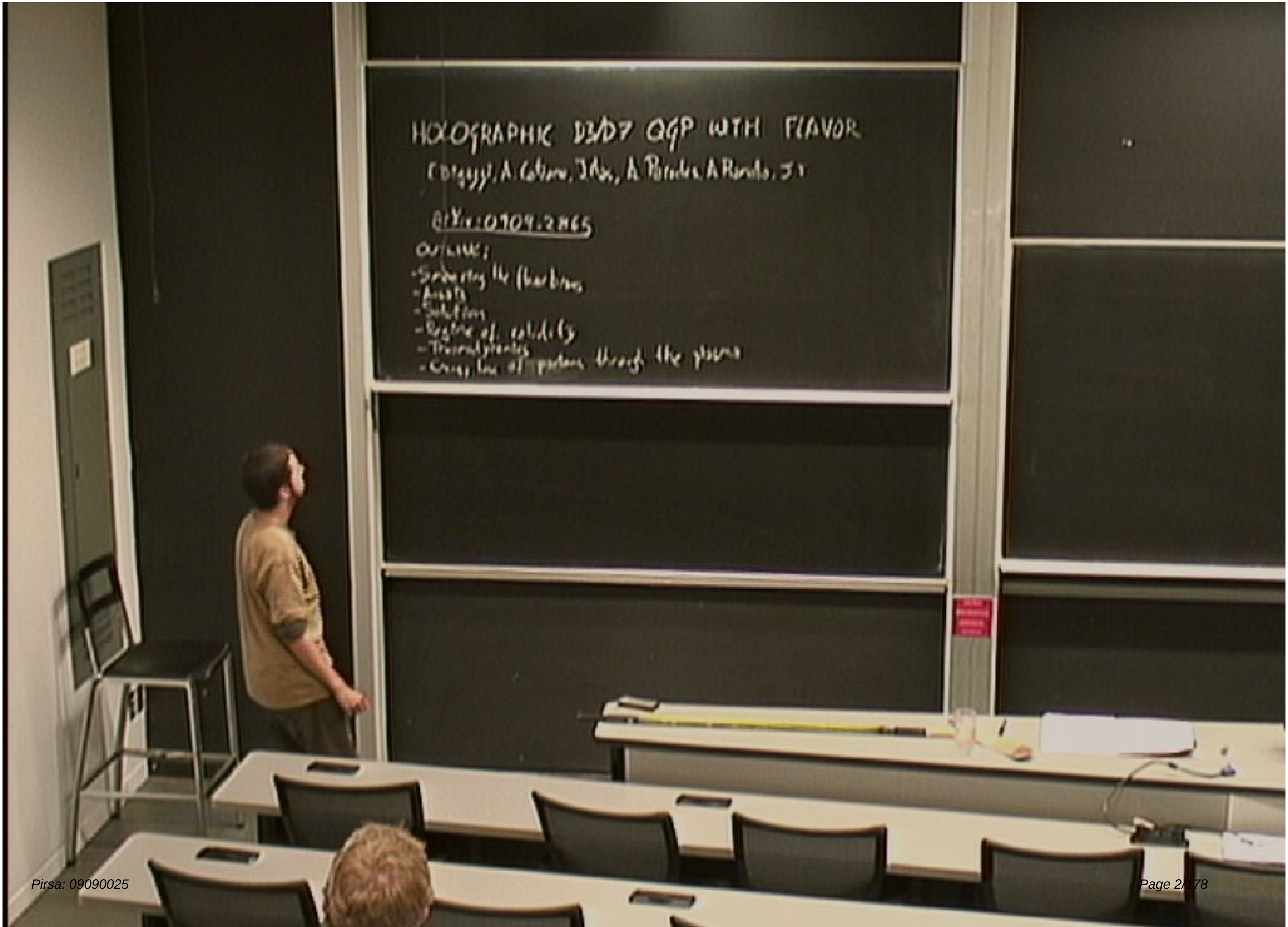
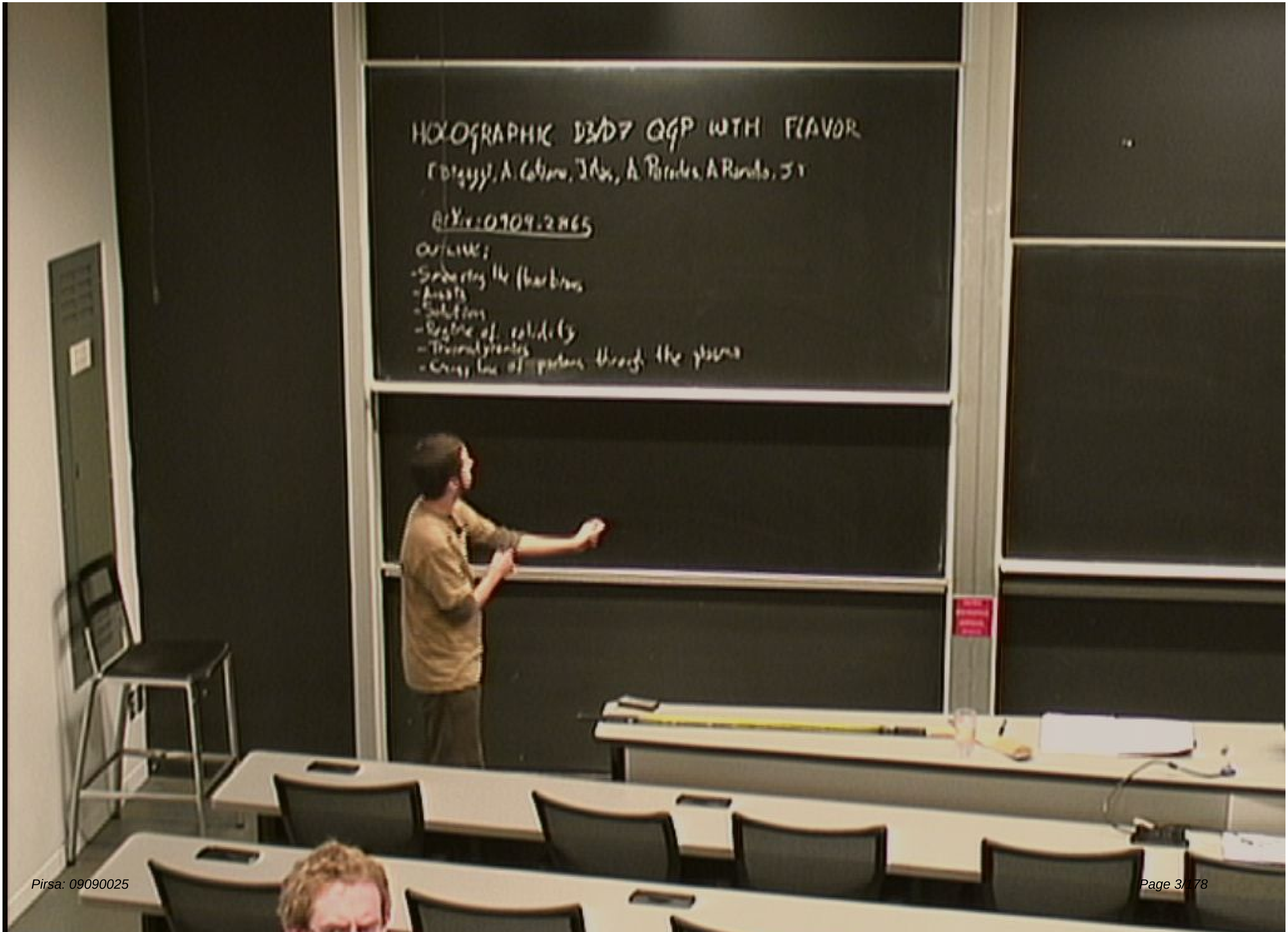
Title: The Supergravity Duals of D3/D7 Quark Gluon Plasmas

Date: Sep 29, 2009 11:00 AM

URL: http://pirsa.org/09090025

Abstract: We present a string dual to finite temperature N=4 SYM coupled to Nf massless flavors with abelian symmetry. The solution includes the backreaction of the flavor up to second order in the ratio N_f/N_c times the 't Hooft coupling at the temperature of the dual QGP. The thermodynamics show a departure from conformality as a second order effect, and the energy loss of a quark through the plasma is enhanced by new degrees of freedom.


