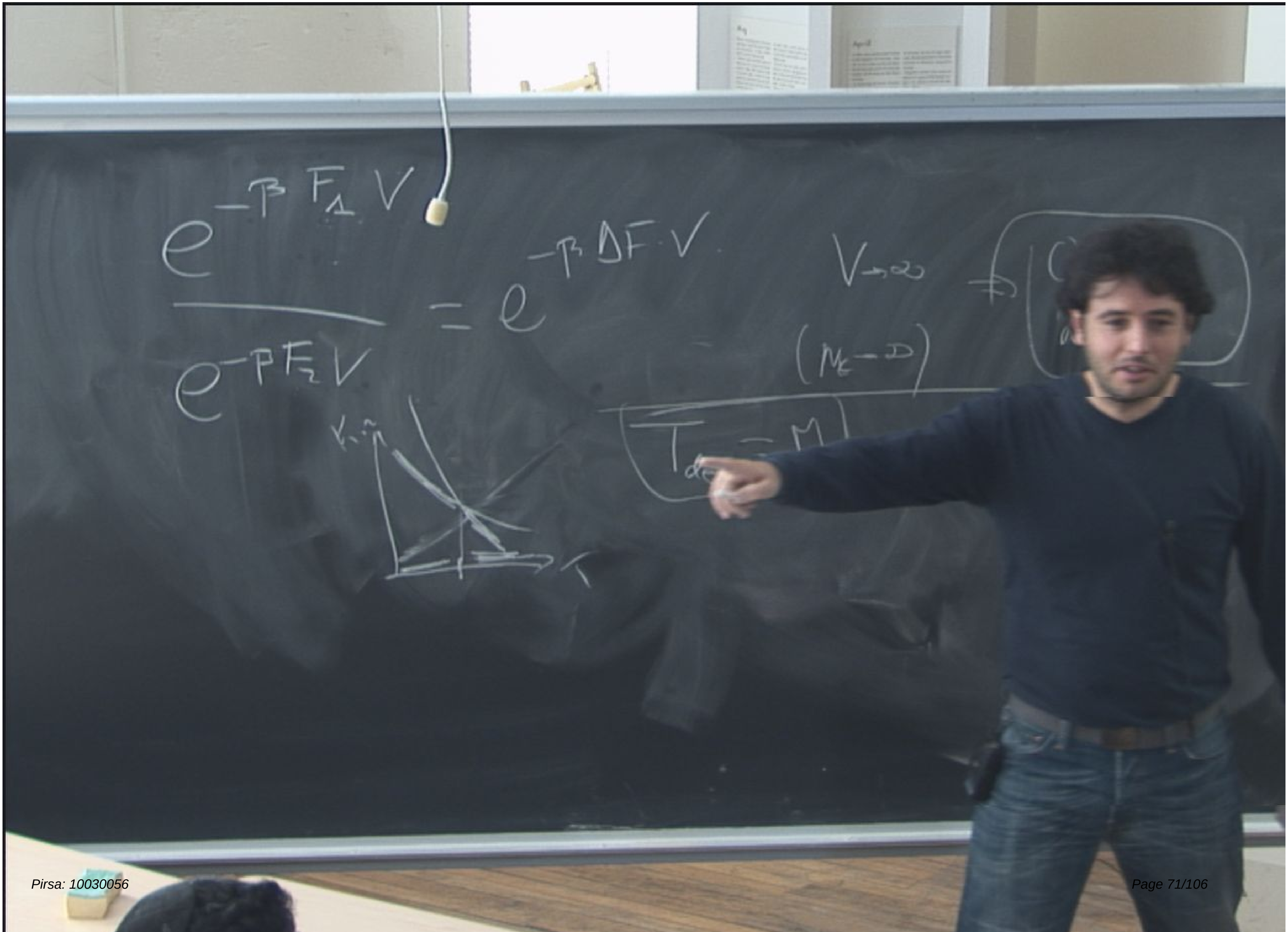
BH

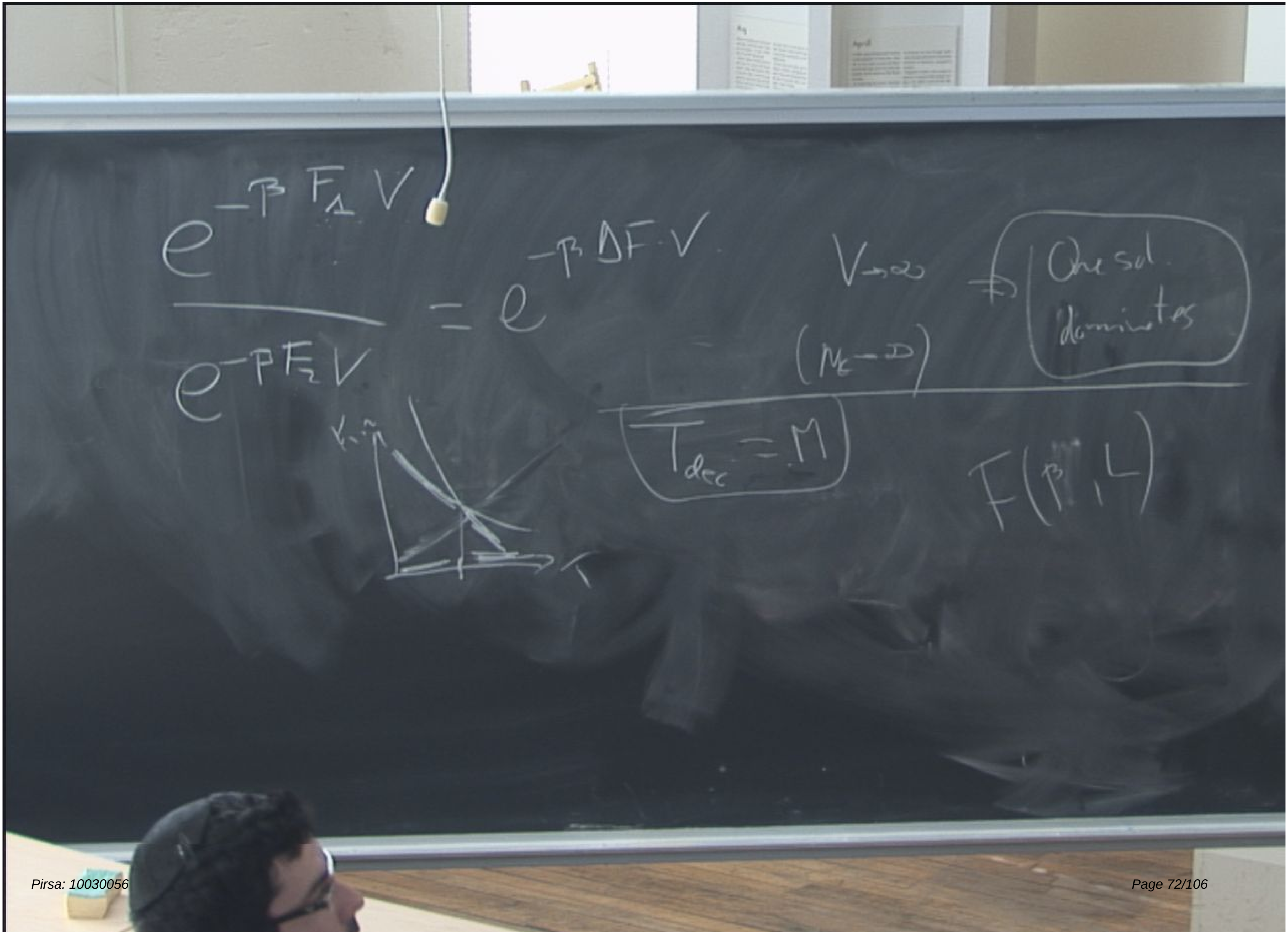


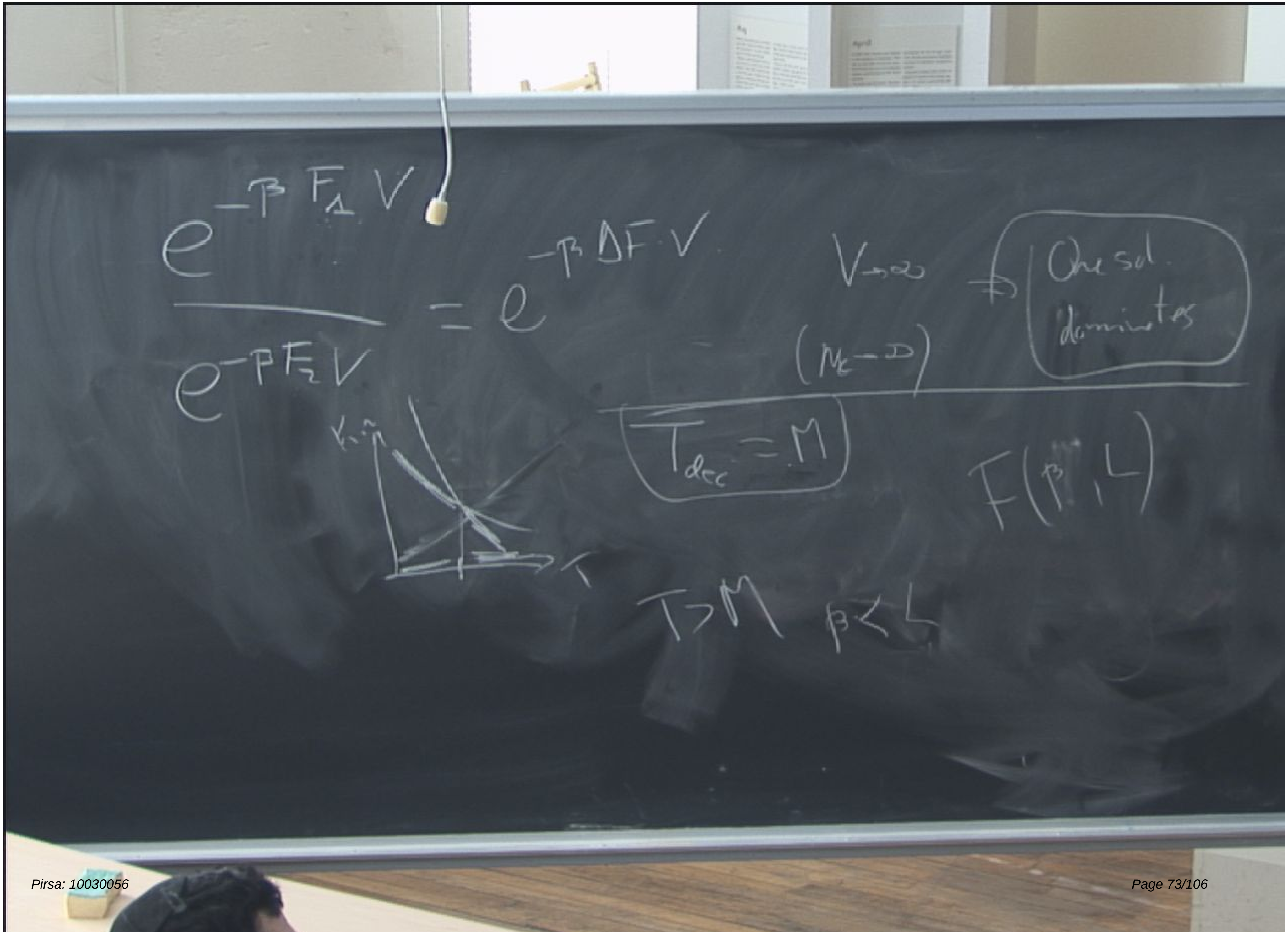
$$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,dt^2 + \right.$$

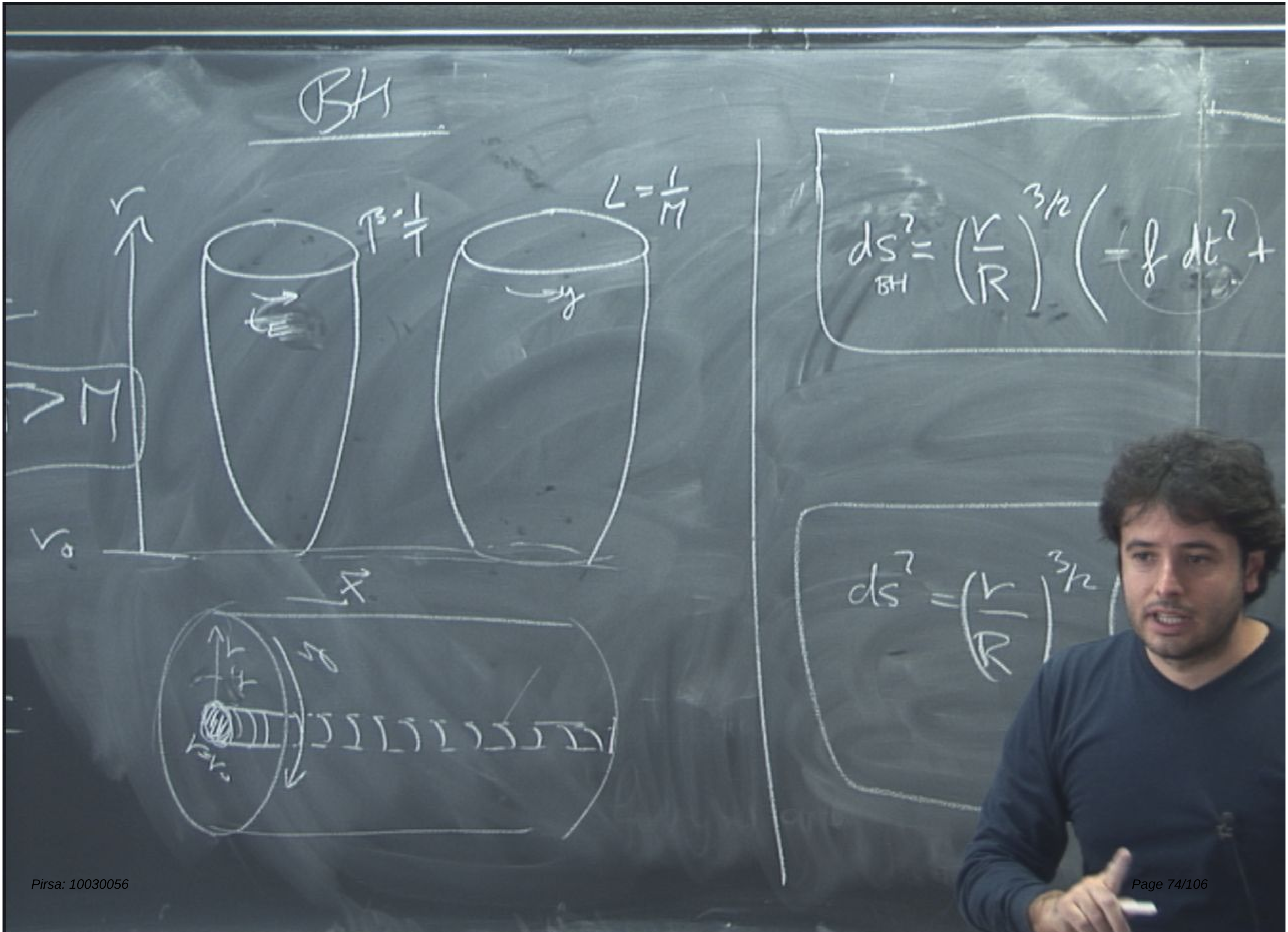
$$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-dt^2 + \right.$$