HOLOGRAPHIC D3/D7 QGP WITH FLAVOR
arXiv:0909.2865
Outline:
- Solutions
- Regime of validity
- Thermodynamics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OUTLINE:
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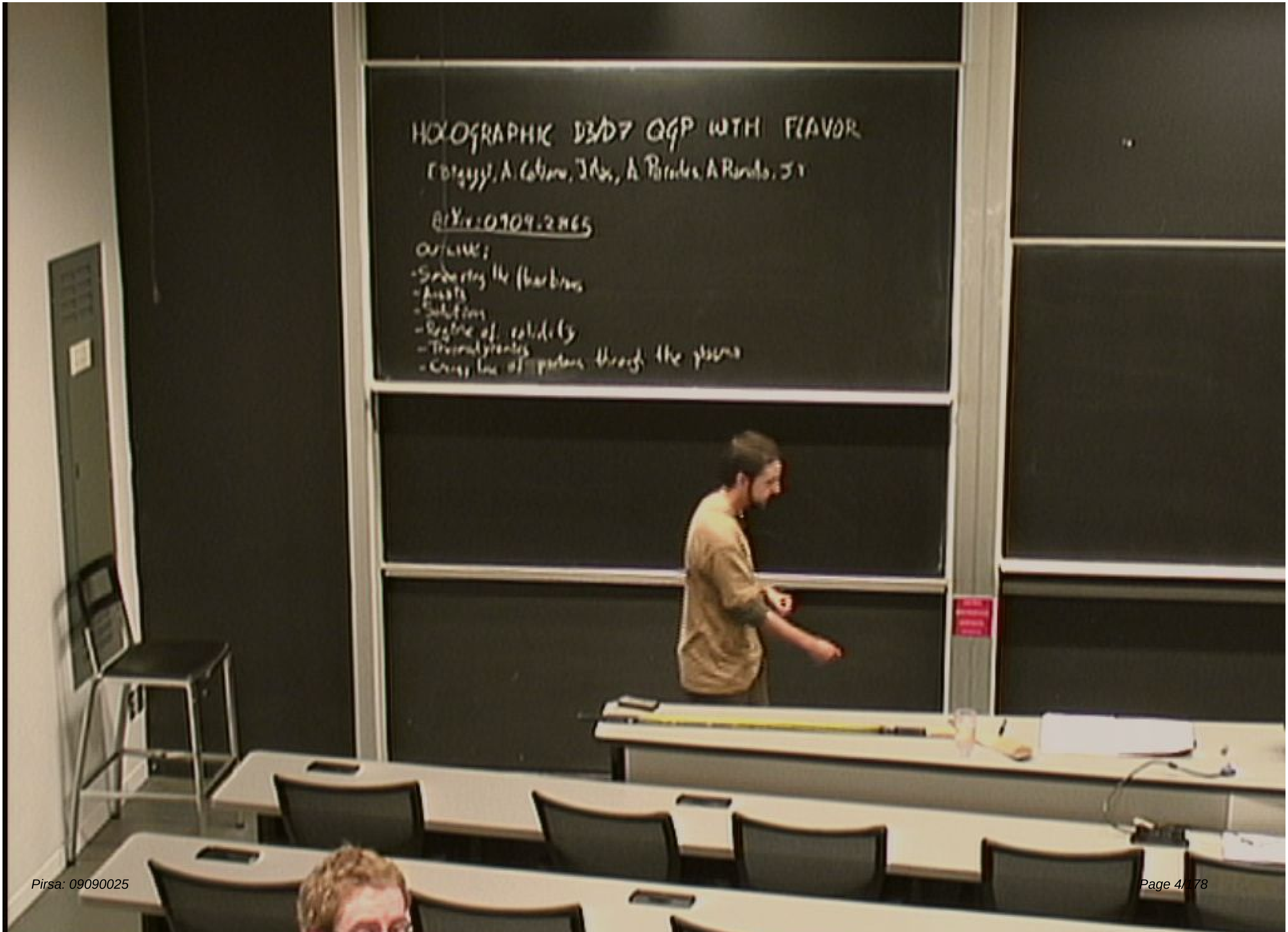
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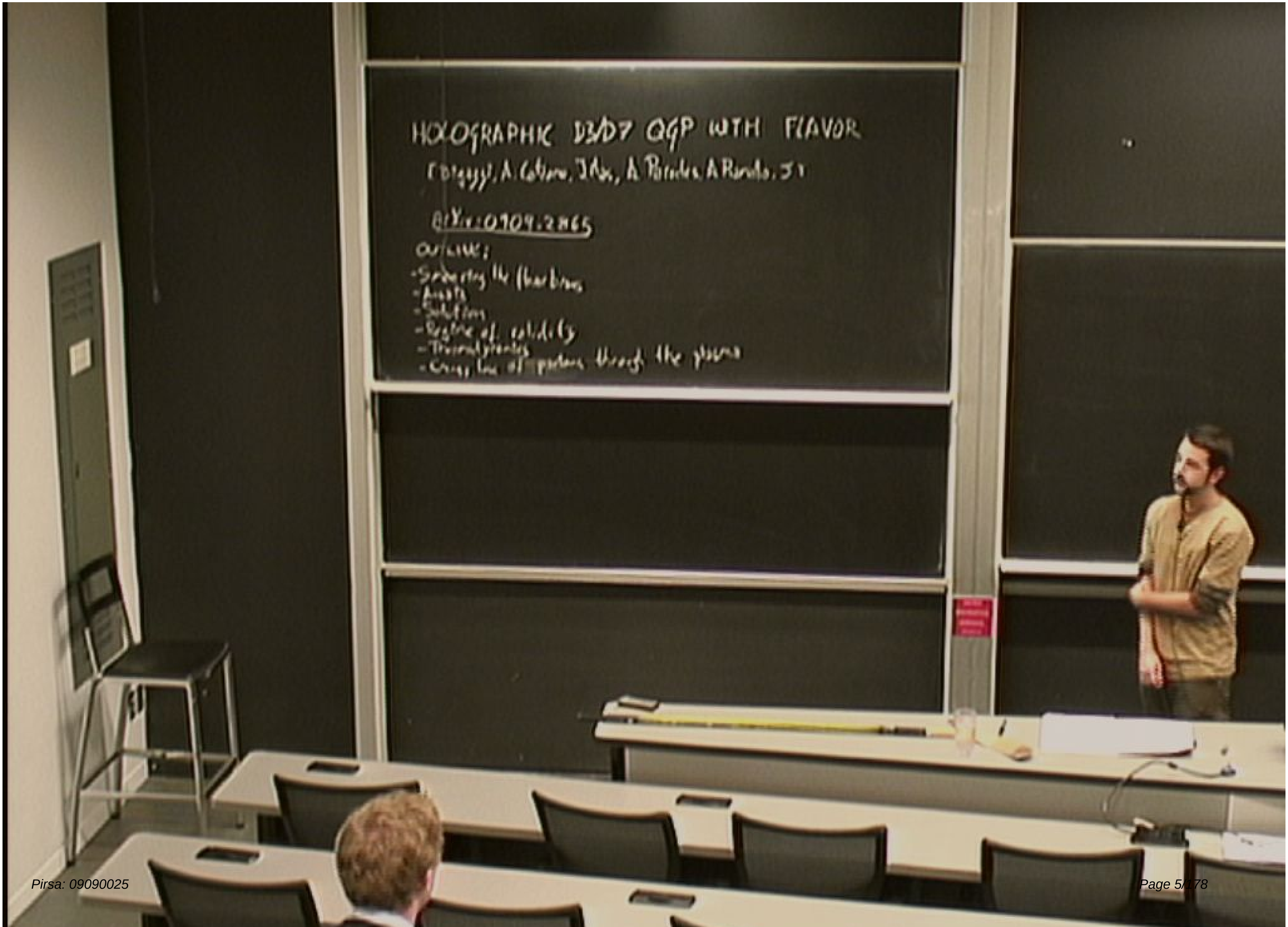
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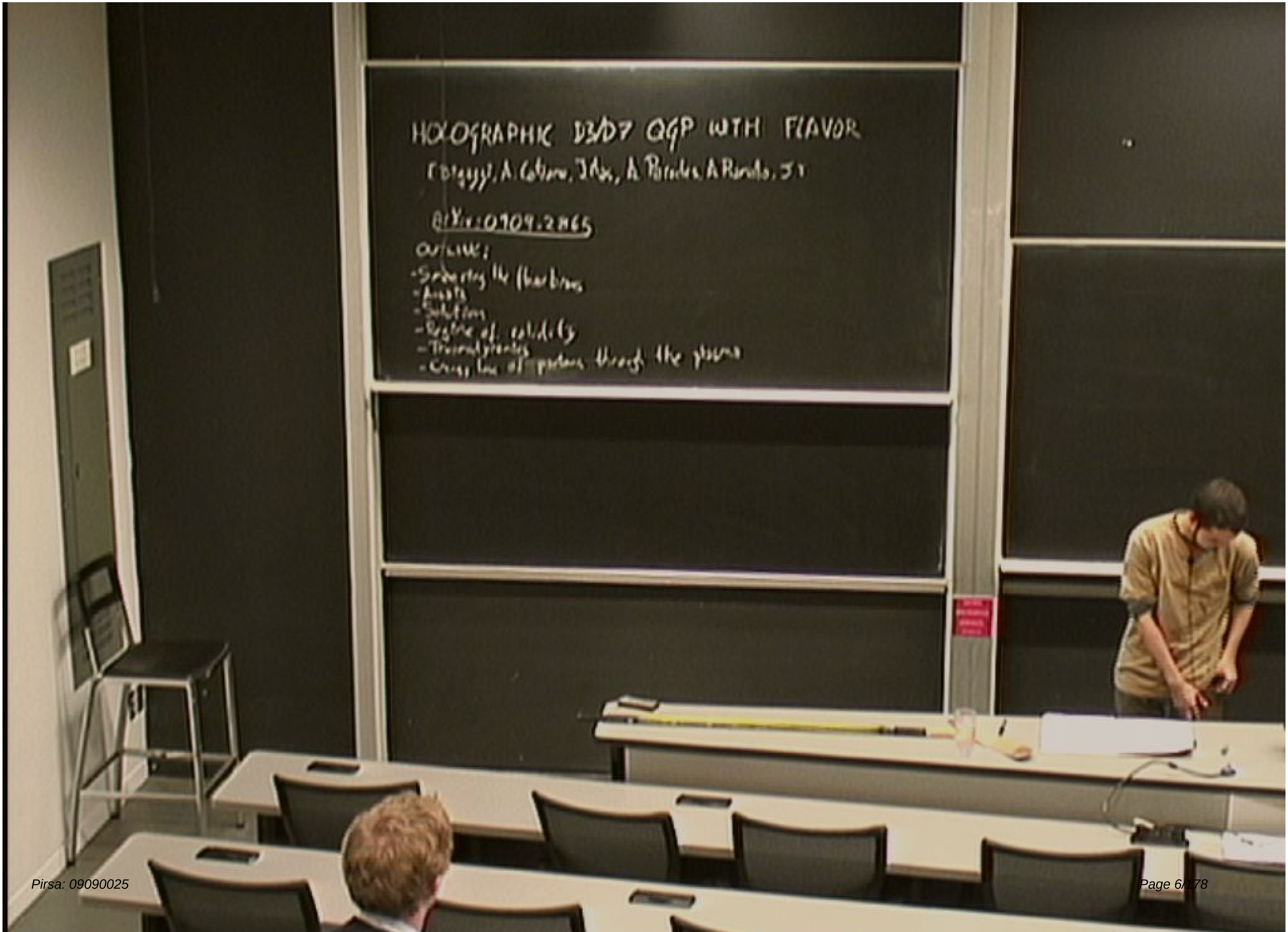
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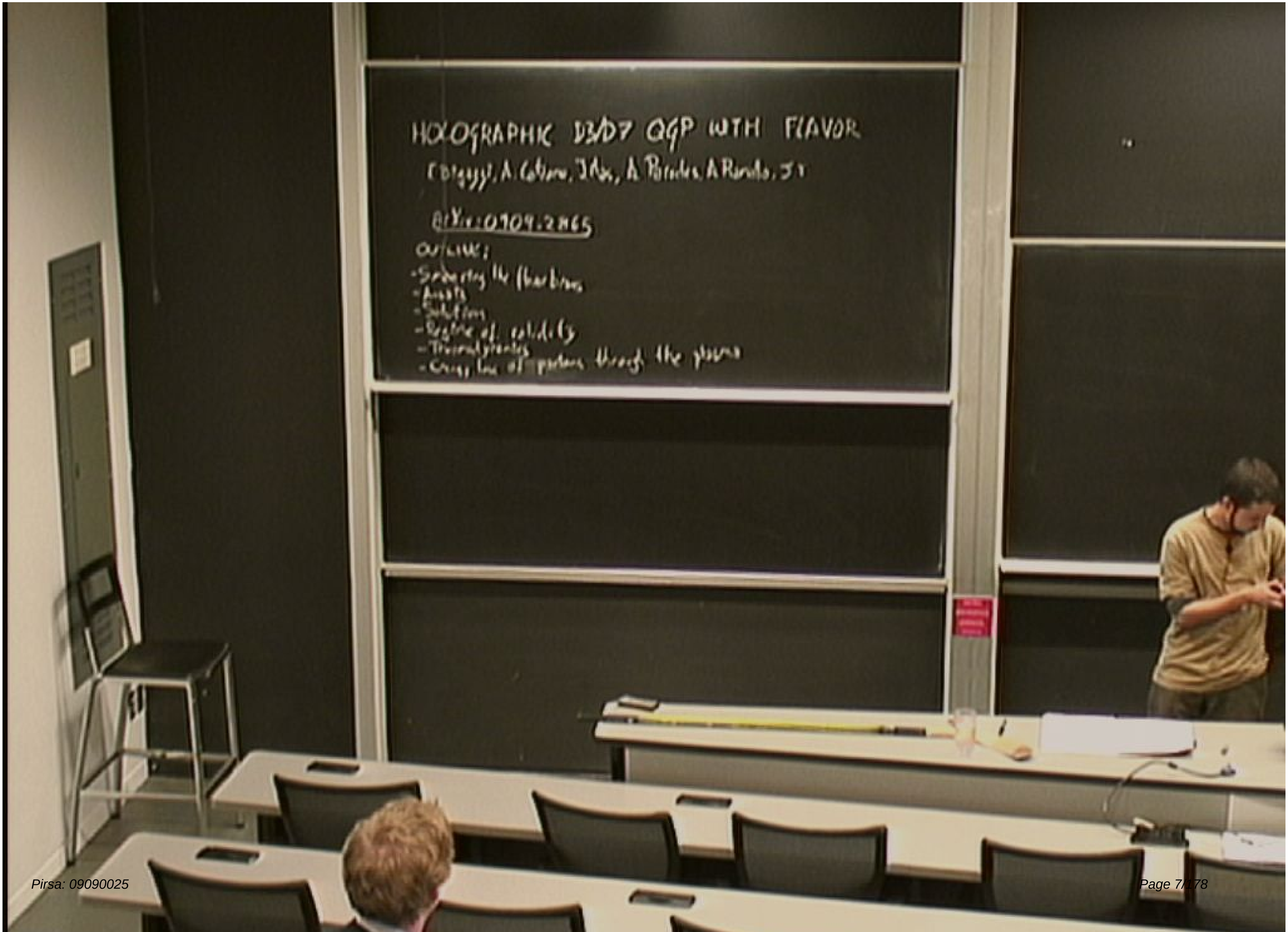
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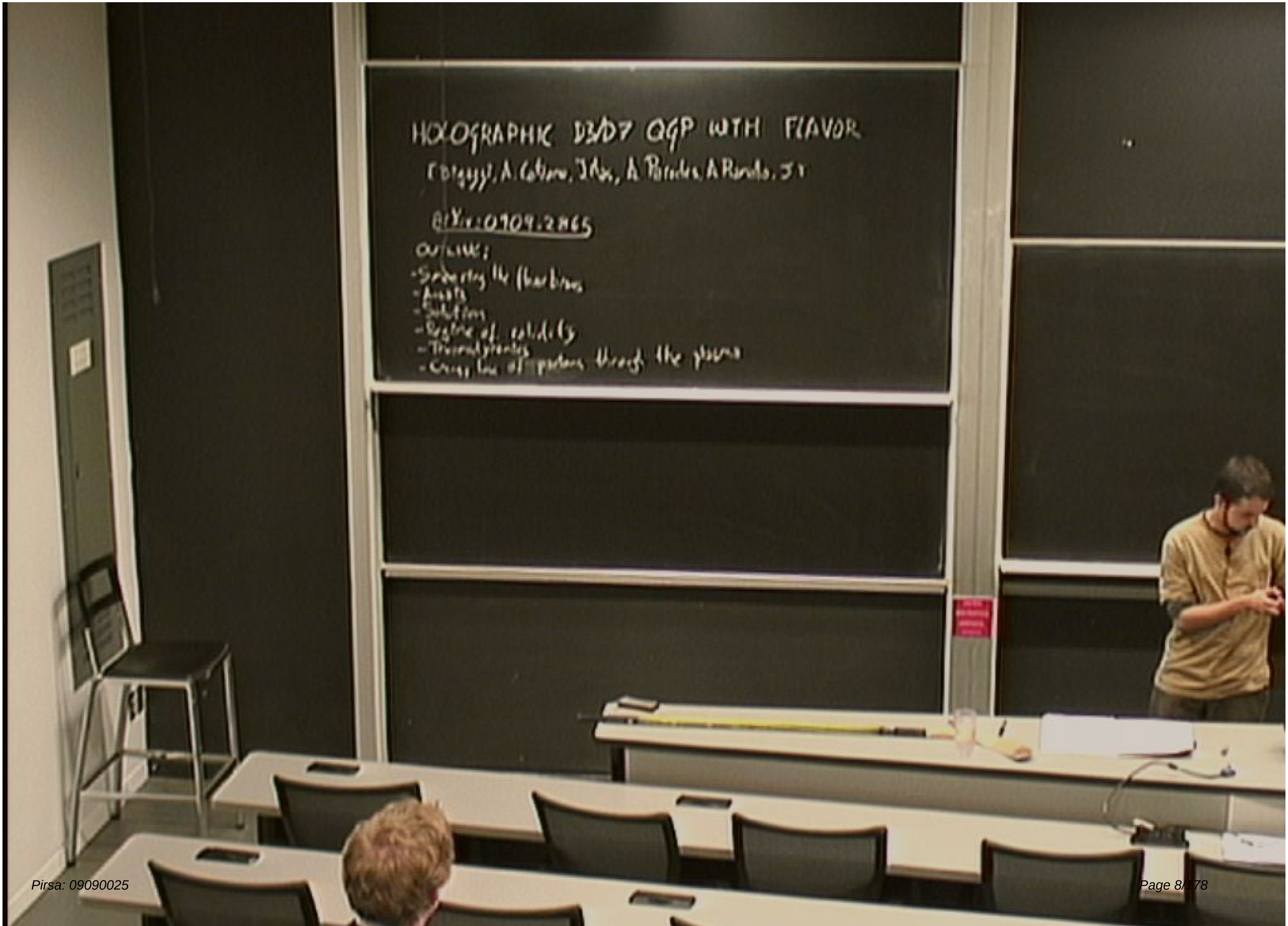
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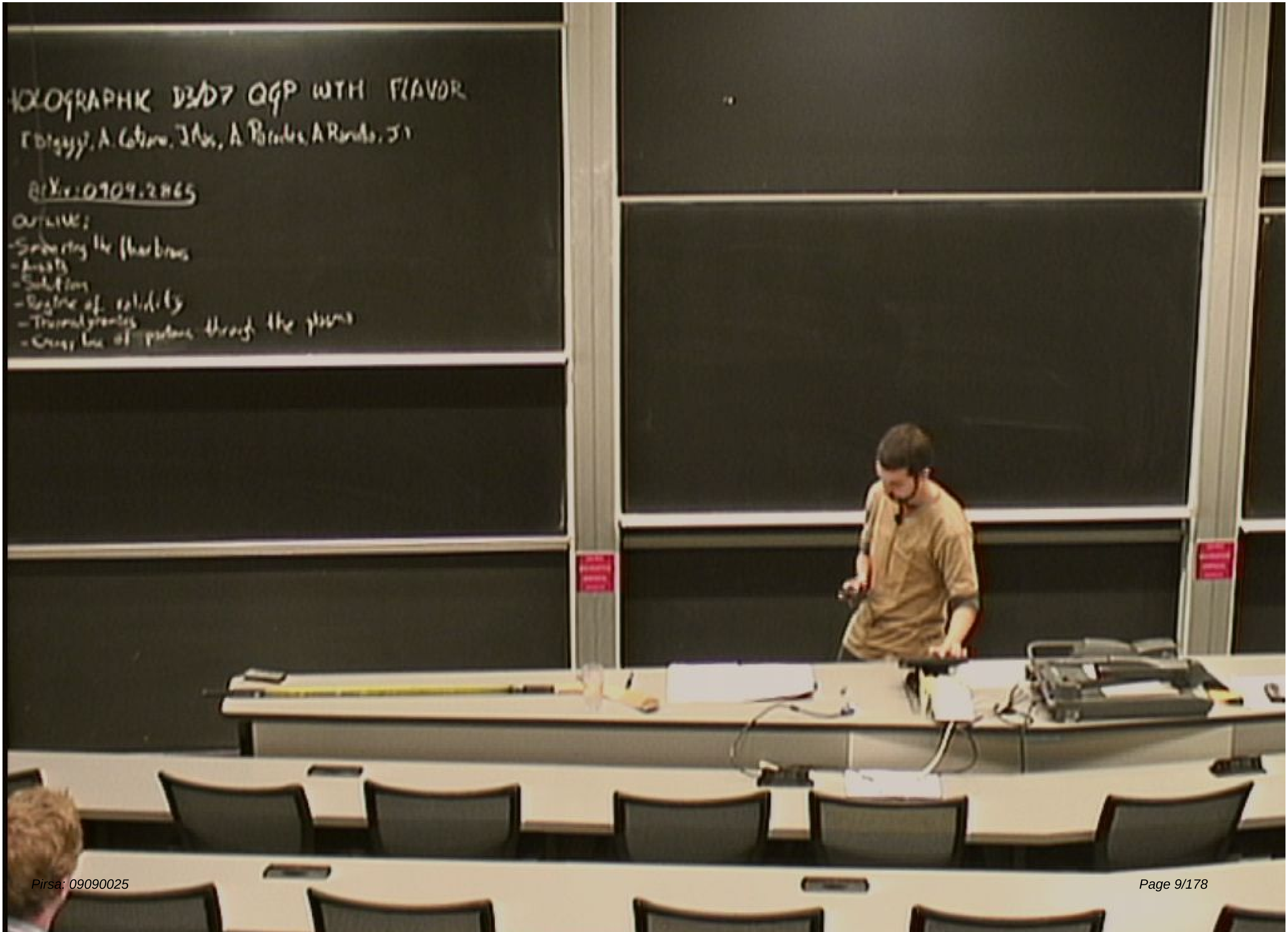
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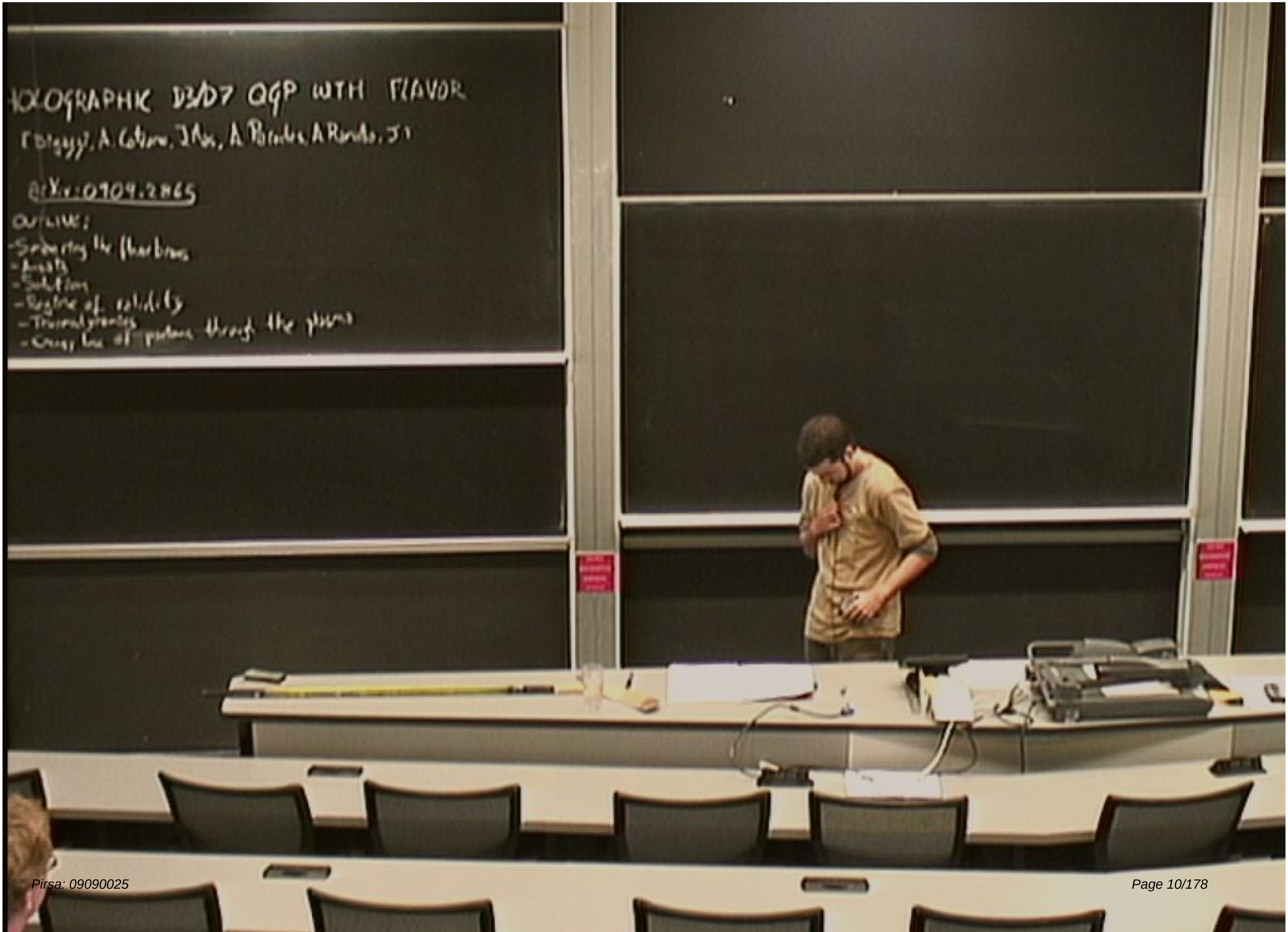
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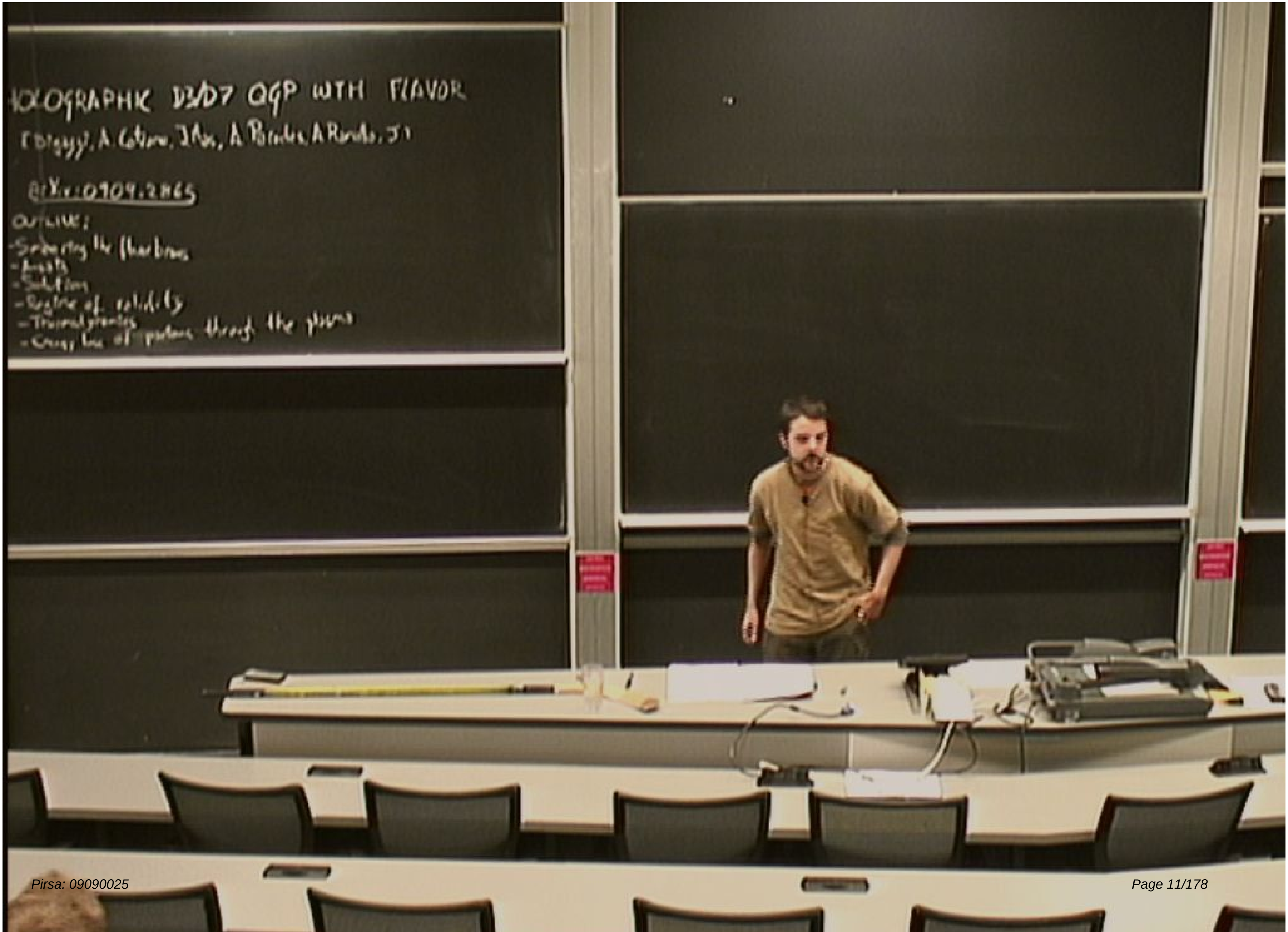
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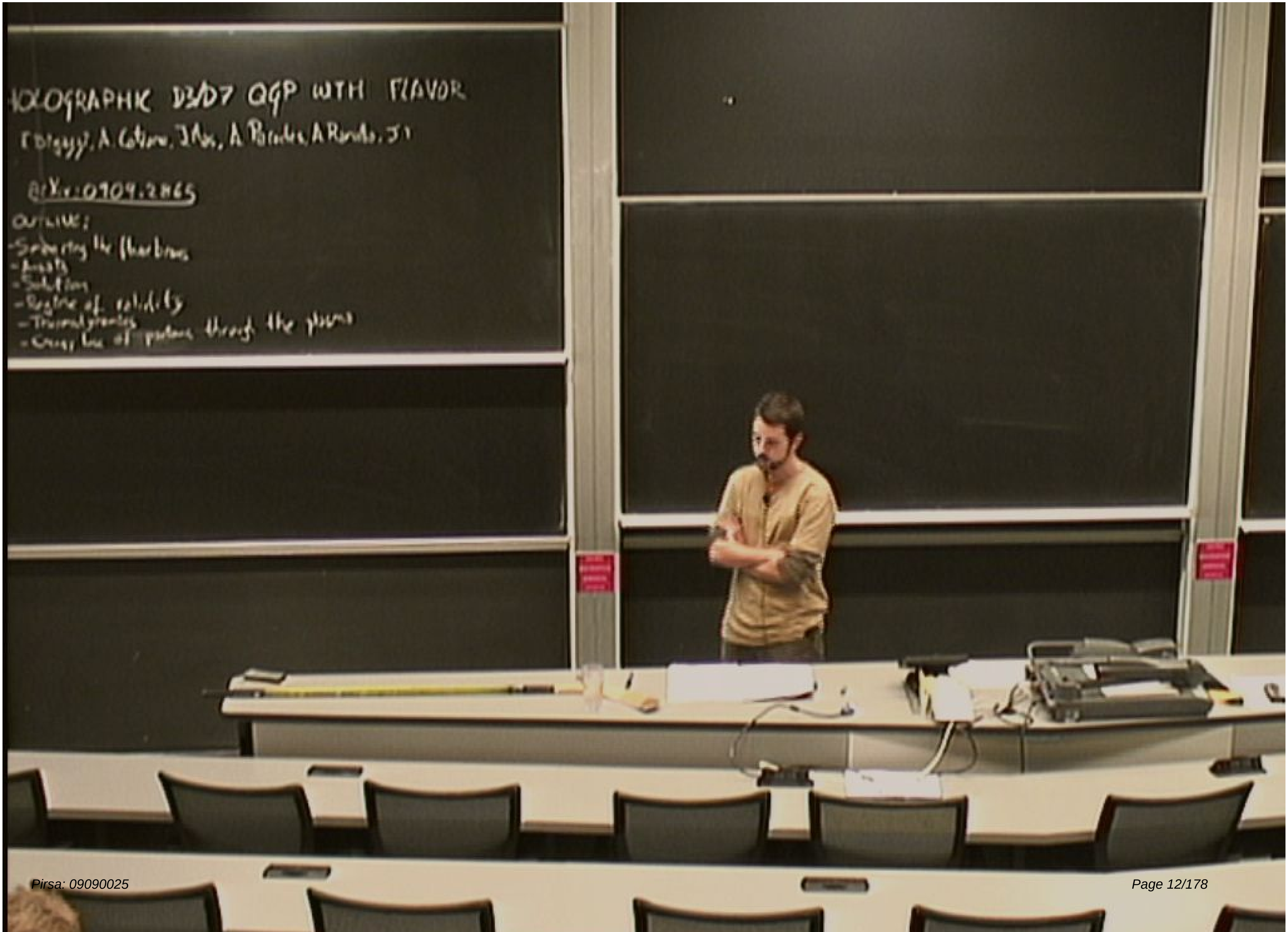
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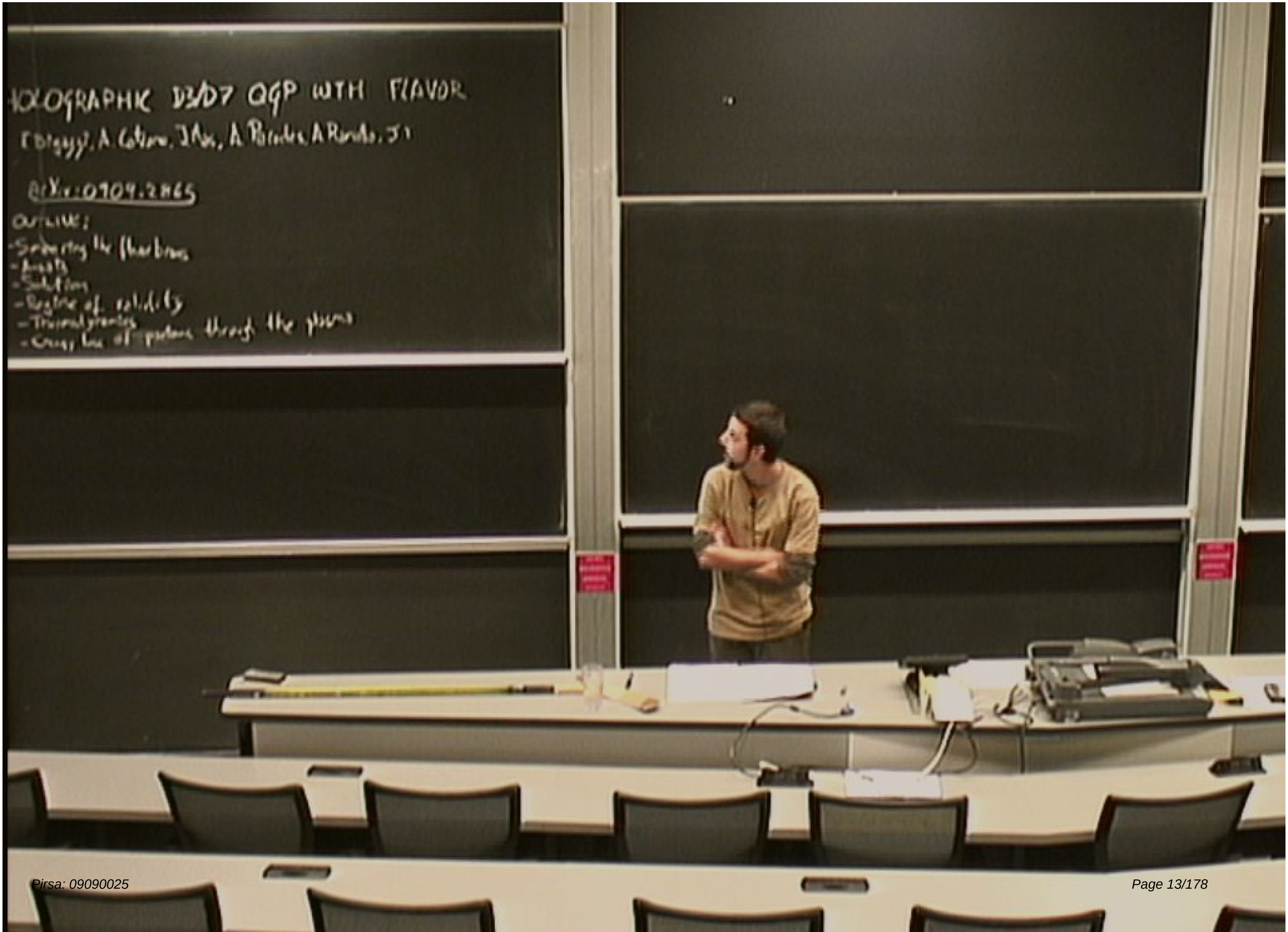
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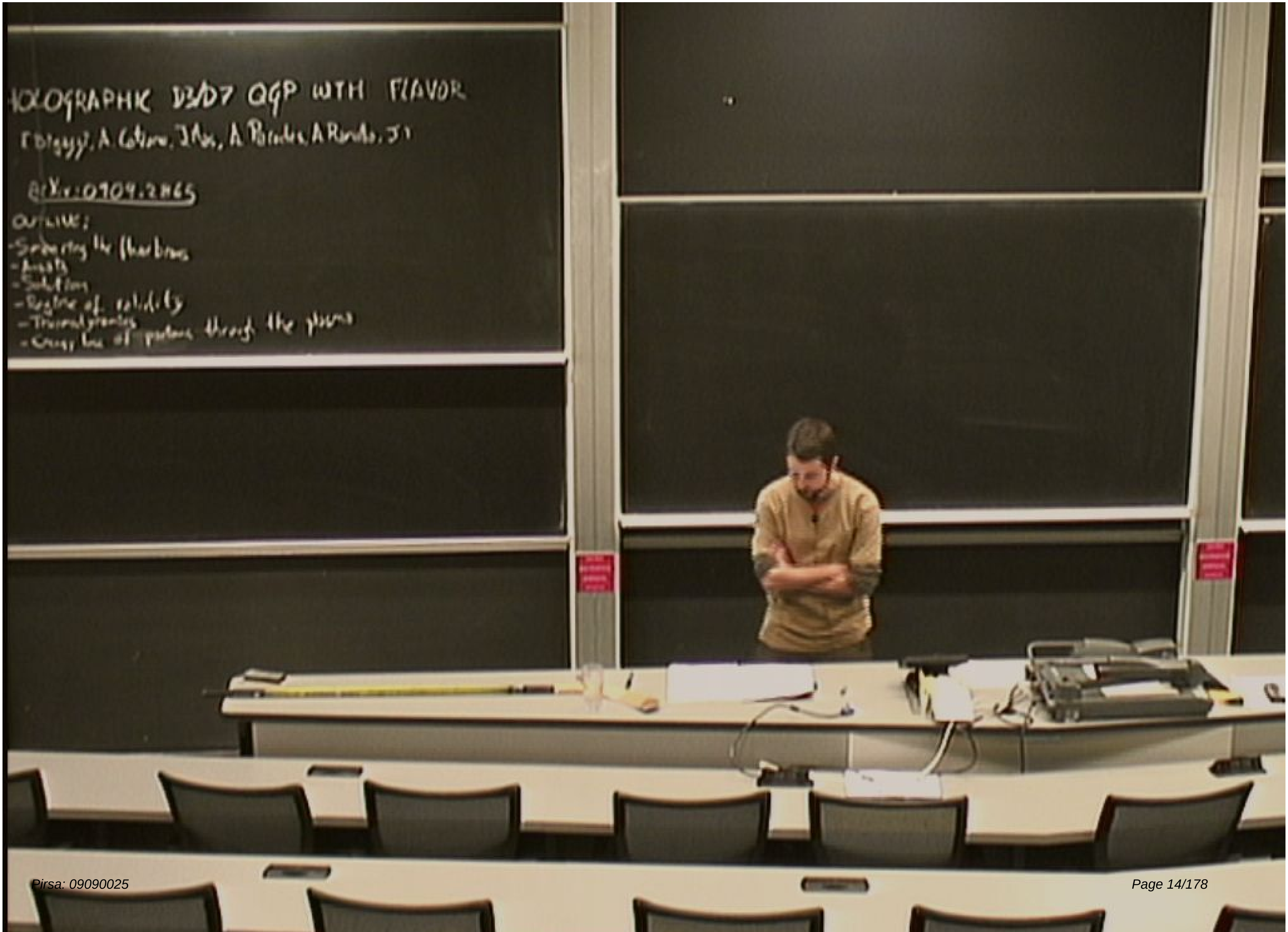
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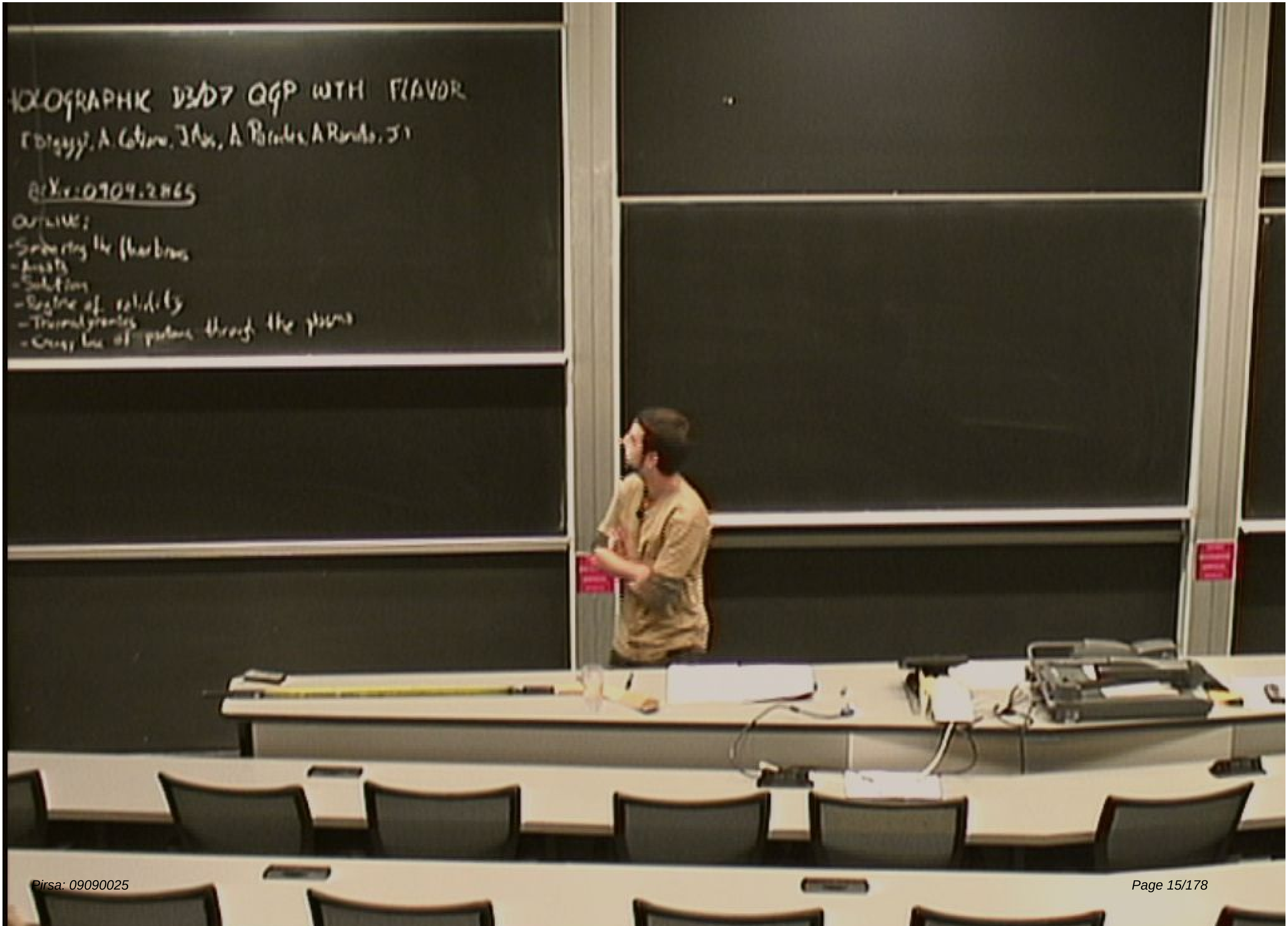
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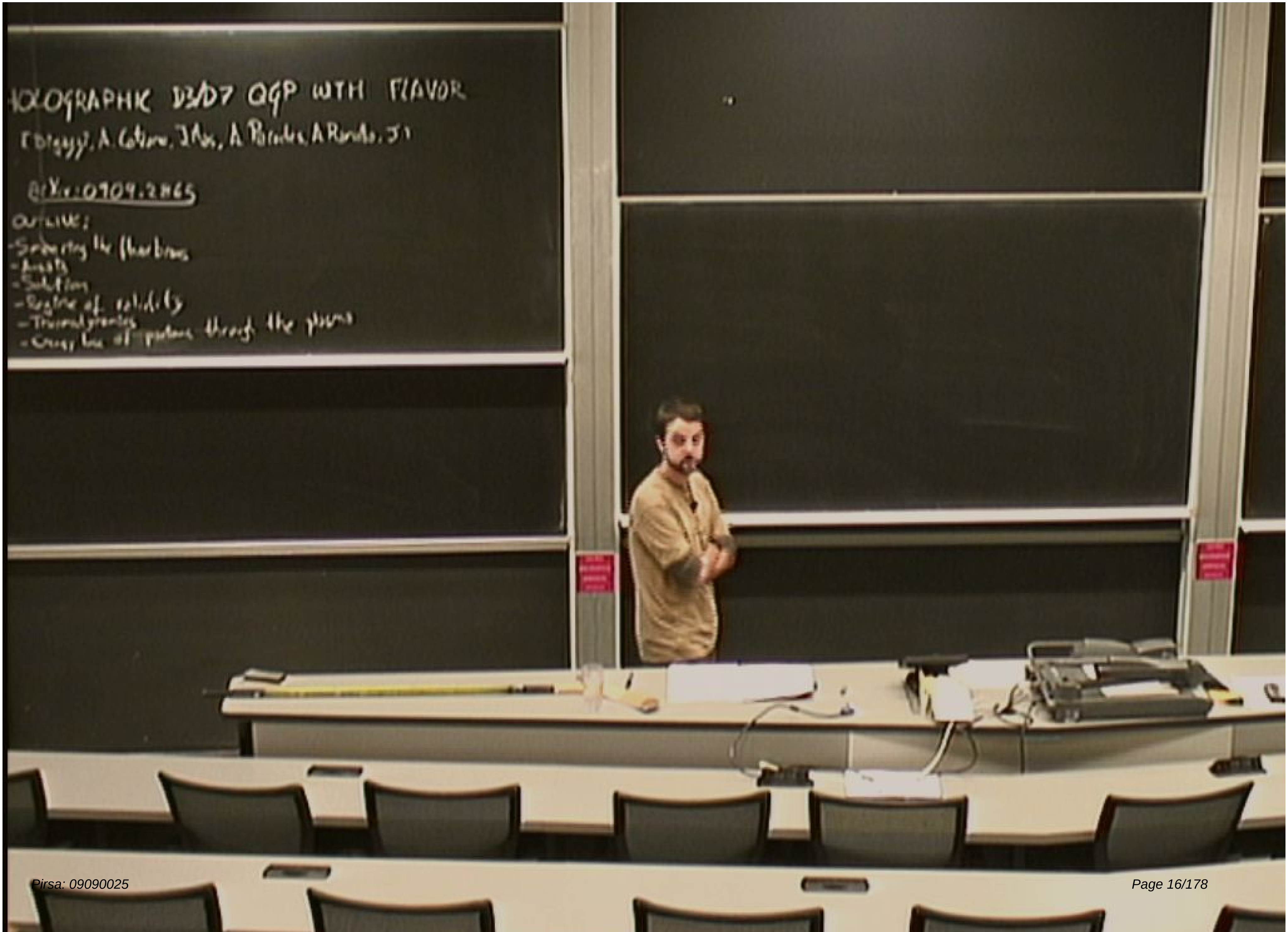
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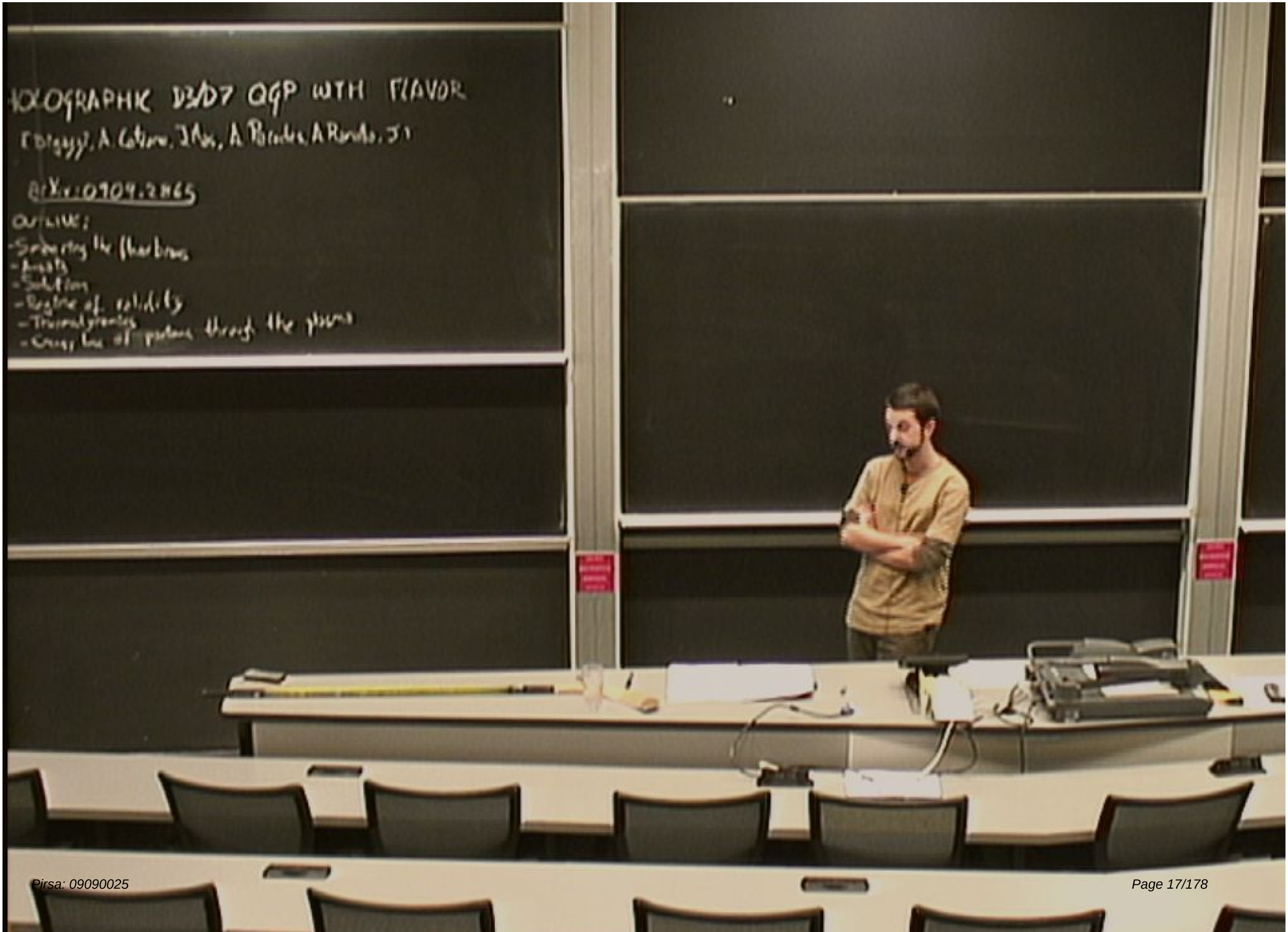
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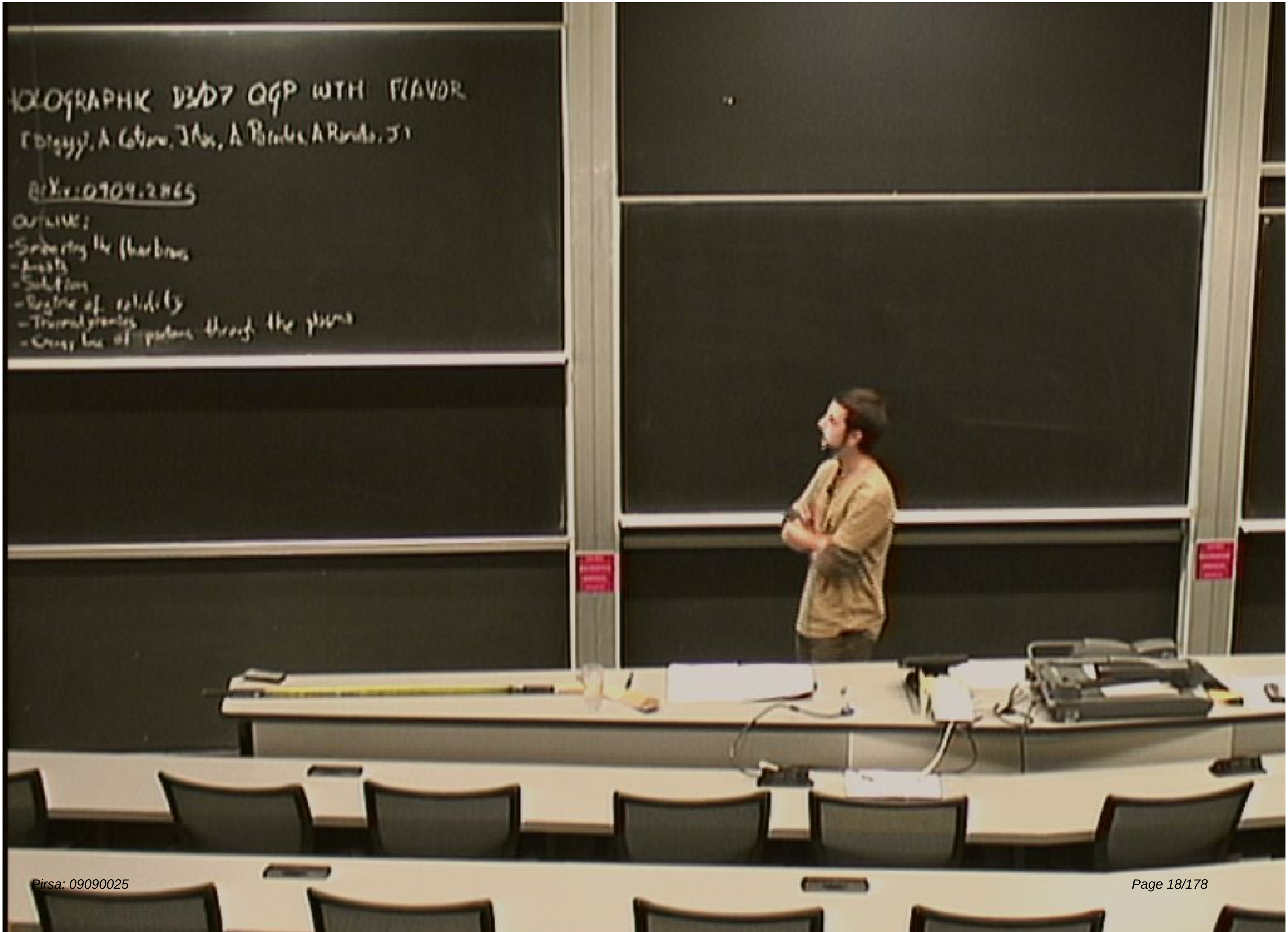
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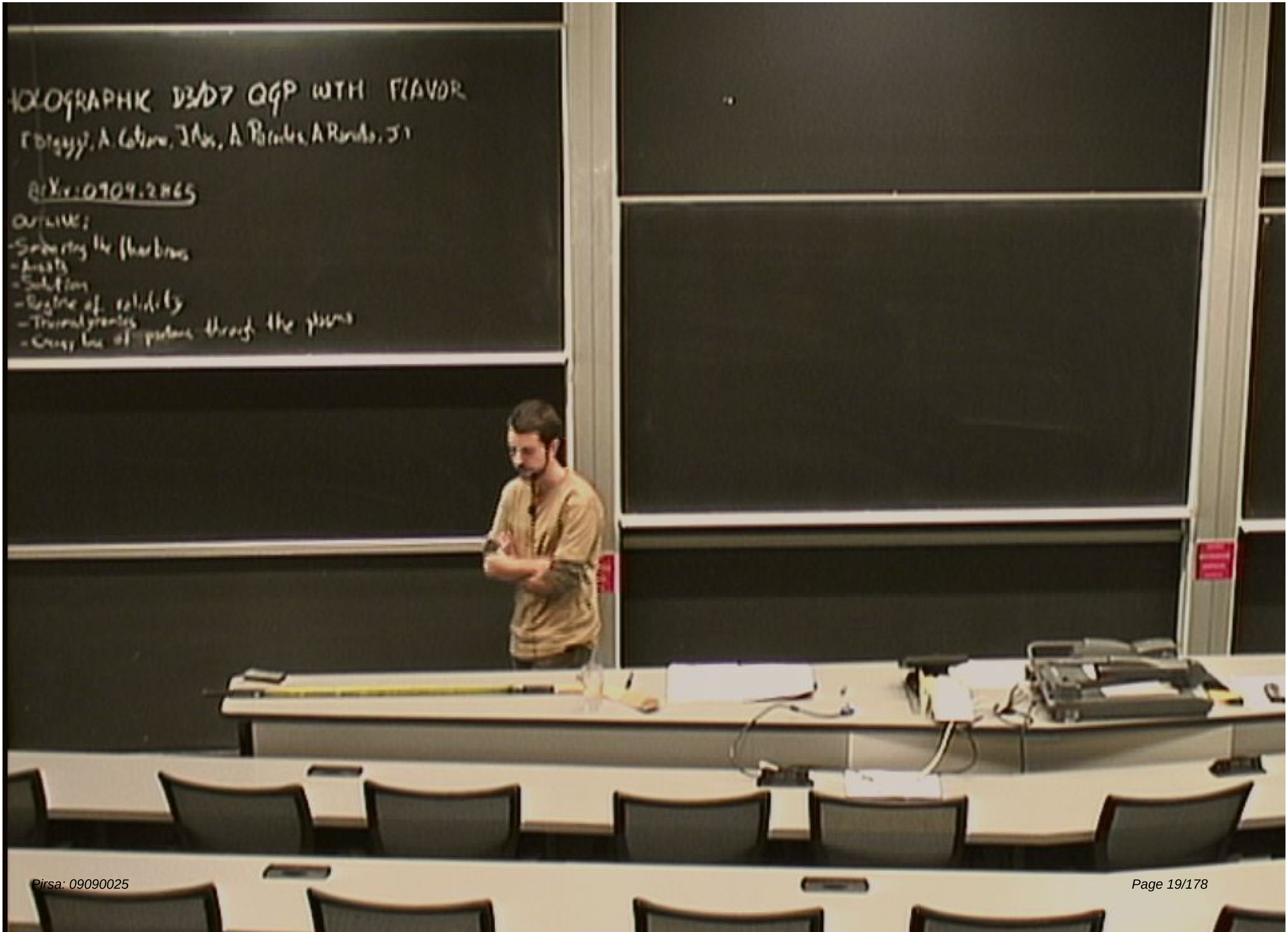
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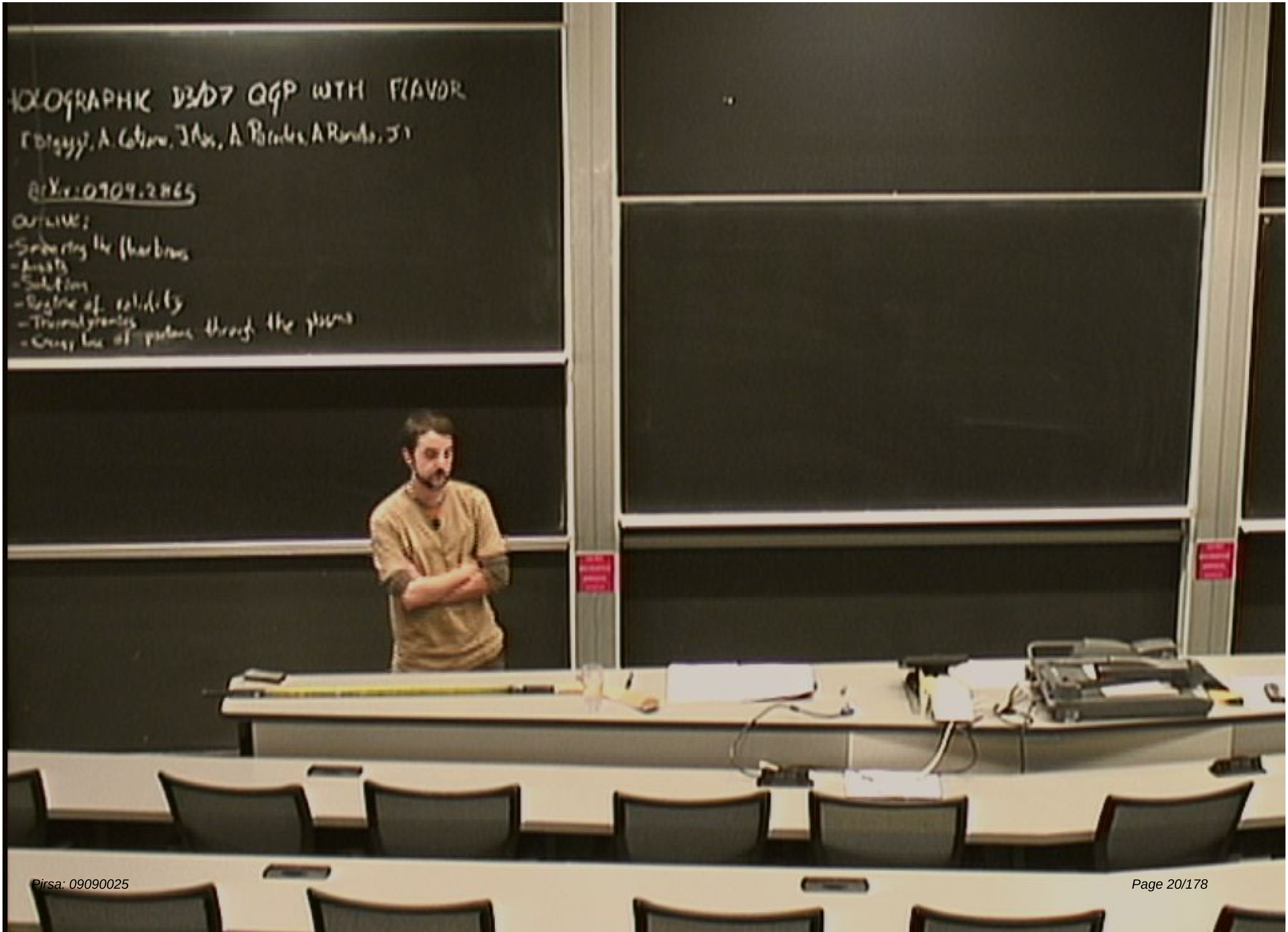
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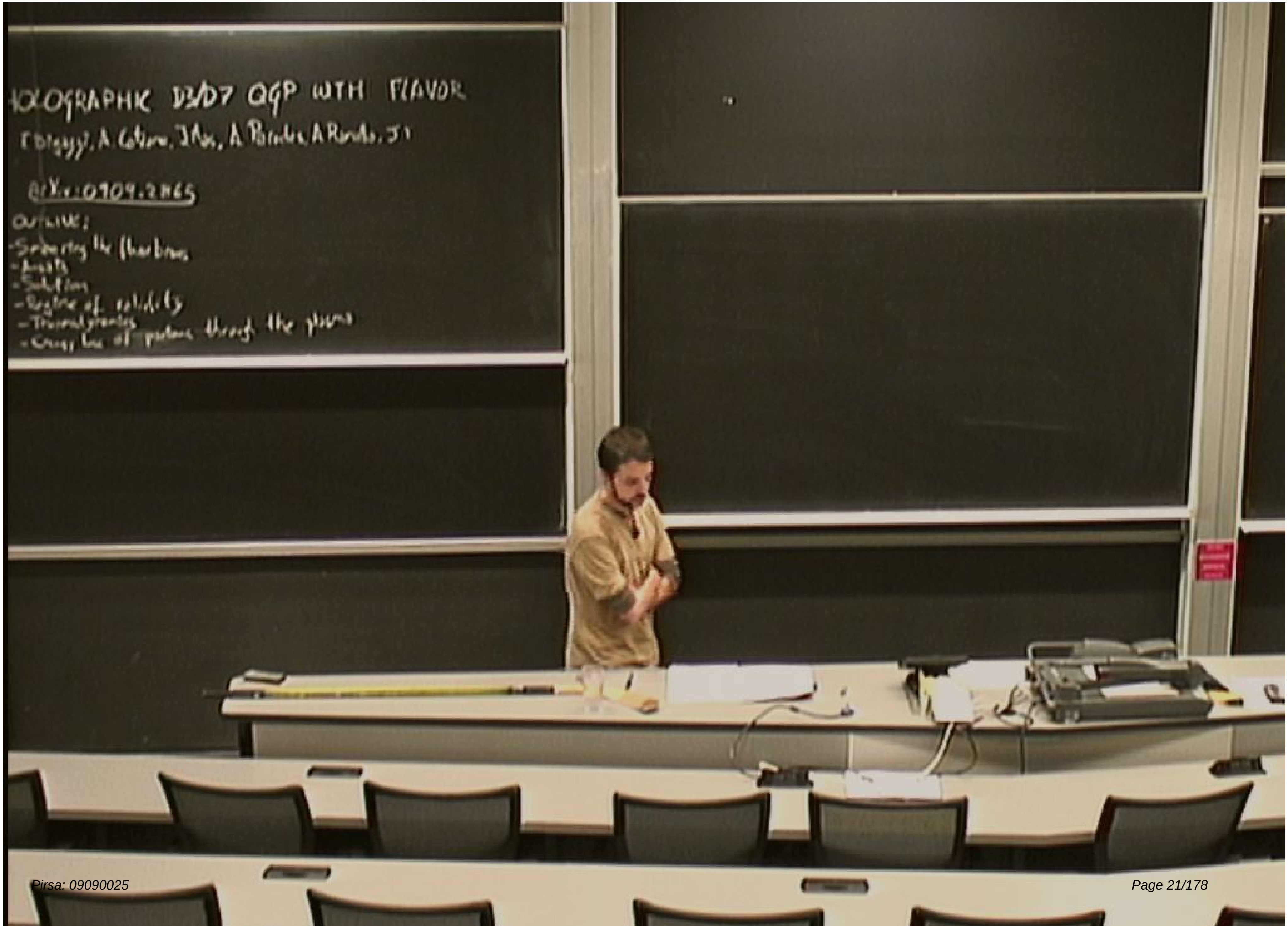
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HOLOGRAPHIC D3/D7 QGP WITH FLAVOR

F. Bigazzi, A. Cotrone, J. Mas, A. Paredes, A. Ramallo, J.T.

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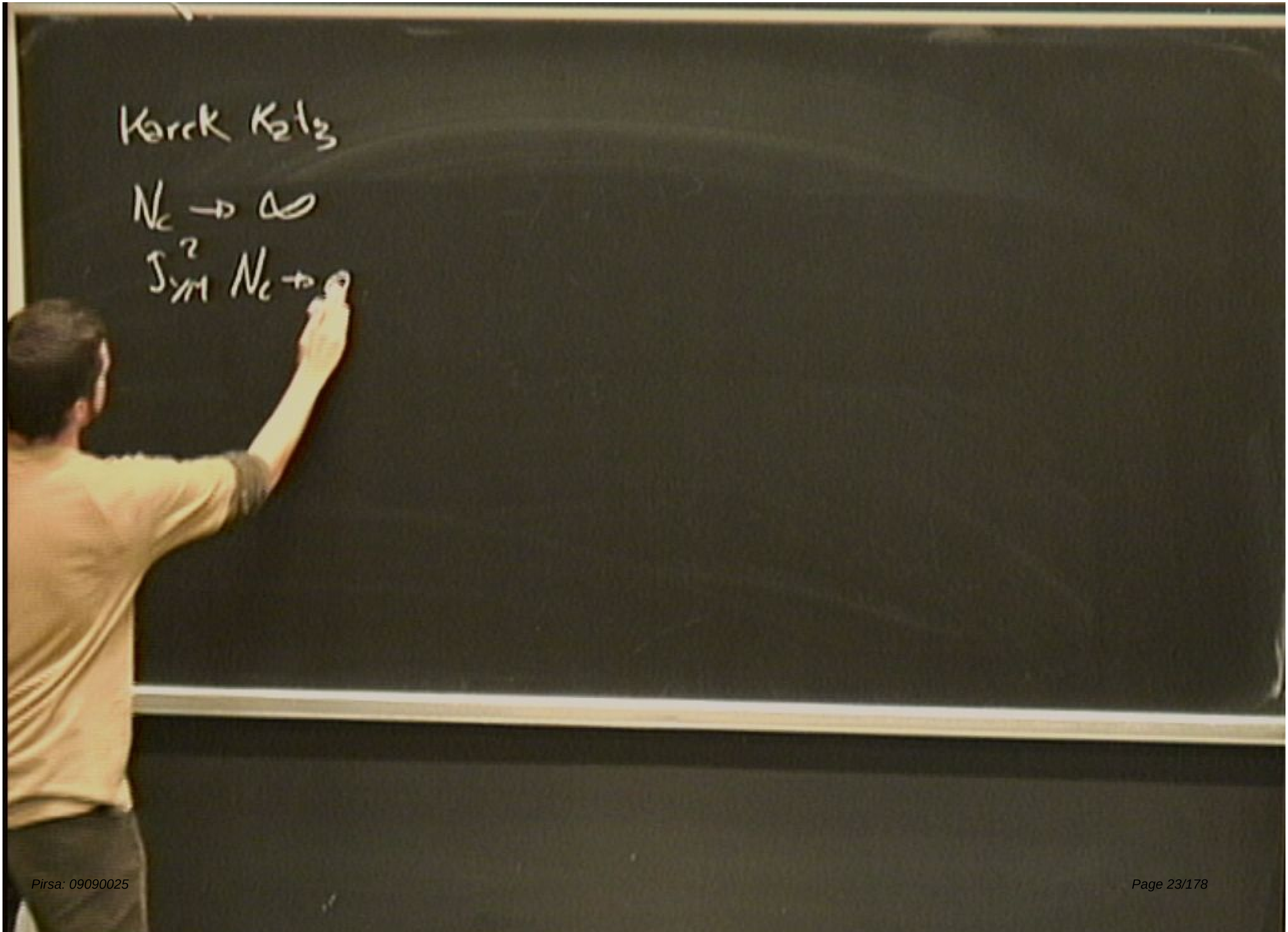
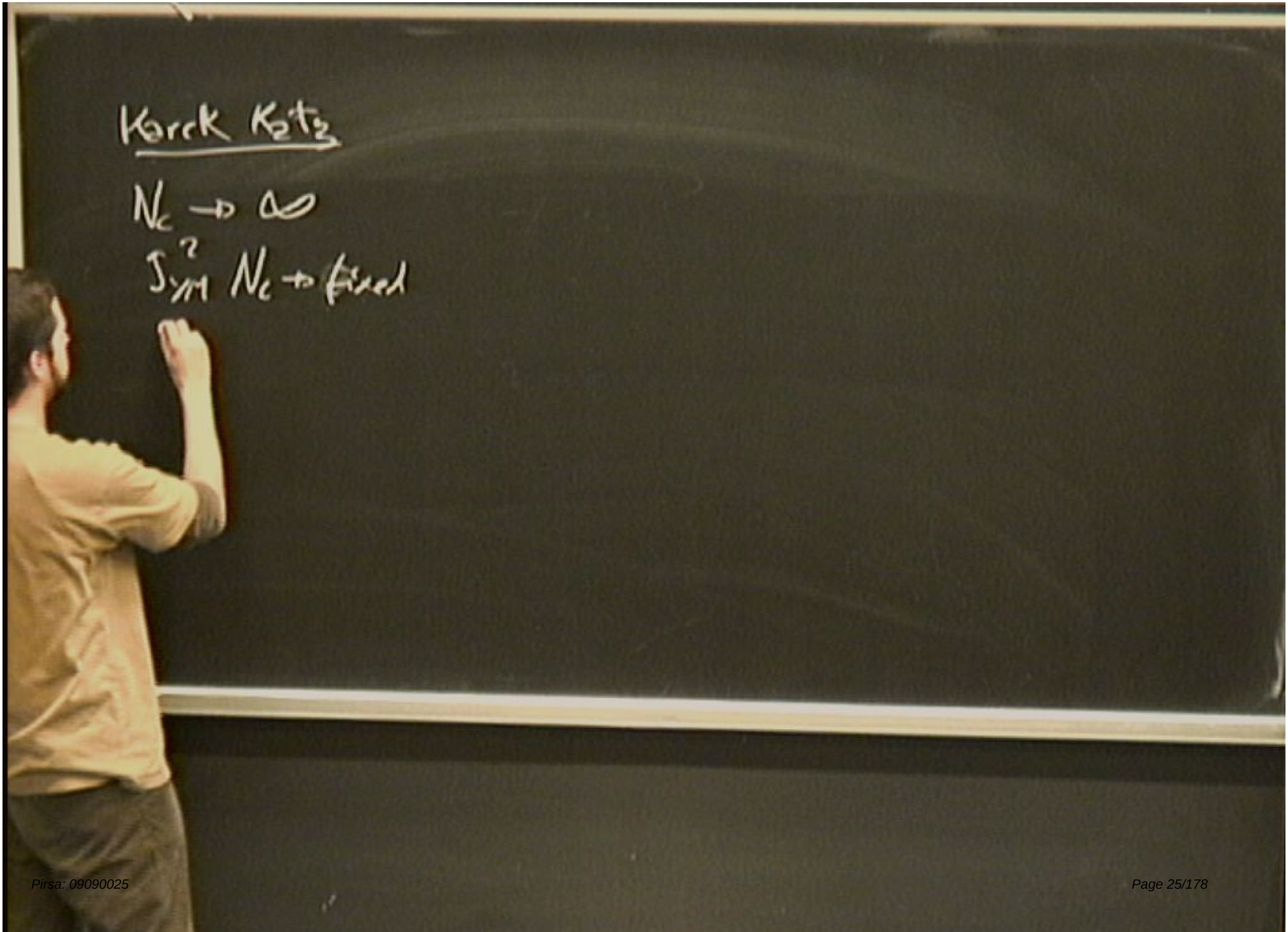

Karch Katz
$N_c \to \infty$
Sym? $N_c \to$

Karch Katz

$N_c \to \infty$

$\overset{?}{\text{Sym}}$ $N_c \to$ fixed


Karck Katz
$N_c \to \infty$
$S_{YM}^{?}$ $N_c \to$ fixed

Karck Katz

$N_c \to \infty$

$g^2_{YM} N_c \to$ fixed

$N_f \to$ fixed / $g^2_{YM} N_f \to 0$

Karck Katz

$N_c \to \infty$

$g_{YM}^2 N_c \to$ fixed

$N_f \to$ fixed / $g_{YM}^2 N_f \to 0$

Karck Katz $(T=0)$

$N_c \to \infty$

$g^2_{YM} N_c \to$ fixed

$N_f \to$ fixed / $g^2_{YM} N_f \to 0$

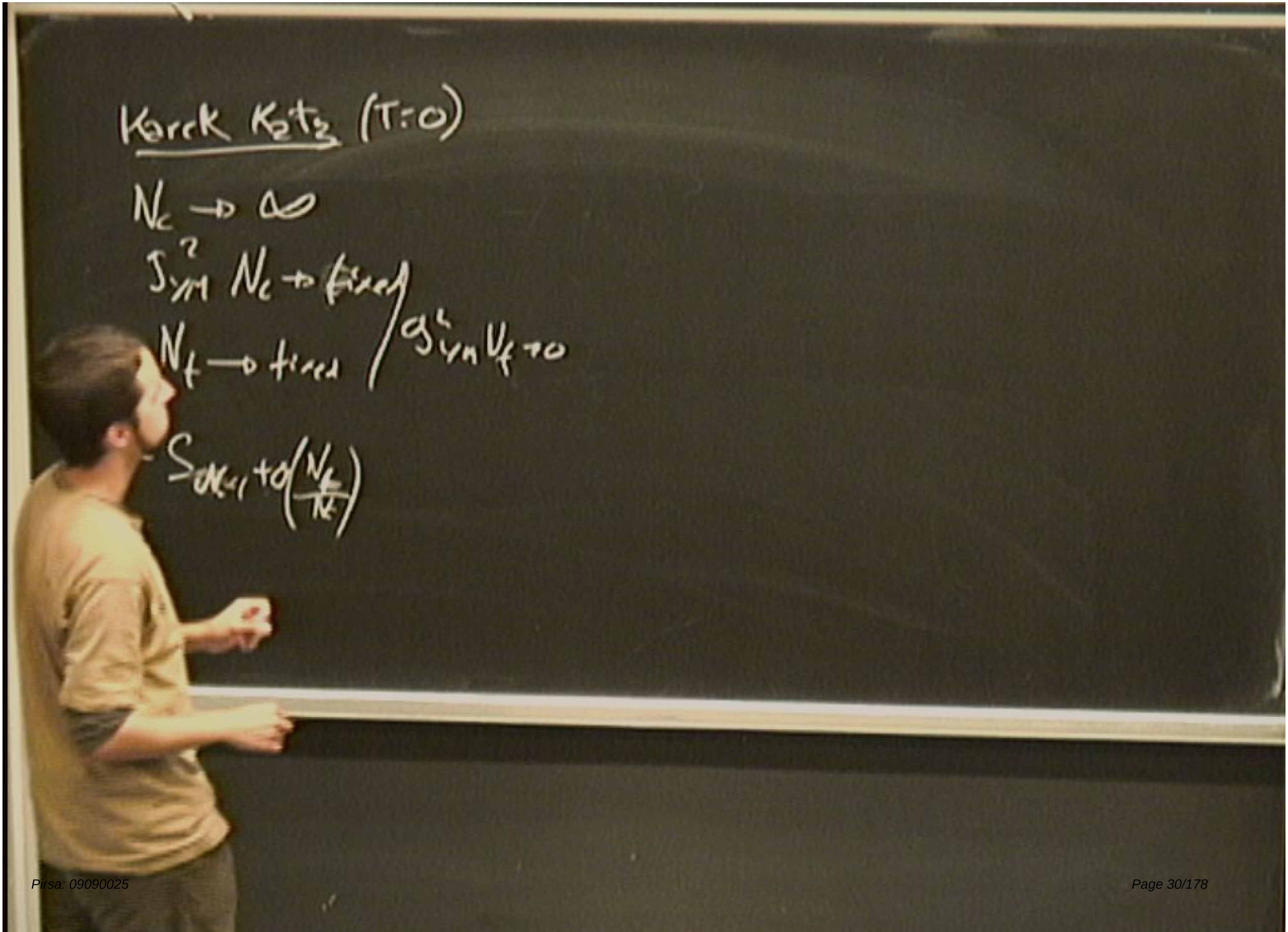
Karch Katz $(T=0)$

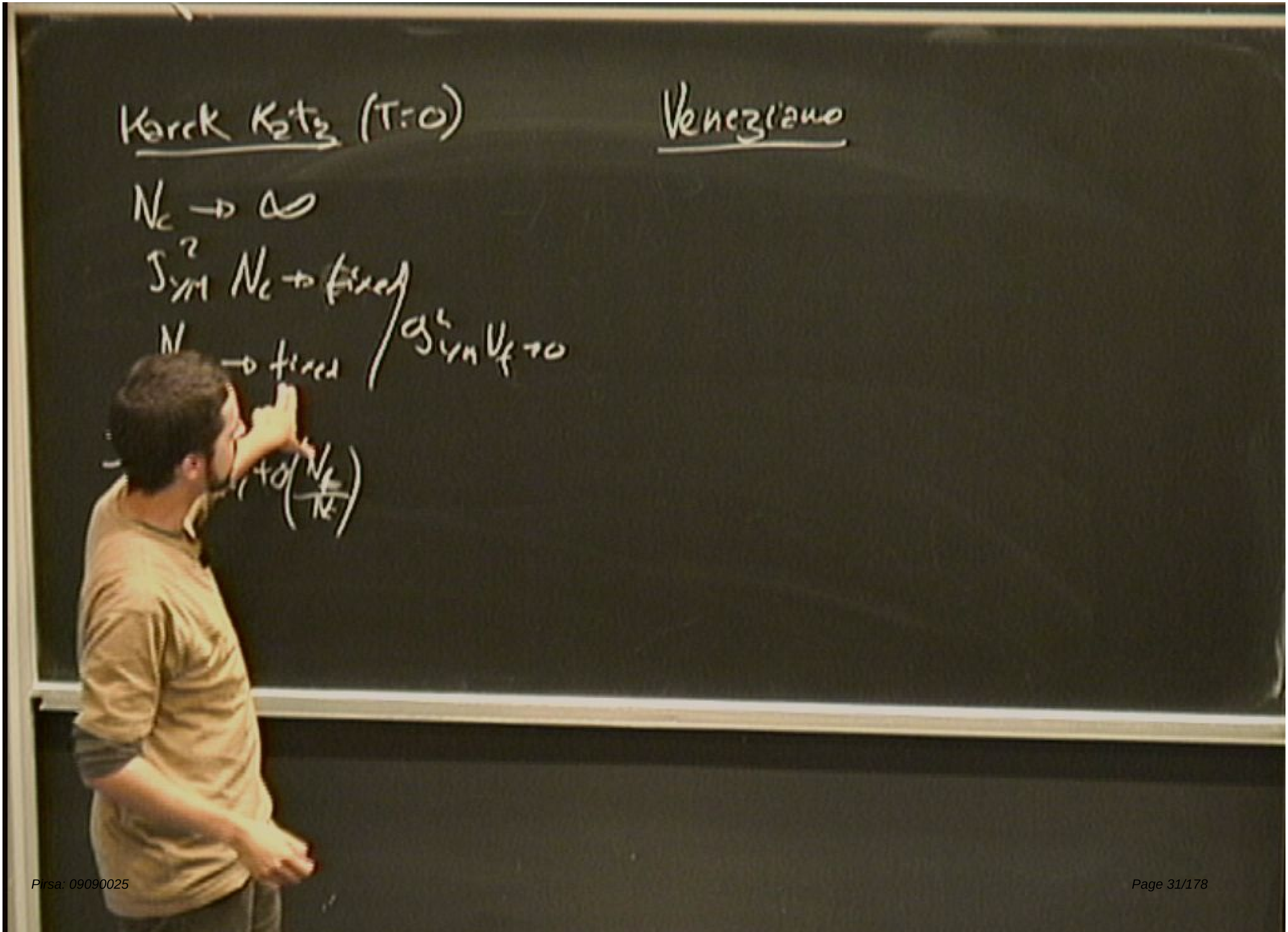
$N_c \to \infty$

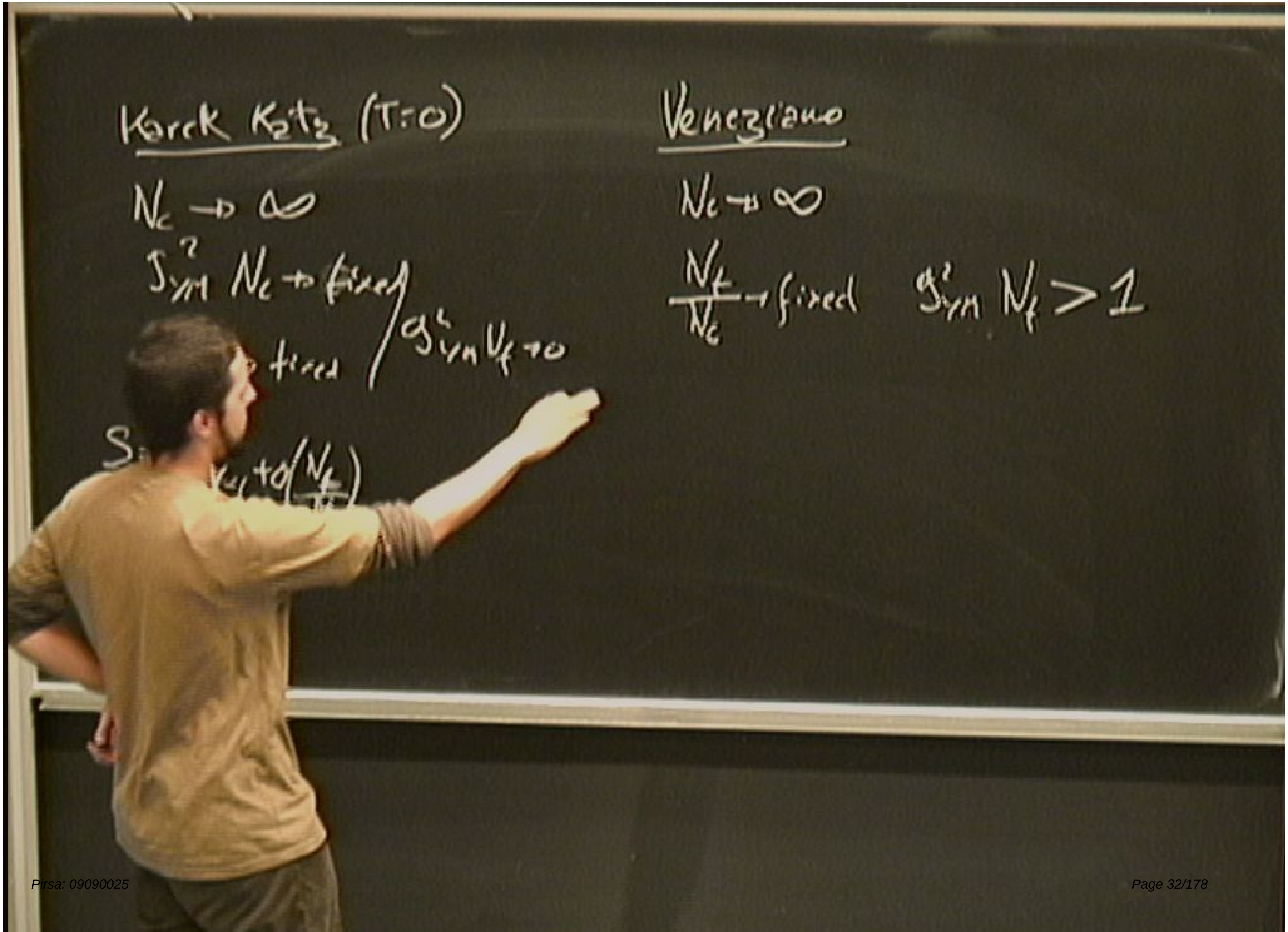
$g^2_{ym} N_c \to$ fixed

$N_f \to$ fixed $\;/\; g^2_{ym} N_f \to 0$

$$S = S_{dual} + O\left(\frac{N_f}{N_c}\right)$$


Karch Katz (T=0)
N_c → ∞
g²_YM N_c → fixed
N_f → fixed
g²_YM N_f → 0
+ O(N_f/N_c)


Karck Katz (T=0)
Veneziano
N_c → ∞
g²_ym N_c → fixed
→ fixed
g²_ym N_f → 0


Karck Katz (T=0)
$N_c \to \infty$
$g^2_{YM} N_c \to$ fixed
fixed
$g^2_{YM} N_f \to 0$
Veneziano
$N_c \to \infty$
$\frac{N_f}{N_c} \to$ fixed
$g^2_{YM} N_f > 1$

Karch Katz $(T=0)$

$N_c \to \infty$

$g_{ym}^2 N_c \to$ fixed

$N_f \to$ fixed

$\to 0$

$S = S$[illegible]$ + O\left(\frac{N_f}{N_c}\right)$

Veneziano

$N_c \to \infty$

$\frac{N_f}{N_c} \to$ fixed $\quad g_{ym}^2 N_f > 1$

$\frac{N_f}{N_c}$

Karch Katz $(T=0)$

$N_c \to \infty$

$g_{YM}^2 N_c \to$ fixed

$N_f \to$ fixed $\Big/\ g_{YM}^2 N_f \to 0$

$S = S_{\text{adj}} + O\left(\frac{N_f}{N_c}\right)$

Veneziano

$N_c \to \infty$

$\frac{N_f}{N_c} \to$ fixed $\quad g_{YM}^2 N_f > 1$

$\left(\frac{N_f}{N_c}\right)^2$

Karch Katz $(T=0)$

$N_c \to \infty$

$g_{YM}^2 N_c \to$ fixed

$N_f \to$ fixed / $g_{YM}^2 N_f \to 0$

$S = S_{adj} + O\left(\frac{N_f}{N_c}\right)$

Veneziano

$N_c \to \infty$

$\frac{N_f}{N_c} \to$ fixed $\quad g_{YM}^2 N_f > 1$

$\left(\frac{N_f}{N_c}\right)^2$

Karch Katz $(T=0)$

$N_c \to \infty$

$g_{YM}^2 N_c \to$ fixed

$N_f \to$ fixed / $g_{YM}^2 N_f \to 0$

$S = S_{\text{dual}} + O\left(\frac{N_f}{N_c}\right)$

Veneziano

$N_c \to \infty$

$\frac{N_f}{N_c} \to$ fixed $\quad g_{YM}^2 N_f > 1$

$\left(\frac{N_f}{N_c}\right)^2$

Karch Katz $(T=0)$

$N_c \to \infty$

$g_{YM}^2 N_c \to$ fixed

$N_f \to$ fixed / $g_{YM}^2 N_f \to 0$

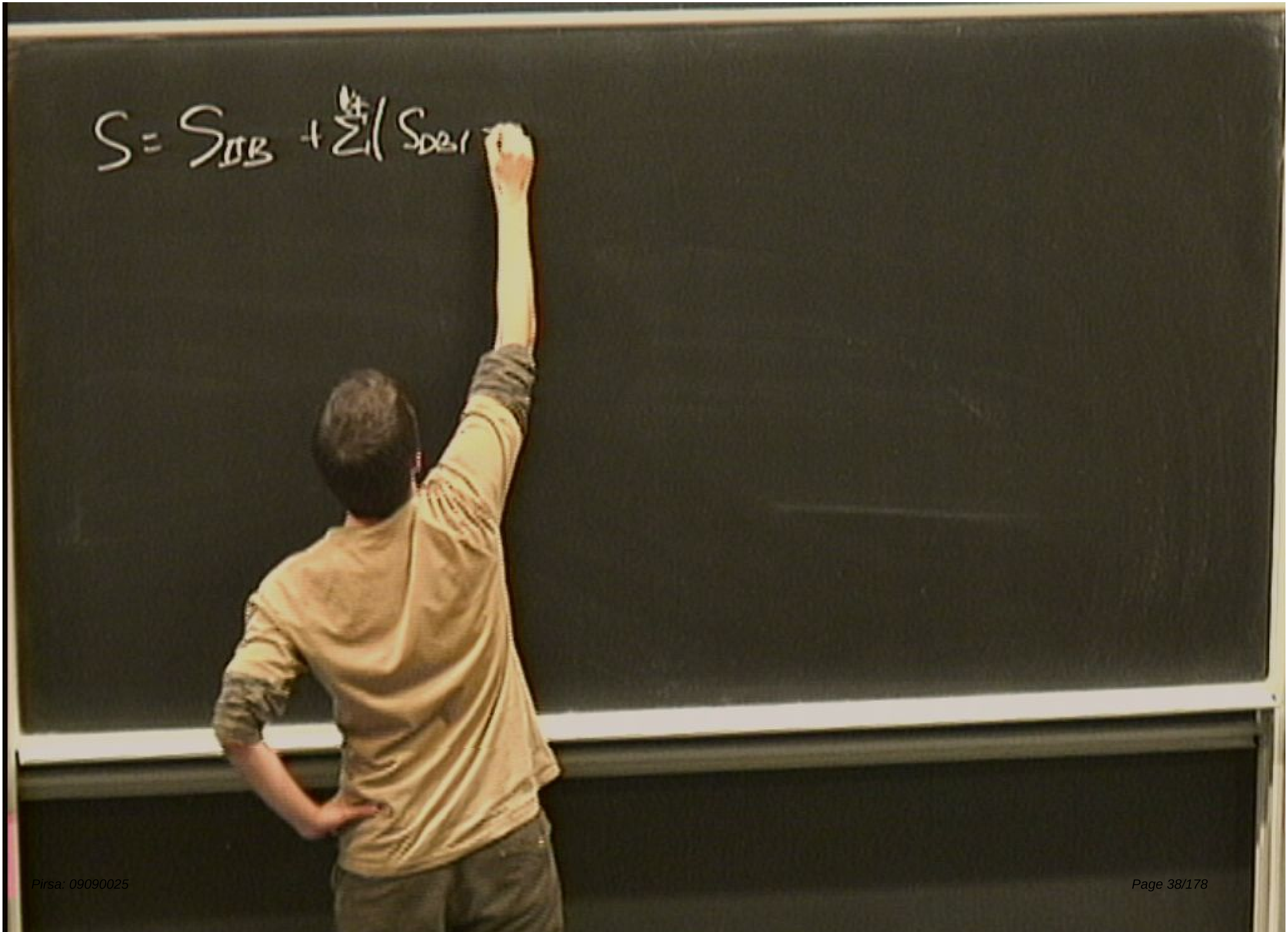
$S = S_{\mathrm{conf}} + O\left(\frac{N_f}{N_c}\right)$

Veneziano

$N_c \to \infty$

$\frac{N_f}{N_c} \to$ fixed $\quad g_{YM}^2 N_f > 1$

$\left(\frac{N_f}{N_c}\right)^2$

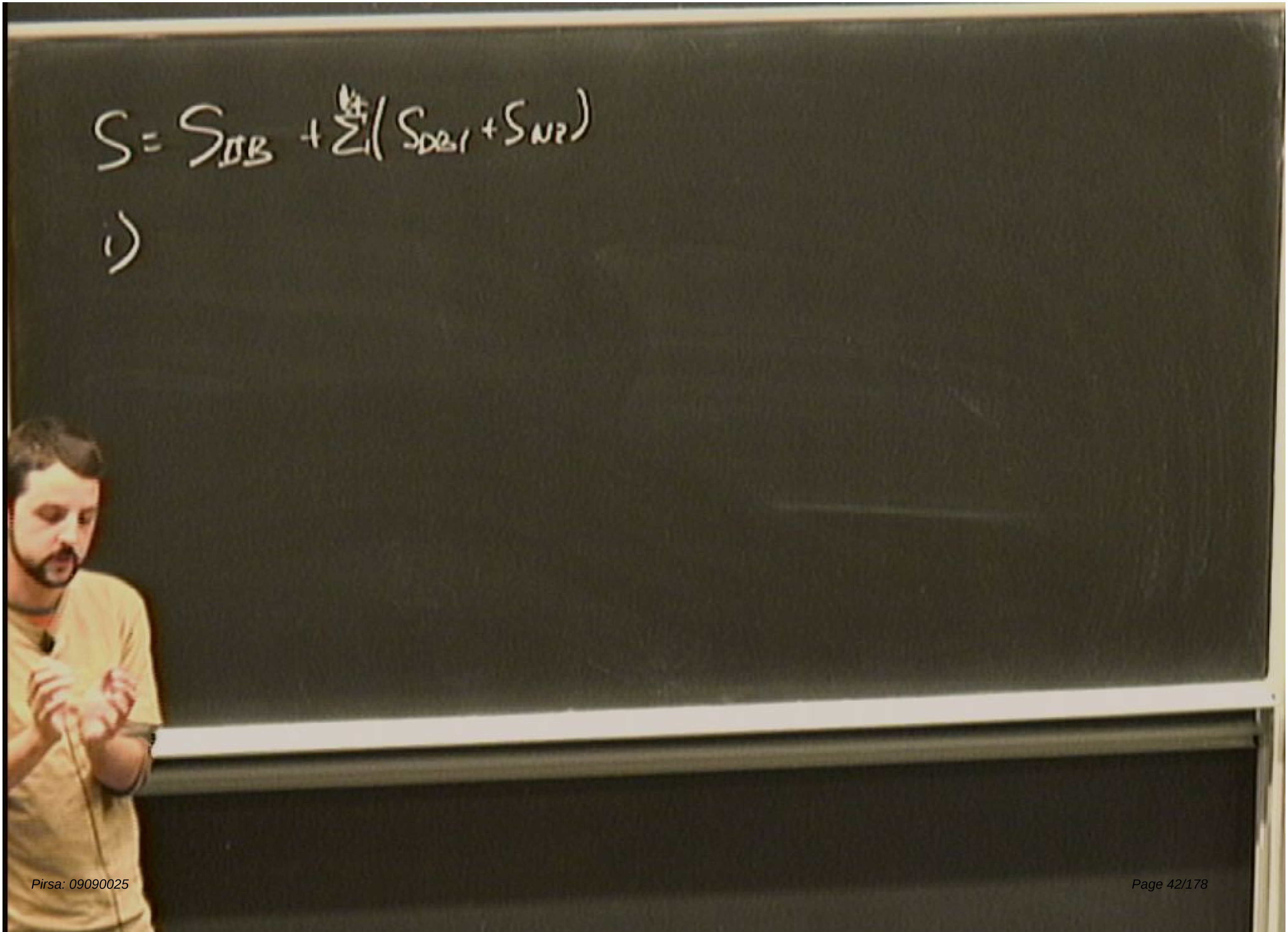

$S = S_{IIB} + \sum_i (S_{DBI}$

$$S = S_{IIB} + \sum_{i}^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

$$S = S_{IIB} + \sum_{i}^{4} \left(S_{DBI} + S_{WZ} \right)$$

$$S = S_{IIB} + \sum_i \left(S_{DBI} + S_{WZ} \right)$$

i)



$S = S_{IIB} + \sum_i (S_{DBI} + S_{WZ})$
i)

$$S = S_{IIB} + \sum_{i}^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$

$$S = S_{IIB} + \sum_{i}^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$

ii)

$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$

ii) $U(N_f)$

$$S = S_{IIB} + \sum_{i}^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$

ii) $U(N_f)$ $\quad g_{YM}^2 N_f$

$$S = S_{IIB} + \sum_{i}^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$

ii) $U(N_f)$ $\quad g_{YM}^2 N_f$

iii)

$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$

ii) $U(N_f)$ $\quad g_{YM}^2 N_f$

iii) dirac deltas $\to$ EOM

$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$

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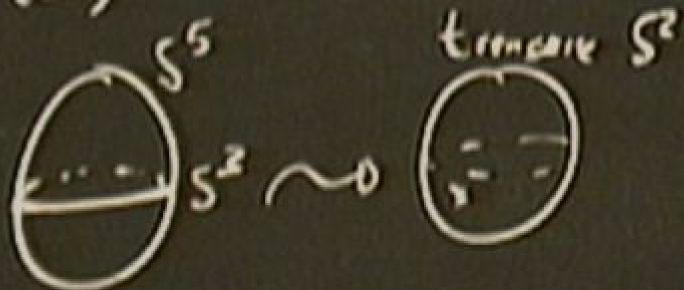

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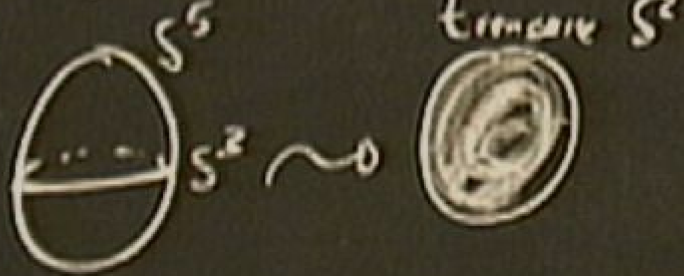

$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \le 12$

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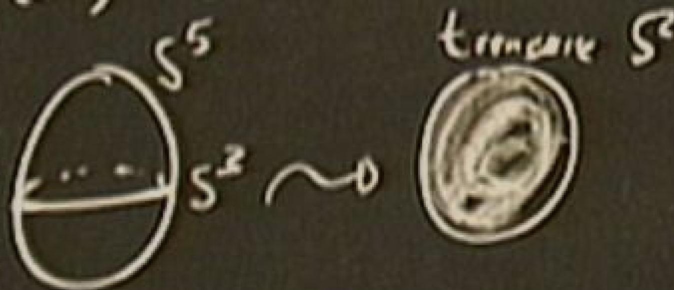
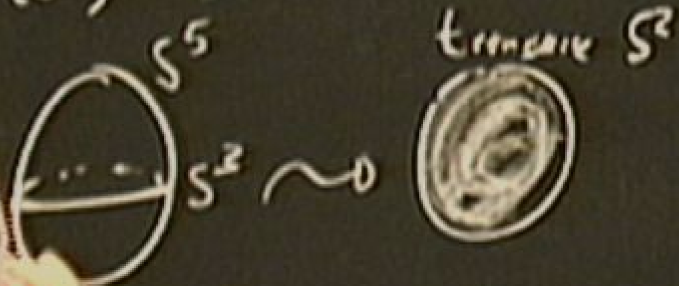


$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$

ii) $U(N_f) \to U(1)^{N_f}$ $\quad g_{YM}^2 N_f$

iii) dirac deltas $\to$ EOM ✓



$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$

ii) $U(N_f) \rightarrow U(1)^{N_f}$ $\quad \dfrac{g_{YM}^2 N_f}{R^2}$

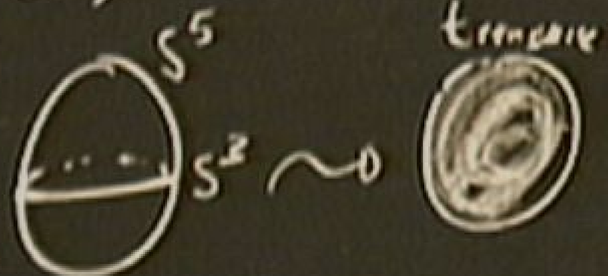
iii) dirac deltas $\rightarrow$ EOM ✓

$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \le 12$

ii) $U(N_f) \to U(1)^{N_f}$ $\quad \dfrac{g_{YM}^2 N_f}{R^2 \to \infty}$

iii) dirac deltas $\to$ EOM ✓

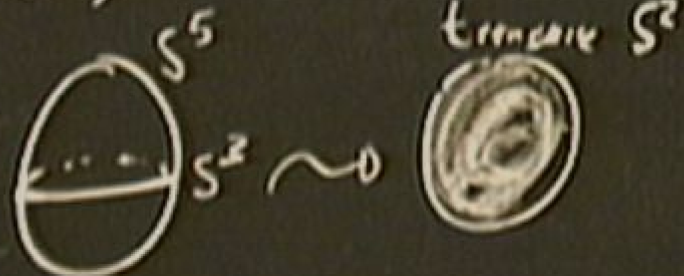


$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$

i) $N_f \leq 12$

ii) $U(N_f) \to U(1)^{N_f}$ $\quad \frac{g_{YM}^2 N_f}{R^2} \to 0$ ✓

iii) dirac deltas → EOM ✓

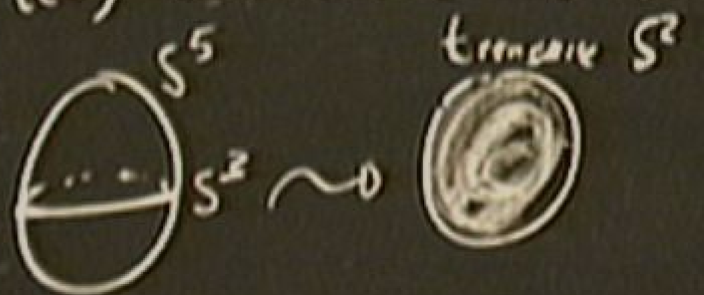


$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \to U(1)^{N_f}$ $\quad \dfrac{g_{YM}^2 N_f}{R^2} \to 0$ ✓

iii) dirac deltas → EOM ✓




i) $N_f \le 12$ ✓
ii) U(N)
$\frac{g_{YM}^2 N_f}{R^2}$ ✓
iii) deltas → EOM ✓
S²

$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \to U(1)^{N_f}$ $\quad \frac{g_{YM}^2 N_f}{R^2} \to \infty$ ✓

iii) dirac delta → EOM ✓

$$S_{WZ} = -T_7 \sum_i^{N_f} \int C_8$$

$$\Downarrow$$

$$-\frac{T_7 N_f}{Vol(X_2)} \int \rho(r)\, \epsilon(X_2) \wedge C_8$$

$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

$$S_{WZ} = -T_7 \sum_i^{N_f} \int C_8$$

$$\Downarrow$$

$$-\frac{T_7 N_f}{Vol(X_2)} \int p(r)\, \epsilon(X_2) \wedge C_8$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \to U(1)^{N_f}$ $\quad \frac{g_{YM}^2 N_f}{R^2 \to \infty}$ ✓

iii) ...ac deltas $\to$ EOM ✓

[illegible] S^2

... $\left(\frac{N_f \lambda}{R^2} \right)$

$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

$$S_{WZ} = -T_7 \sum_i^{N_f} \int C_8$$

$$\Downarrow$$

$$-\frac{T_7 N_f}{Vol(X_2)} \int \rho(r)\, \underline{\epsilon(X_2)} \wedge C_8$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \to U(1)^{N_f}$ $\quad \frac{g_{YM}^2 N_f}{R^2 \to \infty}$ ✓

iii) dirac deltas → EOM ✓

S^5 smeare S^2

$S^2 \rightsquigarrow$ $\left(\frac{N_f x}{R^2} \right)$

$$S = S_{IIB} + \sum_i^{N_f} \left(S_{DBI} + S_{WZ} \right)$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \to U(1)^{N_f}$ $\quad \frac{g_{YM}^2 N_f}{R^2}$ ✓

iii) dirac del... ✓

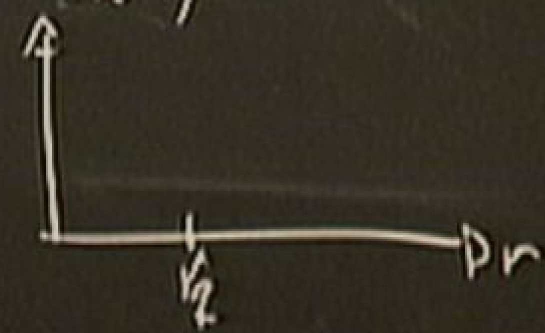
S^5

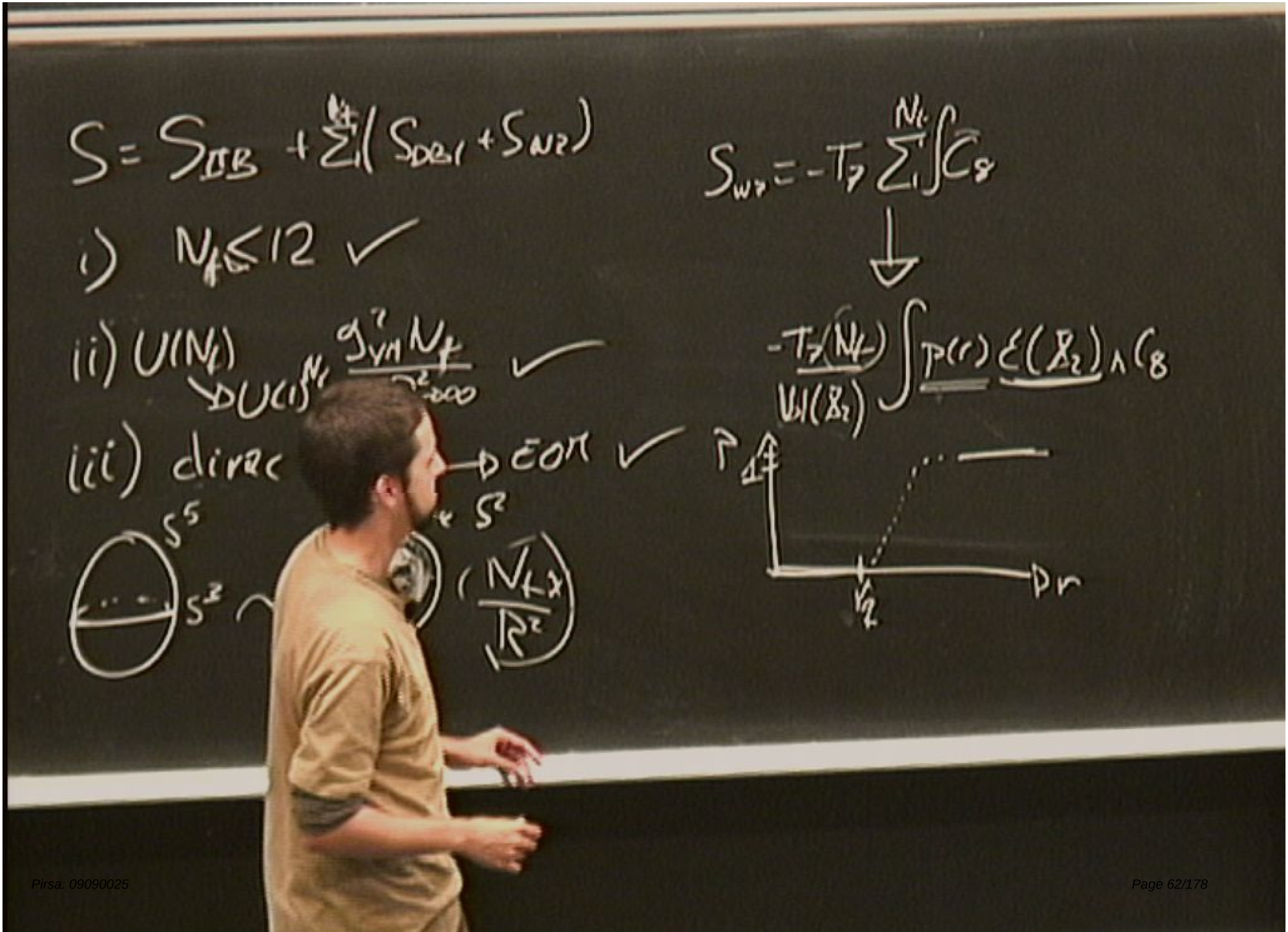
$S^3 \sim 0$ $\quad \frac{N_f \lambda}{R^2}$

$$S_{WZ} = -T_7 \sum_i^{N_f} \int C_8$$

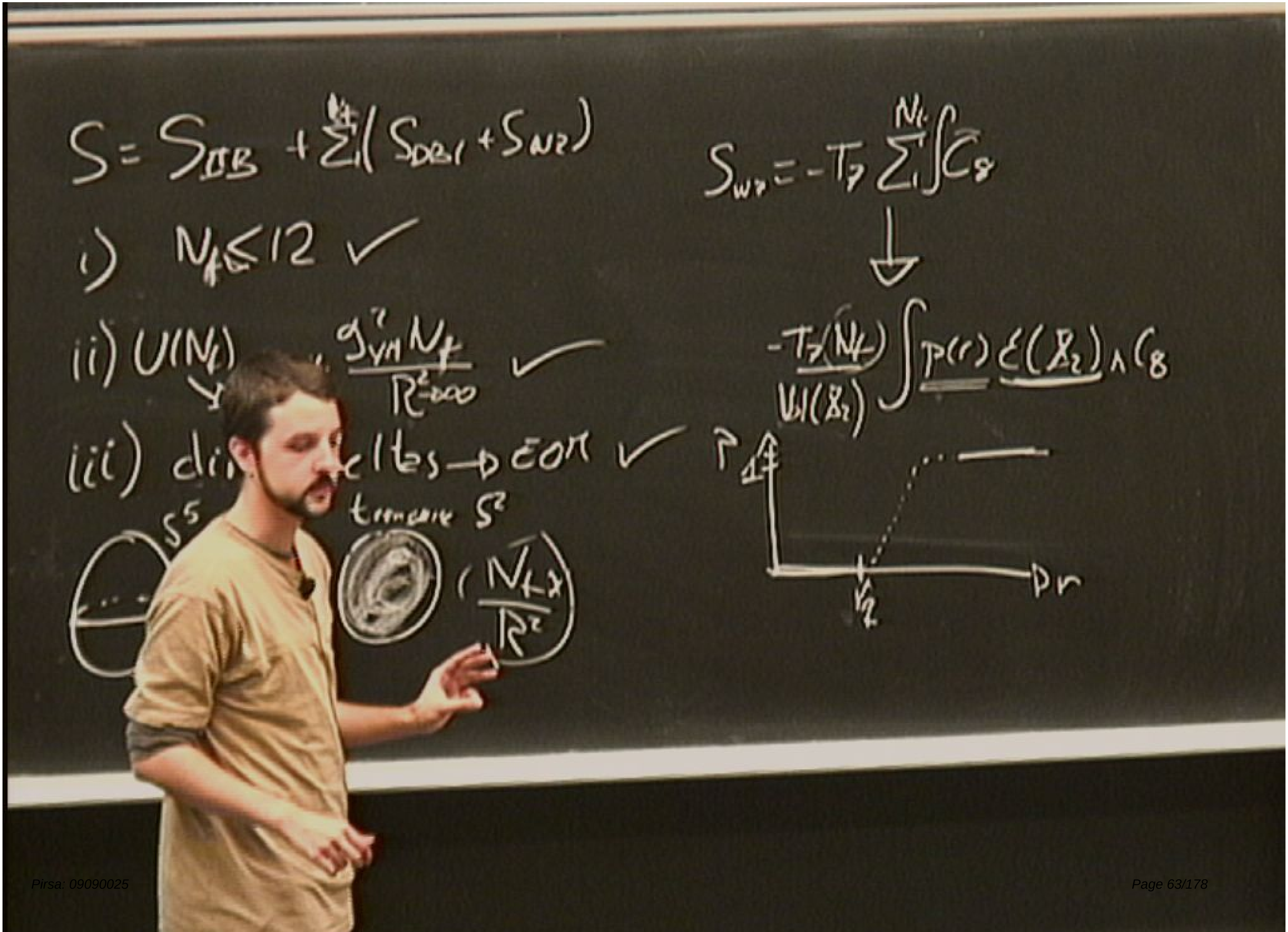
$$\Downarrow$$

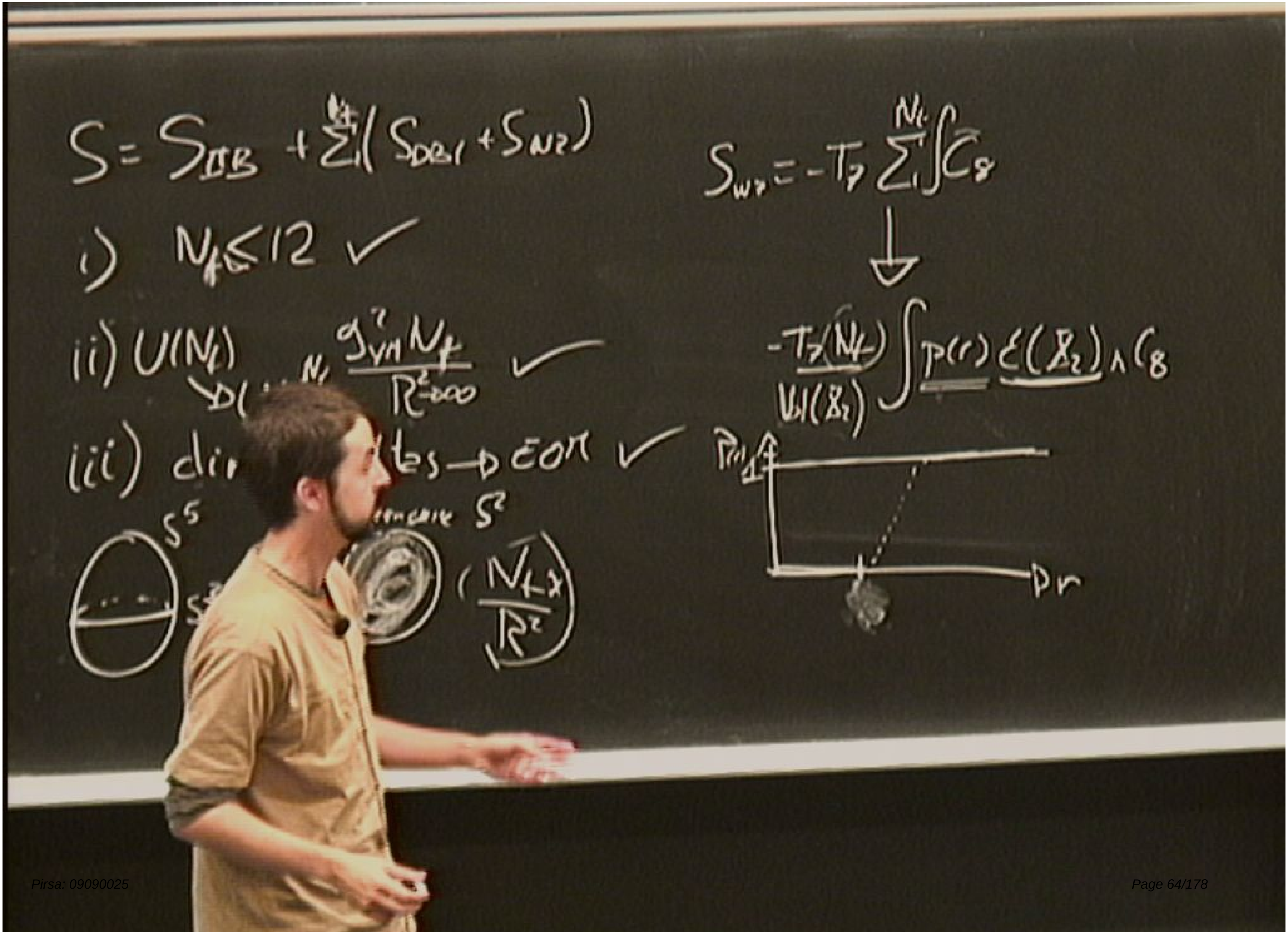
$$-\frac{T_7 (N_f)}{Vol(X_2)} \int p(r) \, \epsilon(X_2) \wedge C_8$$