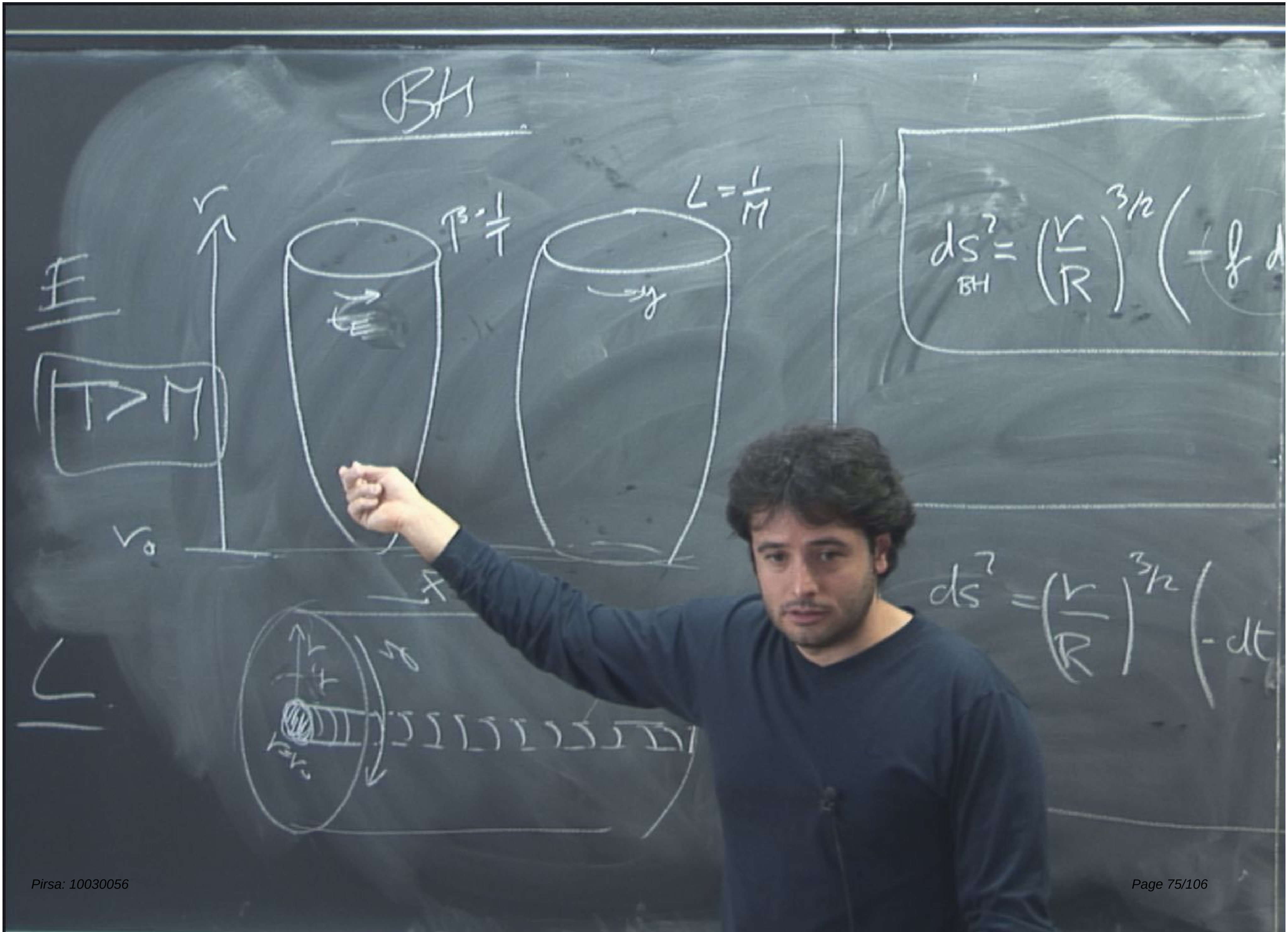

e^{-β F_1 V} / e^{-β F_2 V} = e^{-β ΔF·V}
V→∞ ⇒ One sol. dominates
(N_c→∞)
T_dec = M
F(β, L)

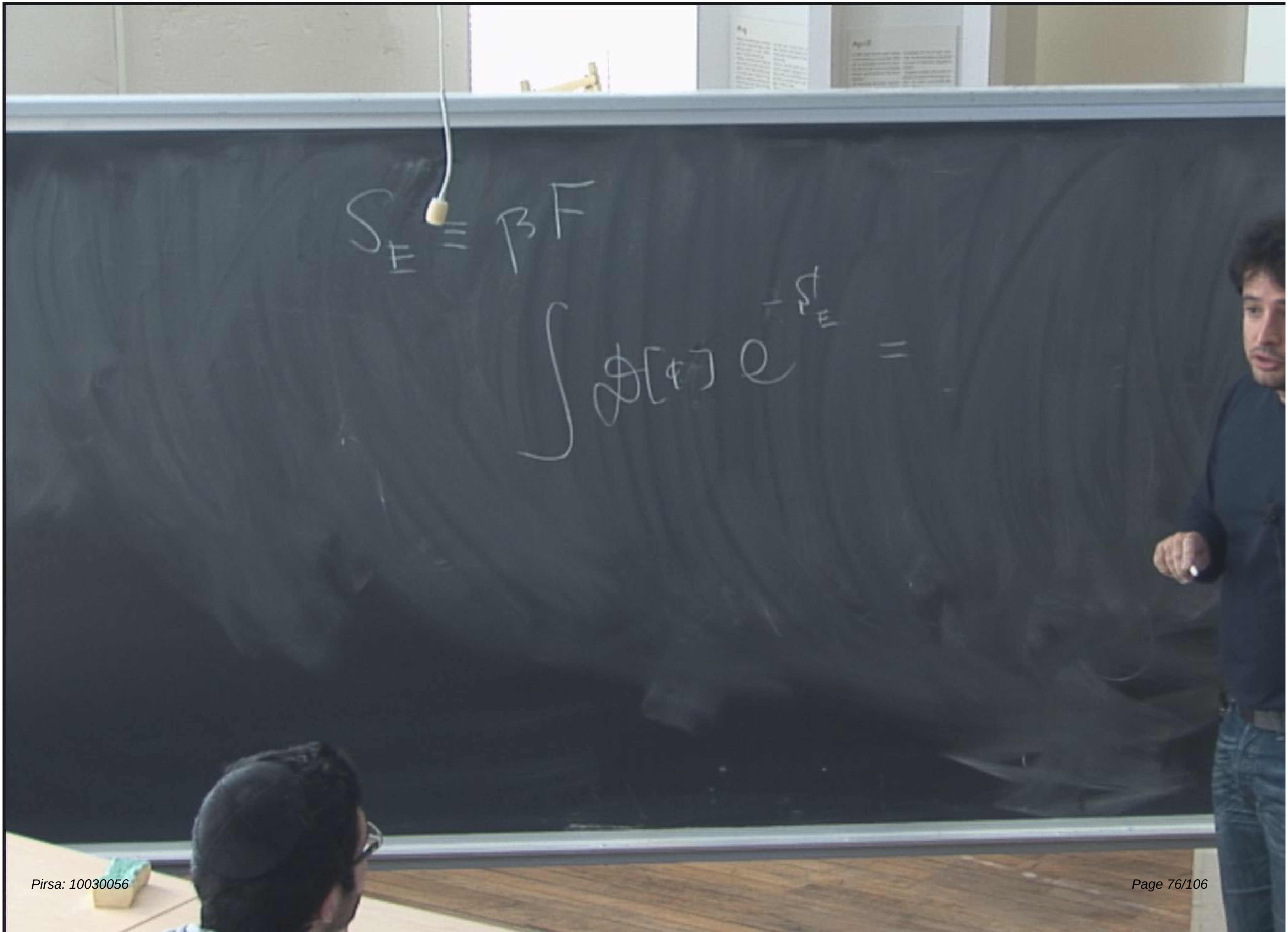

e^{-βF1 V} / e^{-βF2 V} = e^{-βΔF·V}
V→∞

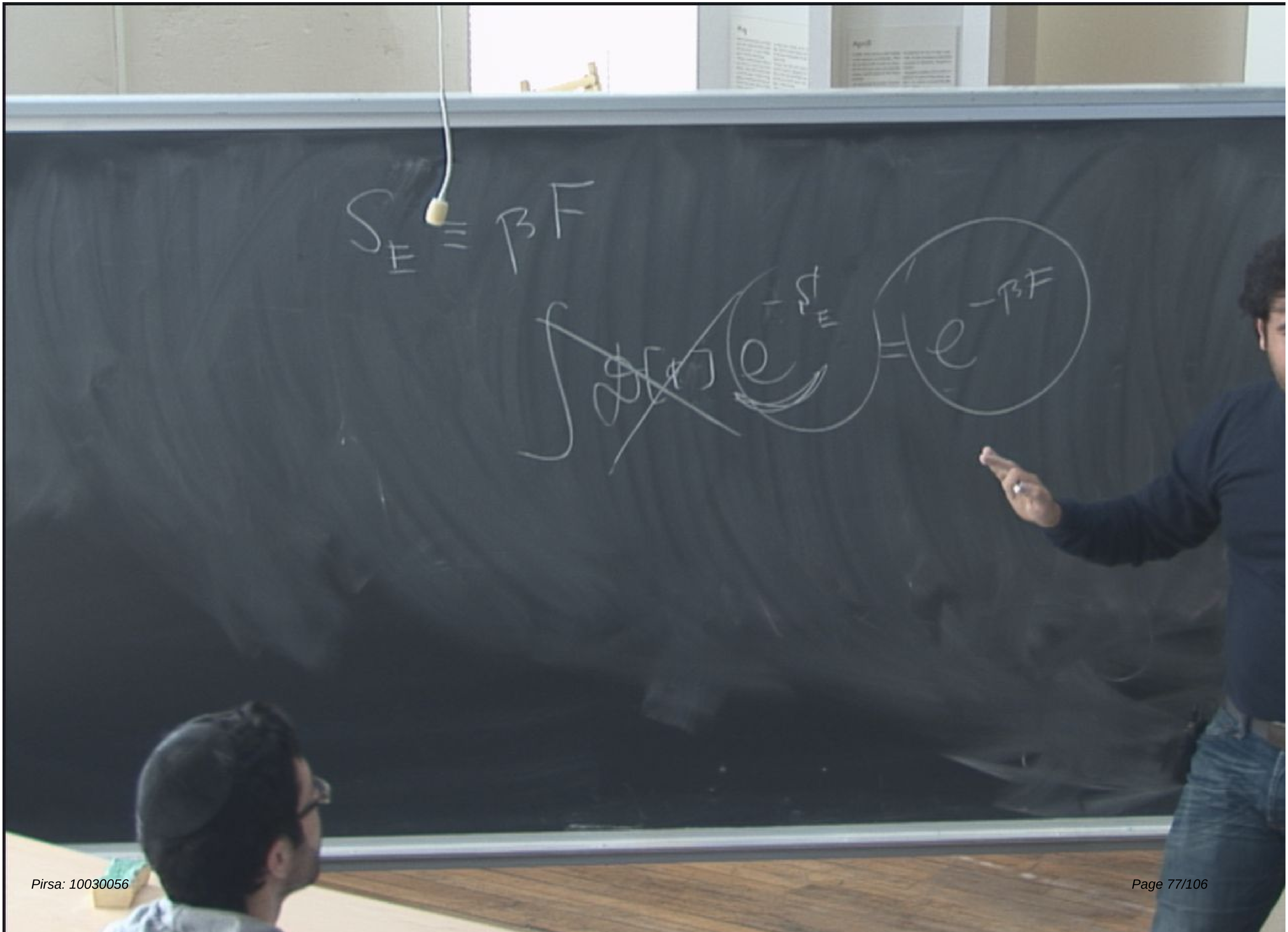

$\frac{e^{-\beta F_1 V}}{e^{-\beta F_2 V}} = e^{-\beta \Delta F \cdot V}$
$V \to \infty$
$(N_c \to \infty)$
One sol. dominates
$T_{dec} = M$
$F(\beta, L)$

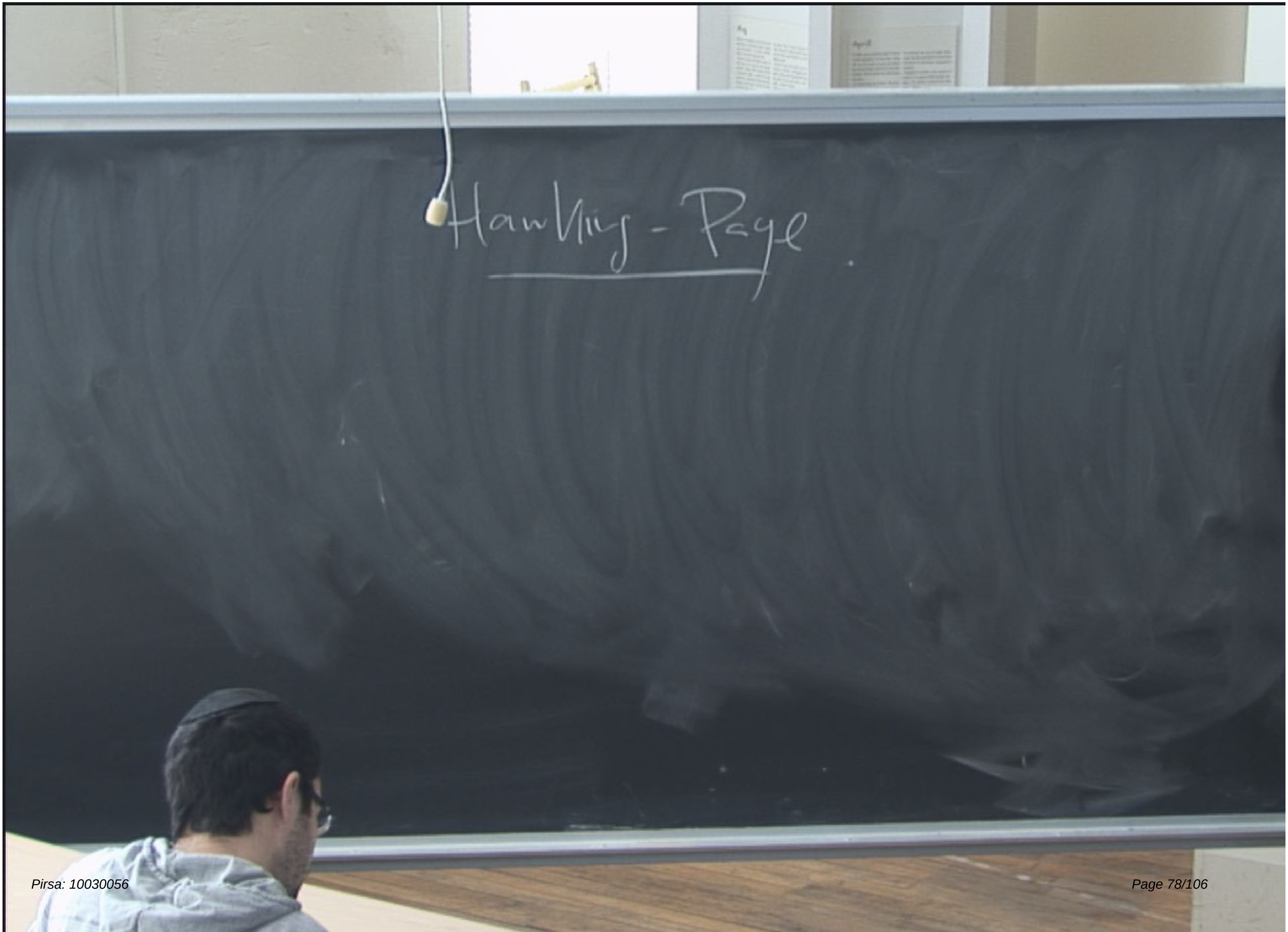

$\frac{e^{-\beta F_1 V}}{e^{-\beta F_2 V}} = e^{-\beta \Delta F \cdot V}$
$V \to \infty$
One sol. dominates
$T_{dec} = M$
$F(\beta, L)$
$T > M$
$\beta < L$

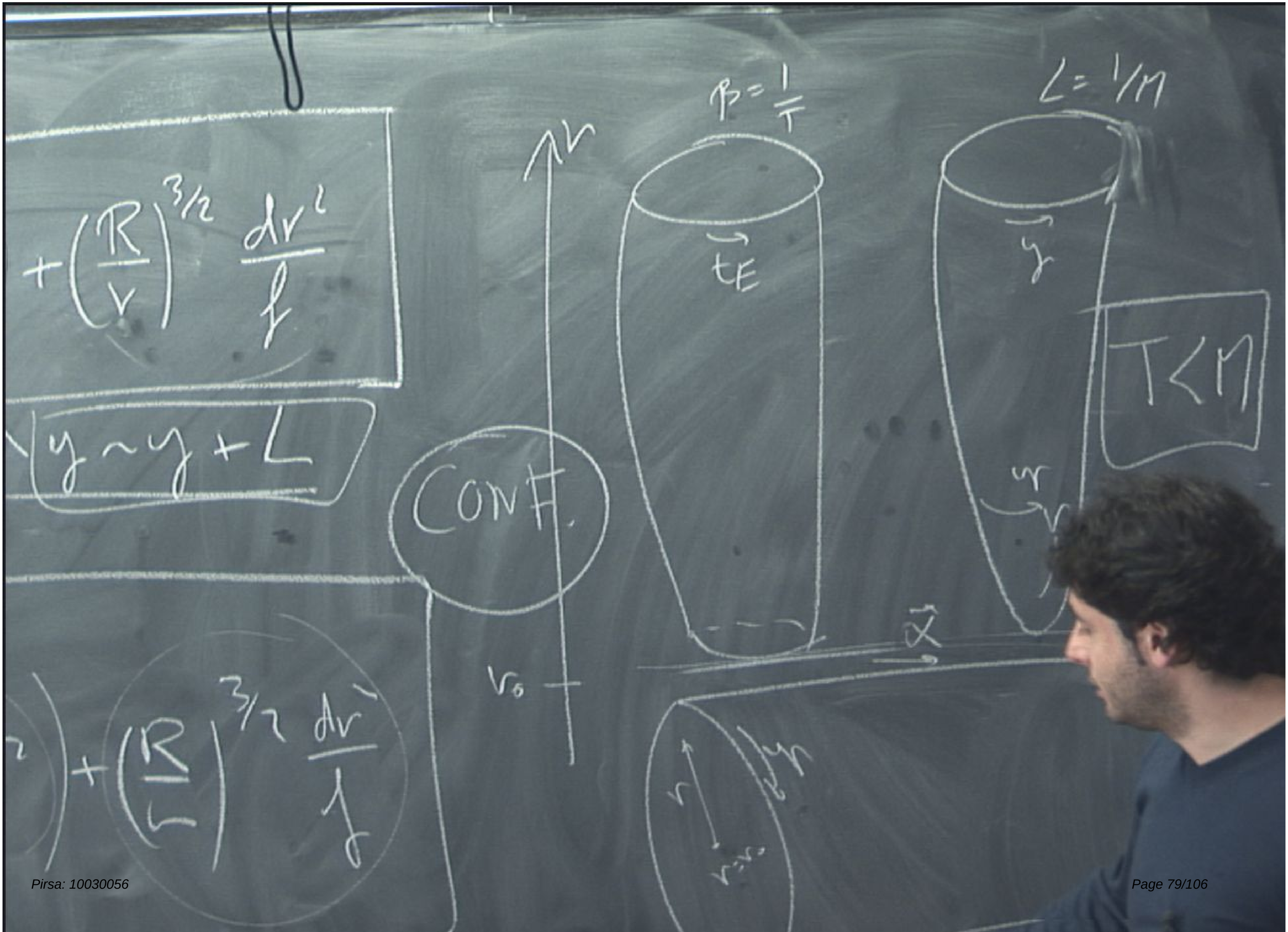

BH
r
β = 1/T
L = 1/M
t_E
y
> M
r_0
x
r ≥ r_0
ds²_BH = (r/R)^{3/2} (− f dt² +
ds² = (r/R)^{3/2}


BH
E
T > M
L
$\beta = \frac{1}{T}$
$L = \frac{1}{M}$
$ds^2_{BH} = \left(\frac{r}{R}\right)^{3/2}\left(-f\,d\right.$
$ds^2 = \left(\frac{r}{R}\right)^{3/2}\left(-dt\right.$

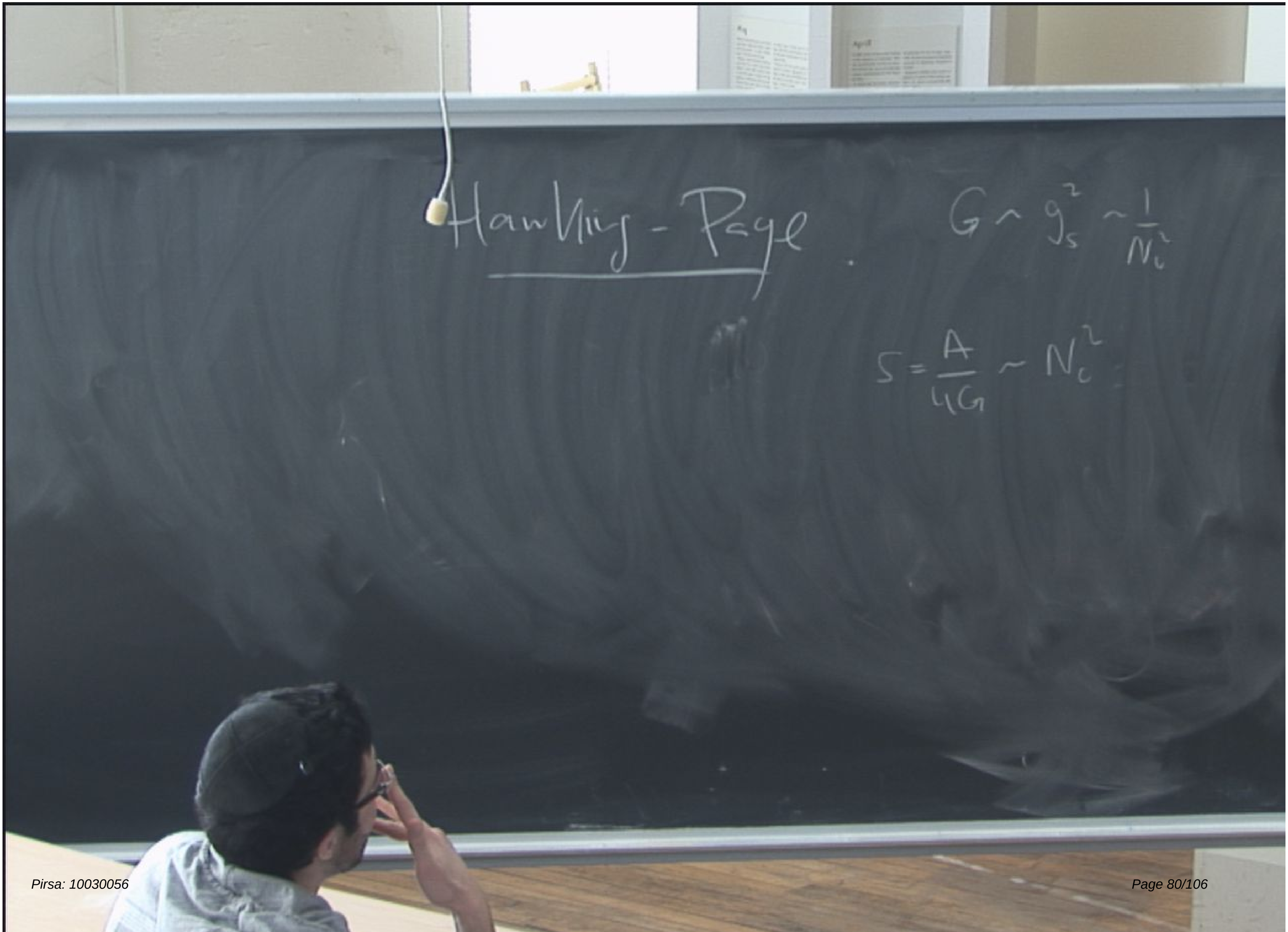

$S_E = \beta F$
$\int \mathcal{D}[\phi]\, e^{-S_E} =$

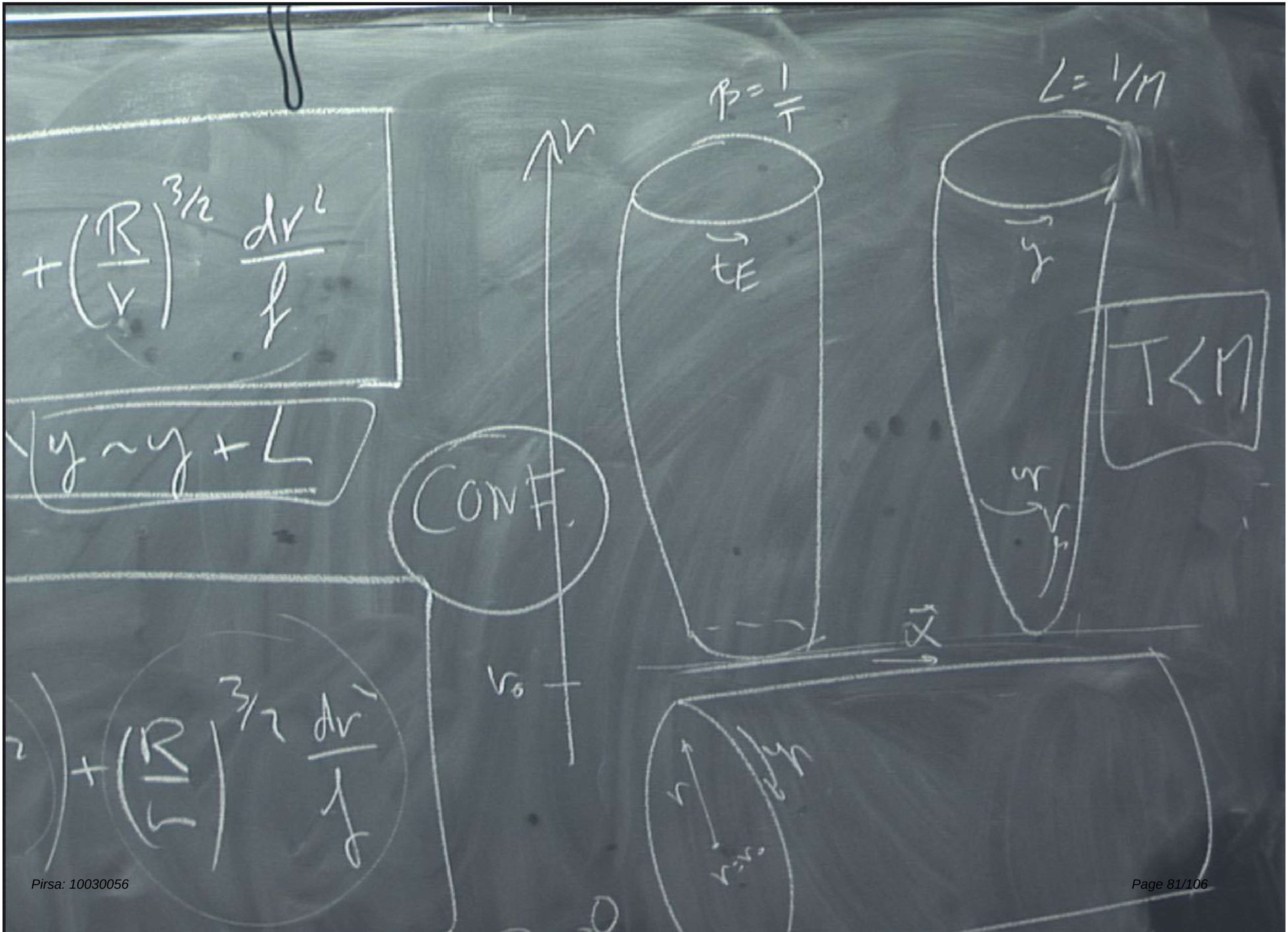

$S_E = \beta F$
$\cancel{\int \mathcal{D}[\phi]}\, e^{-S_E} = e^{-\beta F}$

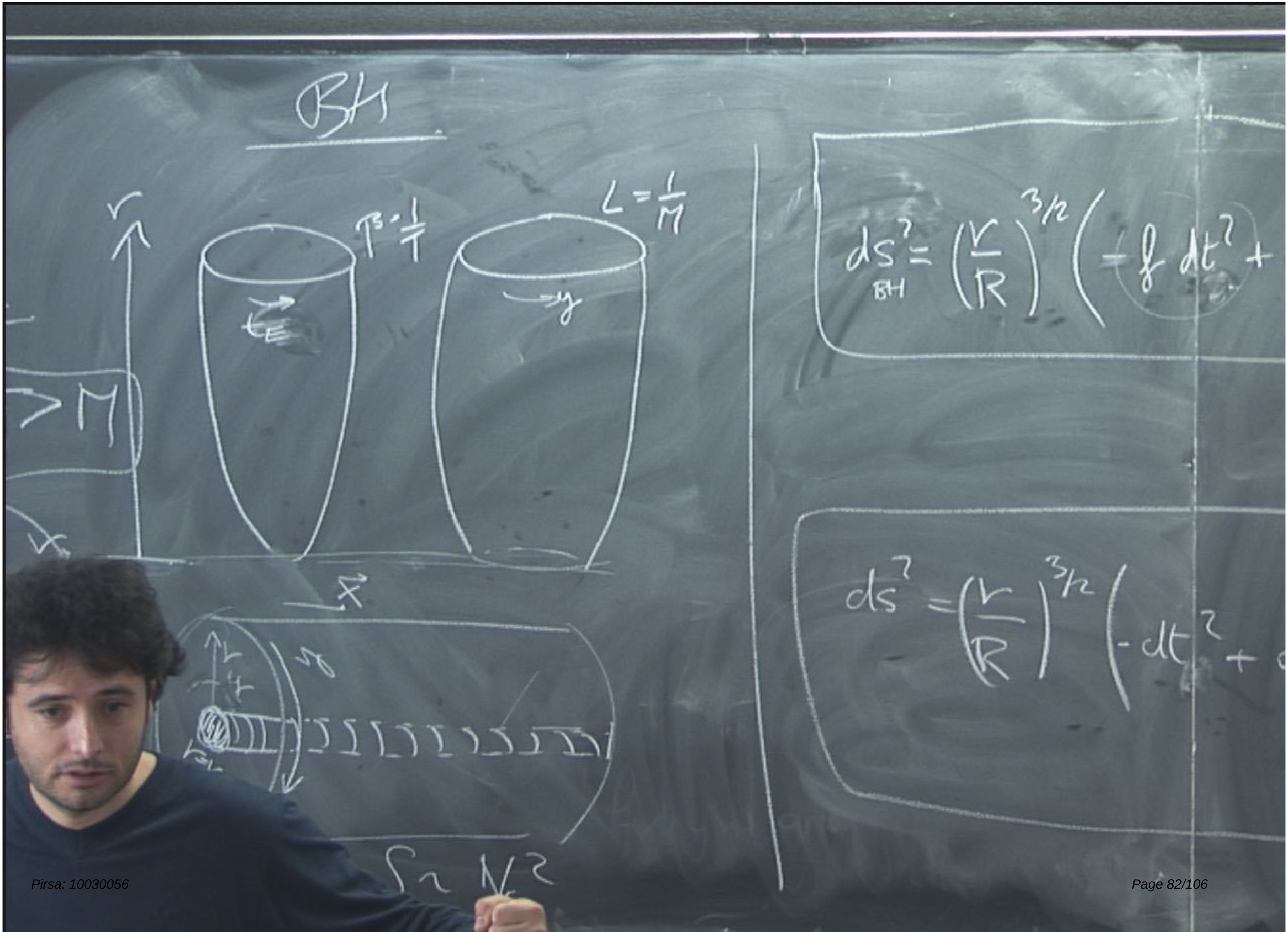

Hawking - Page

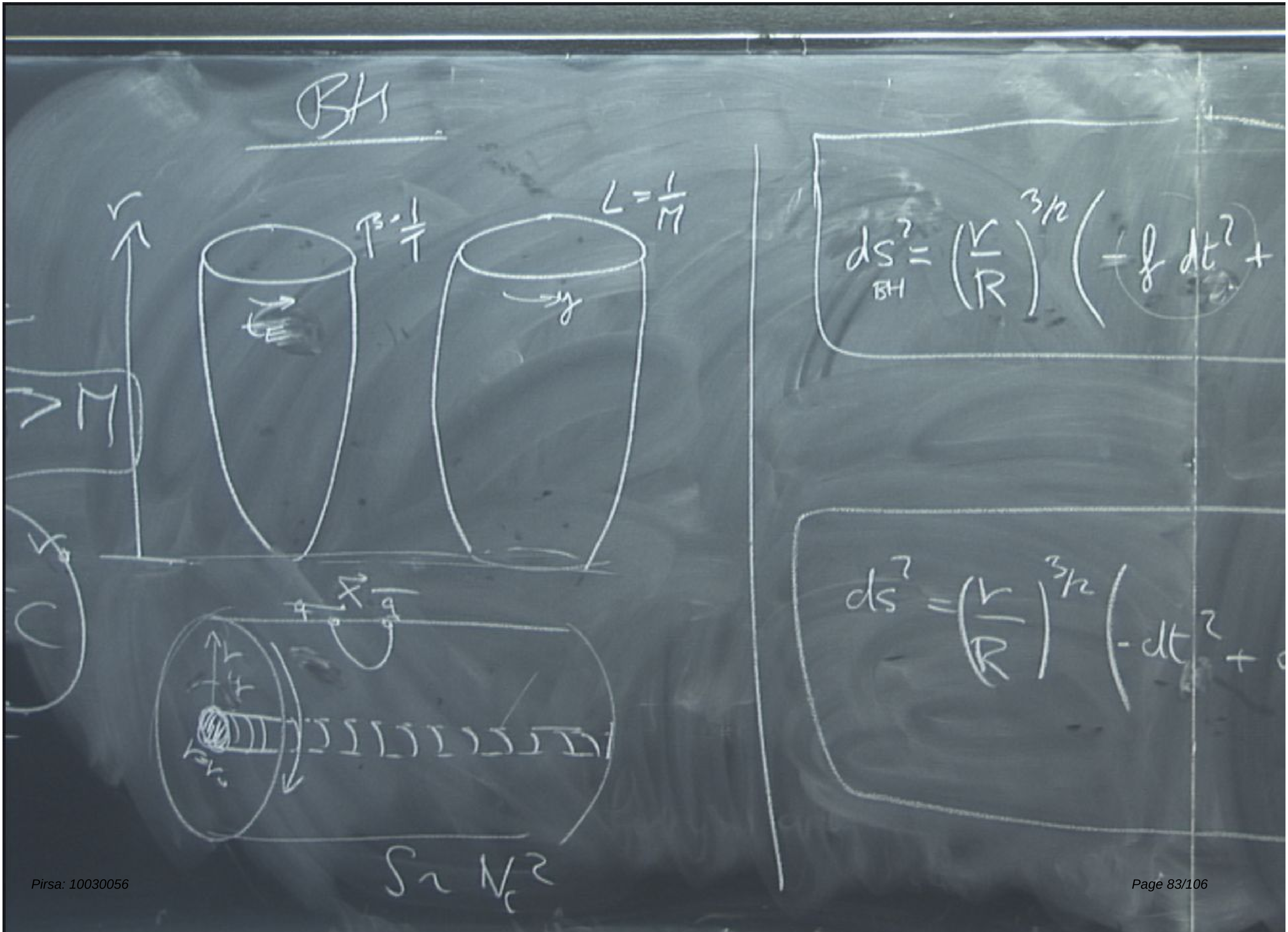


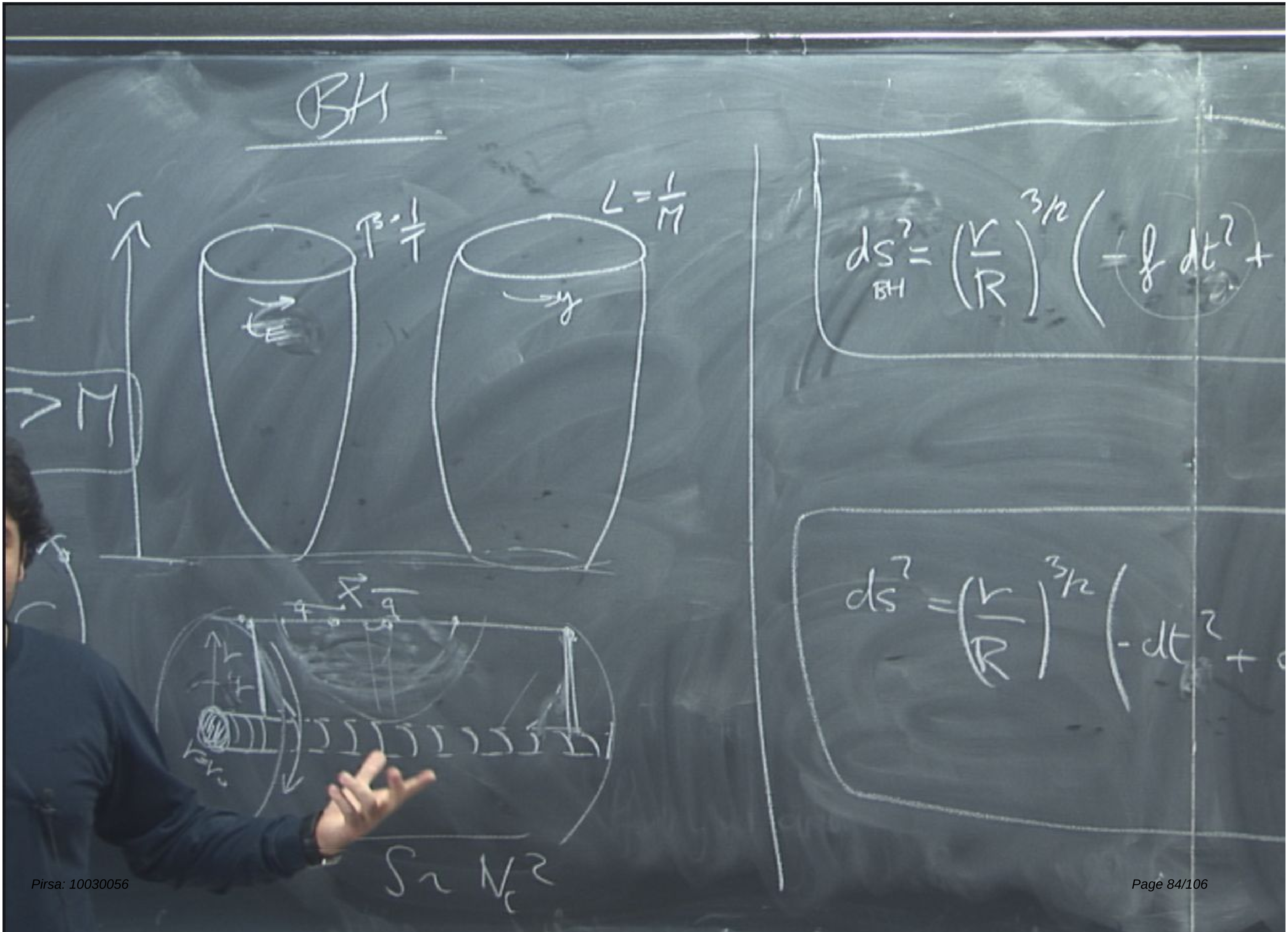
+ (R/r)^{3/2} dr^2/f
y ~ y + L
CONF.
r
β = 1/T
L = 1/M
t_E
y
T < M
r
r_0
x
+ (R/r)^{3/2} dr^2/f