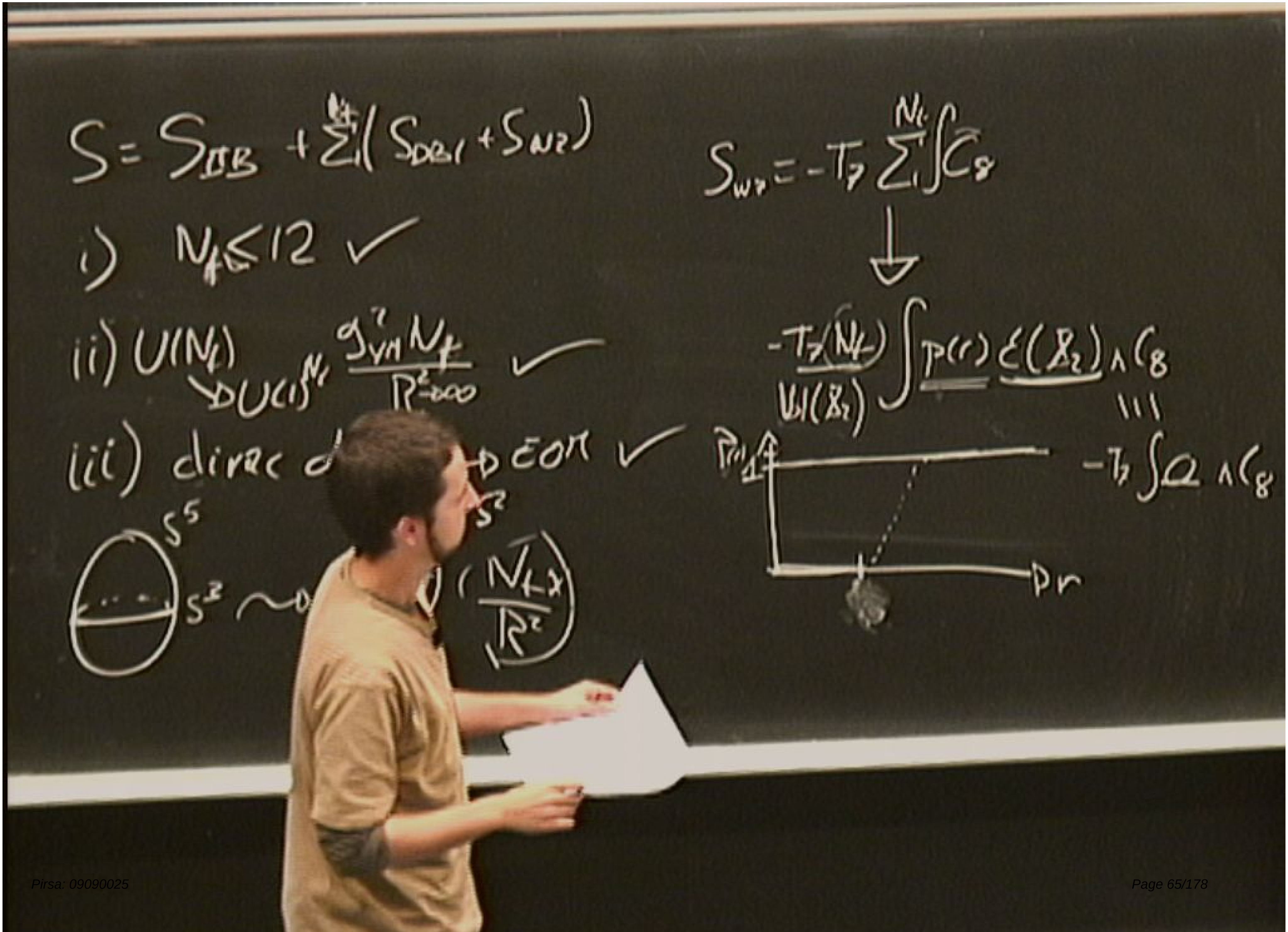


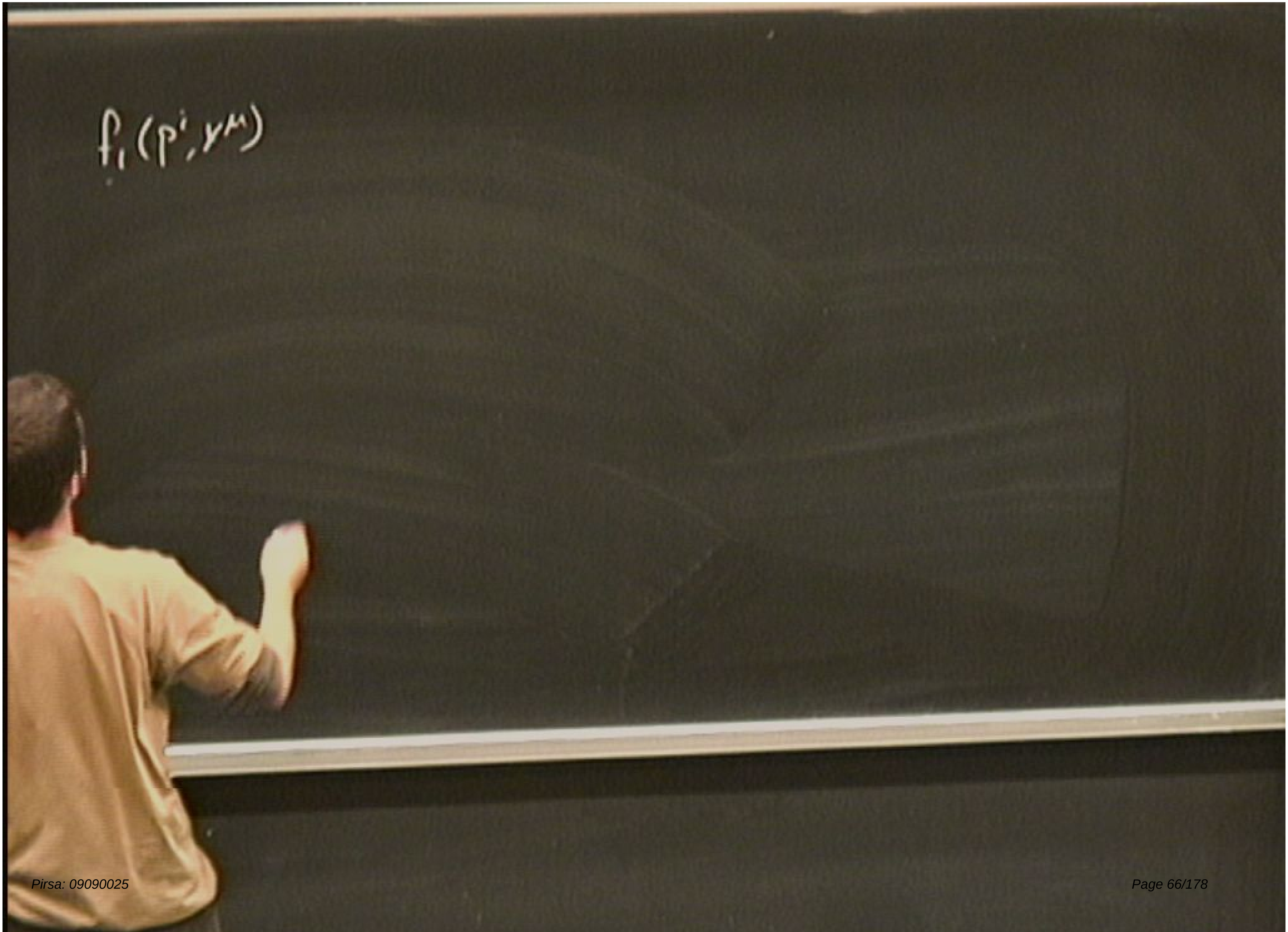


S = S_IIB + Σ_i^{N_f} (S_DBI + S_WZ)
S_WZ = -T_7 Σ_i^{N_f} ∫ C_8
i) N_f ≤ 12 ✓
ii) U(N_f) → U(1)^{N_f}
✓
-T_7 (N_f) / Vol(X_2) ∫ p(r) ε(X_2) ∧ C_8
iii) dirac
EOM ✓
S^5
S^3
S^2
N_f λ / R^2
p
r
r_2


S = S_IIB + Σ_i (S_DBI + S_WZ)
i) N_f ≤ 12
ii) U(N_f)
g²_YM N_f / R² → ∞
iii) di... eltes → EOM
S^5
transverse S^2
N_f x / R^2
S_WZ = −T_7 Σ_i^{N_f} ∫ C_8
−T_7 (N_f) / Vol(X_2) ∫ p(r) ε(X_2) ∧ C_8
p
r
r_2


S = S_IIB + Σ_i^{N_f} (S_DBI + S_WZ)
i) N_f ≤ 12
ii) U(N_f)
g²_YM N_f / R² → ∞
iii) EOM
S^5
S^3
S^2
S_WZ = -T_7 Σ_i^{N_f} ∫ C_8
-T_7 (N_f) / Vol(X_2) ∫ p(r) ε(X_2) ∧ C_8

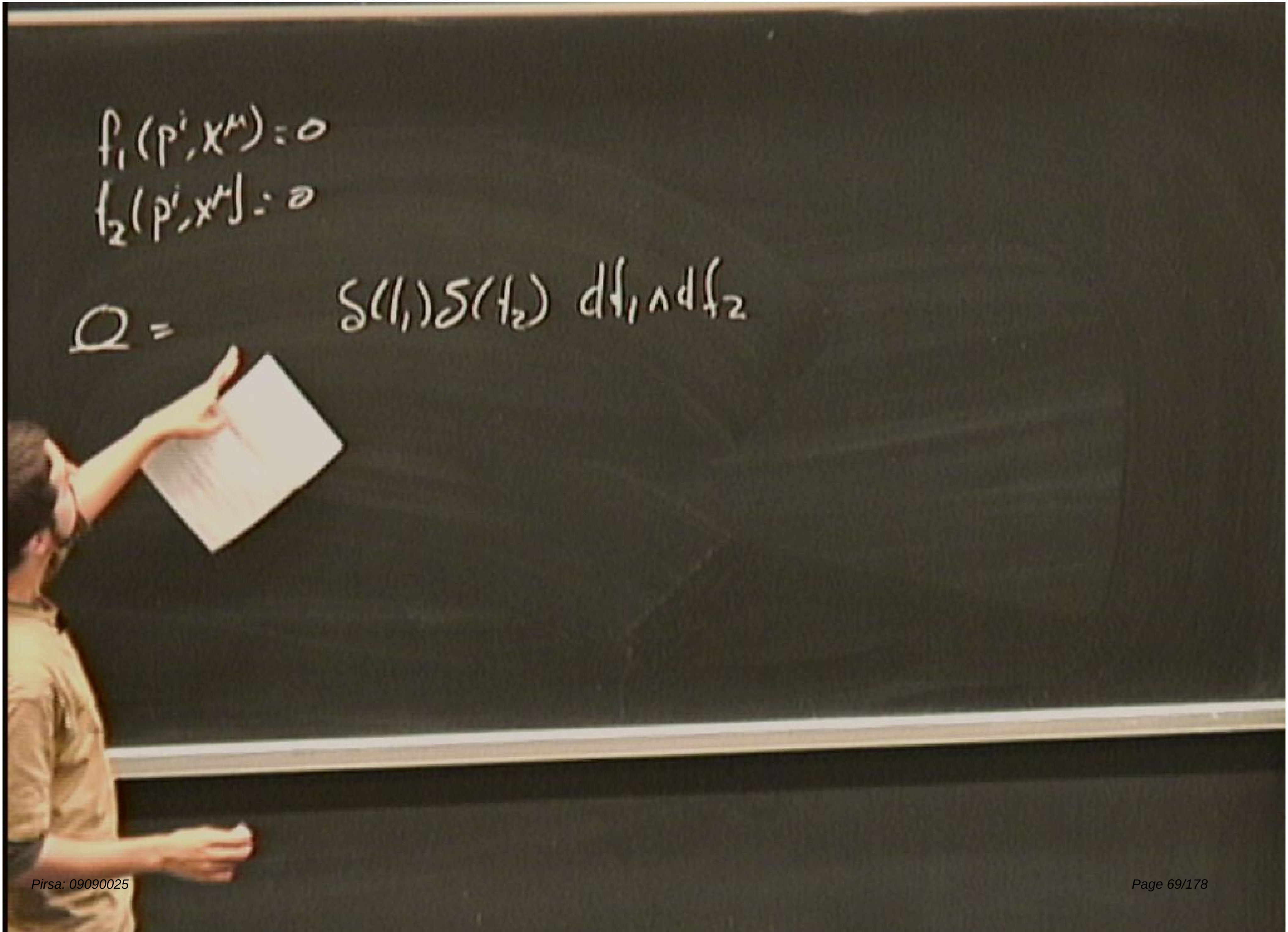

S = S_IIB + Σ_i (S_DBI + S_WZ)
S_WZ = −T_7 Σ_i ∫ C_8
i) N_f ≤ 12
ii) U(N_f) → U(1)^{N_f}
g²_YM N_f / R² → ∞
iii) dirac d
EOM
S^5
S^3
S^3
N_f λ / R²
−T_7 (N_f) / Vol(X_2) ∫ p(r) ε(X_2) ∧ C_8
−T_7 ∫ Ω ∧ C_8
p_r


$f_1(p^i, y^\mu)$

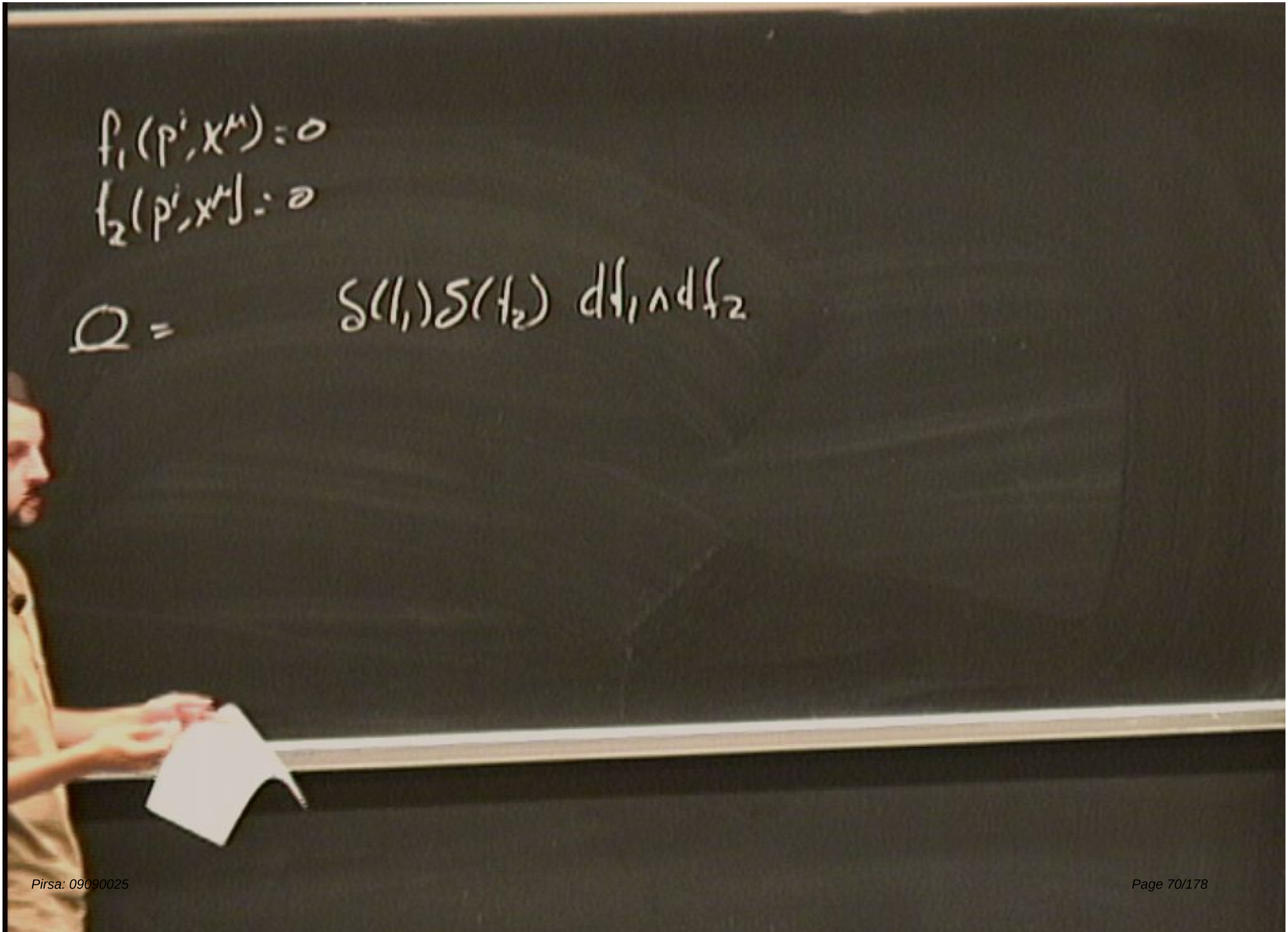
$$f_1(p^i, x^\mu) = 0$$
$$f_2(p^i, x^\mu) = 0$$

$$f_1(p^i, x^\mu) = 0$$
$$f_2(p^i, x^\mu) = 0$$

$$\Omega =$$



f1 (p^i, x^μ) = 0
f2 (p^i, x^μ) = 0
Ω = δ(f1) δ(f2) df1 ∧ df2


$f_1(p^i, x^\mu) = 0$
$f_2(p^i, x^\mu) = 0$
$\Omega = \quad \delta(f_1)\delta(f_2)\, df_1 \wedge df_2$

$$f_1(p^i, x^\mu) = 0$$

$$f_2(p^i, x^\mu) = 0$$

$$\Omega = \rho(p_i)\,\delta(f_1)\,\delta(f_2)\; df_1 \wedge df_2$$

$$f_1(p^i, x^\mu) = 0$$

$$f_2(p^i, x^\mu) = 0$$

$$\Omega = \int \rho(p_i)\,\delta(f_1)\,\delta(f_2)\; df_1 \wedge df_2 \;\; dp_1$$

$$= 0$$

$$= 0$$

$f_1(p^i, x^\mu) = 0$

$f_2(p^i, x^\mu) = 0$

$$\Omega = \int \rho(p_1)\,\delta(f_1)\,\delta(f_2)\; df_1 \wedge df_2 \;\; dp_1$$

$\tau = 0$

$\chi = 0$

$f_1(p^i, x^\mu) = 0$

$f_2(p^i, x^\mu) = 0$

$$\Omega = \int \rho(p_1)\, \delta(f_1)\, \delta(f_2)\; df_1 \wedge df_2 \;\; dp_1$$

$f_1(p^i, x^\mu) = 0$

$f_2(p^i, x^\mu) = 0$

$$\underline{\Omega} = \int \rho(p_1)\,\delta(f_1)\,\delta(f_2)\; df_1 \wedge df_2 \;\; dp_1$$

$$S_{WZ} = -\int \underline{\Omega} \wedge C_8$$

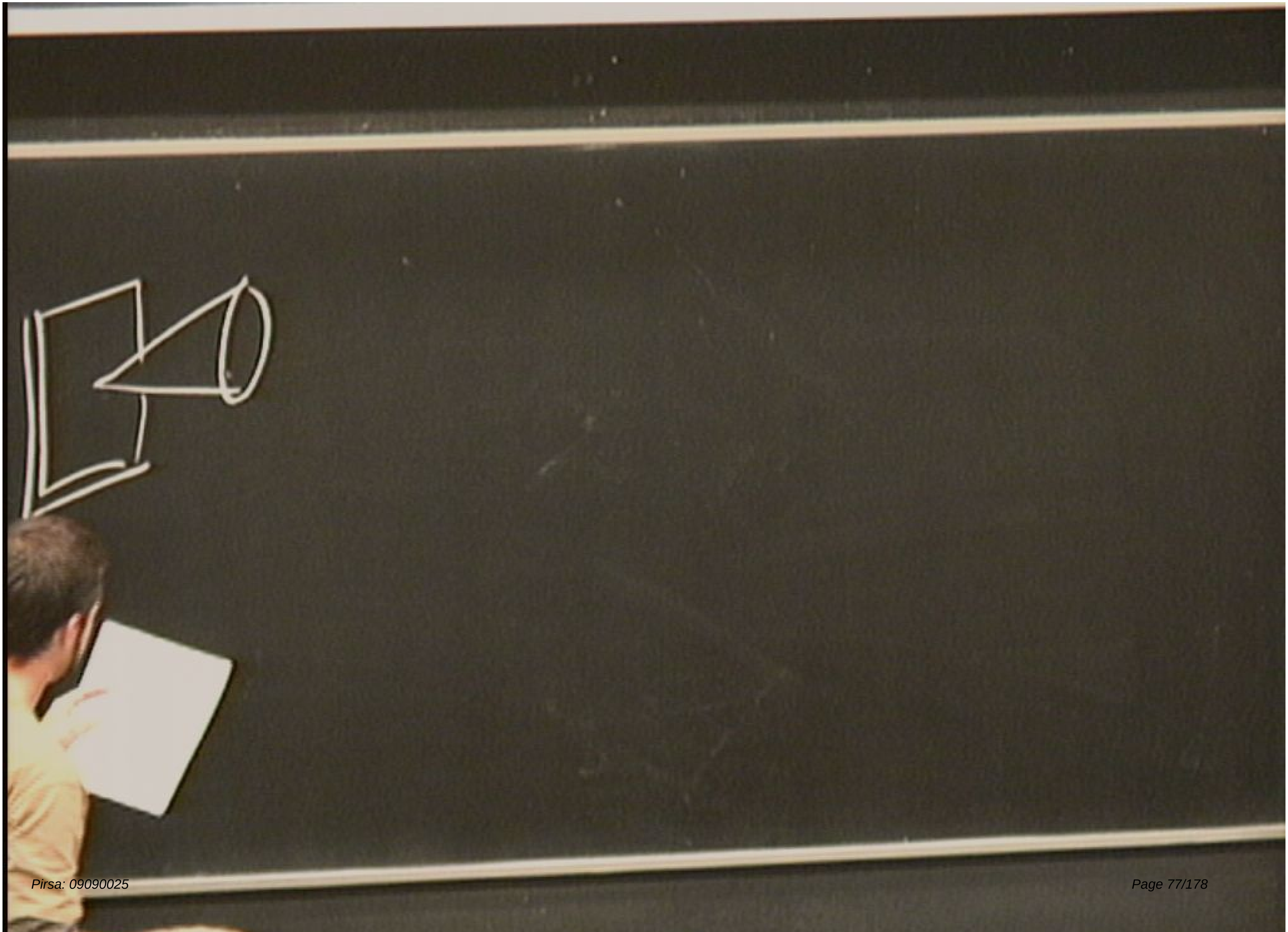
$$f_2(p^i, x^\mu) = 0$$

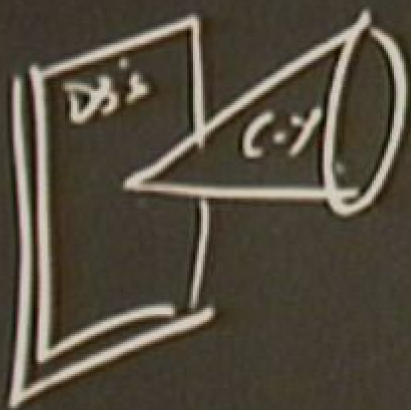
$$\Omega = \int \rho(p_i)\,\delta(f_1)\,\delta(f_2)\; df_1 \wedge df_2 \;\; dp_i$$

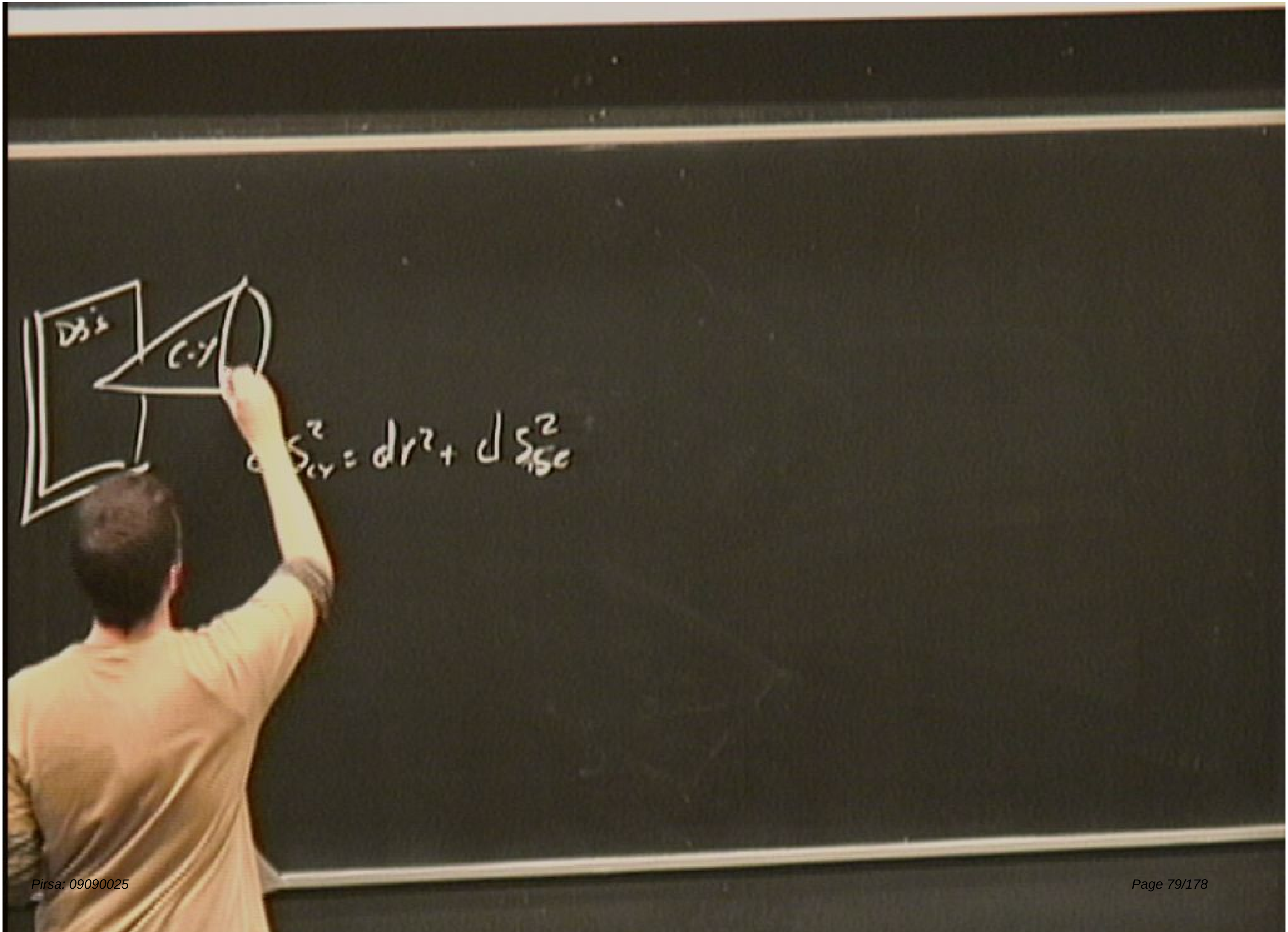
$$S_{WZ} = -\int \Omega \wedge C_8$$

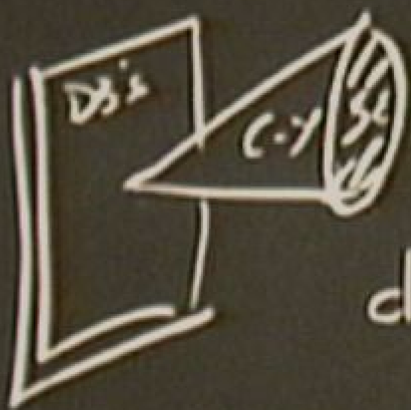
$$\Downarrow$$

$$d\Gamma_{D} = -\, g_s\, \Omega$$

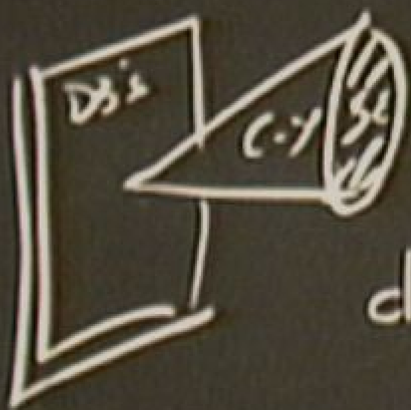



DS's
C-Y

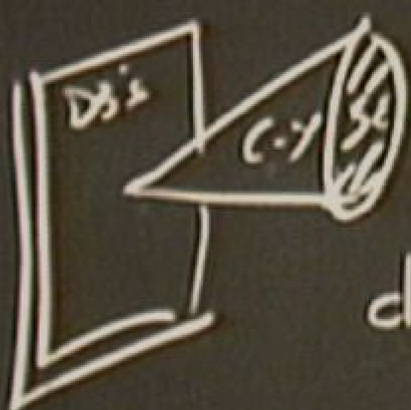

D3's
C-Y
$ds^2_{CY} = dr^2 + ds^2_{SE}$



$$ds^2_{CY} = dr^2 + ds^2_{SE}$$

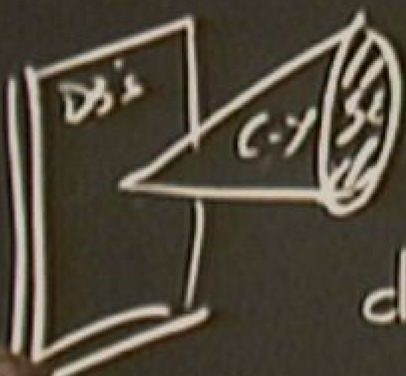


$$ds^2_{CY} = dr^2 + r^2 ds^2_{SE}$$



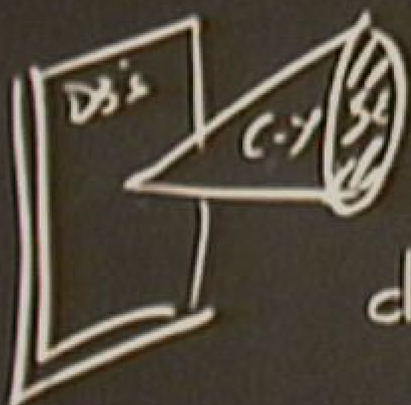
$$ds^2_{CY} = dr^2 + r^2 ds^2_{SE}$$

$$\frac{C\text{-}Y}{R^6}$$



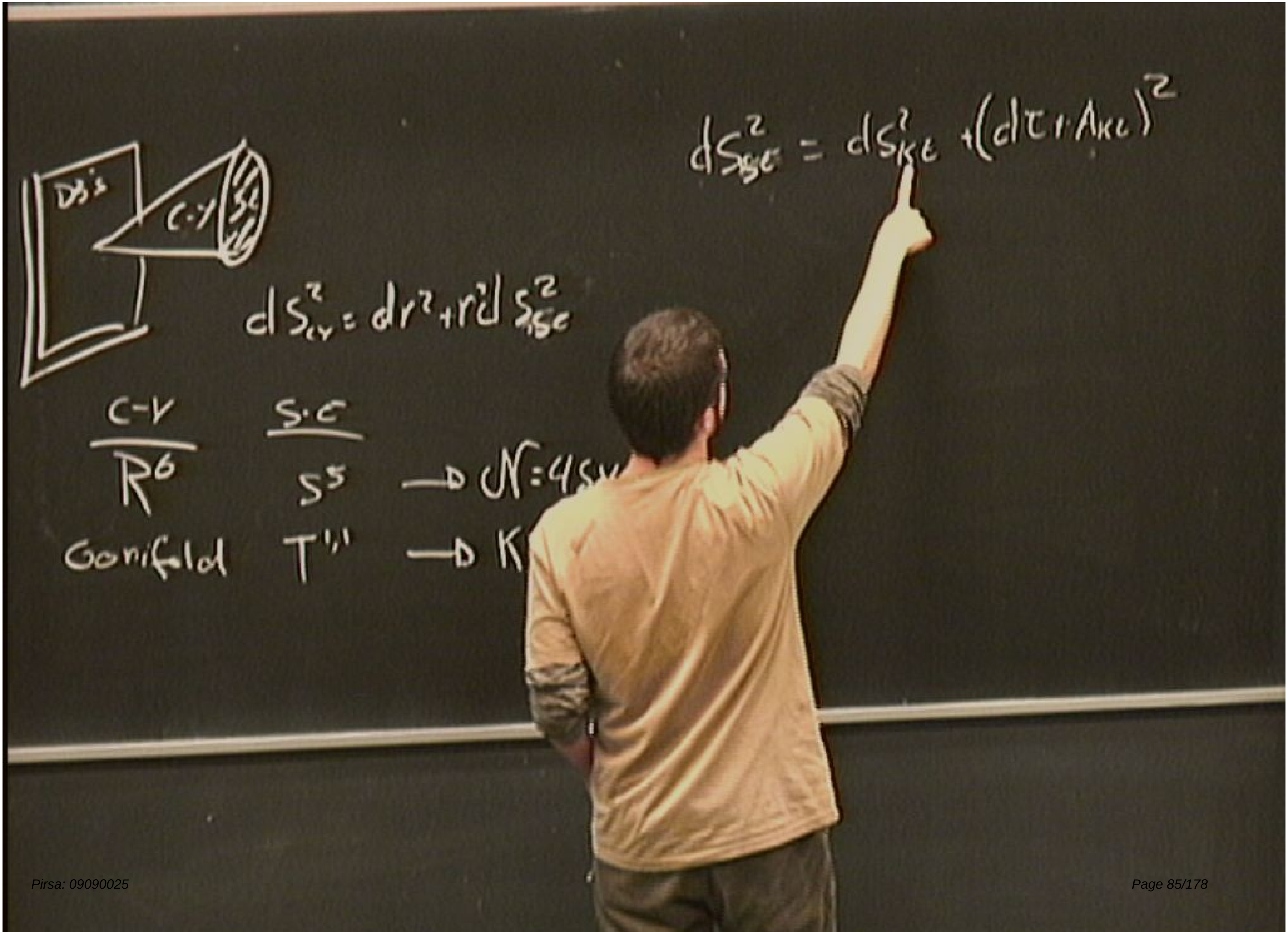
$$dS^2_{CY} = dr^2 + r^2 dS^2_{SE}$$

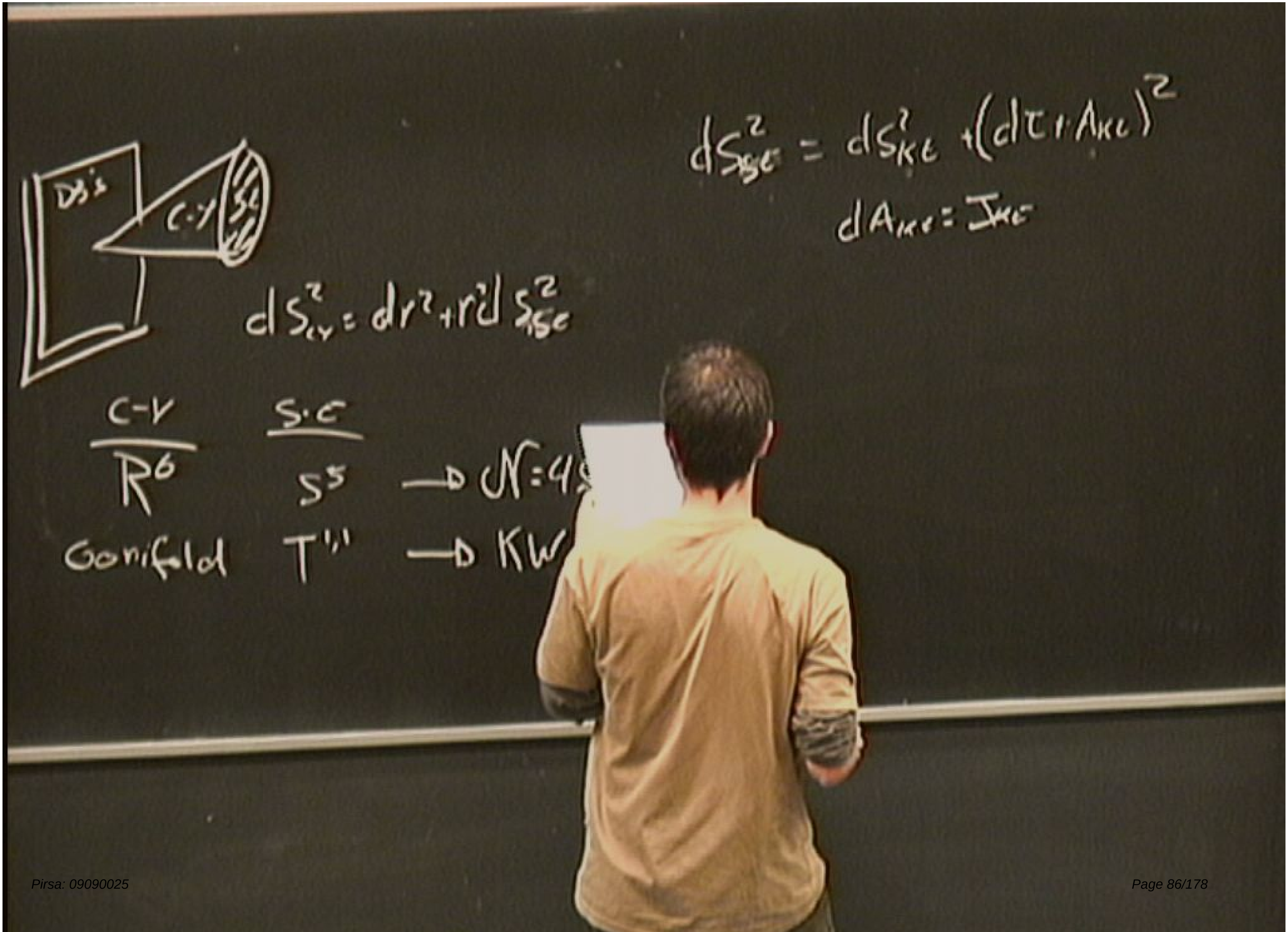
$$\frac{C\text{-}Y}{R^6} \qquad \frac{S.E}{S^5} \longrightarrow \mathcal{N}=4\ \mathrm{SYM}$$

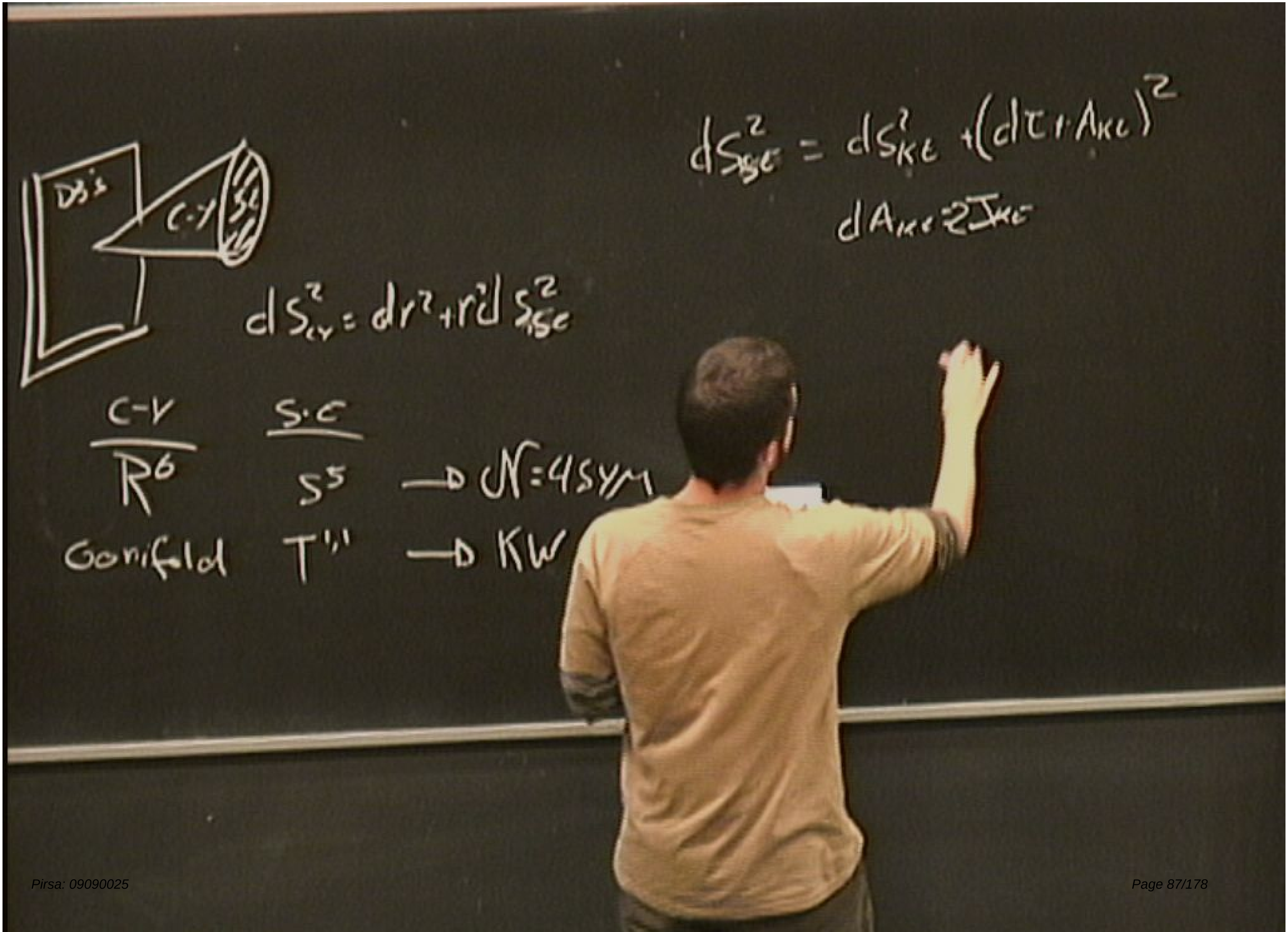


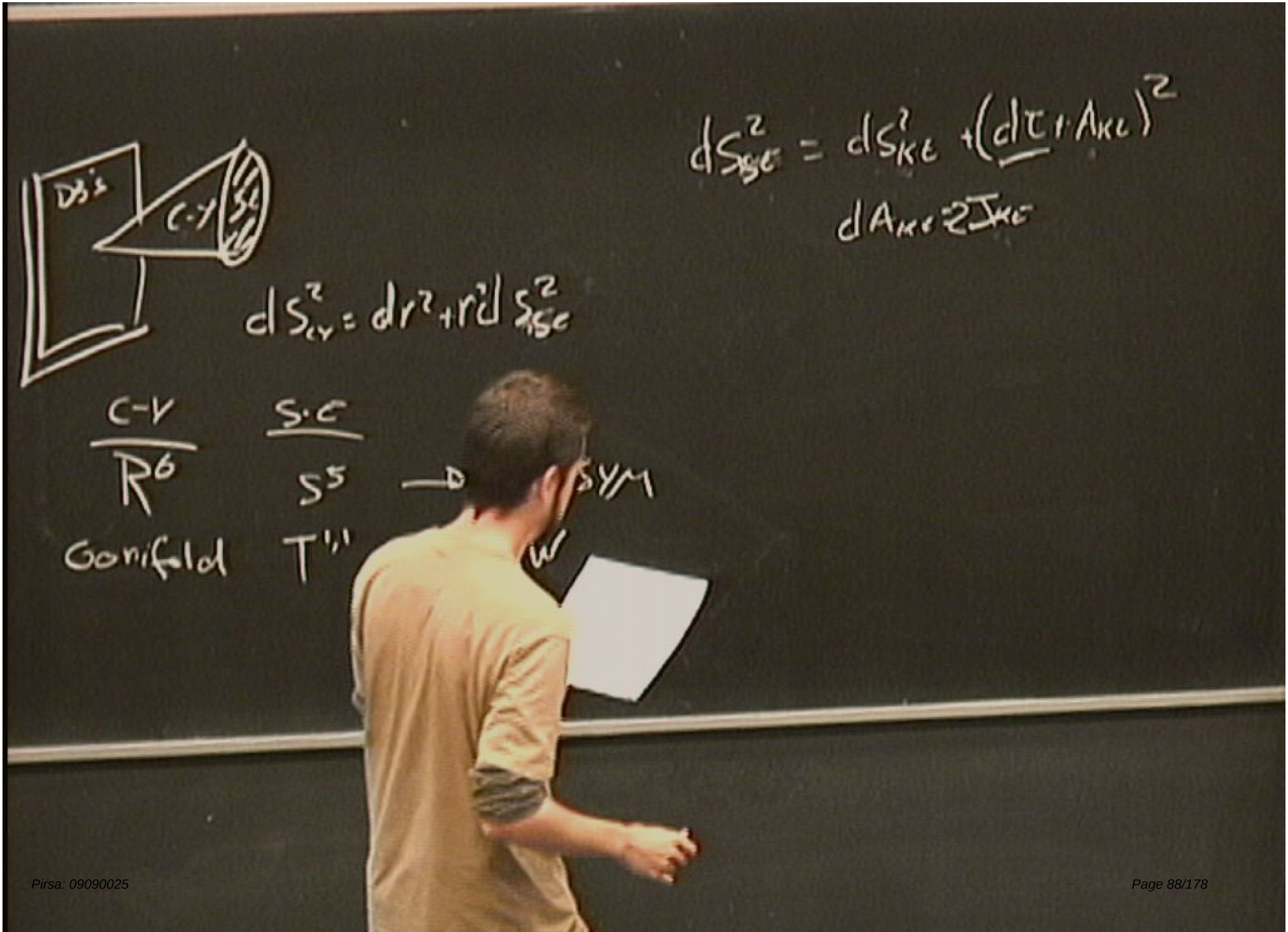
$$ds^2_{CY} = dr^2 + r^2 ds^2_{SE}$$

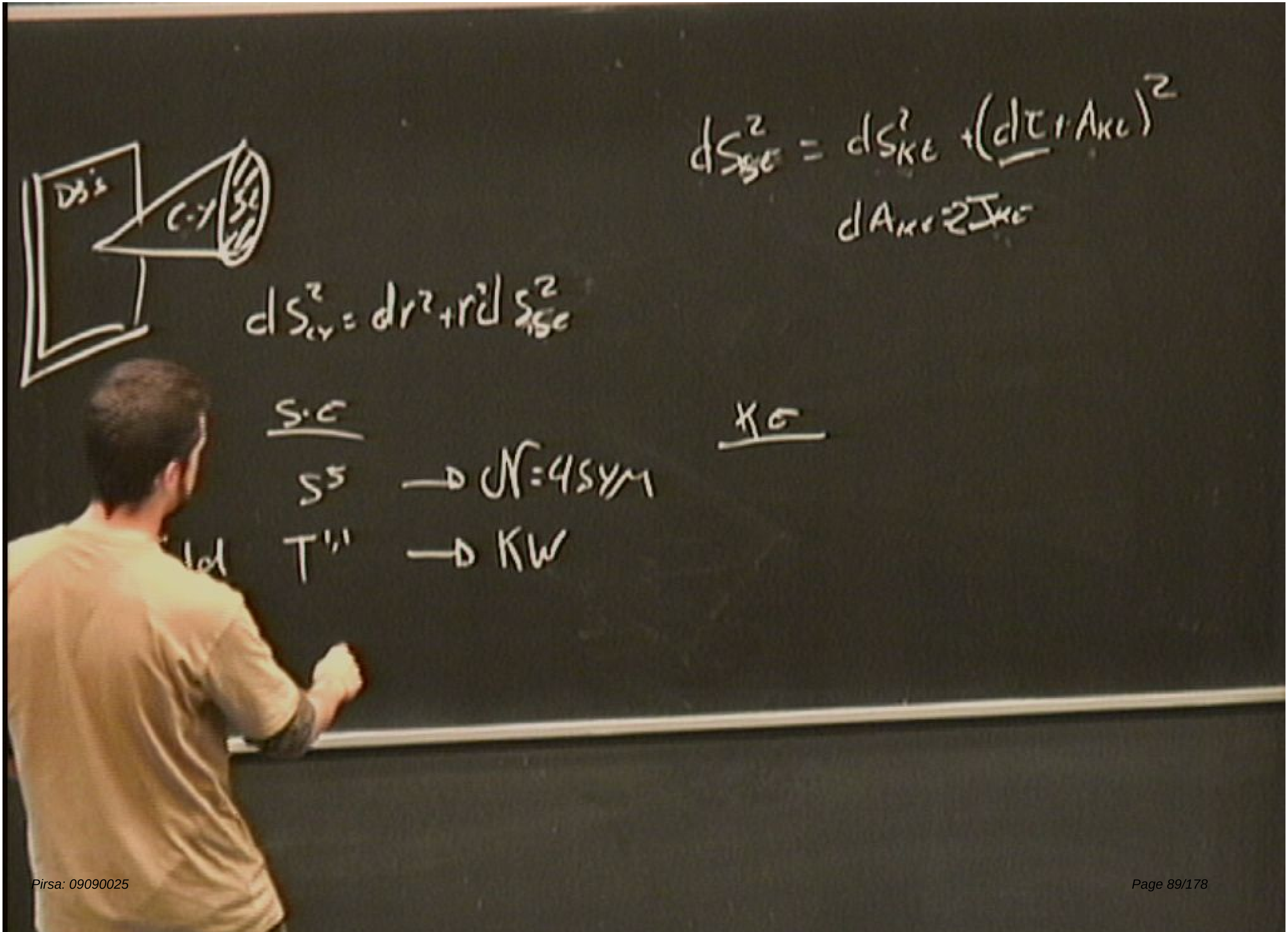
C-Y	S.E	
R^6	S^5	$\longrightarrow \mathcal{N}=4$ SYM
Conifold	$T^{1,1}$	$\longrightarrow$ KW

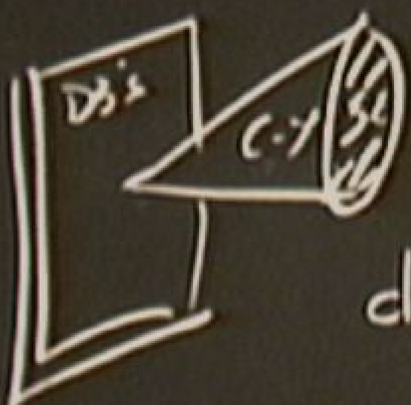

dS²SE = dS²KE + (dτ + AKE)²
D3's
C-Y
SE
dS²CY = dr² + r² dS²SE
C-Y
R⁶
S.E
S⁵
Conifold
T¹,¹


$dS^2_{SE} = dS^2_{KE} + (d\tau + A_{KE})^2$
$dA_{KE} = J_{KE}$
D3's
C-Y
SE
$dS^2_{CY} = dr^2 + r^2 dS^2_{SE}$
C-Y
S.E
R^6
S^5
$\longrightarrow \mathcal{N}=4$
Conifold
$T^{1,1}$
$\longrightarrow$ KW


D3's
C-Y
SE
dS²_SE = dS²_KE + (dτ + A_KE)²
dA_KE = 2J_KE
dS²_CY = dr² + r² dS²_SE
C-Y
R⁶
S.E
S⁵
→ N=4 SYM
Conifold
T¹,¹
→ KW


D3's
C-Y
SE
dS²_CY = dr² + r² dS²_SE
dS²_SE = dS²_KE + (dτ + A_KE)²
dA_KE = 2J_KE
C-Y
R⁶
Conifold
S.E
S⁵
T¹,¹
SYM
W


$dS^2_{SE} = dS^2_{KE} + (d\tau + A_{KE})^2$
$dA_{KE} = 2J_{KE}$
DBs
C.Y
SE
$dS^2_{CY} = dr^2 + r^2 dS^2_{SE}$
S.E
KE
$S^5 \rightarrow \mathcal{N}=4$ SYM
$T^{1,1} \rightarrow$ KW



$$ds^2_{SE} = ds^2_{KE} + (d\tau + A_{KE})^2$$

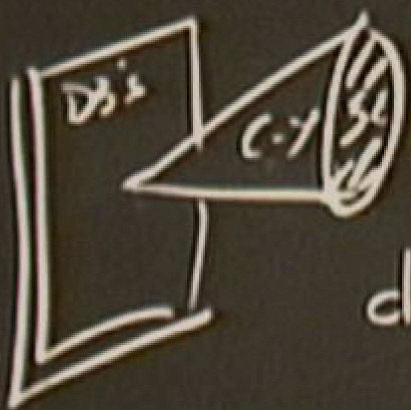
$$dA_{KE} = 2J_{KE}$$

$$ds^2_{CY} = dr^2 + r^2 ds^2_{SE}$$

C-Y	S-E		K-E
R^6	S^5	$\longrightarrow \mathcal{N}=4$ SYM	CP^2
Conifold	$T^{1,1}$	$\longrightarrow$ KW	$S^2 \times S^2$

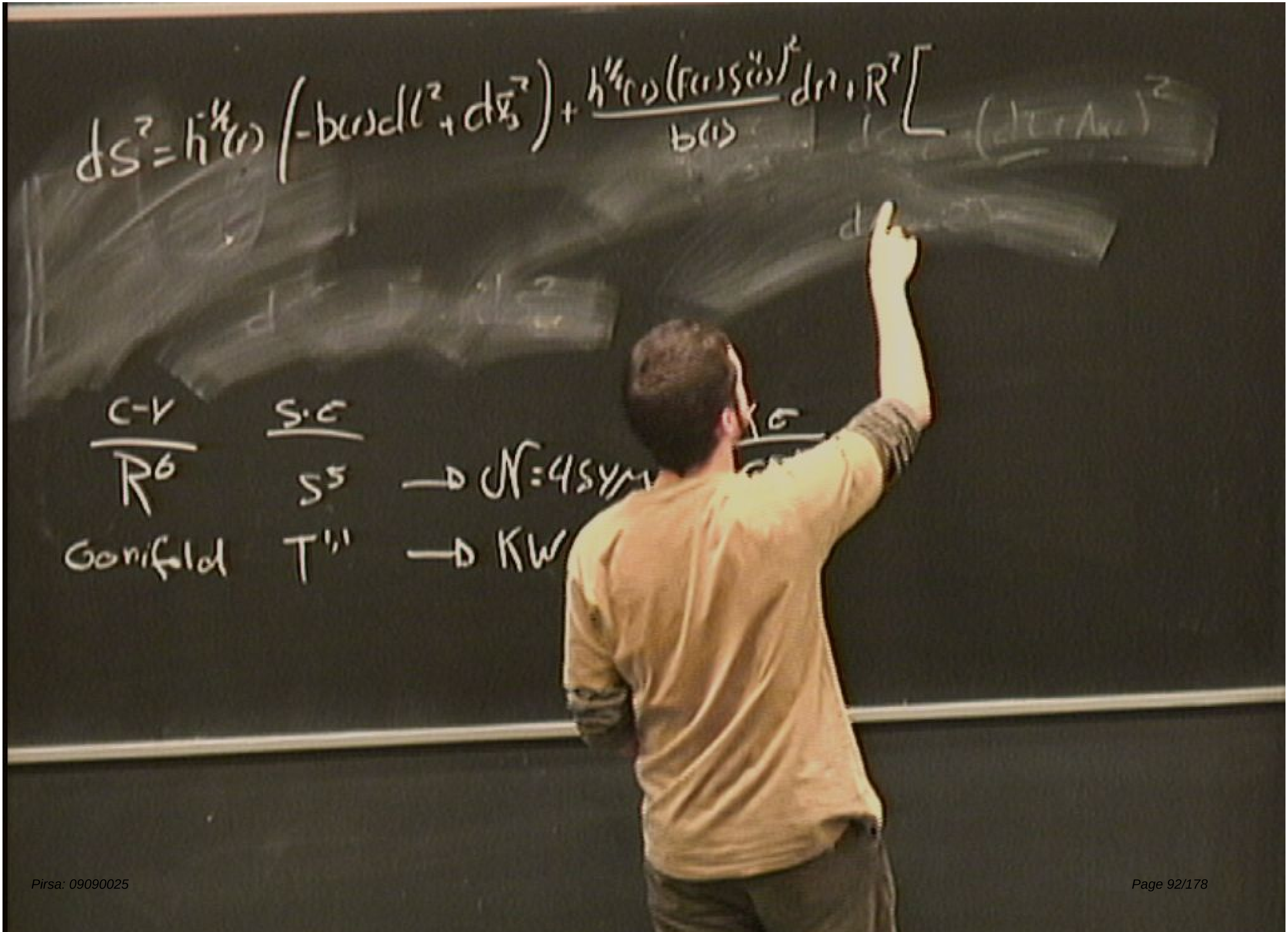
$$ds^2_{SE} = ds^2_{KE} + (d\tau + A_{KE})^2$$

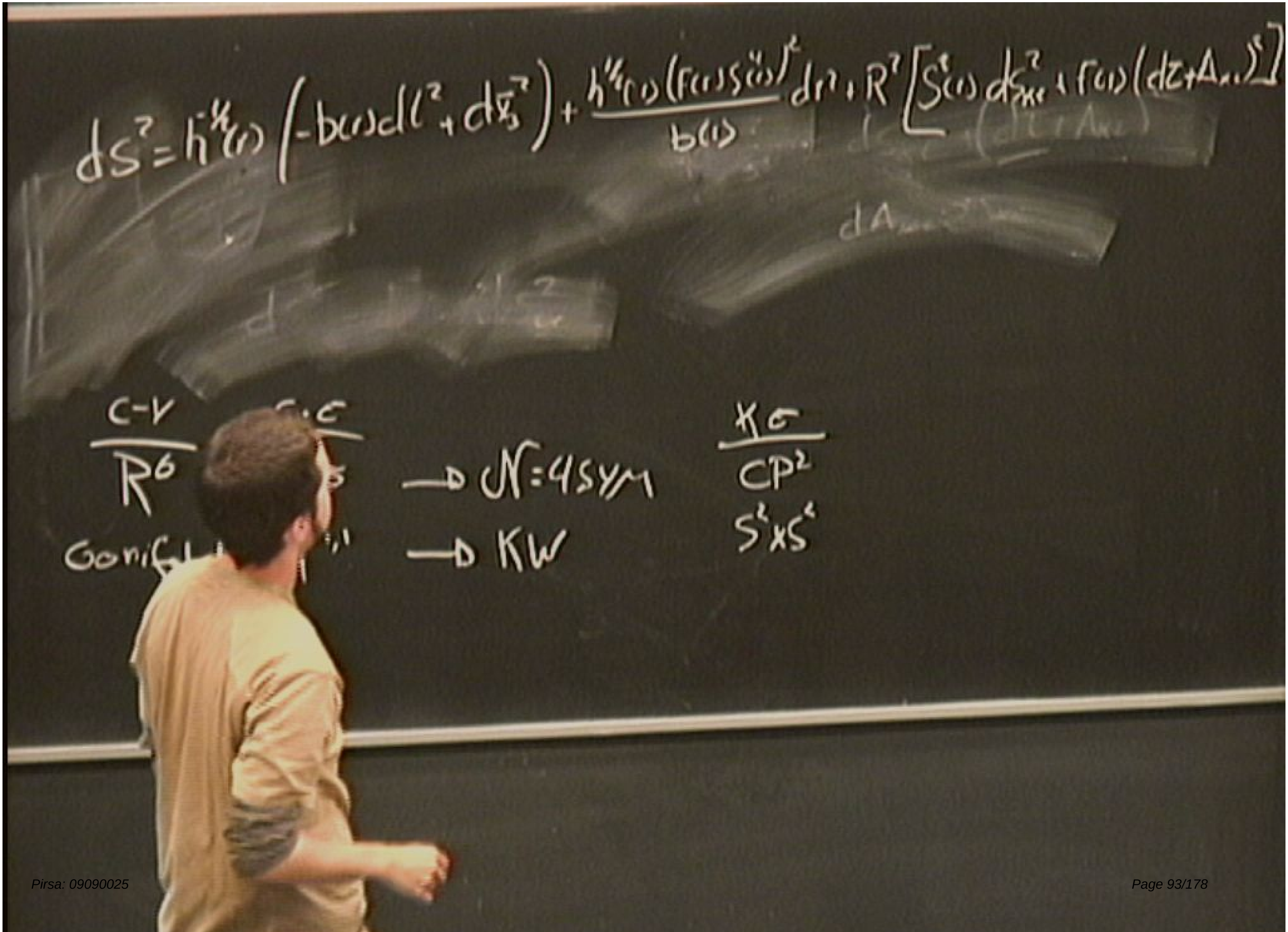
$$dA_{KE} = 2J_{KE}$$

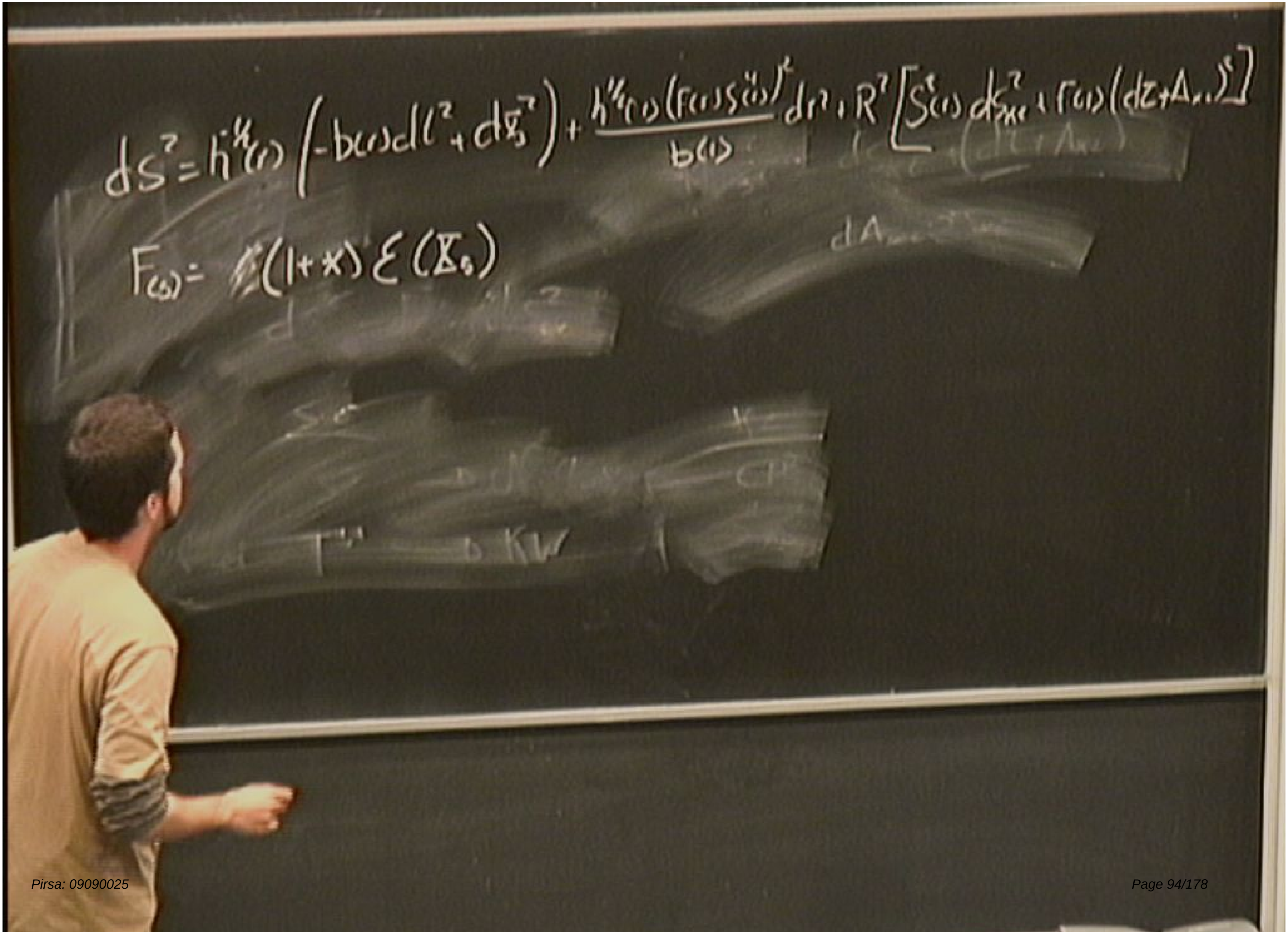


$$ds^2_{CY} = dr^2 + r^2 ds^2_{SE}$$

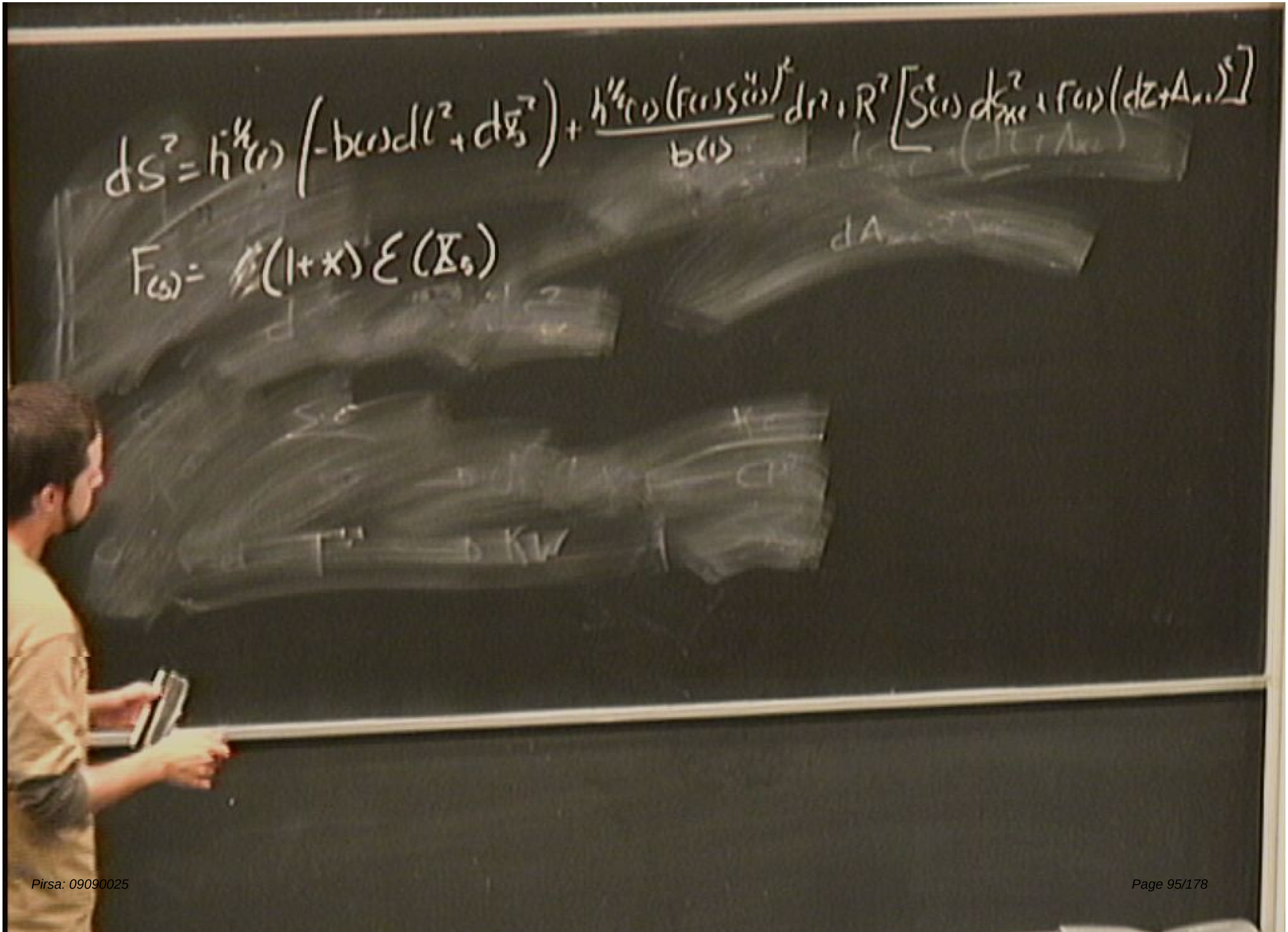
C-Y	S-E		K-E
R^6	S^5	$\longrightarrow \mathcal{N}=4$ SYM	CP^2
Conifold	$T^{1,1}$	$\longrightarrow$ KW	$S^2 \times S^2$

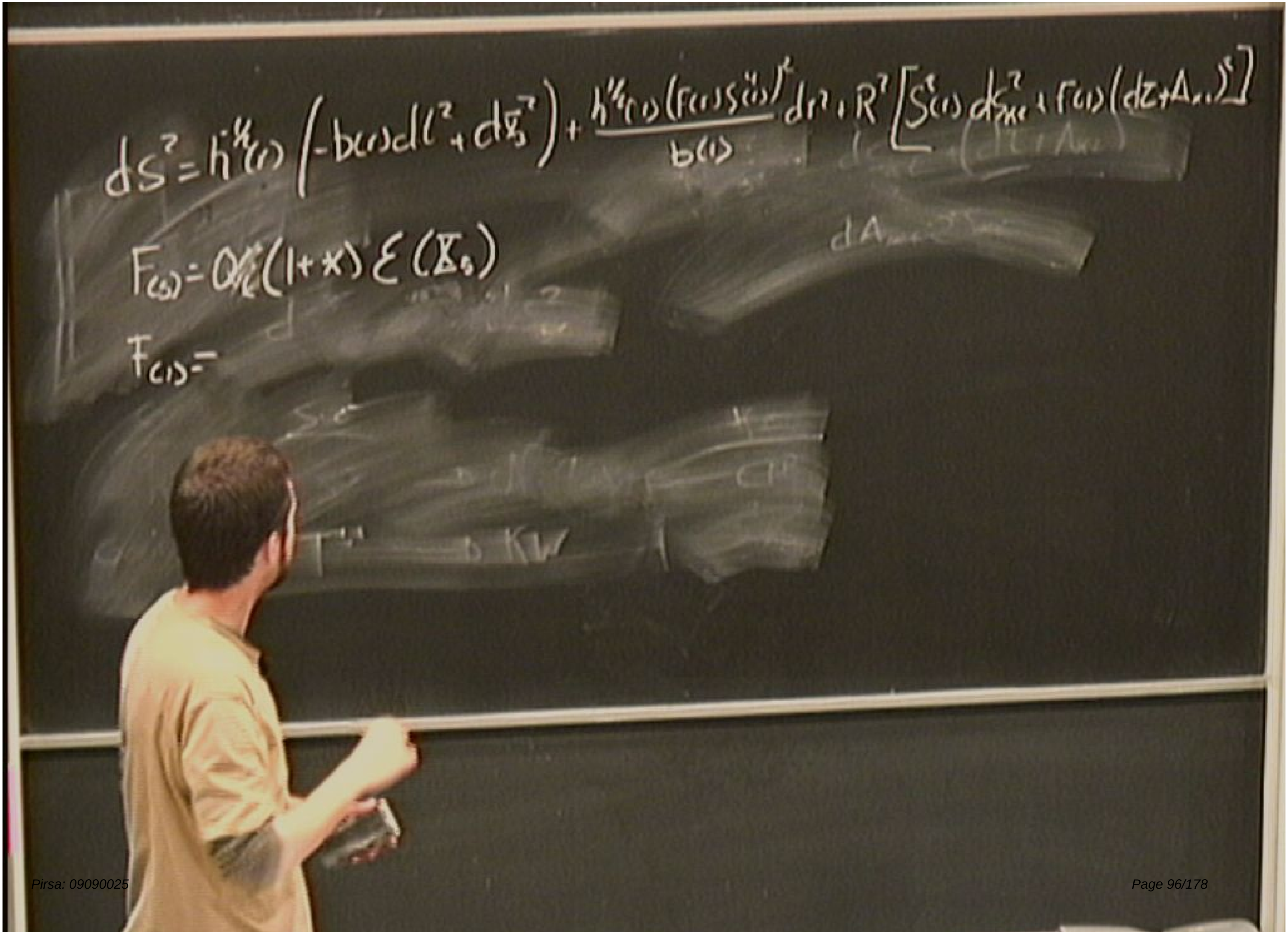

C-Y
R6
S.E
S5
→ N=4 SYM
Conifold
T1,1
→ KW


ds² = h^-1/2(r) (-b(r)dt² + dx₃²) + h^1/2(r)(F(r)S(r))² / b(r) dr² + R²[S²(r) ds²KE + F(r)(dz+AKE)²]
dA
C-Y
R⁶
→ N=4 SYM
→ KW
Conif
KE
CP²
S²xS²



$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S^{4}(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(dz + A_{KE}\right)^2\right]$
$F_{(5)} = (1+*)\,\mathcal{E}(X_5)$

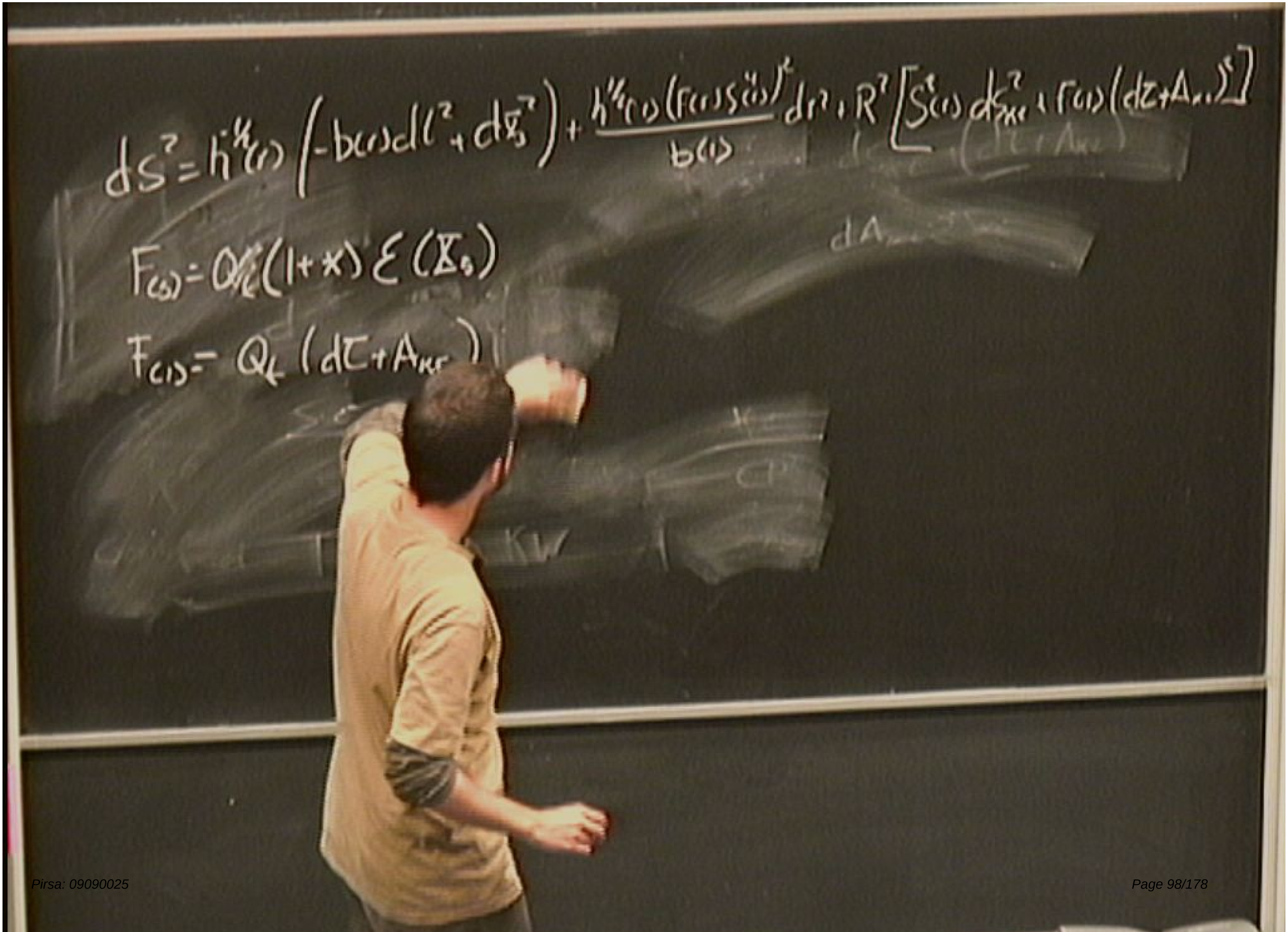

$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,d\Omega_{X_4}^2 + F(r)\left(dz + A_{X_4}\right)^2\right]$
$F(s) = (1+x)\,\mathcal{E}(X_5)$