r

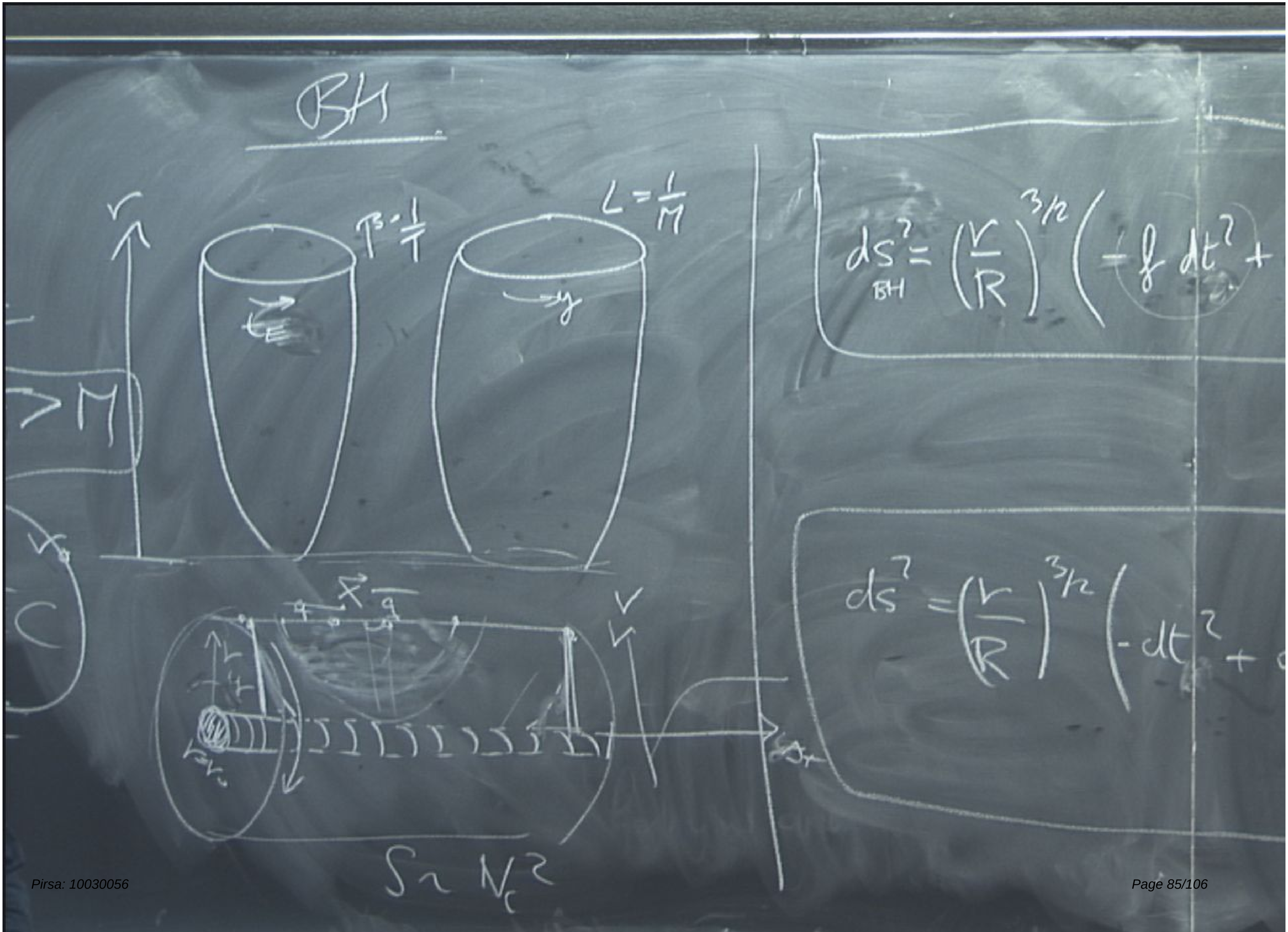

Hawking - Page
$G \sim g_s^2 \sim \frac{1}{N_c^2}$
$S = \frac{A}{4G} \sim N_c^2$

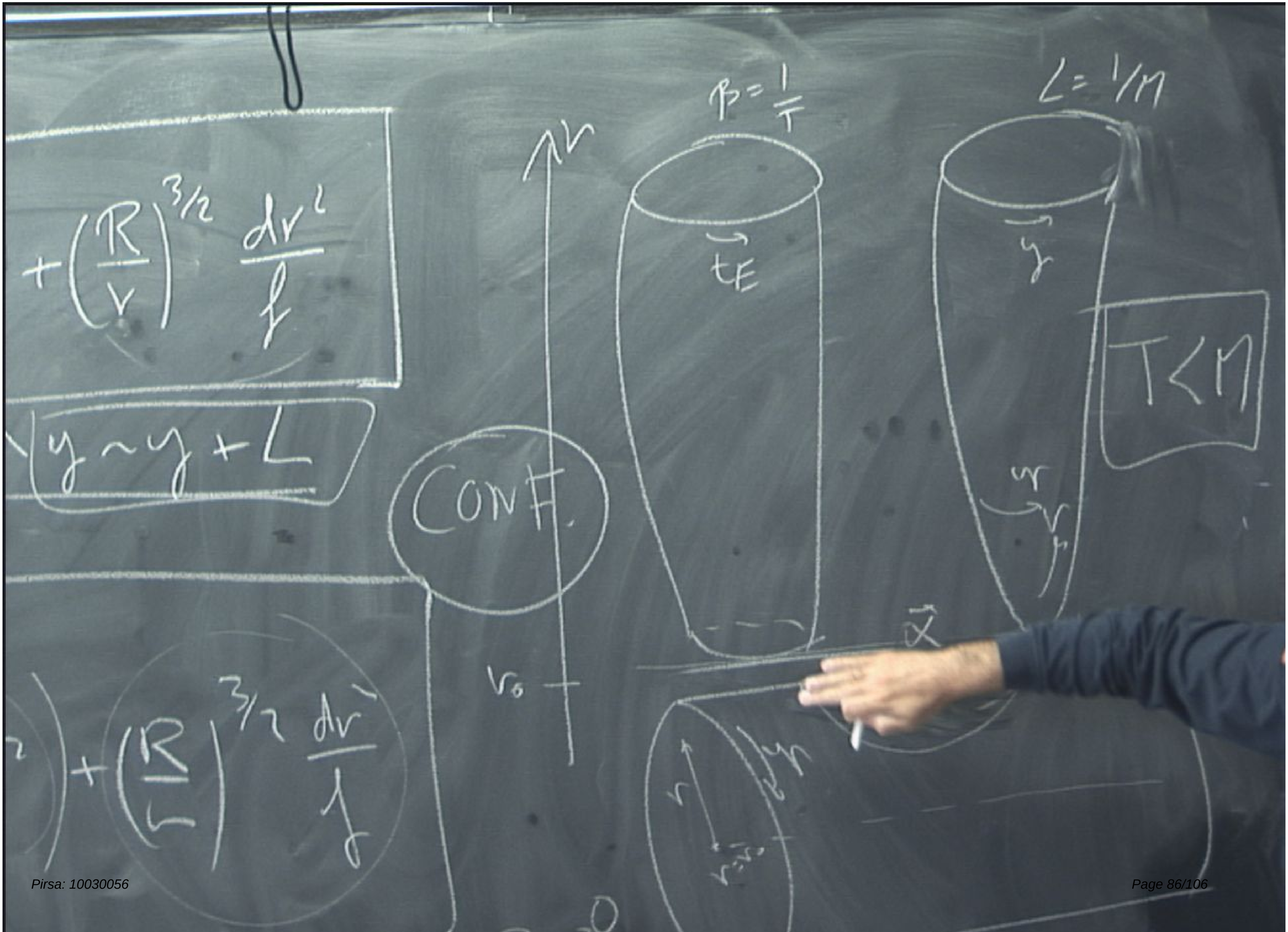

$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$
$y \sim y + L$
CONF.
$\beta = \frac{1}{T}$
$L = 1/M$
t_E
y
$T < M$
r
r_0
$\vec{x}$
$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$


BH
β = 1/T
L = 1/M
ds²_BH = (r/R)^{3/2} (−f dt² +
ds² = (r/R)^{3/2} (−dt² +
> M
∫ ~ N_c²

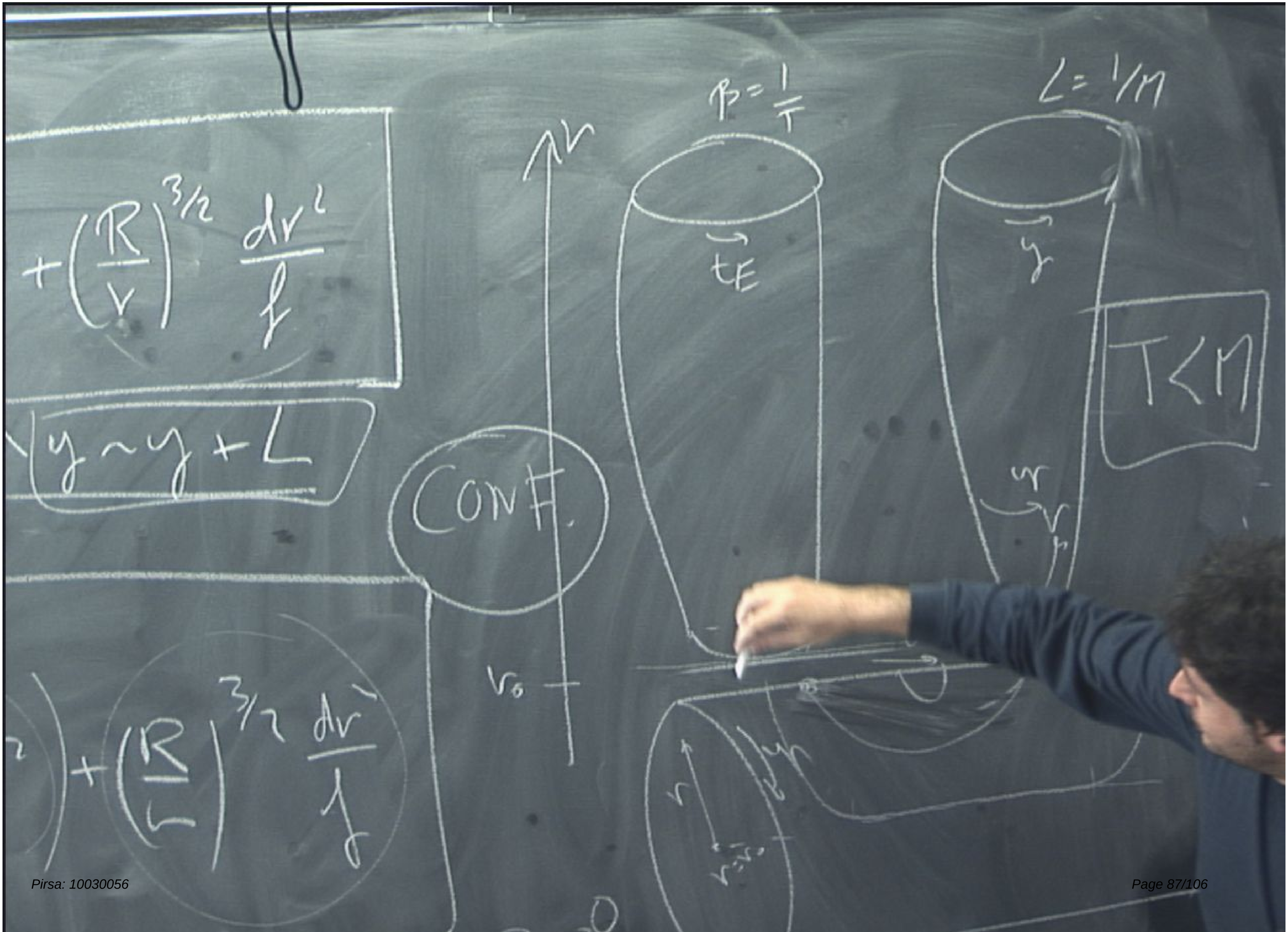

BH
r
β = 1/T
L = 1/M
t_E
y
> M
x
q
q̄
r = r_0
S ~ N_c^2
ds^2_BH = (r/R)^{3/2} (-f dt^2 +
ds^2 = (r/R)^{3/2} (-dt^2 +


BH
r
β = 1/T
L = 1/M
y
> M
x
S ~ N_c^2
ds^2_BH = (r/R)^{3/2} (-f dt^2 +
ds^2 = (r/R)^{3/2} (-dt^2 +


BH
r
β = 1/T
L = 1/M
ds²_BH = (r/R)^3/2 (−f dt² +
ds² = (r/R)^3/2 (−dt² +
S ~ N_c²

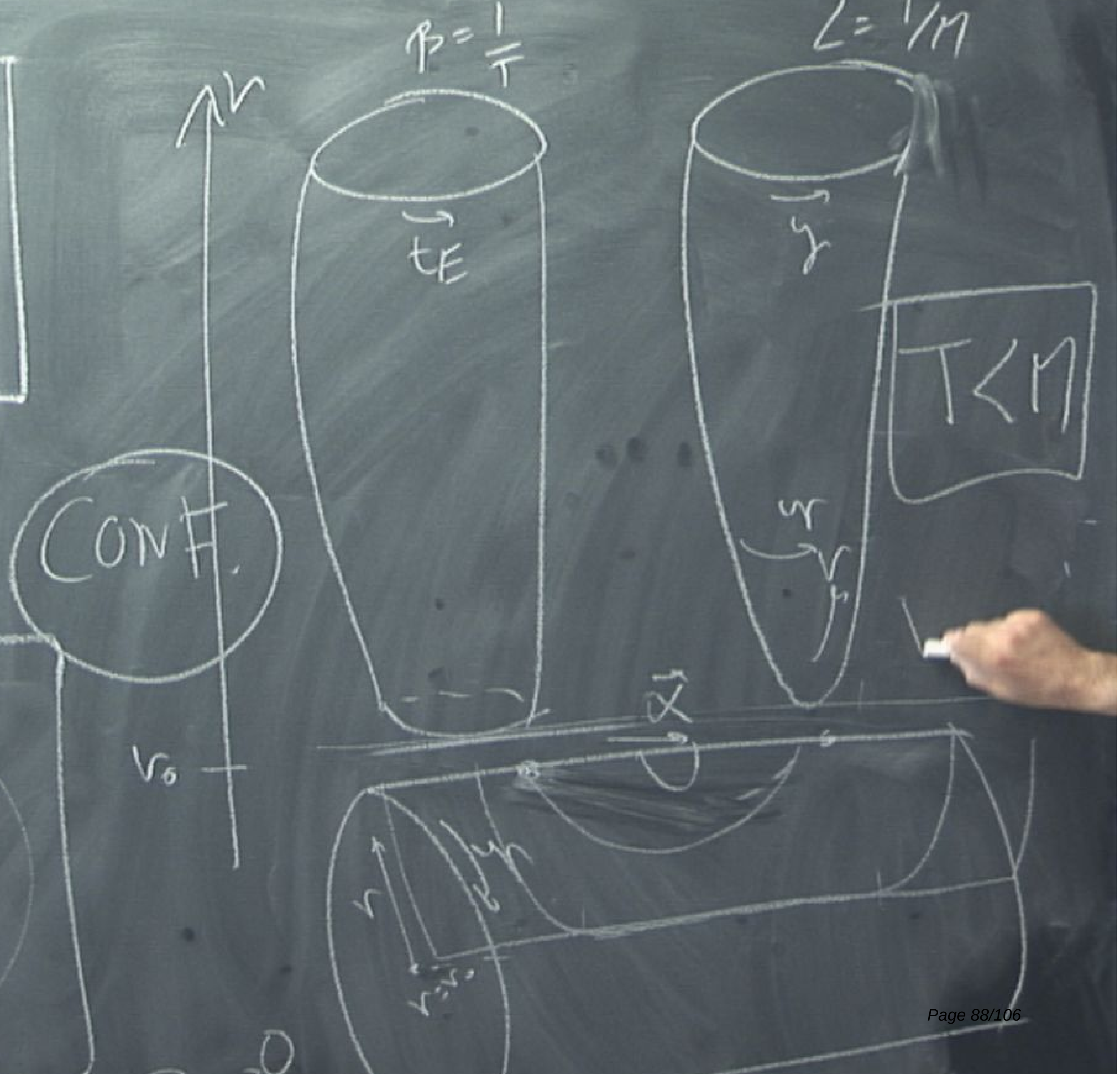


β = 1/T
L = 1/M
T<M
CONF.
y ~ y + L
t_E
y
r
r_0
x


$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$
$y \sim y + L$
$\beta = \frac{1}{T}$
$L = 1/M$
t_E
y
$T < M$
CONF.
r_0
$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$

$$\boxed{+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}}$$

$$\boxed{y \sim y + L}$$

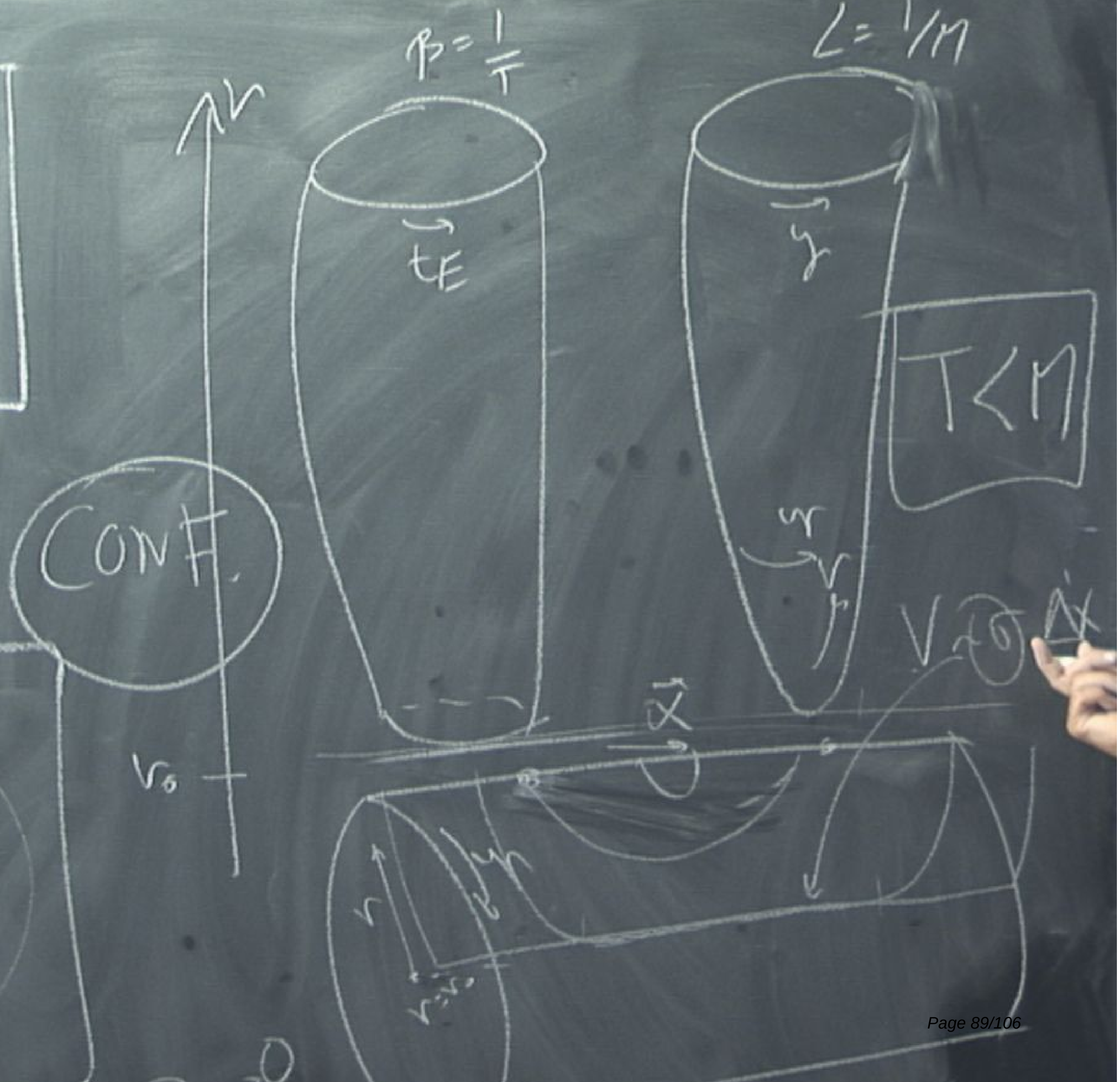


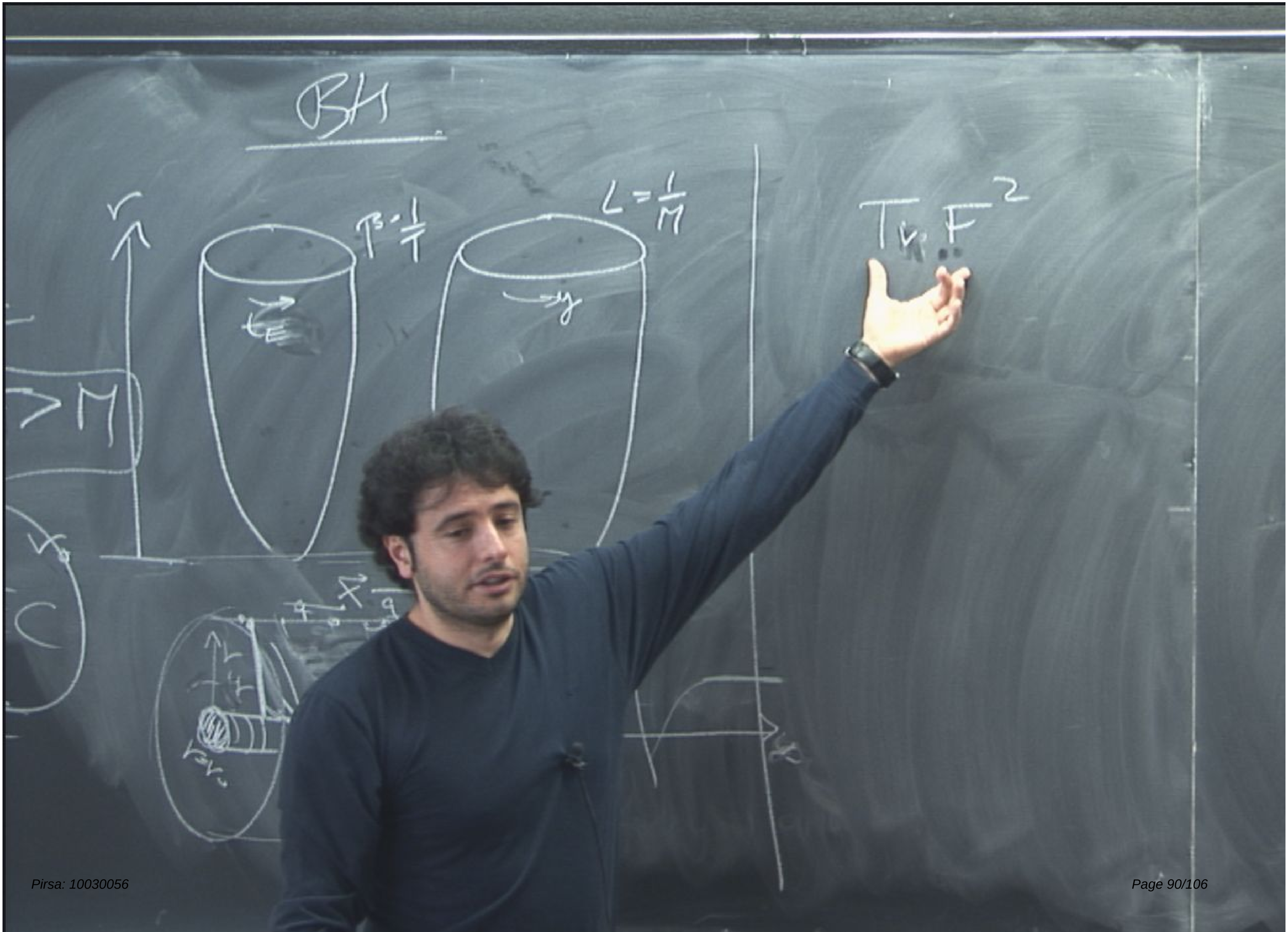
$$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

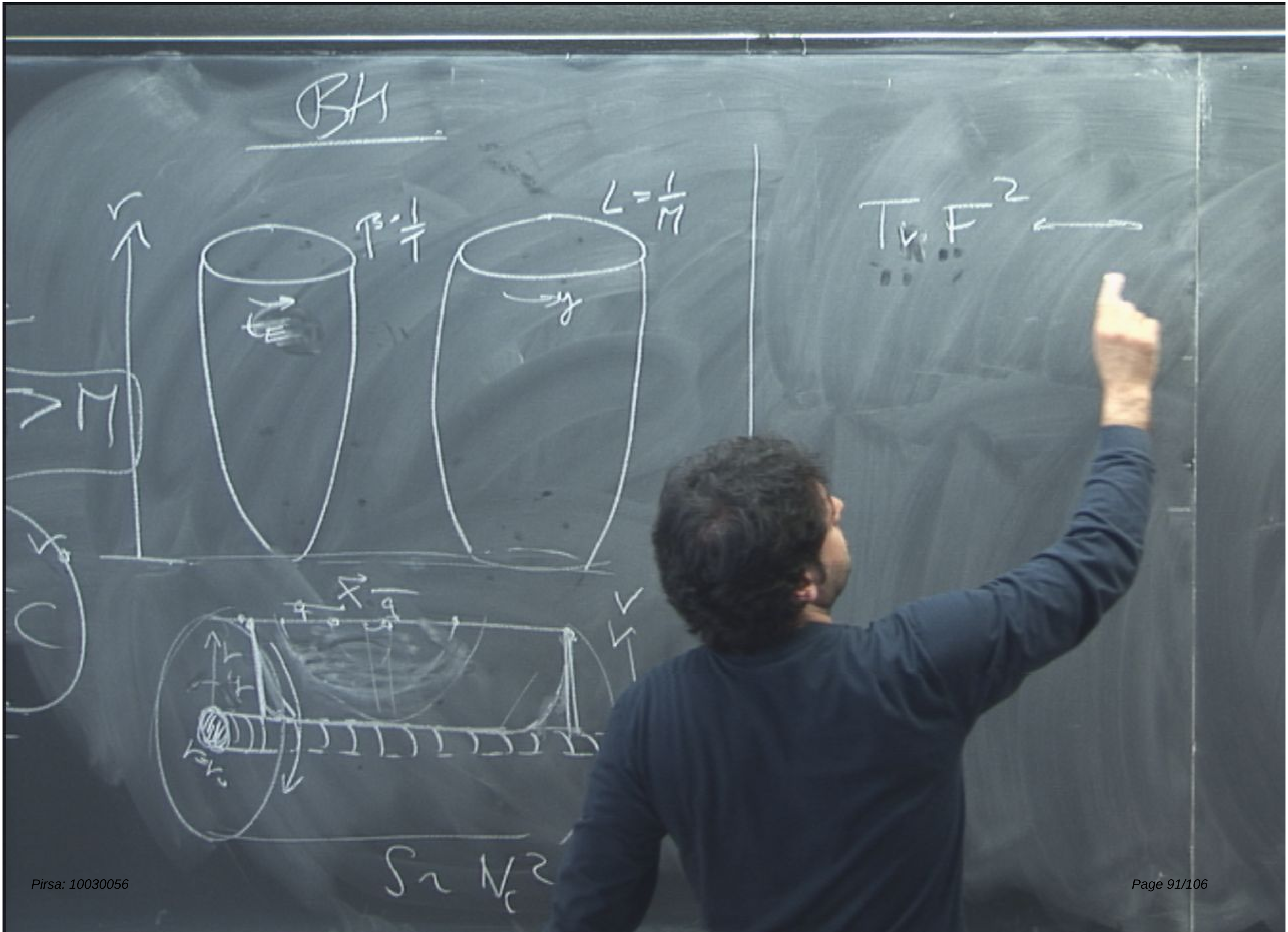
$$+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