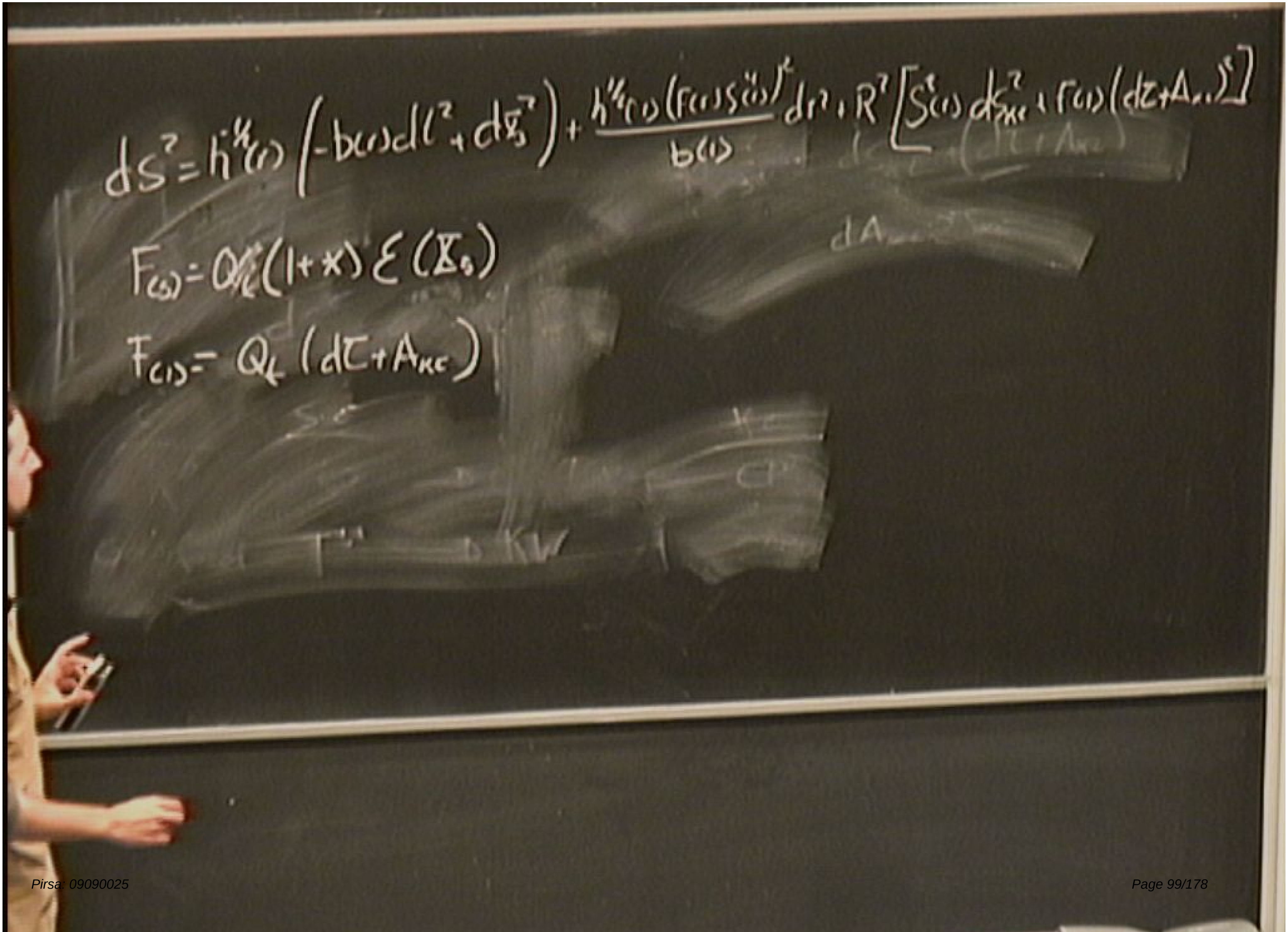

$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dX_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S^2(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,d\Omega_{X_4}^2 + F(r)\left(dZ + A_{X_4}\right)^2\right]$
$F_{(5)} = Q(1+*)\,\mathcal{E}(X_5)$
$F_{(1)} =$

$$ds^2 = h^{-1/2}(r)\left(-b(r)\,dt^2 + d\vec{x}_3^{\,2}\right) + \frac{h^{1/2}(r)\left(F(r)S^{4}(r)\right)^2}{b(r)}\,dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(dz + A_{KE}\right)^2\right]$$

$$F_{(5)} = Q_k\,(1+*)\,\mathcal{E}(X_5)$$

$$F_{(1)} = Q_k$$


$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S^2(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds^2_{KE} + F(r)\left(d\tau + A_{KE}\right)^2\right]$
$F_{(5)} = Q_f(1+*)\,\mathcal{E}(X_5)$
$F_{(1)} = Q_f\left(d\tau + A_{KE}\right)$

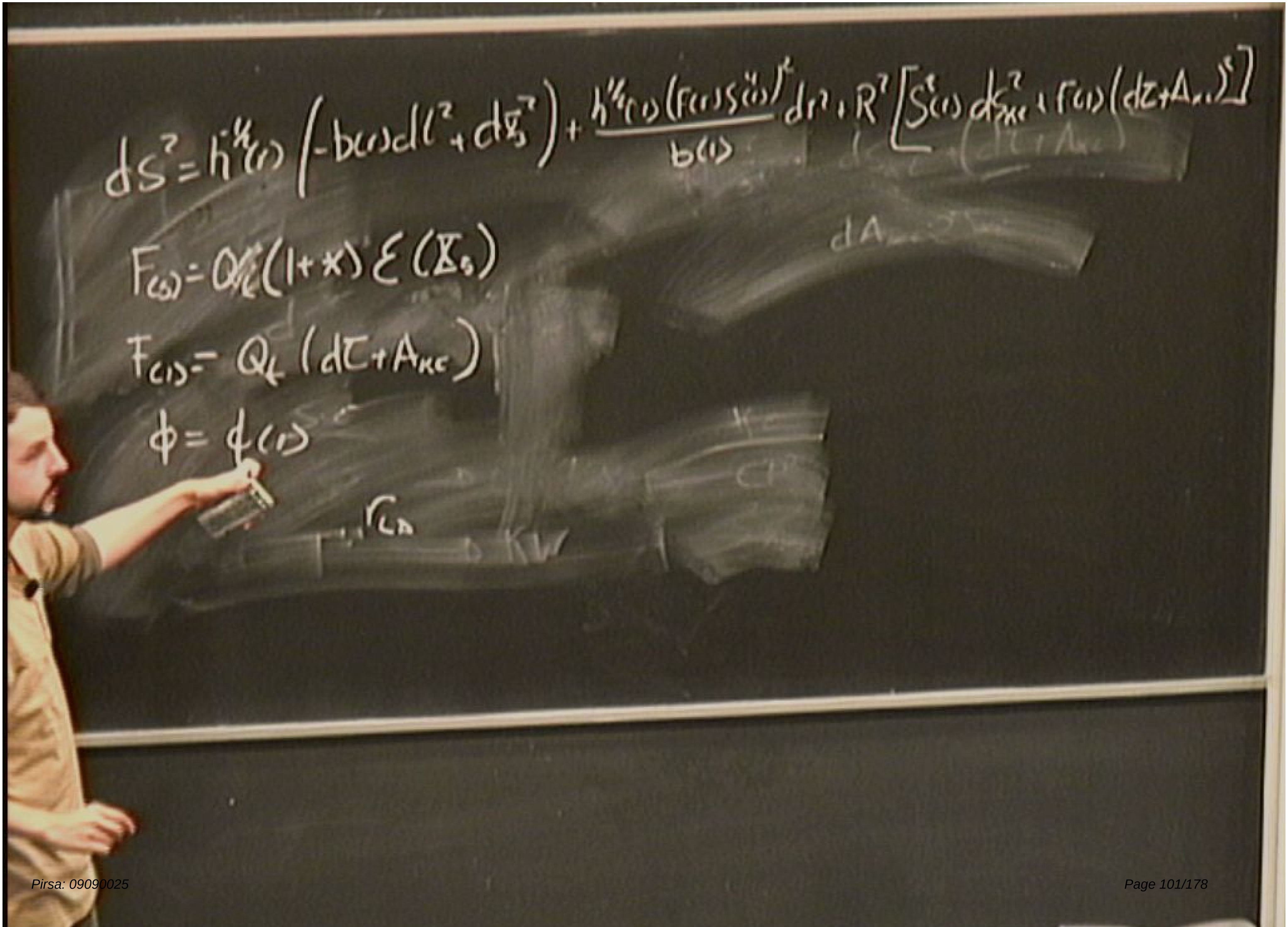

$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S^4(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(d\tau + A_{KE}\right)^2\right]$
$F_{(5)} = Q_t(1+*)\,\mathcal{E}(X_5)$
$F_{(1)} = Q_t\left(d\tau + A_{KE}\right)$
dA

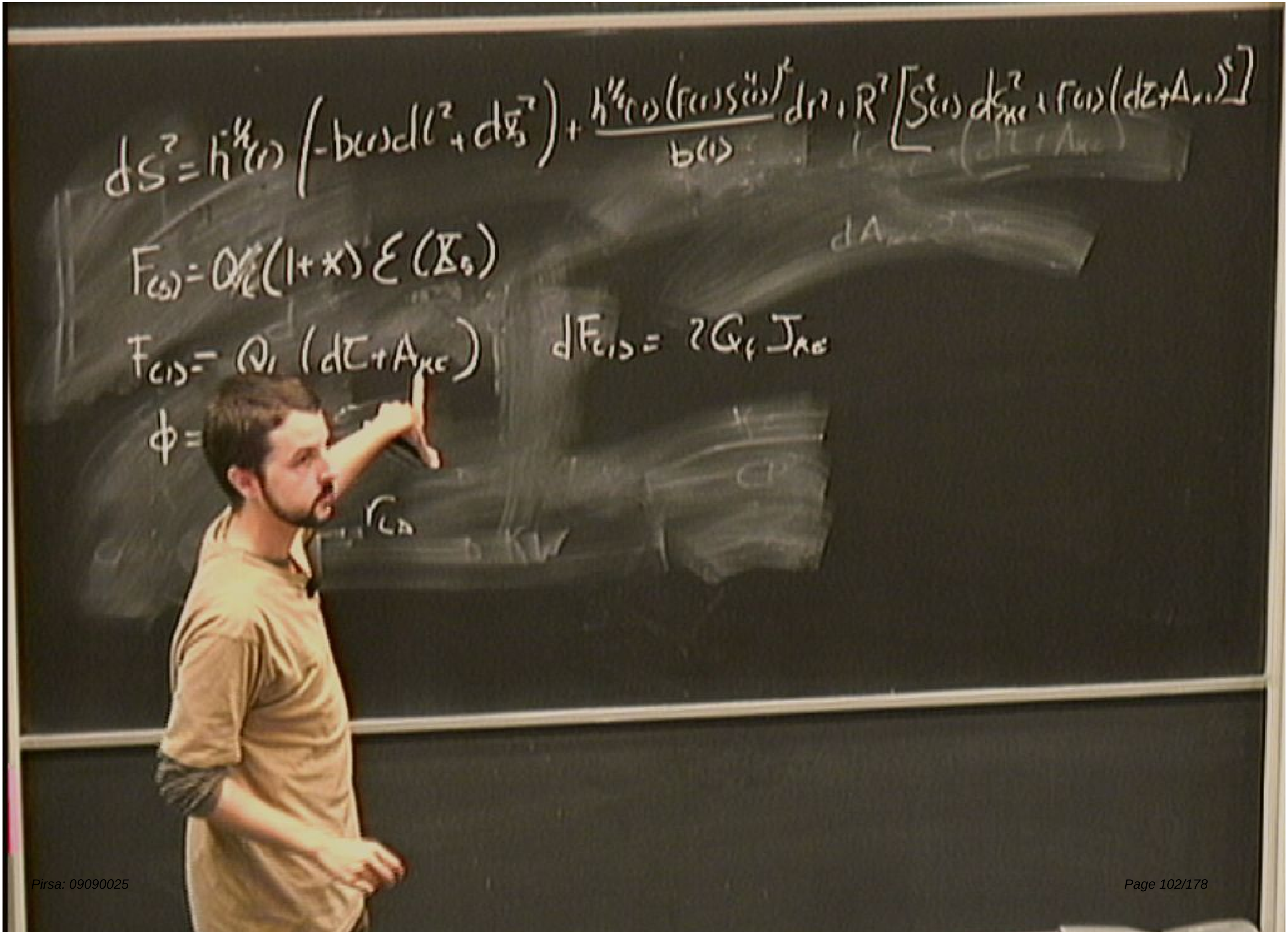
$$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S(r)\right)^{?}}{b(r)}dr^2 + R^2\left[S(r)\, ds_{KE}^2 + F(r)\left(d\tau + A_{KE}\right)^2\right]$$

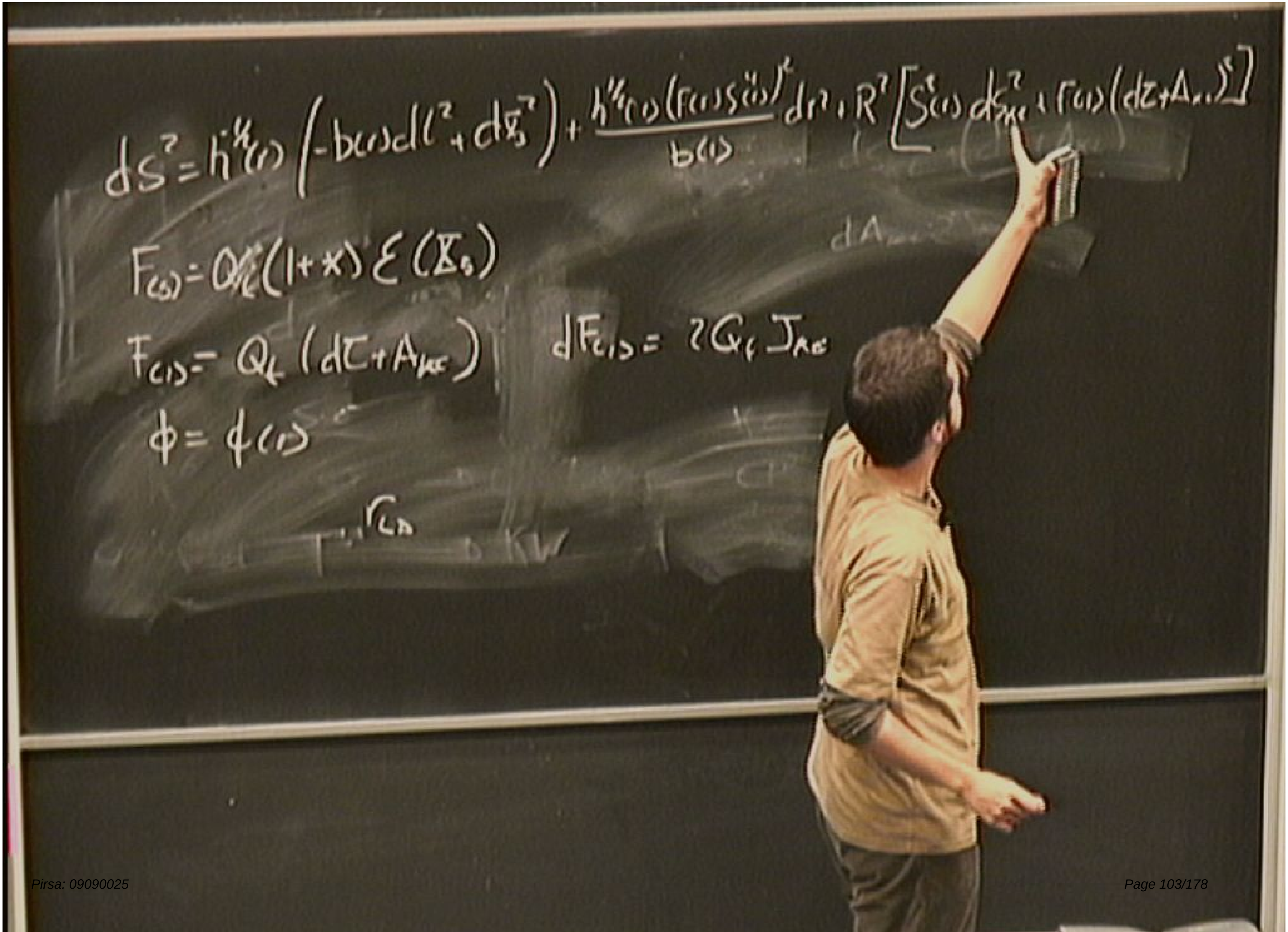
$$F_{(3)} = Q_k(1+*)\,\mathcal{E}(X_5)$$

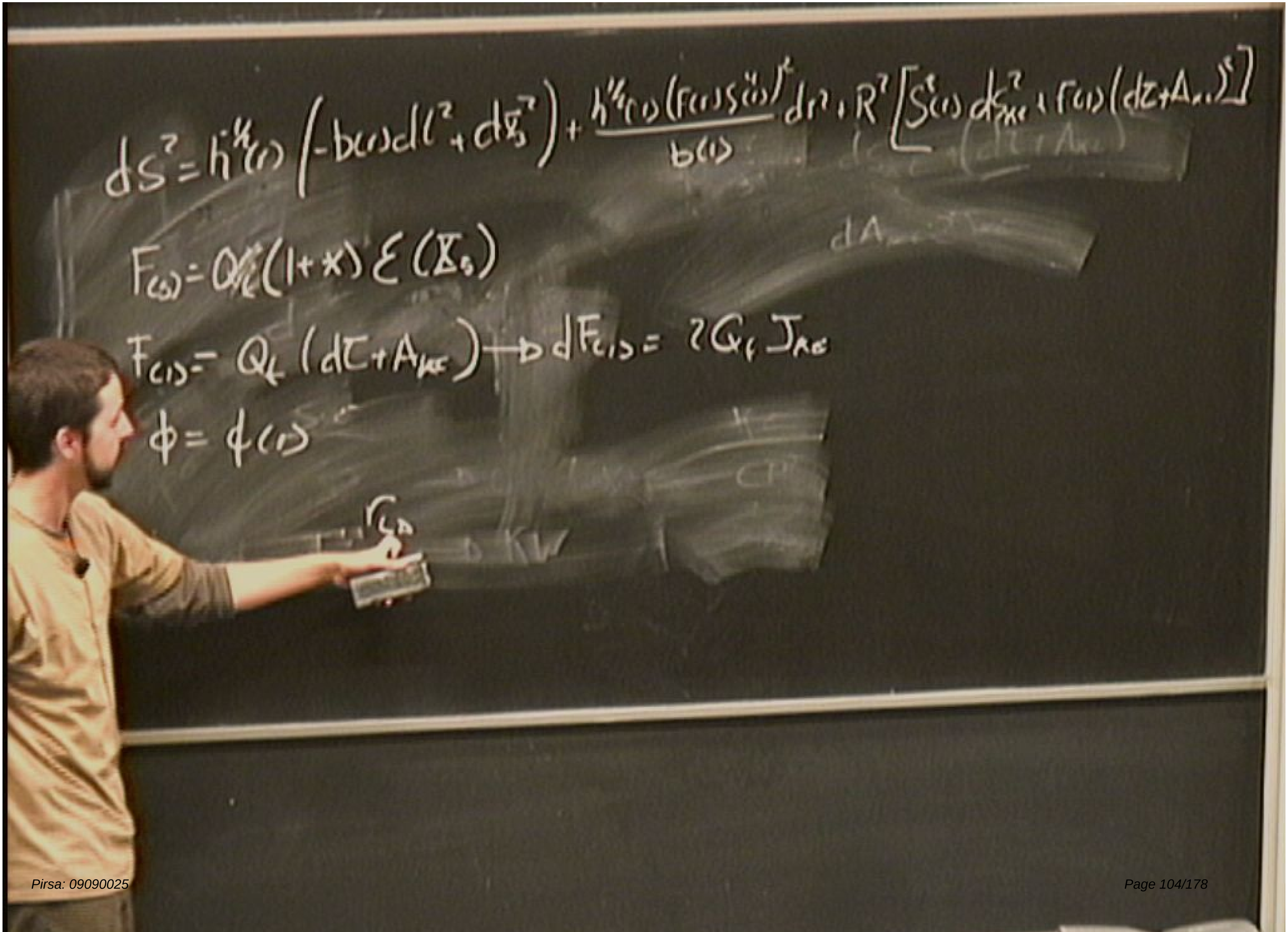
$$F_{(1)} = Q_t\left(d\tau + A_{KE}\right)$$

$$\phi = \phi(r)$$


$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_5^2\right) + \frac{h^{1/2}(r)\left(F(r)S^4(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(d\tau + A_{KE}\right)^2\right]$
$F_{(5)} = Q_c(1+*)\,\mathcal{E}(X_5)$
$F_{(1)} = Q_f\left(d\tau + A_{KE}\right)$
$\phi = \phi(r)$
dA
r_{h}


$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)(F(r)S^2(r))^2}{b(r)} dr^2 + R^2\left[S^2(r)\, ds_{KE}^2 + F(r)(d\tau + A_{KE})^2\right]$
$F_{(5)} = Q_4(1+*)\,\mathcal{E}(X_5)$
$F_{(1)} = Q_f\,(d\tau + A_{KE})$
$dF_{(1)} = 2Q_f\,J_{KE}$
$\phi =$


ds² = h^{-1/2}(r) (-b(r)dt² + dx⃗₃²) + h^{1/2}(r)(F(r)S(r))² / b(r) dr² + R²[S²(r) ds²_KE + F(r)(dτ+A_KE)²]
F(5) = Q_c(1+*) ε(X₅)
F(1) = Q_f (dτ + A_KE)
dF(1) = 2Q_f J_KE
φ = φ(r)
dA
r_LD


$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)(F(r)S^4(r))^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)(d\tau + A_{KE})^2\right]$
$F_{(5)} = Q_c(1+*)\,\mathcal{E}(X_5)$
$F_{(1)} = Q_f\,(d\tau + A_{KE}) \rightarrow dF_{(1)} = 2Q_f\,J_{KE}$
$\phi = \phi(r)$

$$ds^2 = h^{-1/2}(r)\left(-b(r)\,dt^2 + d\vec{x}_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S^4(r)\right)^2}{b(r)}\,dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(d\tau + A_{KE}\right)^2\right]$$

$$F_{(5)} = Q_c(1+*)\,\mathcal{E}(\vec{x}_5)$$

$$F_{(1)} = Q_f\left(d\tau + A_{KE}\right) \longrightarrow dF_{(1)} = 2Q_f J_{KE}$$

$$\phi = \phi(r)$$

$$r < r_* \ll r_{CD}$$

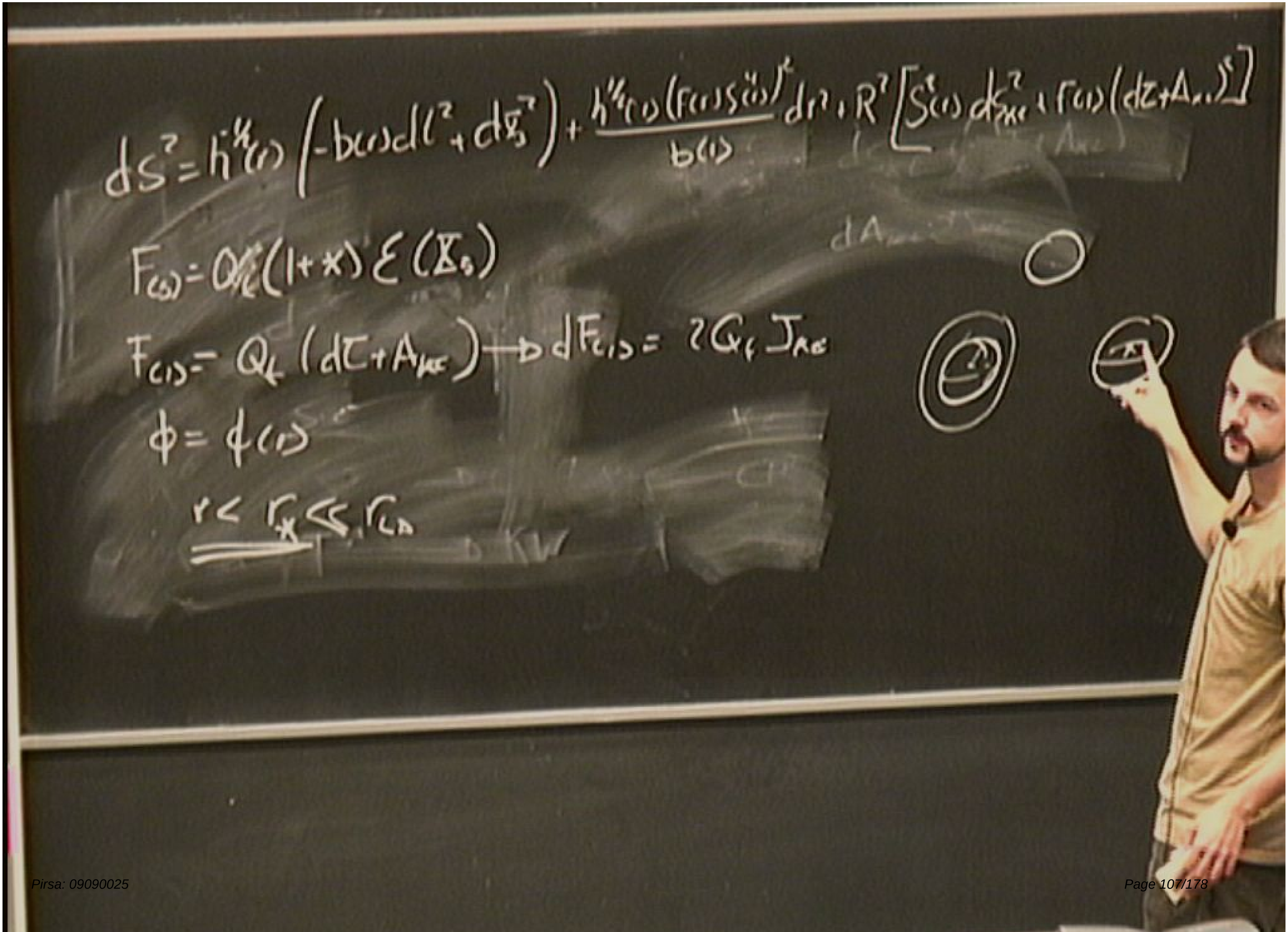
$$ds^2 = h^{-1/2}(r)\left(-b(r)\,dt^2 + d\vec{x}_3^{\,2}\right) + \frac{h^{1/2}(r)\,(F(r)S^{4}(r))^{2}}{b(r)}\,dr^2 + R^2\left[S^2(r)\,ds^2_{KE} + F(r)\,(d\tau + A_{KE})^2\right]$$

$$F_{(5)} = Q_k (1 + *)\,\mathcal{E}(\vec{x}_5)$$

$$F_{(1)} = Q_f\,(d\tau + A_{KE}) \longrightarrow dF_{(1)} = 2Q_f\,J_{KE}$$

$$\phi = \phi(r)$$

$$\underline{\underline{r < r_* \ll r_{LD}}}$$


ds^2 = h^{-1/2}(r) (-b(r)dt^2 + dx_3^2) + h^{1/2}(r)(F(r)S(r))^2 / b(r) dr^2 + R^2 [S^2(r) dΩ_KE^2 + F(r)(dτ + A_KE)^2]
F_(5) = Q(1+*) ε(X_5)
F_(3) = Q_f (dτ + A_KE) → dF_(3) = 2Q_f J_KE
φ = φ(r)
r < r_* << r_LD
dA

$$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + d\vec{x}_3^{\,2}\right) + \frac{h^{1/2}(r)\left(f(r)\,s^2(r)\right)^2}{b(r)}dr^2 + R^2\left[s^2(r)\,ds_{KE}^2 + f(r)\left(d\tau + A_{KE}\right)^2\right]$$

$$F_{(5)} = Q_4(1+*)\,\mathcal{E}(\vec{x}_5)$$

$$F_{(1)} = Q_f\left(d\tau + A_{KE}\right) \rightarrow dF_{(1)} = 2Q_f\,J_{KE}$$

$$\phi = \phi(r)$$

$$r < r_* \ll r_{\Lambda}$$

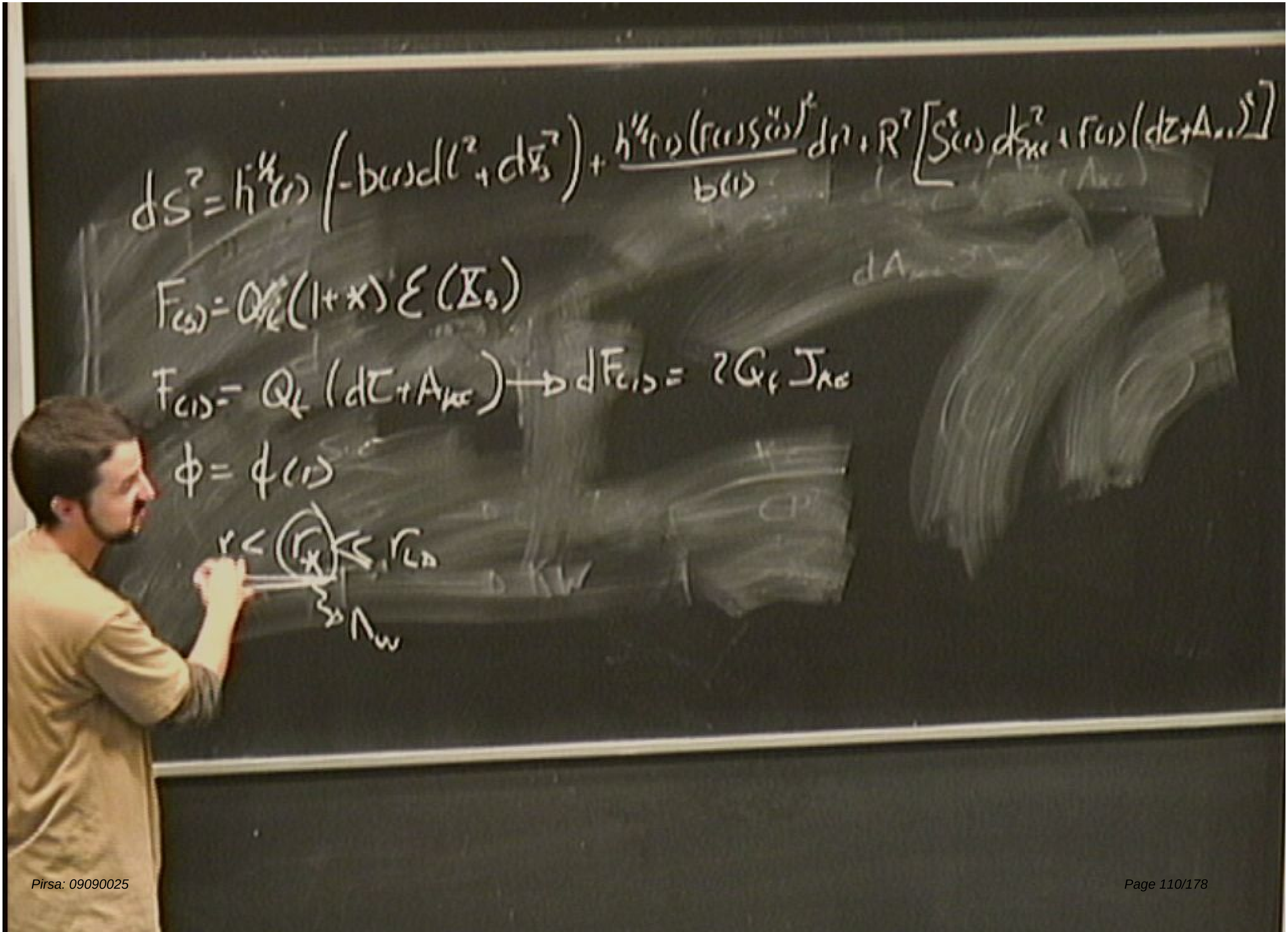
$$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + d\vec{x}_3^{\,2}\right) + \frac{h^{1/2}(r)\left(F(r)S^2(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds^2_{KE} + F(r)\left(d\tau + A_{KE}\right)^2\right]$$

$$F_{(5)} = Q_c(1+*)\,\mathcal{E}(\vec{X}_5)$$

$$F_{(1)} = Q_f\left(d\tau + A_{KE}\right) \longrightarrow dF_{(1)} = 2Q_f\,J_{KE}$$

$$\phi = \phi(r)$$

$$r < r_* \ll r_{LD}$$


$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)(r(r)S(r))^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + r(r)(d\tau + A_{KE})^2\right]$
$F_{(5)} = Q_c(1+*)\,\mathcal{E}(X_5)$
$F_{(1)} = Q_f\,(d\tau + A_{KE}) \rightarrow dF_{(1)} = 2Q_f\,J_{KE}$
$\phi = \phi(r)$
$r < r_* < r_{LD}$
Λ_W

$$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)\left(r(r)s(r)\right)^2}{b(r)}dr^2 + R^2\left[s^2(r)\,ds_{KE}^2 + f(r)\left(dz + A_{KE}\right)^2\right]$$

$$F_{(5)} = Q_{4}(1 + *)\,\mathcal{E}(X_5)$$

$$F_{(1)} = Q_{f}\left(d\tau + A_{KE}\right) \longrightarrow dF_{(1)} = 2Q_f J_{KE}$$

$$\phi = \phi(r)$$

$$r < r_{*} < r_{cD}$$

$$\rightsquigarrow \Lambda_W$$

$$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S^4(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(d\tau + A_{KE}\right)^2\right]$$

$$F_{(3)} = Q_f^{3/4}(1+x)\,\mathcal{E}(X_3)$$

$$F_{(1)} = Q_f\left(d\tau + A_{KE}\right) \longrightarrow dF_{(1)} = 2Q_f J_{KE}$$

$$\phi = \phi(r)$$

$$r < r_* \lesssim r_{LD}$$

$$\frac{\Lambda_{IR}}{\Lambda}$$

$$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)\left(r(r)S(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(dz + A_{KE}\right)^2\right]$$

$$F_{(5)} = Q_{K}(1+*)\,\mathcal{E}(X_5)$$

$$F_{(1)} = Q_t\left(d\tau + A_{KE}\right) \rightarrow dF_{(1)} = 2Q_t J_{KE}$$

$$\phi = \phi(r)$$

$$r < r_* \ll r_D$$

$$\frac{\Lambda_{IR}}{\Lambda_{UV}}$$

$$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + dx_3^2\right) + \frac{h^{1/2}(r)\left(f(r)S(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(d\tau + A_{KE}\right)^2\right]$$

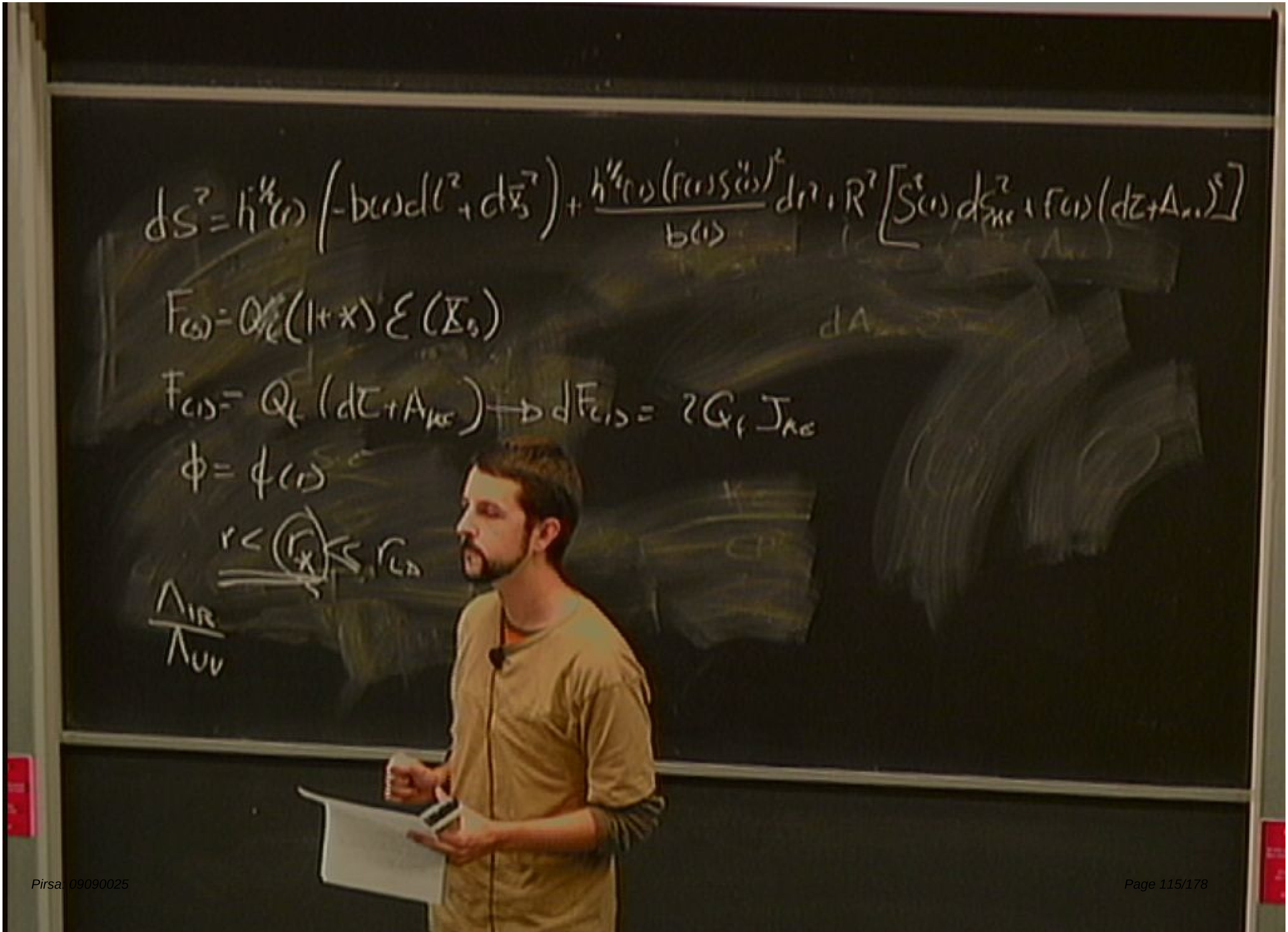
$$F_{(5)} = Q_k (1 + *)\,\mathcal{E}(X_5)$$