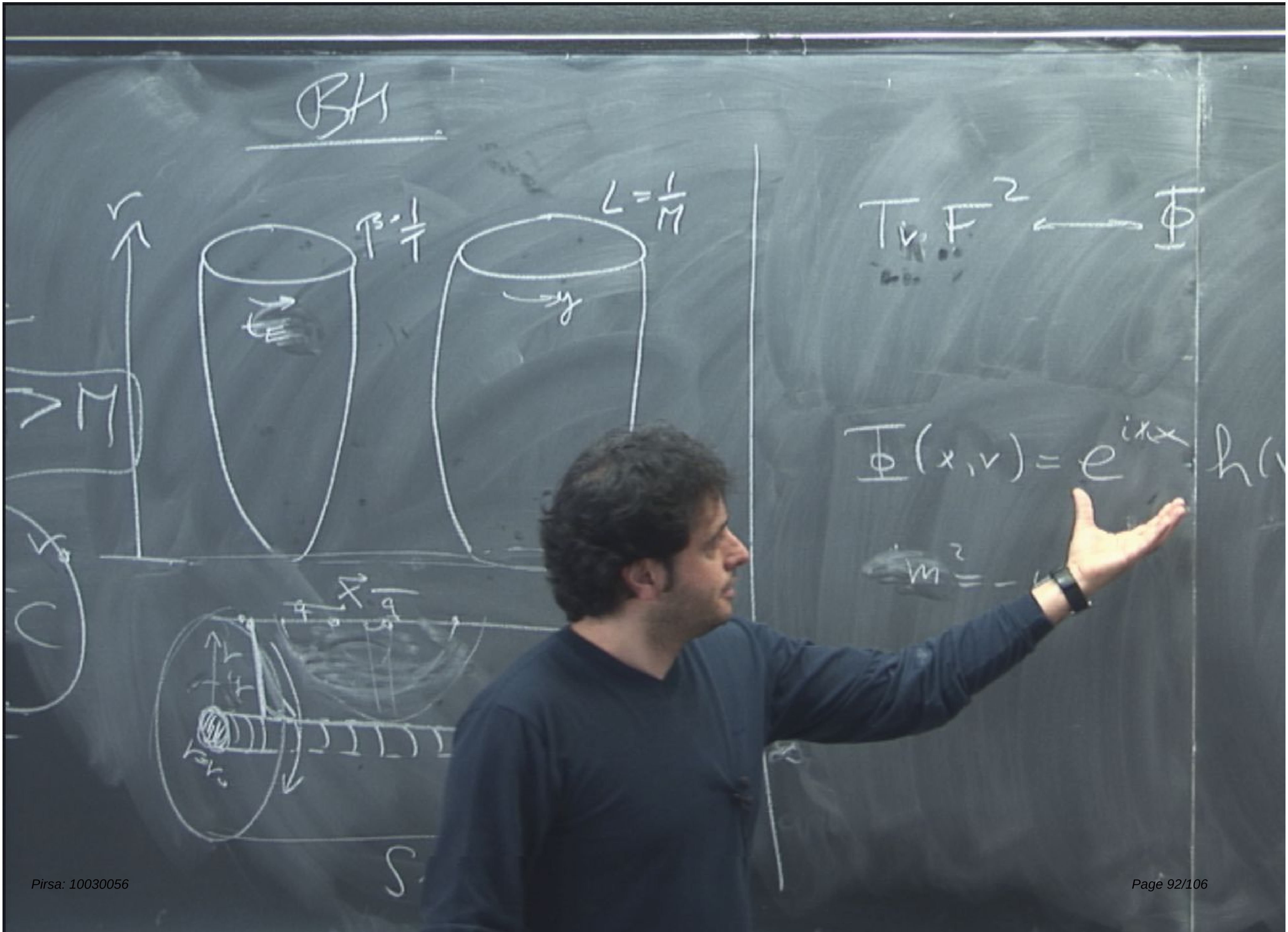
$$y \sim y + L$$

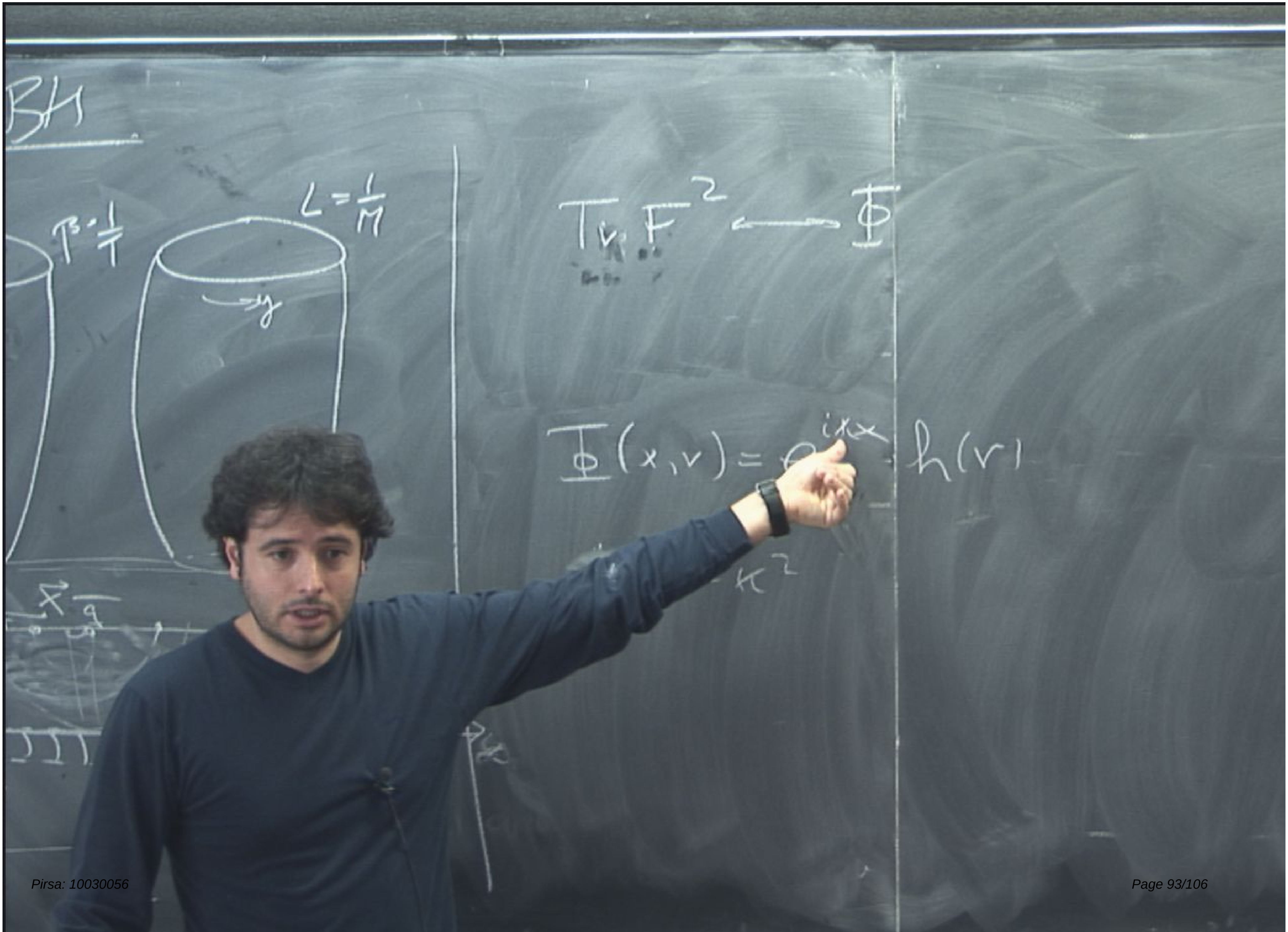
$$)+\left(\frac{R}{r}\right)^{3/2}\frac{dr^2}{f}$$

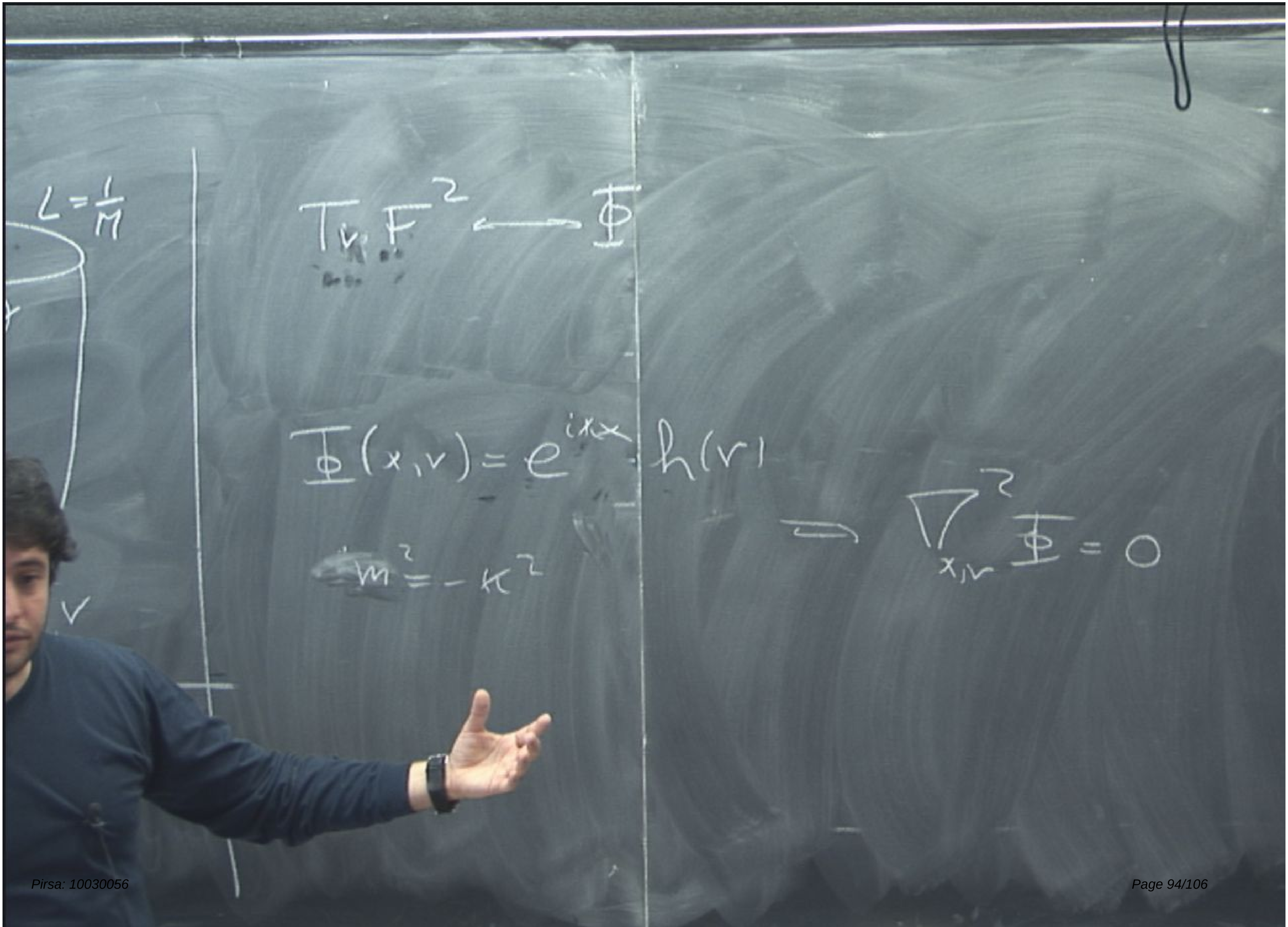


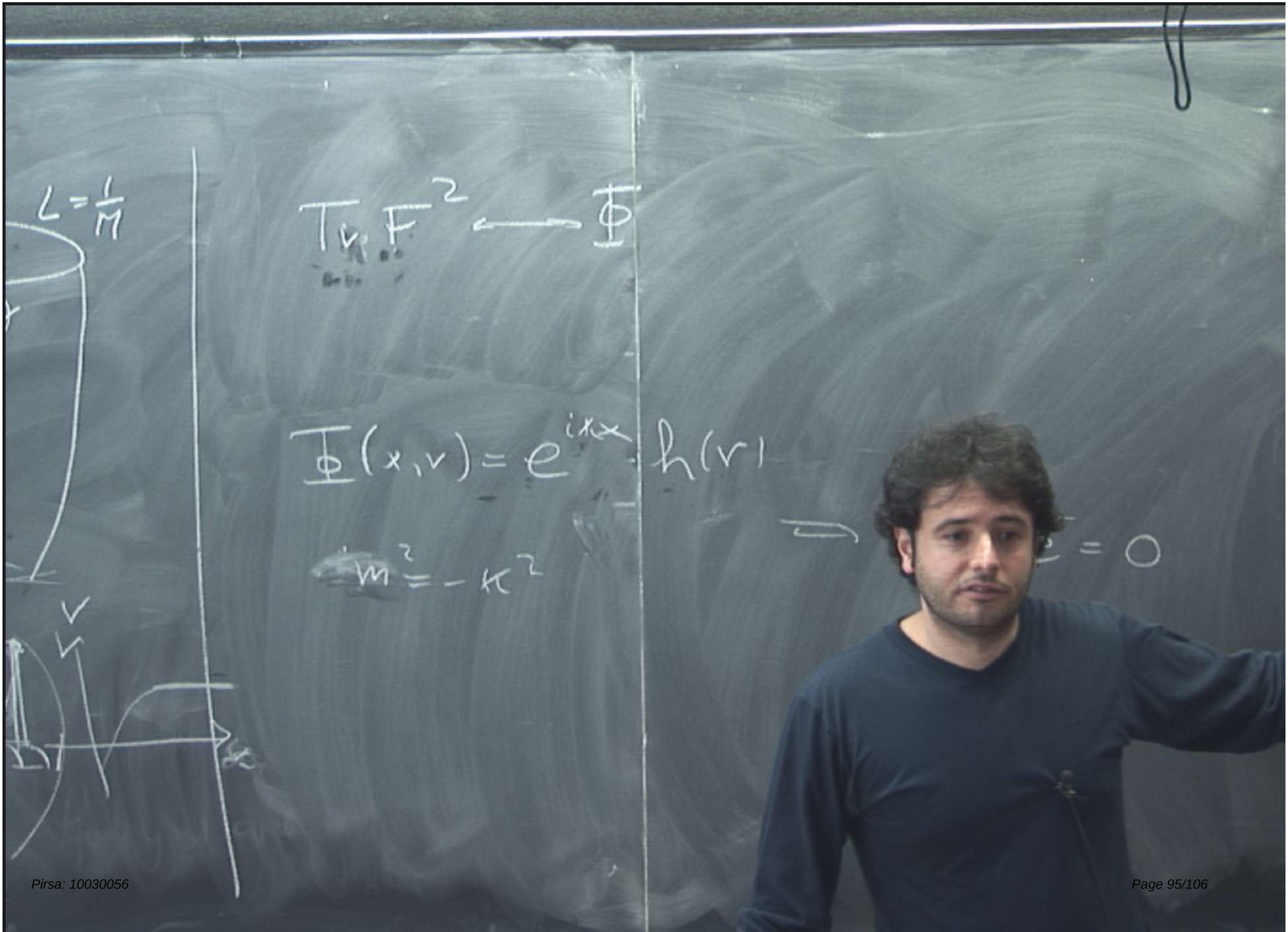



BH
L = 1/M
Tr F²
S ~ Nc²

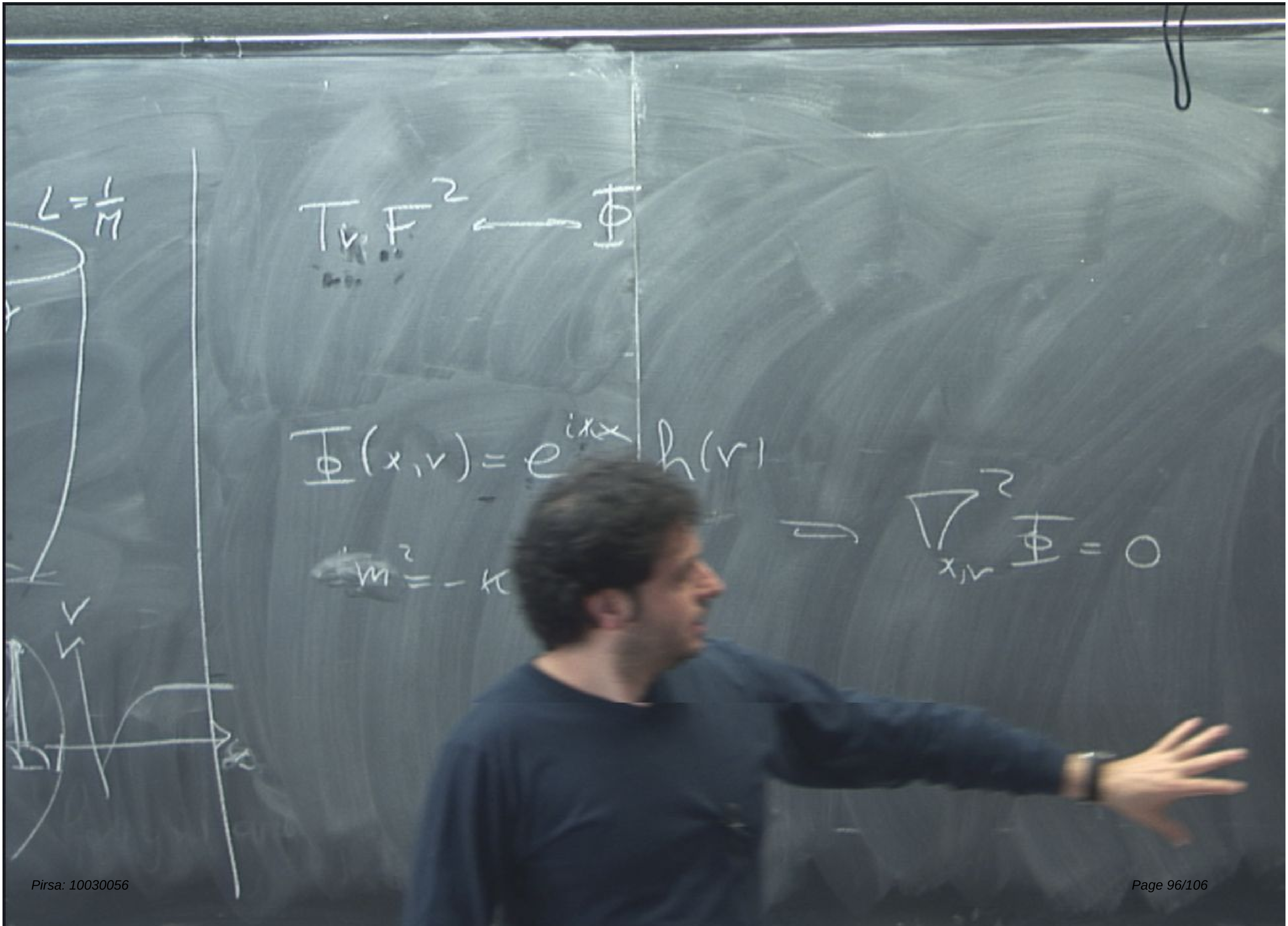

BH
$\beta = \frac{1}{T}$
$L = \frac{1}{M}$
$\mathrm{Tr}\, F^2 \longleftrightarrow \Phi$
$\Phi(x,r) = e^{ikx}\, h(r$

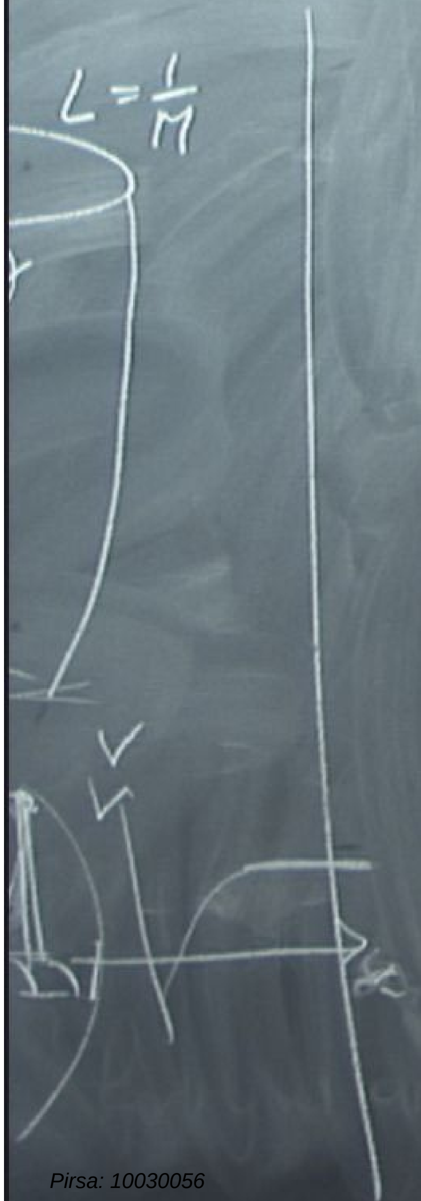

BH
$\beta = \frac{1}{T}$
$L = \frac{1}{M}$
y
$\mathrm{Tr}\,F^2 \longleftrightarrow \Phi$
$\Phi(x,r) = e^{ikx}\,h(r)$
k^2


$L = \frac{1}{M}$
$\mathrm{Tr}\, F^2 \longleftrightarrow \Phi$
$\Phi(x,r) = e^{ikx} h(r)$
$m^2 = -k^2$
$\Longrightarrow \nabla^2_{x,r} \Phi = 0$
r



L = 1/M
Tr F^2 ⟵ Φ
Φ(x, r) = e^{ikx} h(r)
m^2 = −k^2
= 0


$L = \frac{1}{M}$
$\mathrm{Tr} F^2 \longleftrightarrow \Phi$
$\Phi(x,r) = e^{ikx} h(r)$
$\Longrightarrow \nabla^2_{x,r} \Phi = 0$
$m^2 = -k$