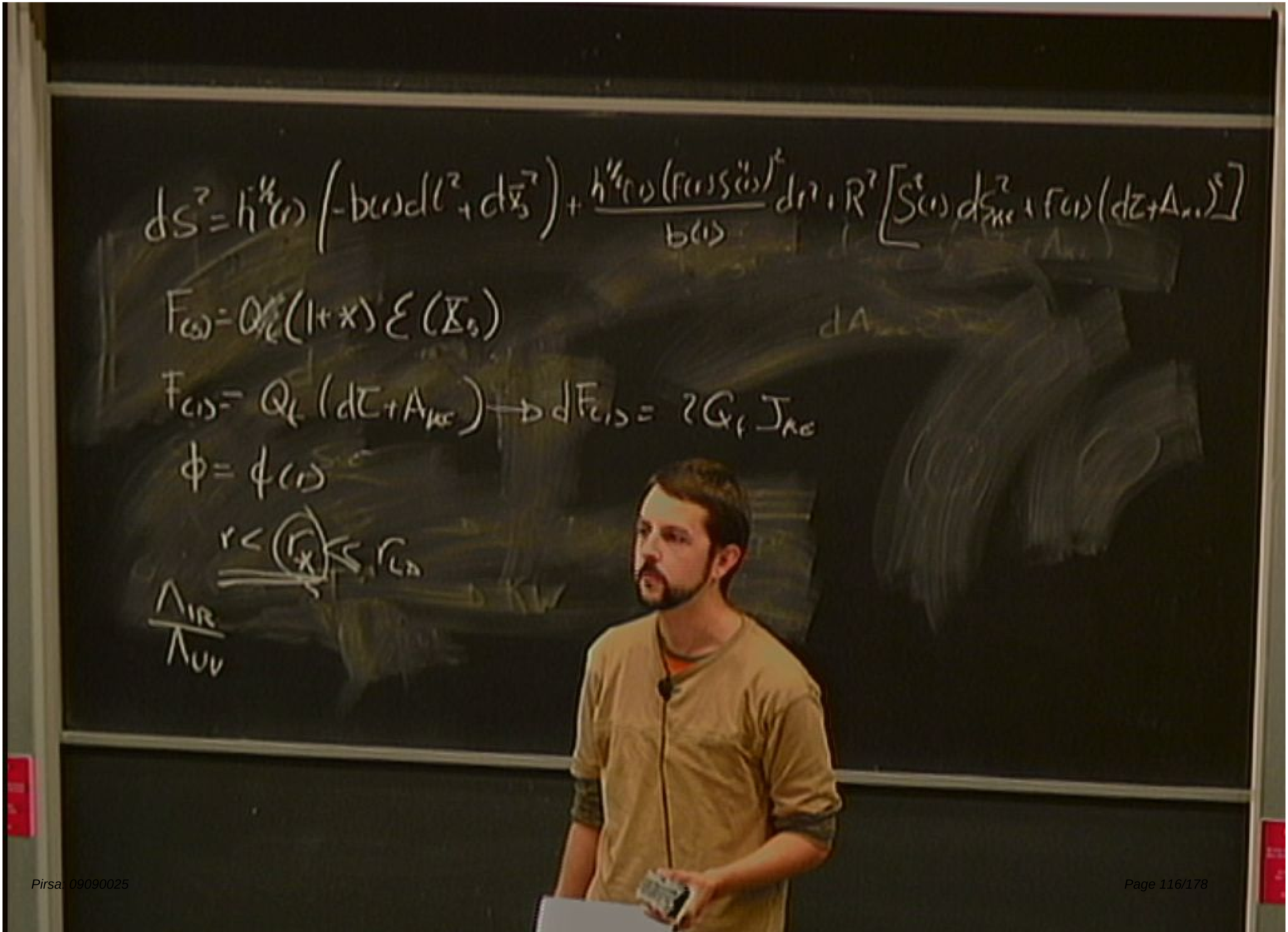
$$F_{(1)} = Q_f\left(d\tau + A_{KE}\right) \longrightarrow dF_{(1)} = 2Q_f J_{KE}$$

$$\phi = \phi(r)$$

$$r < r_* \ll r_{LD}$$

$$\frac{\Lambda_{IR}}{\Lambda_{UV}}$$


F(r) = Q_f (dτ + A_KE) → dF(r) = 2Q_f J_KE
φ = φ(r)
Λ_IR / Λ_UV


$F_{(1)} = Q_\ell (d\tau + A_{KE}) \to dF_{(1)} = 2Q_\ell J_{KE}$
$\phi = \phi(r)$
$\Lambda_{IR} / \Lambda_{UV}$

$$ds^2 = h^{-1/2}(r)\left(-b(r)\,dt^2 + d\vec{x}_3^{\,2}\right) + \frac{h^{1/2}(r)\left(F(r)S^{1/2}(r)\right)^2}{b(r)}\,dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(d\tau + A_{KE}\right)^2\right]$$

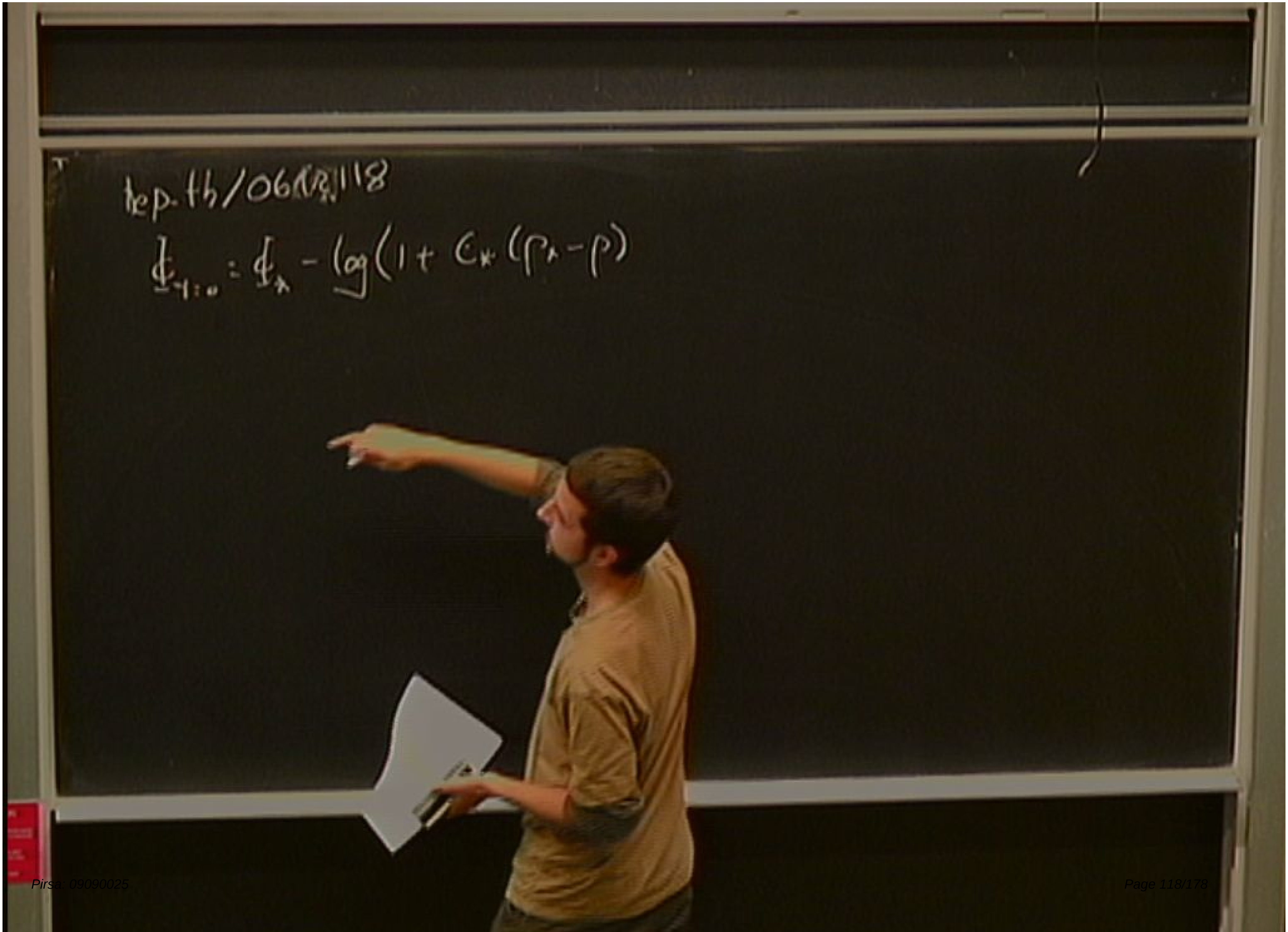
$$F_{(5)} = Q_c\,(1+*)\,\mathcal{E}(X_5)$$

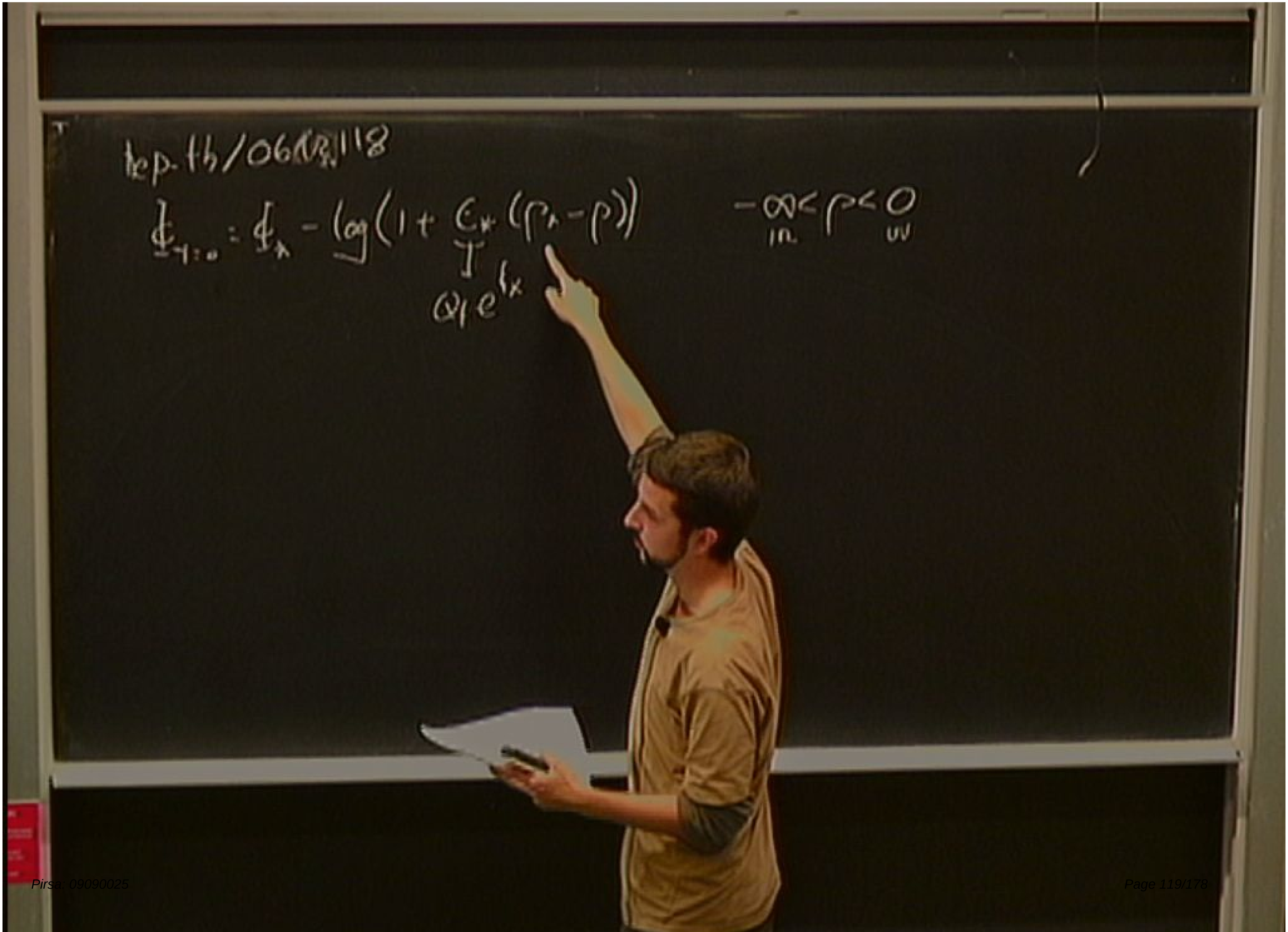
$$F_{(1)} = Q_f\,(d\tau + A_{KE}) \to dF_{(1)} = 2Q_f\,J_{KE}$$

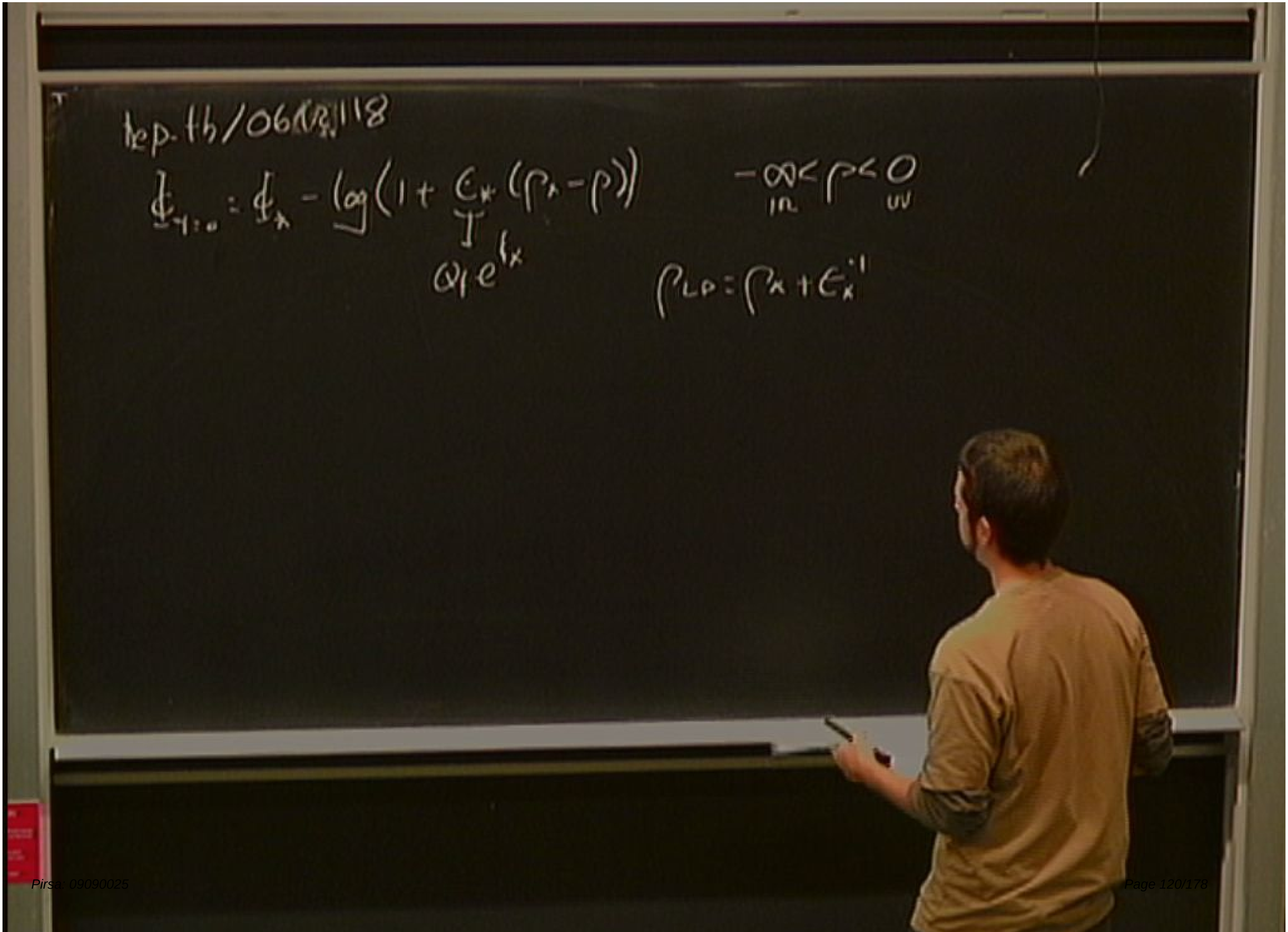
$$\phi = \phi(r)$$

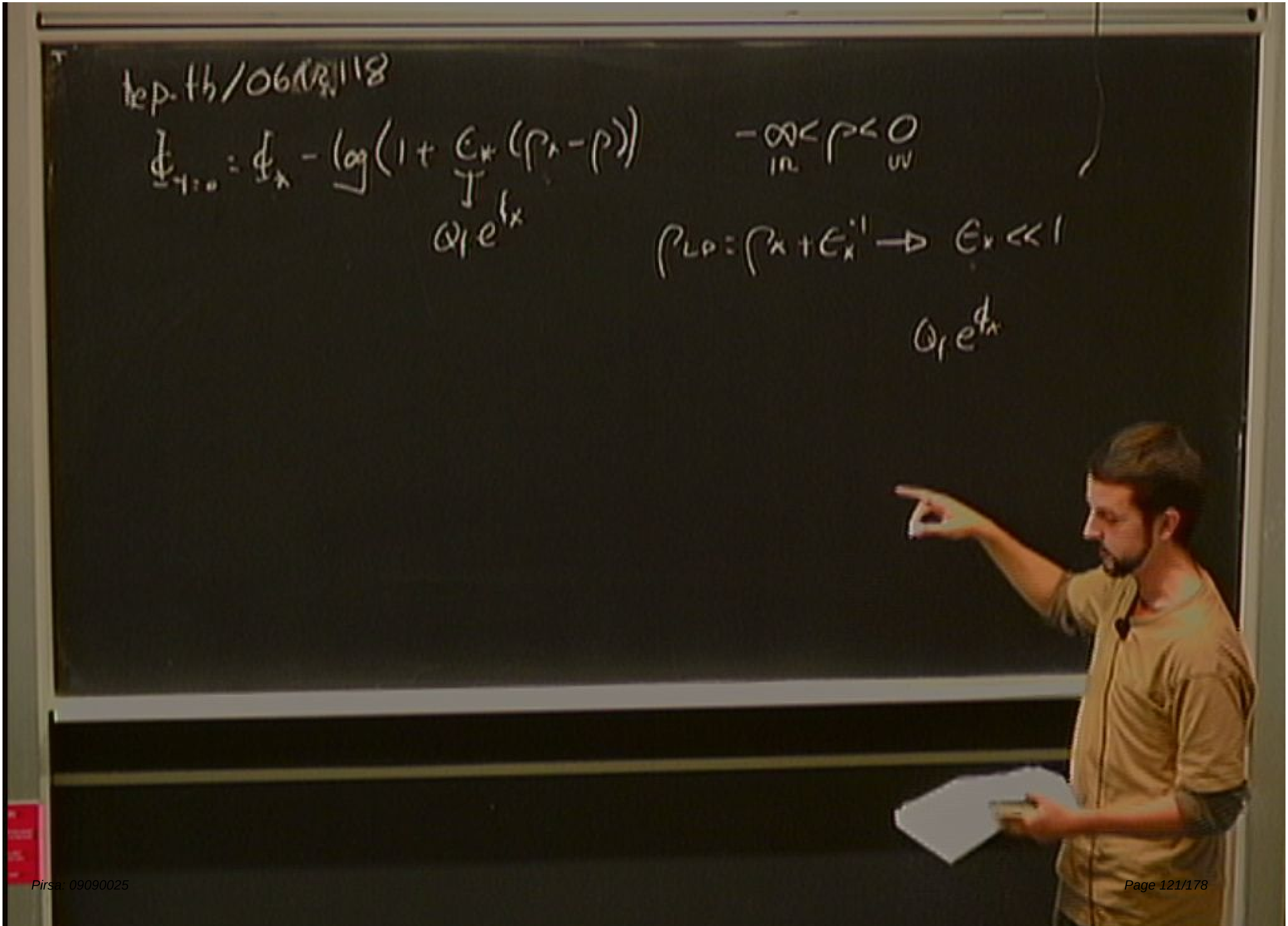
$$r < r_* < r_{LD}$$

$$\frac{\Lambda_{IR}}{\Lambda_{UV}}$$




hep-th/06
$\phi_{r=0} = \phi_* - \log(1 + c_*(\rho_* - \rho))$
$Q_1 e^{\phi_*}$
$-\infty < \rho < 0$
IR
UV


hep-th/06??118
φ_{η=0} = φ_* − log(1 + ε_*(ρ_* − ρ))
−∞ < ρ < 0
IR UV
Q_f e^{φ_*}
ρ_LD = ρ_* + ε_*^{-1}


hep-th/06
$\Phi_{\eta=\infty} = \Phi_* - \log(1 + \epsilon_*(\rho_* - \rho))$
$-\infty < \rho < 0$
IR
UV
$Q_1 e^{\phi_*}$
$\rho_{LP} = \rho_* + \epsilon_*^{-1} \rightarrow \epsilon_* \ll 1$
$Q_1 e^{\phi_*}$

hep-th/0612118

$$\Phi_{\eta=0} = \Phi_* - \log\big(1 + \underbrace{\epsilon_*}_{Q_f e^{\Phi_*}} (\rho_* - \rho)\big) \qquad \underset{\mathrm{IR}}{-\infty} < \rho < \underset{\mathrm{UV}}{0}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \longrightarrow \epsilon_* \ll 1$$

$$Q_f e^{\Phi_*} = \frac{\mathrm{Vol}(X_3)}{16\pi \, \mathrm{Vol}(X_5)} \lambda_* \cdot \frac{N_f}{N_c}$$

hep-th/06[illegible]118

$$\Phi_{\tau=\infty} = \Phi_* - \log\left(1 + \underset{\underset{Q_f e^{\Phi_*}}{\parallel}}{\epsilon_*}\left(\rho_* - \rho\right)\right) \qquad \underset{IR}{-\infty} < \rho < \underset{UV}{0}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \longrightarrow \epsilon_* \ll 1$$

$$Q_f e^{\Phi_*} = \frac{Vol(X_3)}{16\pi Vol(X_5)} \lambda_* \cdot \frac{N_f}{N_c}$$

hep-th/06[illegible]118

$$\phi_{\eta=0} = \phi_* - \log\left(1 + \epsilon_*(\rho_* - \rho)\right) \qquad -\underset{IR}{\infty} < \rho < \underset{UV}{0}$$

$$\epsilon_* \sim Q_f e^{\phi_*}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \rightarrow \epsilon_* \ll 1$$

$$Q_f e^{\phi_*} = \frac{\mathrm{Vol}(Y_5)}{16\pi\,\mathrm{Vol}(X_3)} \lambda_* \cdot \frac{N_f}{N_c}$$

$$\lambda_* = 4\pi g_s e^{\phi_*}$$

hep-th/06[illegible]118

$$\Phi_{\rho=0} = \Phi_* - \log\left(1 + \underbrace{\epsilon_*}_{Q_f e^{\Phi_*}} (\rho_* - \rho)\right)$$

$$-\underset{IR}{\infty} < \rho < \underset{UV}{0}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \to \epsilon_* \ll 1$$

$$Q_f e^{\Phi_*} = \frac{Vol(X_3)}{16\pi Vol(X_5)} \lambda_* \frac{N_f}{N_c}$$

$$\lambda_* = 4\pi g_s e^{\Phi_*}$$

$$\Downarrow$$

$$\lambda_H = 4\pi g_s e^{\Phi_H}$$

hep-th/06[illegible]118

$$\Phi_{\text{dil}} = \Phi_* - \log\left(1 + \epsilon_*(\rho_* - \rho)\right)$$

$\epsilon_* \sim Q_f e^{\phi_*}$

$-\infty < \rho < 0$ (IR, UV)

$\rho_{LP} = \rho_* + \epsilon_*^{-1} \to \epsilon_* \ll 1$

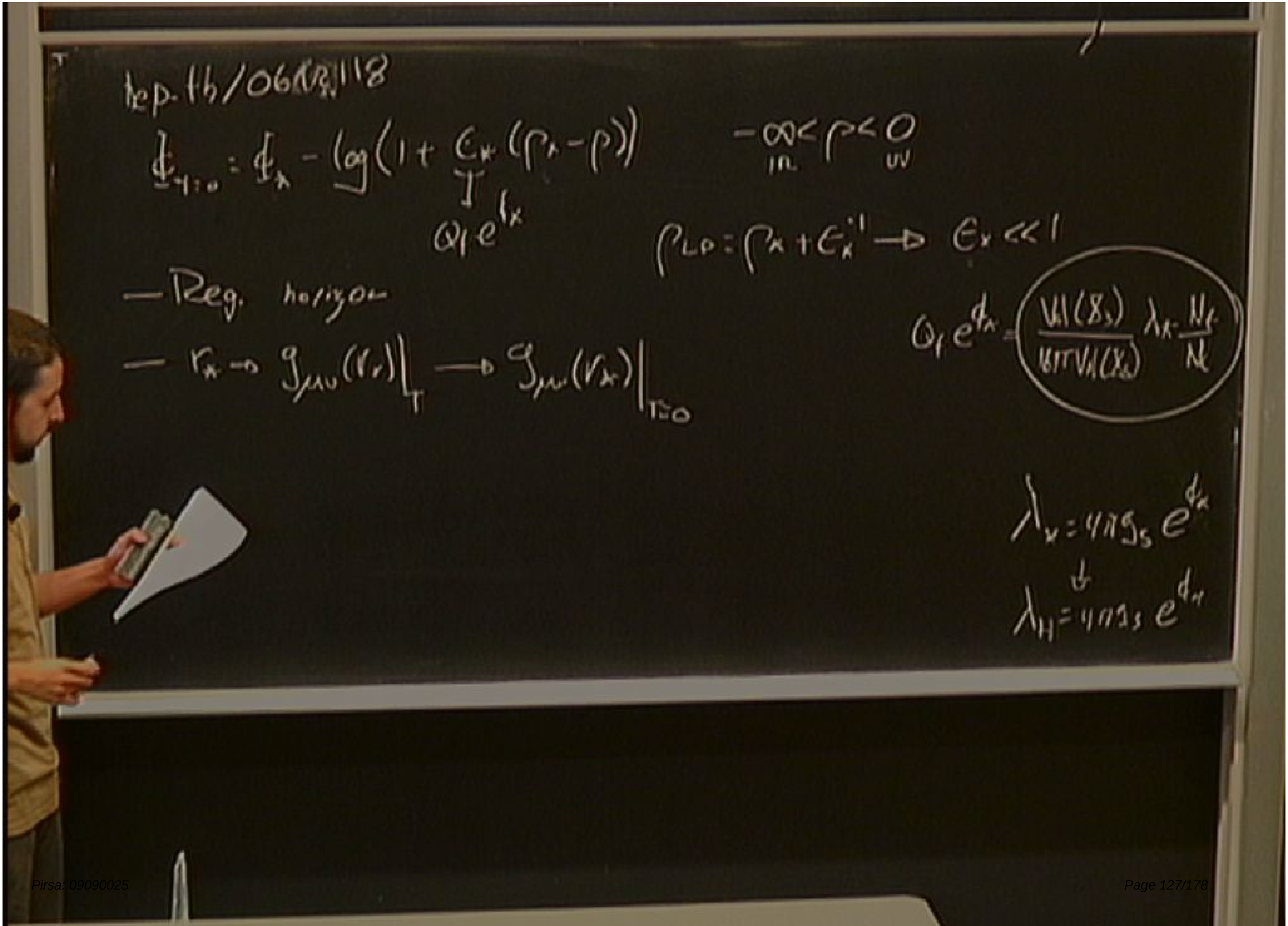
— Reg. horizon

$$Q_f e^{\phi_*} = \frac{Vol(X_3)}{16\pi Vol(X_5)} \lambda_* \frac{N_f}{N_c}$$

$\lambda_* = 4\pi g_s e^{\phi_*}$

$\Downarrow$

$\lambda_H = 4\pi g_s e^{\phi_H}$


$\phi_{T=0} = \phi_* - \log(1 + \epsilon_*(\rho_* - \rho))$
$-\infty < \rho < 0$
IR
UV
$Q_f e^{\phi_*}$
$\rho_{LP} = \rho_* + \epsilon_*^{-1} \to \epsilon_* \ll 1$
— Reg. horizon
$Q_f e^{\phi_*} = \frac{Vol(X_5)}{16\pi Vol(X_3)} \lambda_* \frac{N_f}{N_c}$
$— r_* \to g_{\mu\nu}(r_*)|_T \to g_{\mu\nu}(r_*)|_{T=0}$
$\lambda_* = 4\pi g_s e^{\phi_*}$
$\lambda_H = 4\pi g_s e^{\phi_H}$

hep-th/06[illegible]118

$$\Phi_{\eta=0} = \Phi_* - \log\left(1 + \underset{\substack{\Downarrow \\ Q_1 e^{\phi_*}}}{\epsilon_*}(\rho_* - \rho)\right) \qquad \underset{IR}{-\infty} < \rho < \underset{UV}{0}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \to \epsilon_* \ll 1$$

— Reg. horizon

$$Q_1 e^{\phi_*} = \frac{Vol(X_3)}{16\pi Vol(X_6)} \lambda_* \frac{N_f}{N_c}$$

— $r_* \to g_{\mu\nu}(r_*)\big|_T \longrightarrow g_{\mu\nu}(r_*)\big|_{T=0}$

$$g_{tt} = 1 - \ldots \quad = 1$$

$$\lambda_* = 4\pi g_s e^{\phi_*}$$

$$\Downarrow$$

$$\lambda_H = 4\pi g_s e^{\phi_H}$$

hep-th/06[illegible]118

$$\Phi_{\tau=0} = \phi_* - \log(1 + \epsilon_*(\rho_* - \rho))$$

$$\epsilon_* \sim Q_f e^{\phi_*}$$

$$\underset{IR}{-\infty} < \rho < \underset{UV}{0}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \rightarrow \epsilon_* \ll 1$$

$$Q_f e^{\phi_*} = \frac{Vol(X_5)}{16\pi Vol(X_6)} \lambda_* \cdot \frac{N_f}{N}$$

— Reg. horizon

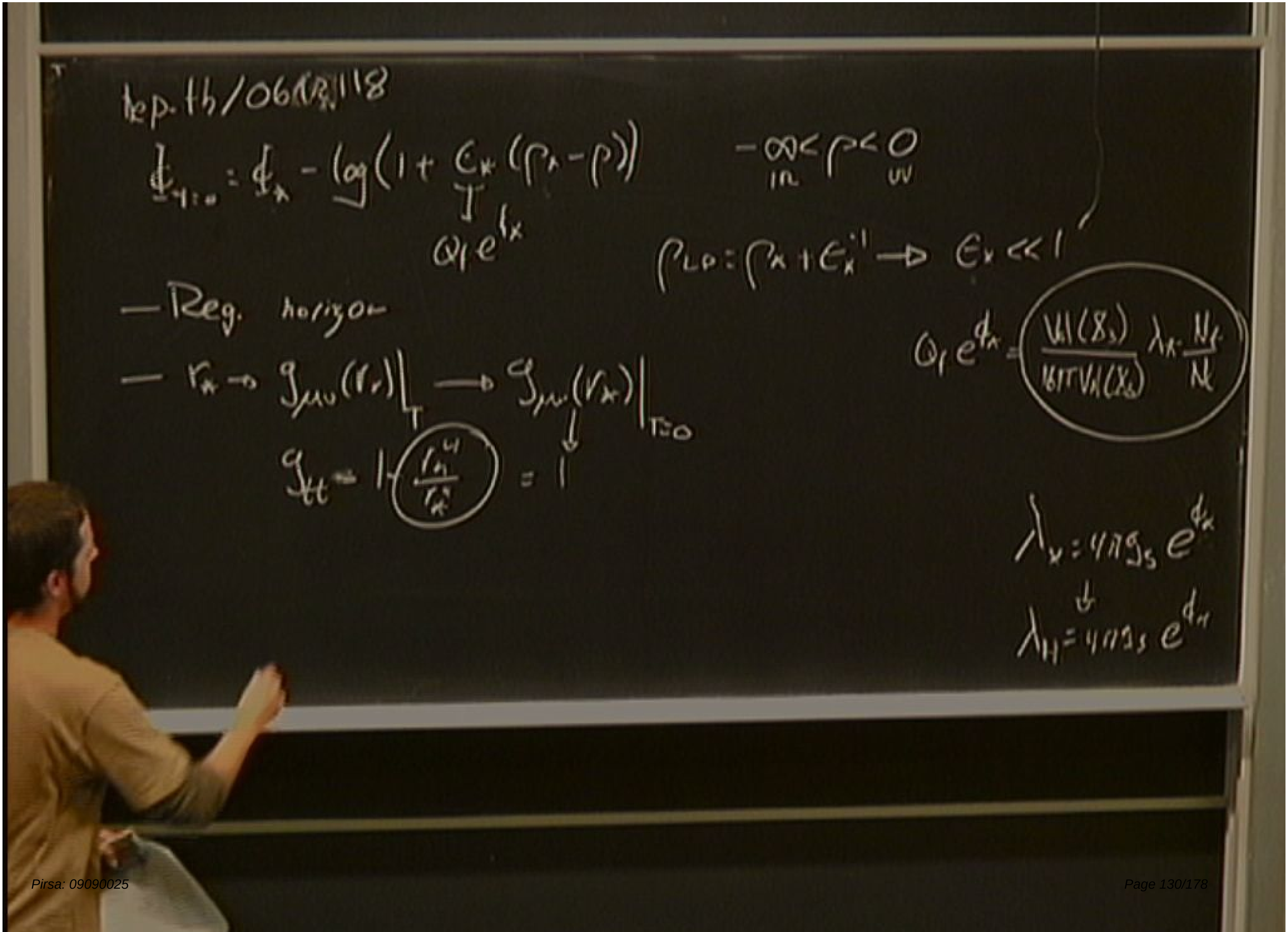
— $r_* \rightarrow g_{\mu\nu}(r_*)\big|_T \longrightarrow g_{\mu\nu}(r_*)\big|_{T=0}$

$$g_{tt} = 1 - \frac{r_H^4}{r^4} = 1$$

$$\lambda_* = 4\pi g_s e^{\phi_*}$$

$$\Downarrow$$

$$\lambda_H = 4\pi g_s e^{\phi_H}$$


hep-th/06
— Reg. horizon
$\lambda_* = 4\pi g_s e^{\phi_*}$
$\lambda_H = 4\pi g_s e^{\phi_H}$

hep-th/06[illegible]118

$$\Phi_{T=0} = \Phi_* - \log\left(1 + \underbrace{\epsilon_*}_{Q_f e^{\Phi_*}} (\rho_* - \rho)\right) \qquad \underset{\mathrm{IR}}{-\infty} < \rho < \underset{\mathrm{UV}}{0}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \longrightarrow \epsilon_* \ll 1$$

— Reg. horizon

$$Q_f e^{\Phi_*} = \frac{\mathrm{Vol}(X_3)}{16\pi \mathrm{Vol}(X_5)} \lambda_* \frac{N_f}{N_c}$$

$$— \; r_* \to g_{\mu\nu}(r_*)\Big|_T \longrightarrow g_{\mu\nu}(r_*)\Big|_{T=0}$$

$$g_{tt} = 1 - \frac{r_H^4}{r_*^4} = 1$$

$$\lambda_* = 4\pi g_s e^{\Phi_*}$$

$$\Downarrow$$

$$\lambda_H = 4\pi g_s e^{\Phi_H}$$

$$ds^2 = h^{-1/2}(r)\left(-b(r)\,dt^2 + d\vec{x}_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S(r)\right)^2}{b(r)}\,dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + F(r)\left(d\tau + A_{KE}\right)^2\right]$$

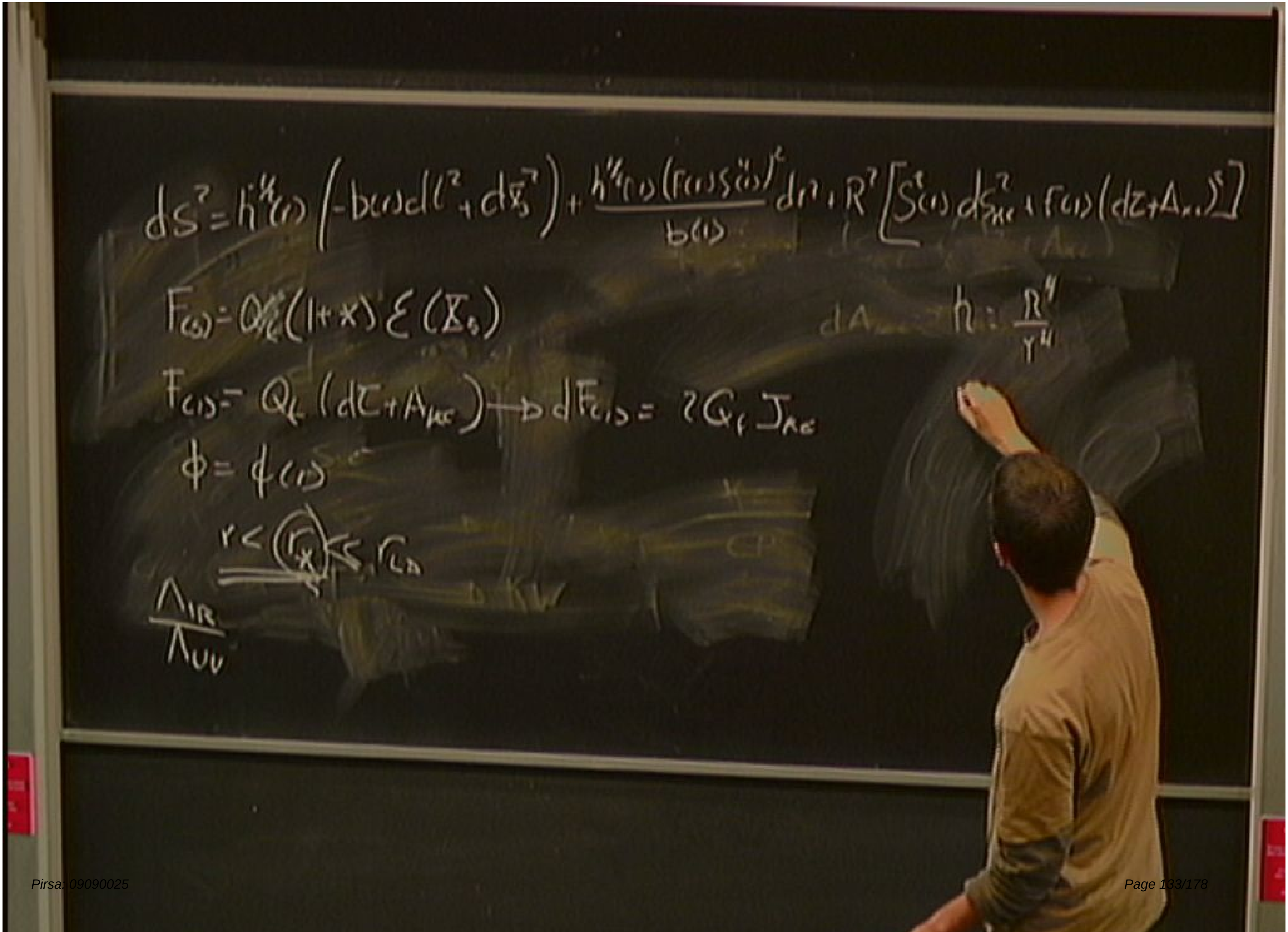
$$F_{(5)} = Q_c(1+\star)\,\mathcal{E}(X_5) \qquad dA_{KE} \qquad h = \frac{R^4}{r^4}$$

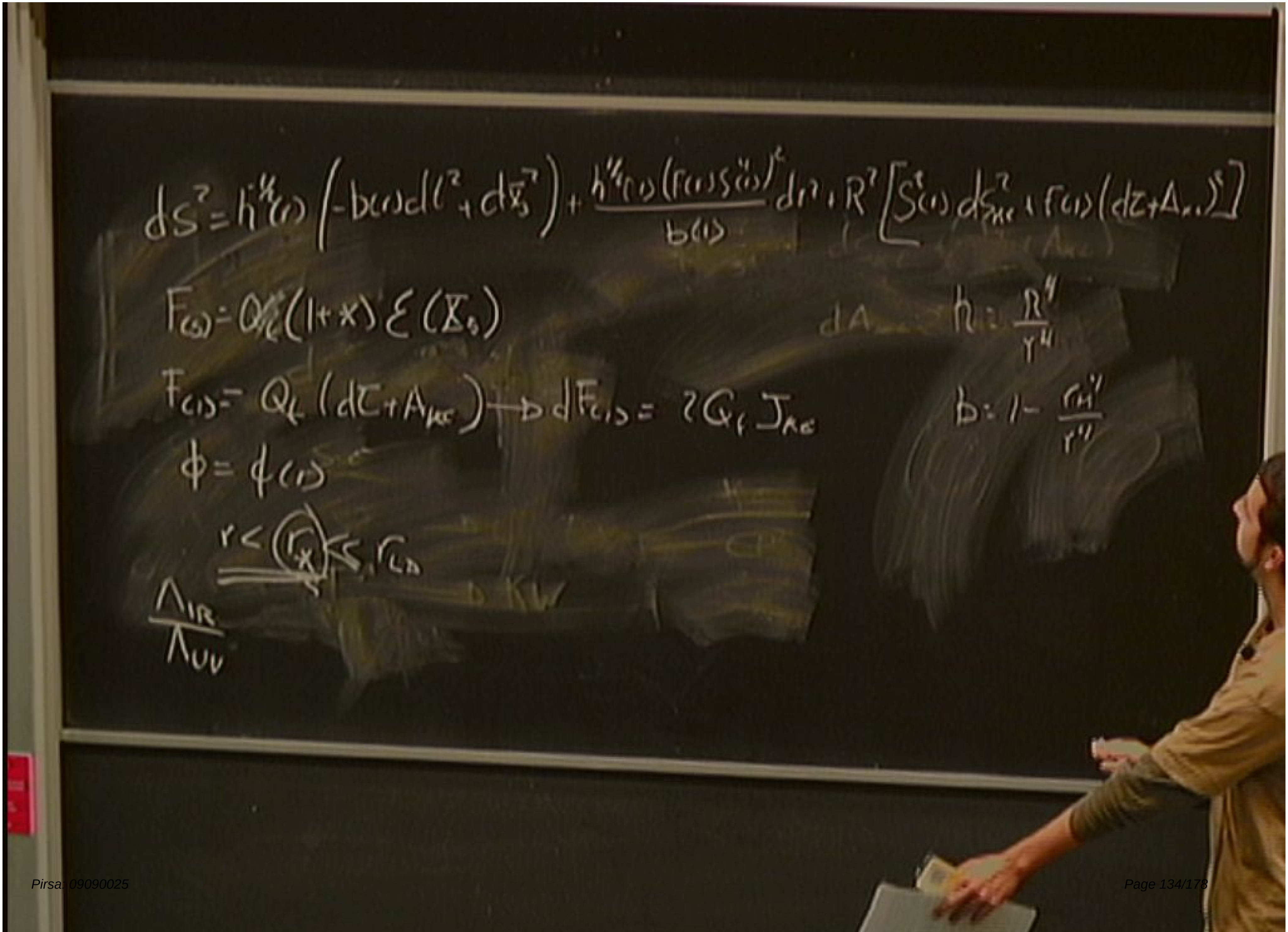
$$F_{(1)} = Q_f\left(d\tau + A_{KE}\right) \to dF_{(1)} = 2Q_f J_{KE}$$

$$\phi = \phi(r)$$

$$r < r_* < r_{UV}$$

$$\frac{\Lambda_{IR}}{\Lambda_{UV}}$$


$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + d\vec{x}_3^2\right) + \frac{h^{1/2}(r)\left(r(r)S(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds_{KE}^2 + f(r)(d\tau + A_{KE})^2\right]$
$F_{(5)} = Q_c(1+*)\,\mathcal{E}(X_5)$
$h = \frac{R^4}{r^4}$
$F_{(1)} = Q_f\,(d\tau + A_{KE}) \to dF_{(1)} = 2Q_f\,J_{KE}$
$\phi = \phi(r)$
$r < r_* \ll r_{LD}$
$\frac{\Lambda_{IR}}{\Lambda_{UV}}$


ds^2 = h^{-1/2}(r) (-b(r)dt^2 + dx_3^2) + h^{1/2}(r)(r(r)S(r))^2 / b(r) dr^2 + R^2 [S^2(r) ds_{KE}^2 + f(r)(dτ + A_{KE})^2]
F_(5) = Q_c (1+*) ε(X_5)
F_(3) = Q_f (dτ + A_KE) → dF_(3) = 2Q_f J_KE
φ = φ(r)
r < r_x < r_s, r_LD
Λ_IR / Λ_UV
h = R^4 / r^4
b = 1 - r_H^4 / r^4

$$ds^2 = h^{-1/2}(r)\left(-b(r)\,dt^2 + d\vec{x}_3^{\,2}\right) + \frac{h^{1/2}(r)\,(F(r)S^{4}(r))^{2}}{b(r)}\,dr^2 + R^2\left[S^2(r)\,ds^2_{KE} + F(r)\,(d\tau + A_{KE})^2\right]$$

$$F_{(5)} = Q_c\,(1+*)\,\mathcal{E}(\vec{x}_5)$$

$$F_{(1)} = Q_f\,(d\tau + A_{KE}) \rightarrow dF_{(1)} = 2Q_f\,J_{KE}$$

$$\phi = \phi(r)$$

$$r < r_\chi < r_s, r_{LD}$$

$$\frac{\Lambda_{IR}}{\Lambda_{UV}}$$

dA

$$h = \frac{R^4}{r^4}$$

$$b = 1 - \frac{r_H^4}{r^4}$$

hep-th/06[illegible]118

$$\phi_{\eta=0} = \phi_* - \log\left(1 + \underset{\substack{\| \\ Q_f e^{\phi_*}}}{\epsilon_*}(\rho_* - \rho)\right) \qquad \underset{IR}{-\infty} < \rho < \underset{UV}{0}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \rightarrow \epsilon_* \ll 1$$