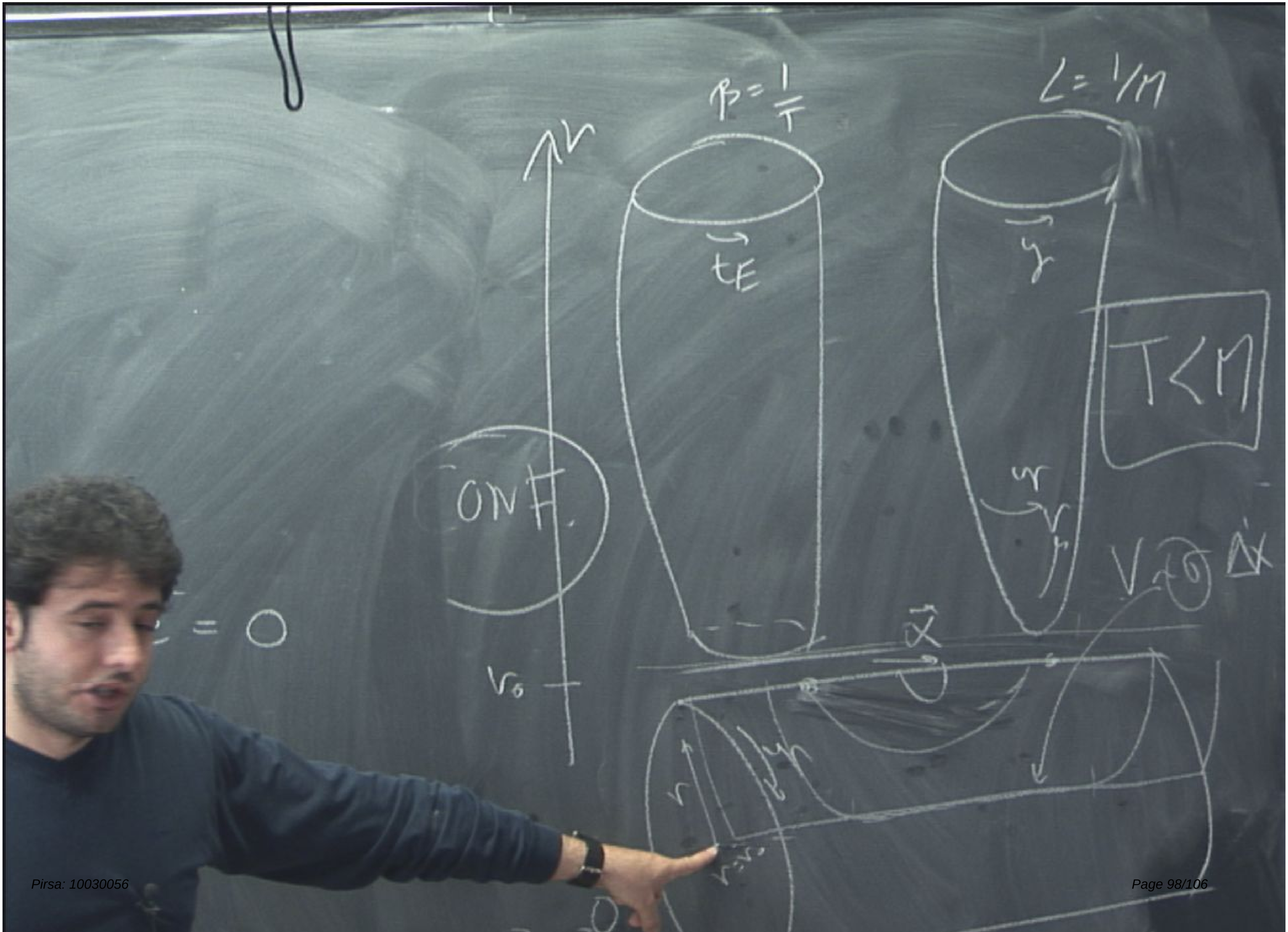


$$\mathrm{Tr}\, F^2 \longleftrightarrow \Phi$$

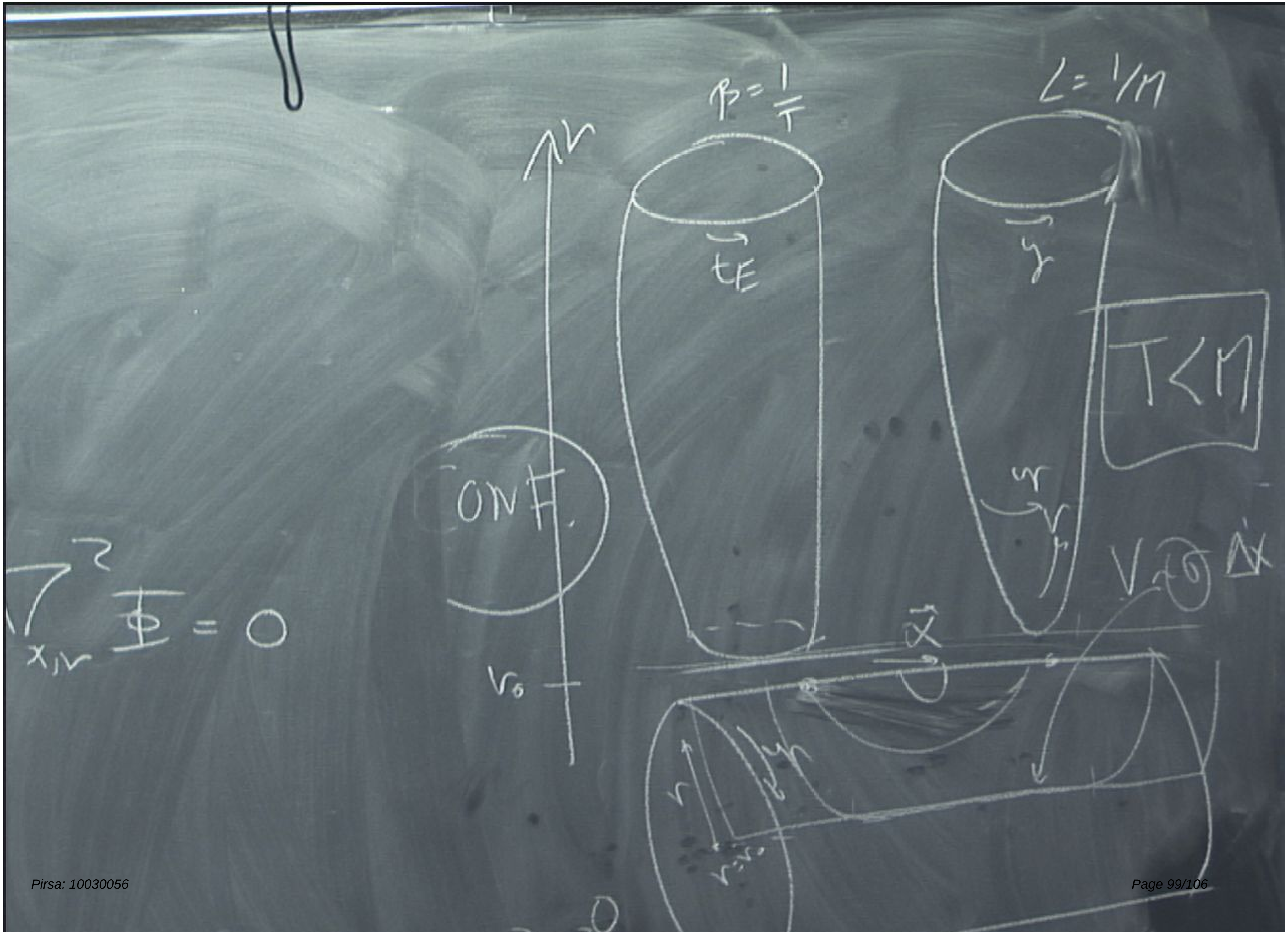
$$\Phi(x,r) = e^{ikx}\, h(r)$$

$$m^2 = -k^2$$

$$\Longrightarrow \nabla^2_{x,r}\, \Phi = 0$$

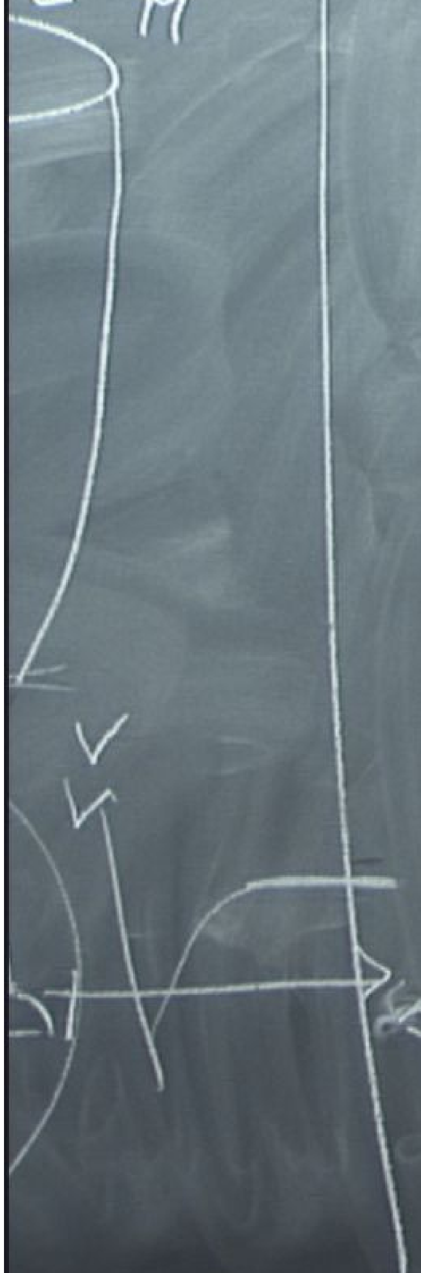


$\beta = \frac{1}{T}$
$L = 1/M$
t_E
CONF.
$T < M$
r_0
$= 0$



β = 1/T
L = 1/M
r
t_E
y
T<M
CONF.
r_0
x
∇²_{x,r} Φ = 0

$L = \frac{1}{M}$



$\mathrm{Tr}\, F^2 \longleftarrow \Phi$

$\Phi(x,r) = e^{ikx}\, h(r)$

$\Longrightarrow \nabla^2_{x,r}\, \Phi =$

$m^2 = -k^2$

$\Downarrow$

k^2 discre

$L = \frac{1}{M}$

$$\mathrm{Tr}\,F^2 \longleftarrow \Phi$$

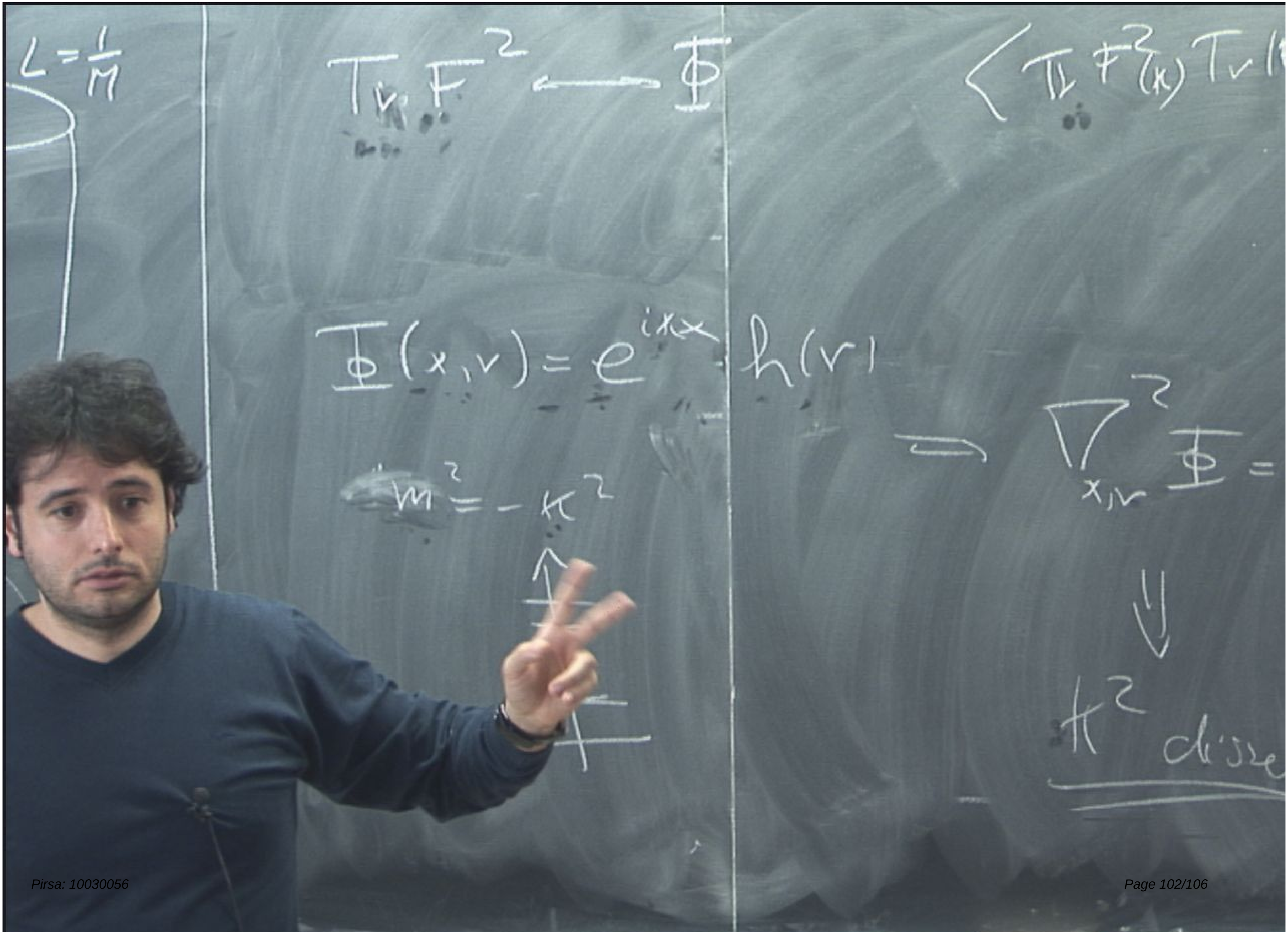
$$\Phi(x,r) = e^{ikx}\, h(r)$$

$$m^2 = -k^2$$

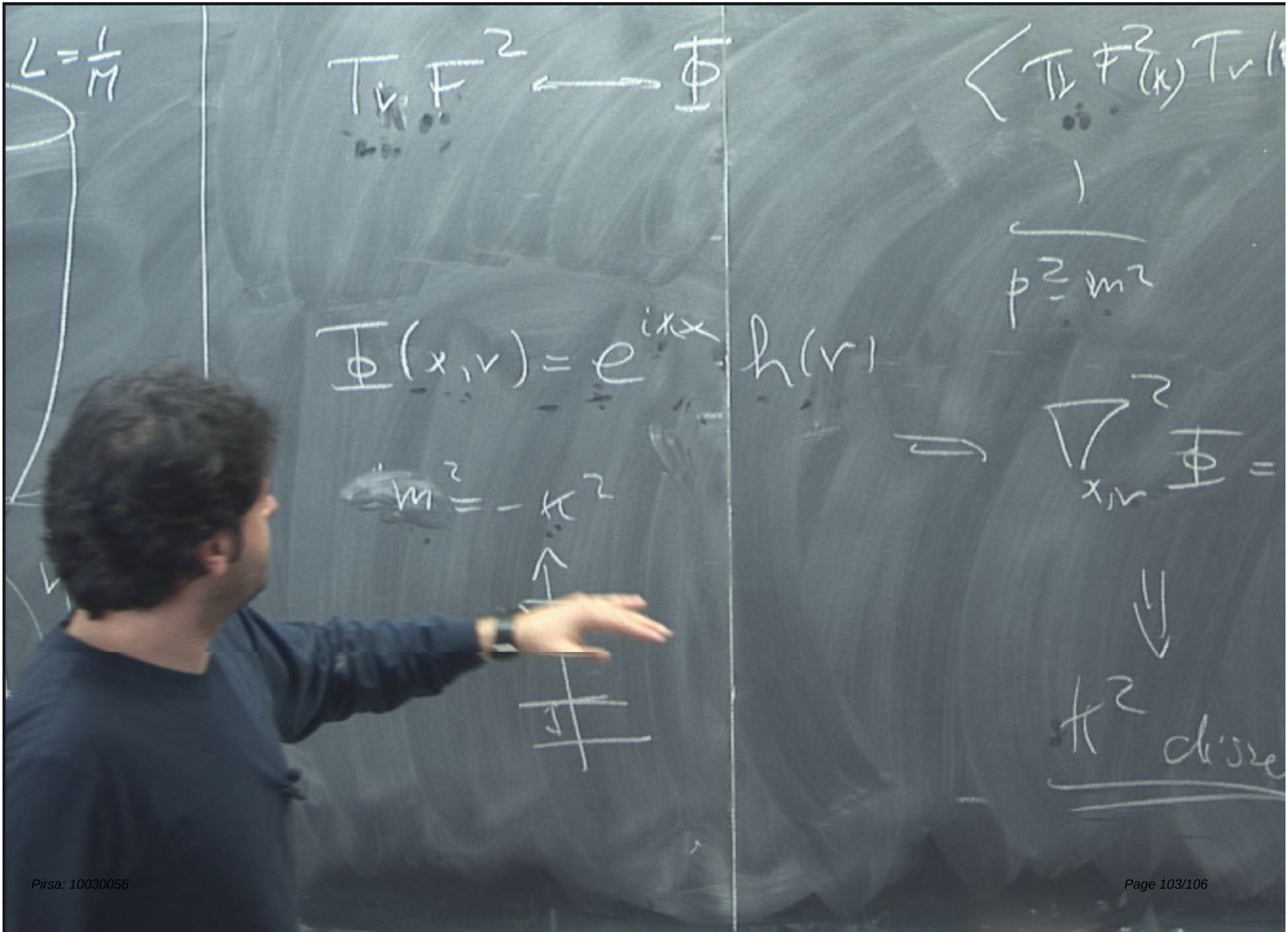
$$\Rightarrow \nabla^2_{x,r}\,\Phi =$$

$$\Downarrow$$

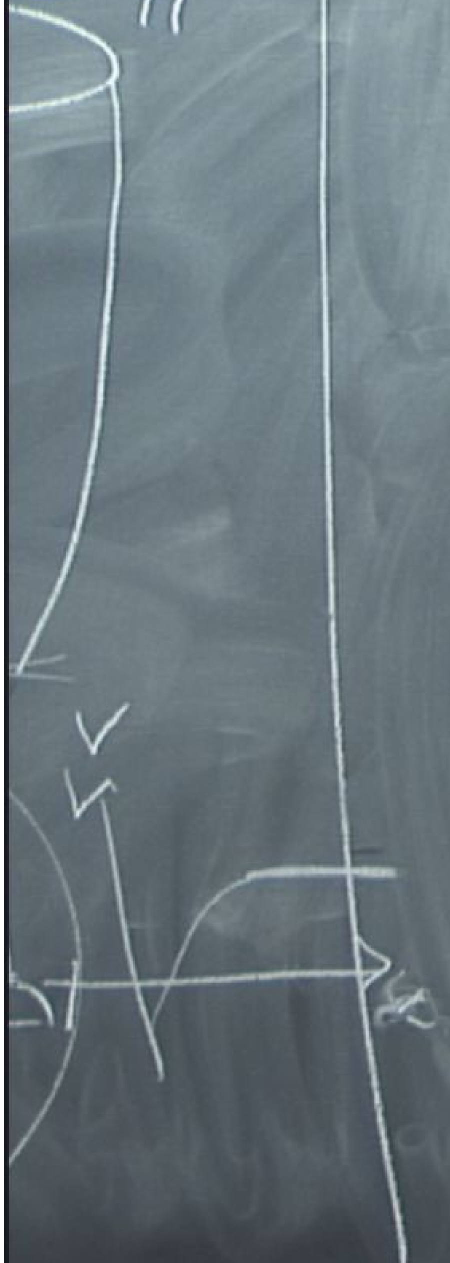
k^2 discre



L = 1/M
Tr F² ⟵ Φ
⟨ Tr F²(x) Tr
Φ(x,r) = e^{ikx} h(r)
m² = −k²
⟹ ∇²_{x,r} Φ =
k² discre


L = 1/M
Tr F² ⟵ Φ
Φ(x,r) = e^{ikx} h(r)
m² = −k²
⟨Tr F²(x) Tr(
1 / p² − m²
∇²_{x,r} Φ =
k² discre

$L = \frac{1}{M}$



$\mathrm{Tr}\, F^2 \longleftarrow \Phi$

$$\boxed{\Phi(x,r) = e^{ikx} h(r)}$$

$m^2 = -k^2$

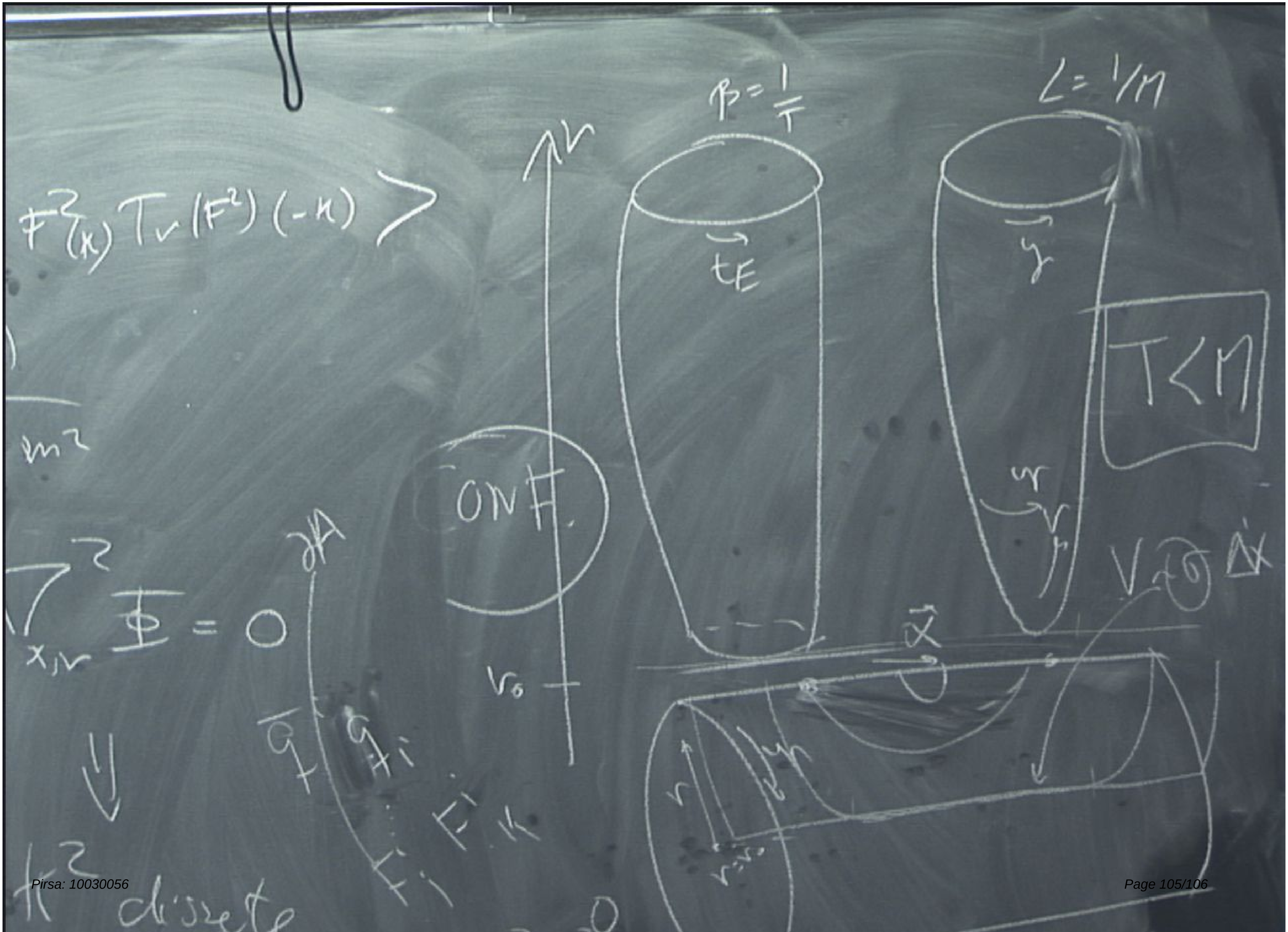
$\langle \mathrm{Tr}\, F^2(x)\, \mathrm{Tr}\, ($

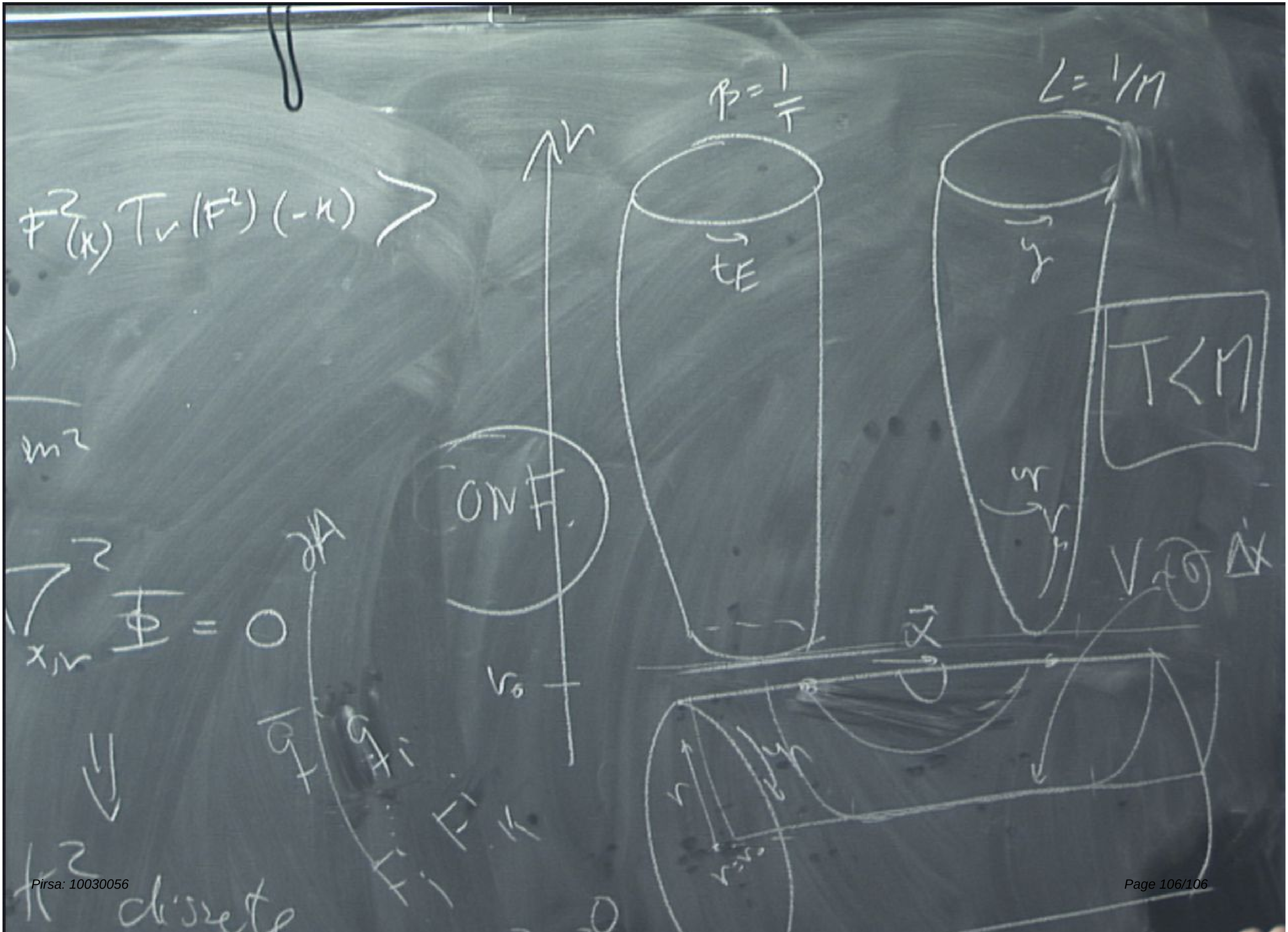
$\frac{1}{p^2 - m^2}$

$\Longrightarrow \nabla^2_{x,r} \Phi =$

$\Downarrow$

k^2 discre


F²(x) Tr(F²)(-x) >
m²
∂A
CONF.
r
β = 1/T
L = 1/M
t_E
y
T<M
x
r_0
discrete


β = 1/T
L = 1/M
T<M
CONF.
t_E
discrete