— Reg. horizon

$$\underline{\epsilon_*} = Q_f e^{\phi_*} = \frac{V_1(\delta_3)}{16\pi V_1(\delta_5)} \lambda_* \frac{N_f}{N_c}$$

$$— \; r_* \rightarrow g_{\mu\nu}(r_*)\Big|_T \longrightarrow g_{\mu\nu}(r_*)\Big|_{T=0}$$

$$g_{tt} = 1 - \frac{r_H^{4}}{r_*^{4}} = 1$$

$$\lambda_* = 4\pi g_s e^{\phi_*}$$

$$\lambda_H = 4\pi g_s e^{\phi_H}$$

hep-th/06??118

$$\phi_{\eta=0} = \phi_* - \log\Big(1 + \underbrace{\epsilon_*}_{Q_f e^{\phi_*}}(\rho_* - \rho)\Big) \qquad \underset{IR}{-\infty} < \rho < \underset{UV}{0}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \rightarrow \epsilon_* \ll 1$$

— Reg. horizon

— $r_* \to g_{\mu\nu}(r_*)\big|_T \longrightarrow g_{\mu\nu}(r_*)\big|_{T=0}$

$$g_{tt} = 1 - \frac{r_H^4}{r_*^4} = 1$$

$$\underline{\epsilon_*} = Q_f e^{\phi_*} = \frac{V_1(S_3)}{16\pi V_1(X_5)} \lambda_* \frac{N_f}{N_c}$$

$$F = 1 - \mathcal{O}(\epsilon_*)$$

$$\lambda_* = 4\pi g_s e^{\phi_*}$$
$$\Downarrow$$
$$\lambda_H = 4\pi g_s e^{\phi_H}$$

hep-th/06[illegible]118

$$\Phi_{T=0} = \Phi_* - \log\left(1 + \underset{Q_f e^{\phi_*}}{\underbrace{\epsilon_*}} (\rho_* - \rho)\right) \qquad \underset{IR}{-\infty} < \rho < \underset{UV}{0}$$

$$\rho_{LP} = \rho_* + \epsilon_*^{-1} \rightarrow \epsilon_* \ll 1$$

— Reg. horizon

— $r_* \rightarrow g_{\mu\nu}(r_*)\big|_T \longrightarrow g_{\mu\nu}(r_*)\big|_{T=0}$

$$g_{tt} = 1 - \frac{r_H^4}{r_*^4} = 1$$

$$\underline{\epsilon_*} = Q_f e^{\phi_*} = \frac{Vol(X_3)}{16\pi Vol(X_5)} \lambda_* \frac{N_f}{N_c}$$

$F = 1 - \mathcal{O}(\epsilon_*)$

$S = 1 + \mathcal{O}(\epsilon_*)$

$\phi = \phi_* + \ldots$

$$\lambda_* = 4\pi g_s e^{\phi_*}$$
$$\Downarrow$$
$$\lambda_H = 4\pi g_s e^{\phi_H}$$

hep-th/06[illegible]118

$\phi_{T=0} = \phi_* - \log(1 + \epsilon_*(\rho_* - \rho))$ $\quad -\underset{IR}{\infty} < \rho < \underset{UV}{0}$

$\epsilon_* = Q_f e^{\phi_*}$

$\rho_{LP} = \rho_* + \epsilon_*^{-1} \to \epsilon_* \ll 1$

— Reg. horizon

— $r_* \to g_{\mu\nu}(r_*)\big|_T \longrightarrow g_{\mu\nu}(r_*)\big|_{T=0}$

$g_{tt} = 1 - \frac{r_H^4}{r_*^4} = 1$

$\underline{\epsilon_*} = Q_f e^{\phi_*} = \frac{Vol(X_3)}{16\pi Vol(X_5)} \lambda_* \frac{N_f}{N_c}$

$F = 1 - \mathcal{O}(\epsilon_*) + \ldots$

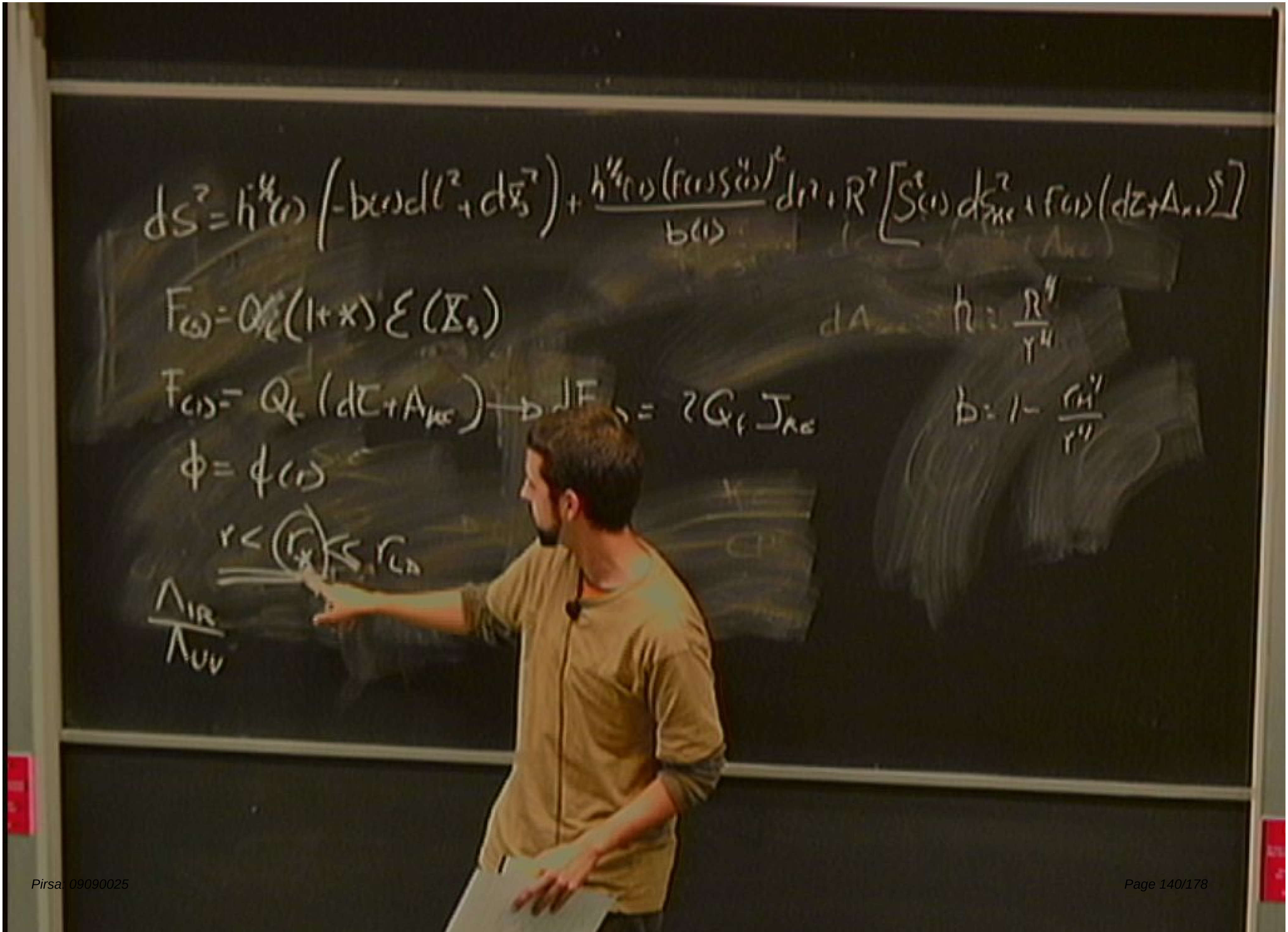
$S = 1 + \mathcal{O}(\epsilon_*)$

$\phi = \phi_* + \ldots$

$\lambda_* = 4\pi g_s e^{\phi_*}$

$\Downarrow$

$\lambda_H = 4\pi g_s e^{\phi_H}$


ds² = h^-½(r)(-b(r)dt² + dx₃²) + h^½(r)(F(r)S²(r))² / b(r) dr² + R²[S²(r) ds²KE + F(r)(dτ+A_KE)²]
F(3) = Q_f (1+x) ε(X₃)
F(1) = Q_f (dτ + A_KE) → dF(1) = 2Q_f J_KE
φ = φ(r)
r < r* < S, r_LD
Λ_IR / Λ_UV
dA
h = R⁴/r⁴
b = 1 − r_H⁴/r⁴

$$ds^2 = h^{-1/2}(r)\left(-b(r)dt^2 + d\vec{x}_3^2\right) + \frac{h^{1/2}(r)\left(F(r)S^{1/2}(r)\right)^2}{b(r)}dr^2 + R^2\left[S^2(r)\,ds^2_{KE} + F(r)\left(d\tau + A_{KE}\right)^2\right]$$

$$F_{(5)} = Q(1+*)\,\mathcal{E}(\Sigma_5)$$

$$F_{(3)} = Q_f\left(d\tau + A_{KE}\right) \to dF_{(3)} = 2Q_f\,J_{KE}$$

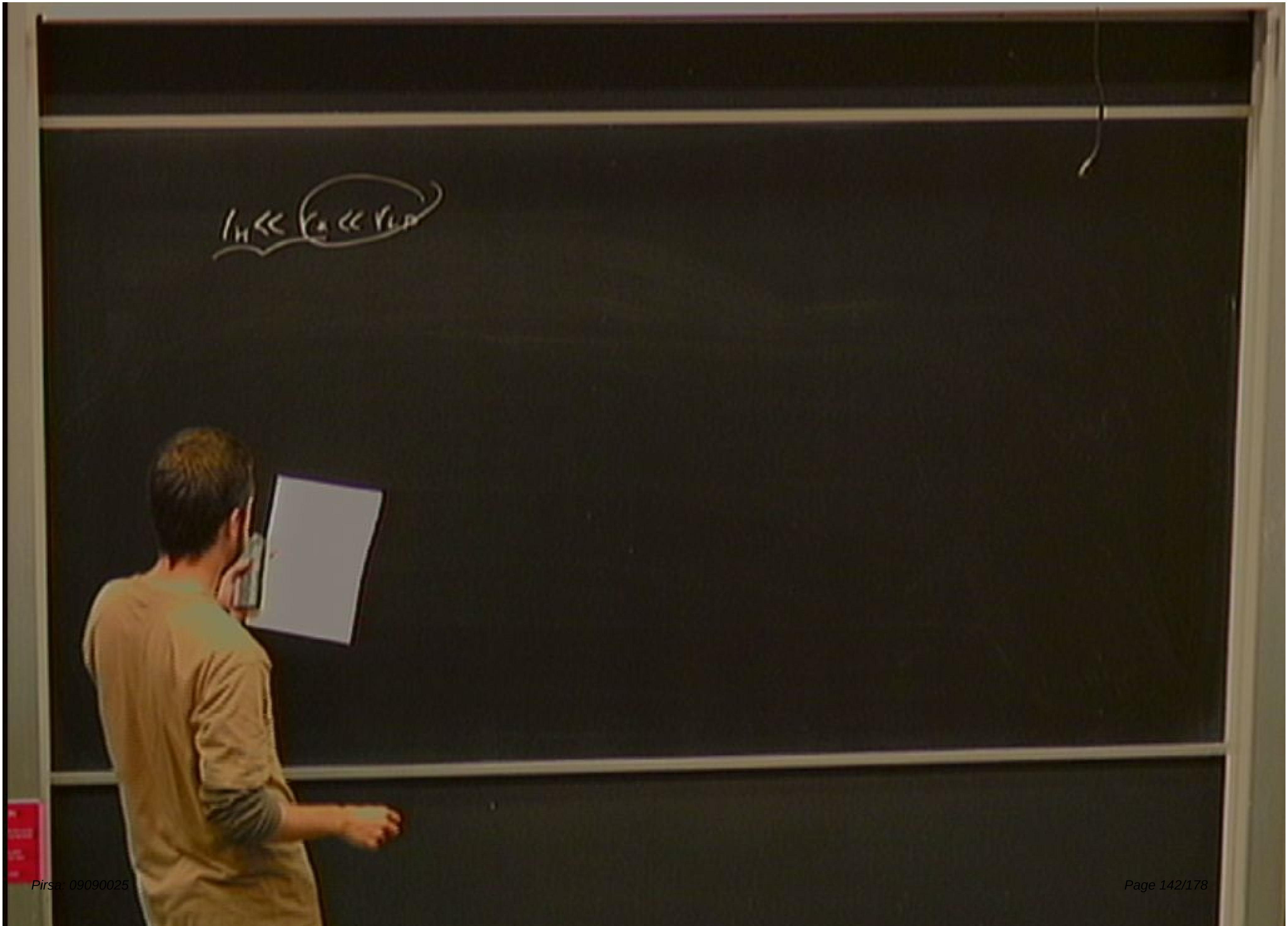
$$h = \frac{R^4}{r^4}$$

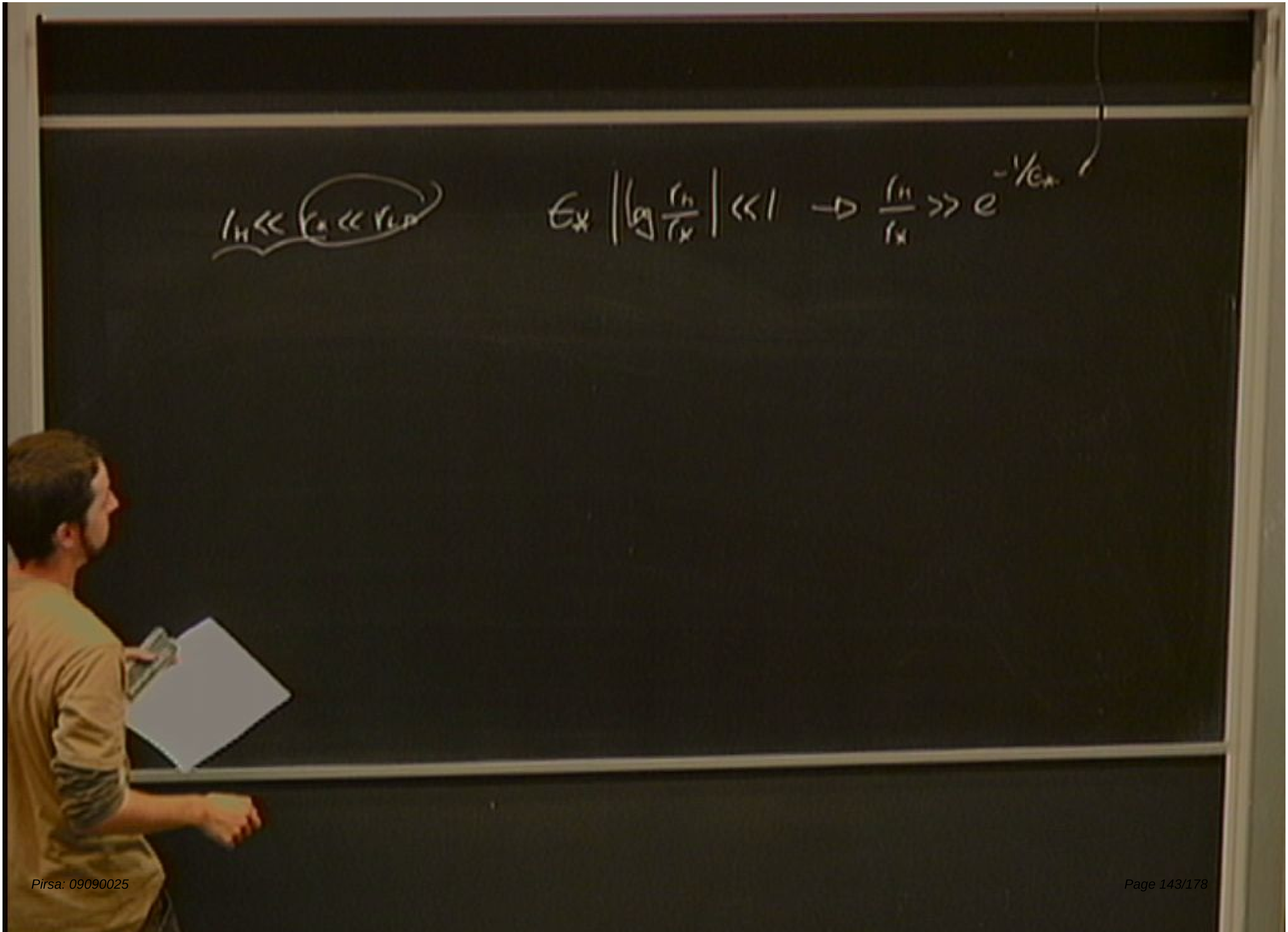
$$b = 1 - \frac{r_H^4}{r^4}$$

$$\phi = \phi(r)$$

$$r < r_* < r_{LD}$$

$$\frac{\Lambda_{IR}}{\Lambda_{UV}}$$


$l_H \ll r_* \ll r_{LP}$



$l_H \ll r_* \ll r_{LP}$
$\epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \to \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$

$$r_H \ll r_* \ll r_{UV}$$

$$\epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \longrightarrow \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$$

$$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \epsilon_* \ll 1$$

$r_H \ll r_* \ll r_{LP}$

$\epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \rightarrow \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$

$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \epsilon_* \ll 1$

$$r_H \ll r_* \ll r_{LP} \qquad \epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \rightarrow \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$$

$$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \epsilon_* \ll 1$$

$$r_H \ll r_* \ll r_{UV}$$

$$\epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \;\rightarrow\; \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$$

$$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \epsilon_* \ll 1$$

$$N_c \gg 1$$

$$N_f \gg 1$$

$$\lambda_H \gg 1$$

$$r_H \ll r_* \ll r_{UV}$$

$$\epsilon_* \left|\log \frac{r_H}{r_*}\right| \ll 1 \longrightarrow \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$$

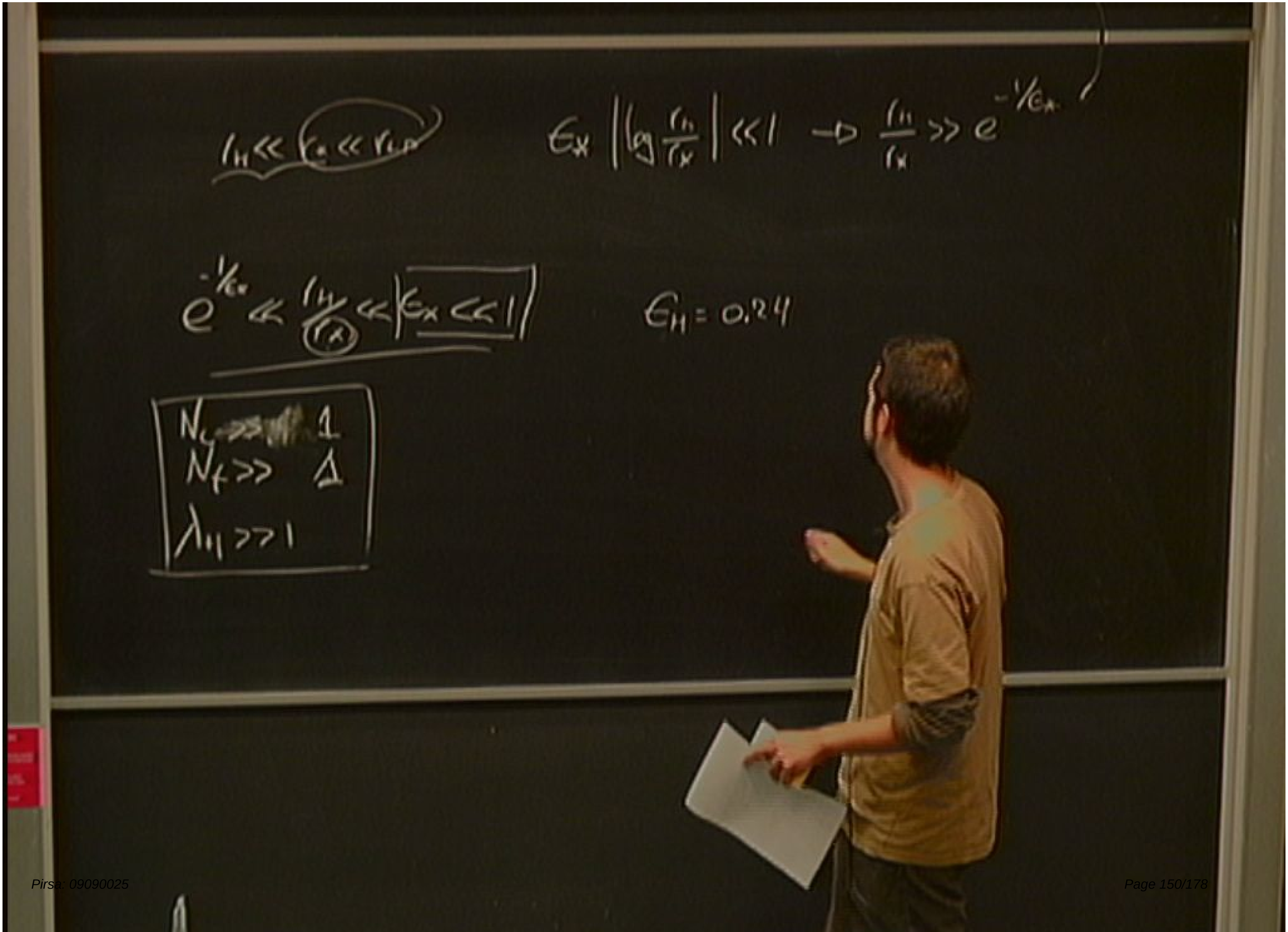
$$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \epsilon_* \ll 1$$

$$\boxed{\begin{array}{l} N_c \quad 1 \\ N_f \gg 1 \\ \lambda_H \gg 1 \end{array}}$$

$r_H \ll r_* \ll r_{LP}$ $\qquad \epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \longrightarrow \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$

$$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \boxed{\epsilon_* \ll 1}$$

$$\boxed{\begin{array}{l} N_c \quad\quad 1 \\ N_f \gg \quad 1 \\ \lambda_H \gg 1 \end{array}}$$

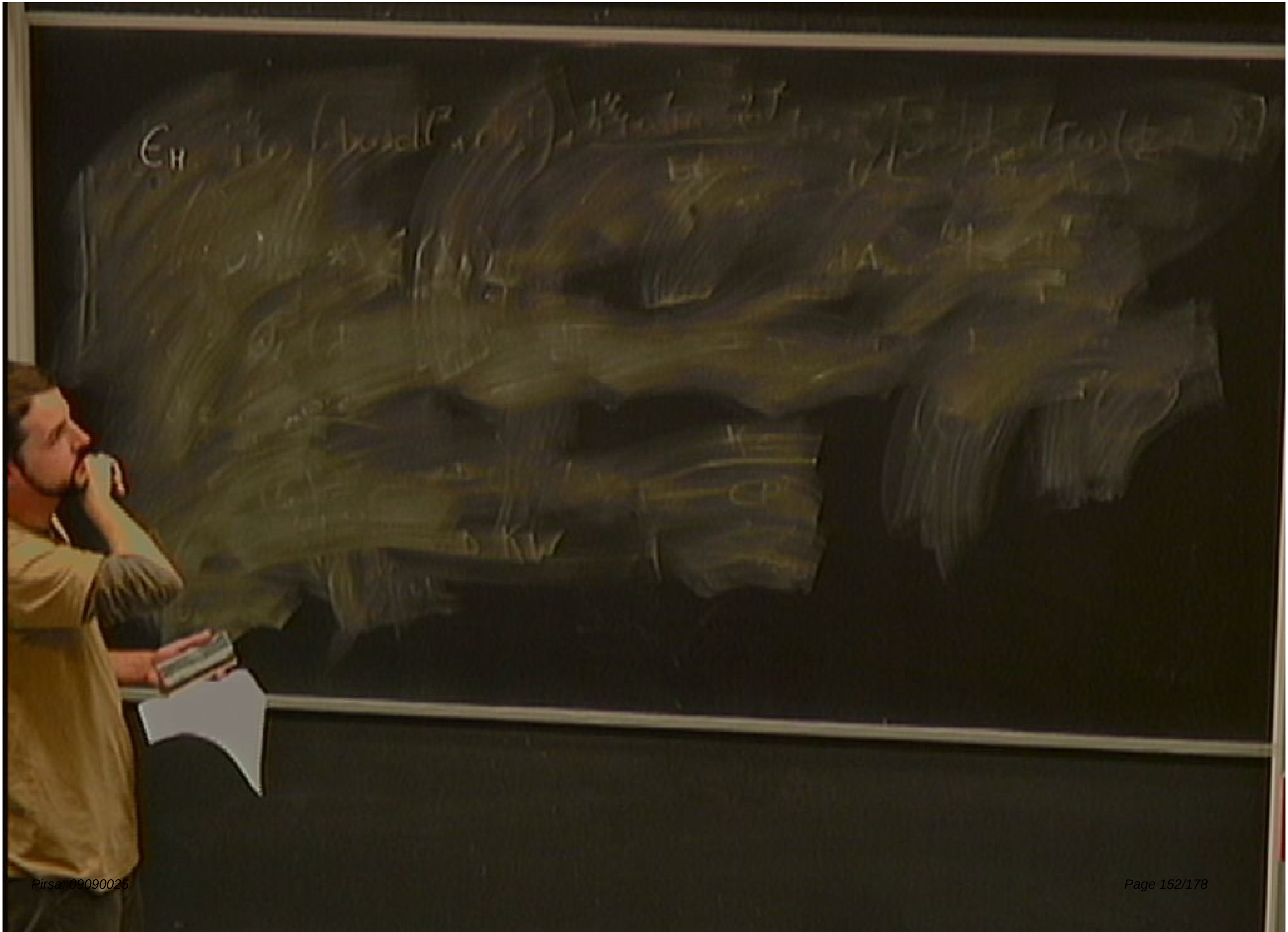

$r_H \ll r_* \ll r_{LP}$
$\epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \rightarrow \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$
$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \epsilon_* \ll 1$
$\epsilon_H = 0.24$
N_c 1
$N_f \gg 1$
$\lambda_H \gg 1$

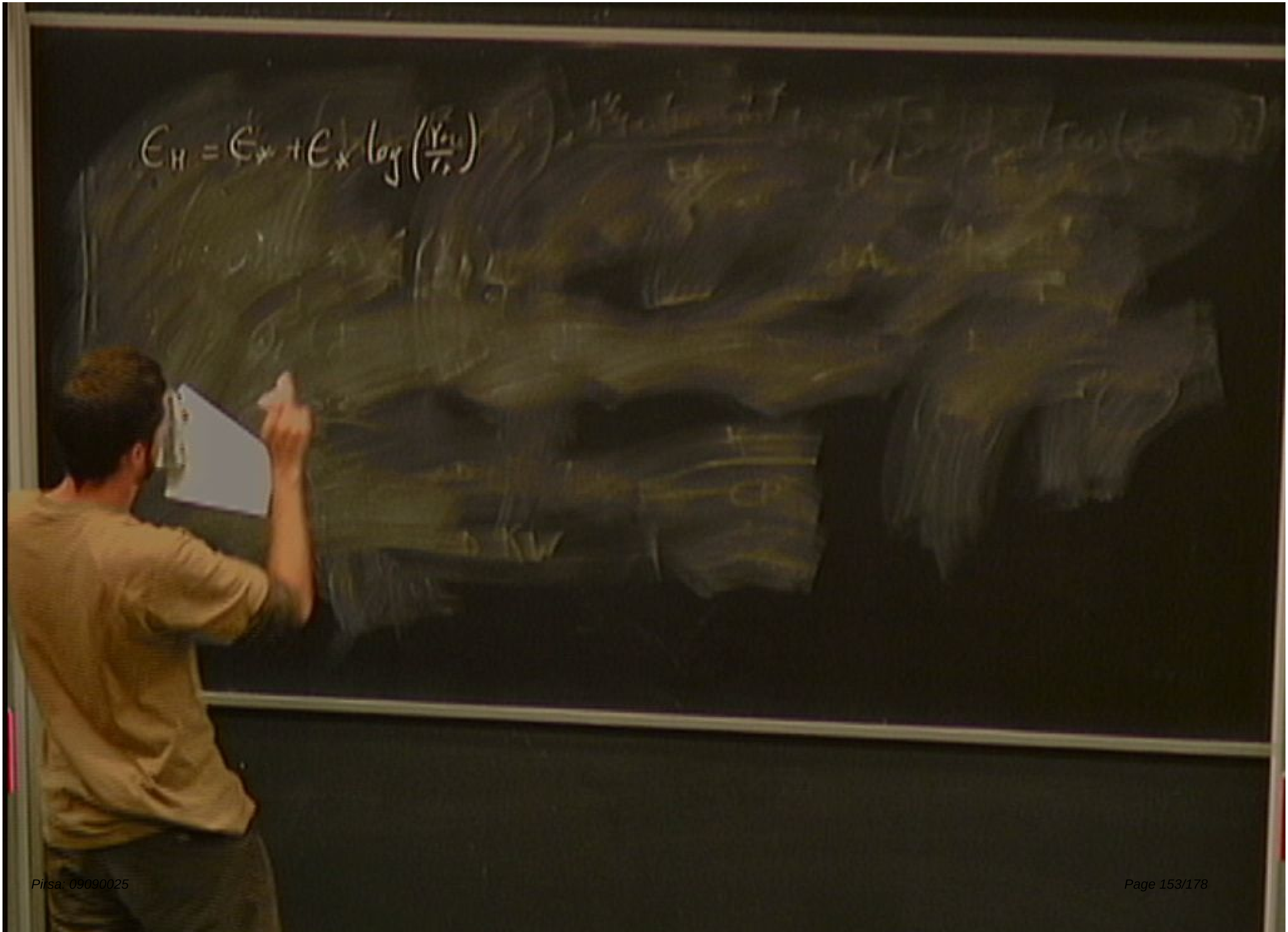
$r_H \ll r_* \ll r_{UV}$

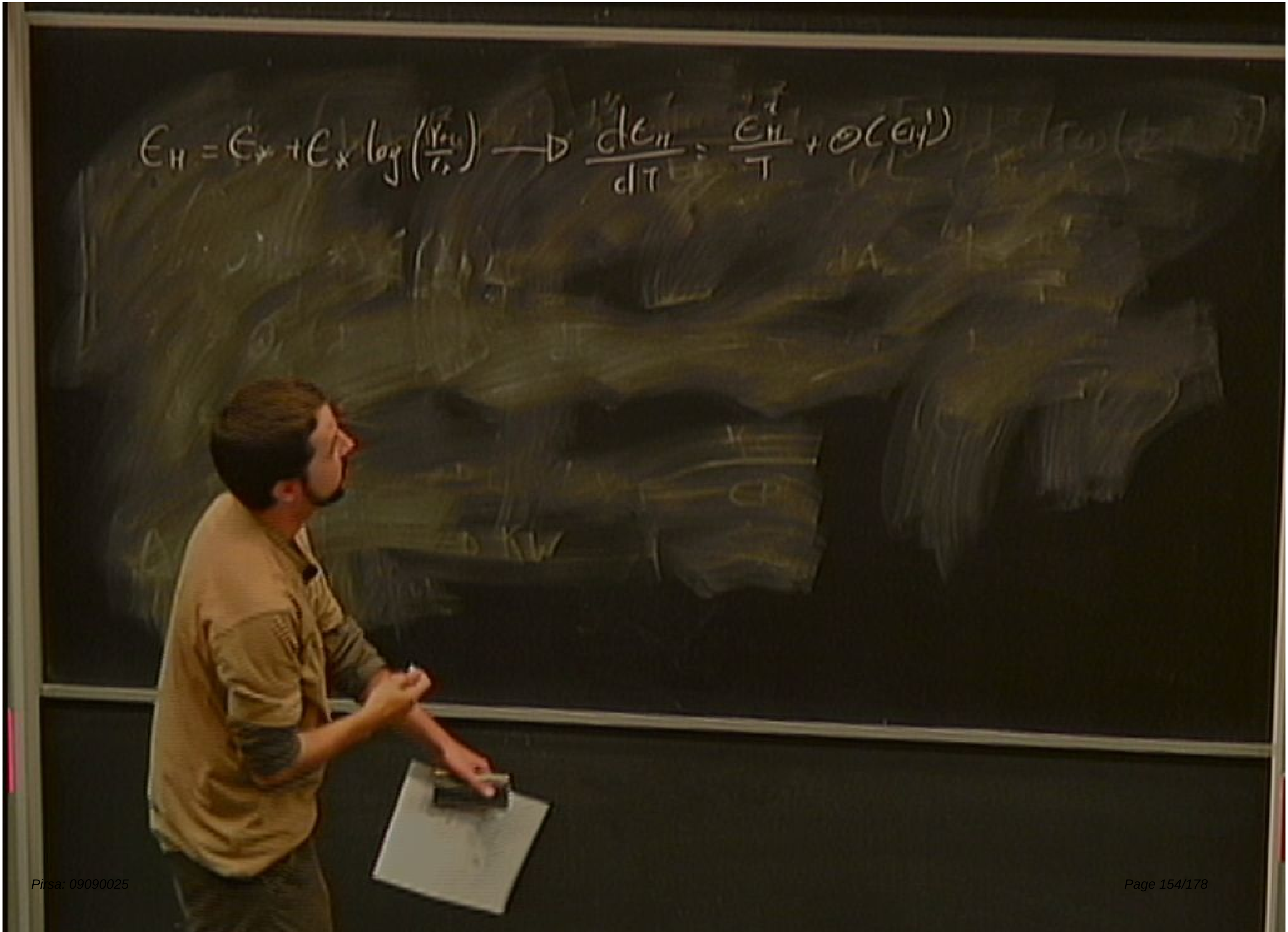
$\epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \to \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$

$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \boxed{\epsilon_* \ll 1}$

$$\boxed{\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_H \gg 1 \end{array}}$$




$\epsilon_H = \epsilon_* + \epsilon_* \log$


$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{Y_{H}}{Y_*}\right) \longrightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$

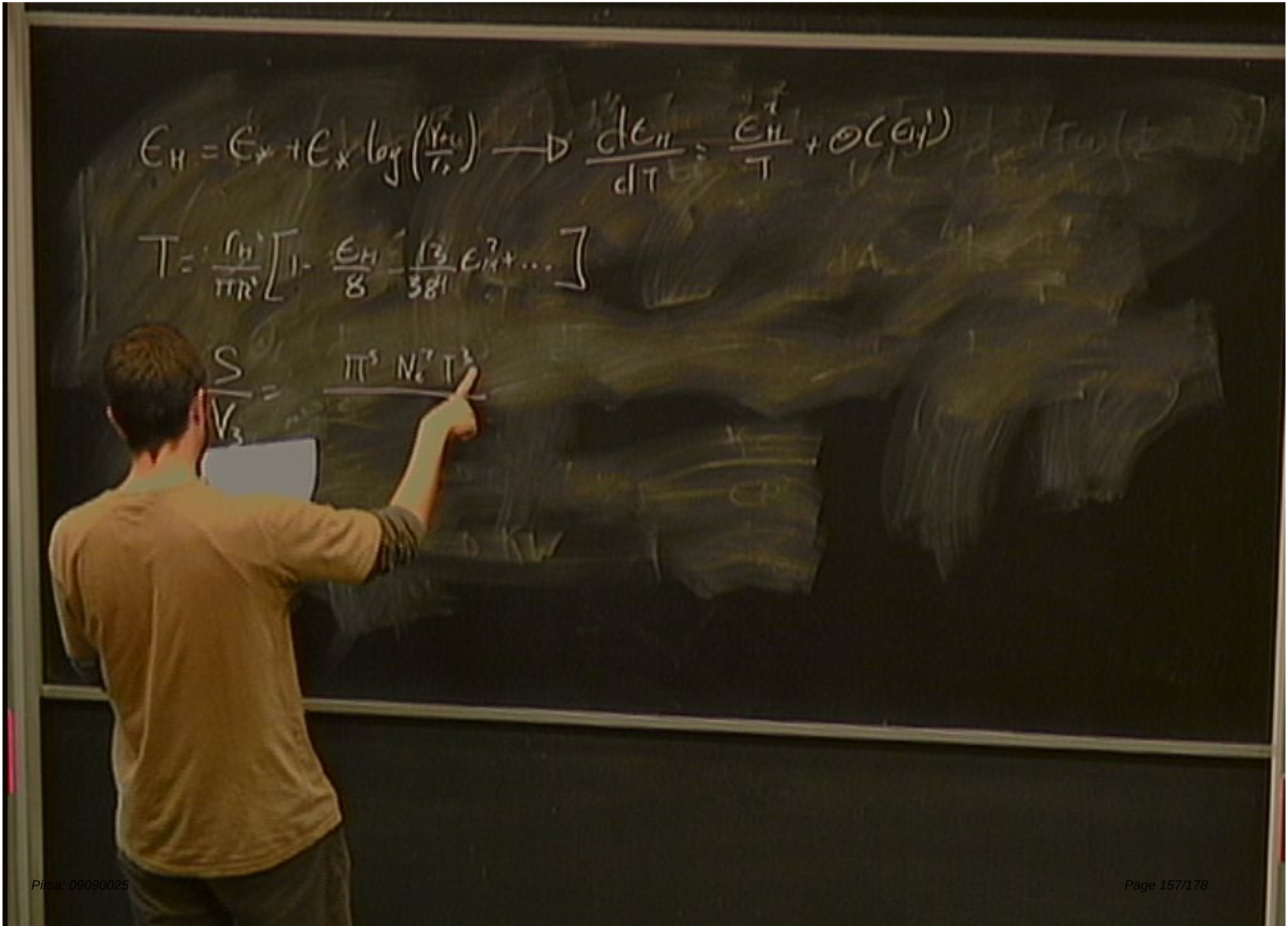
$$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{dr} = \frac{\epsilon_H^2}{r} + \mathcal{O}(\epsilon_H^3)$$

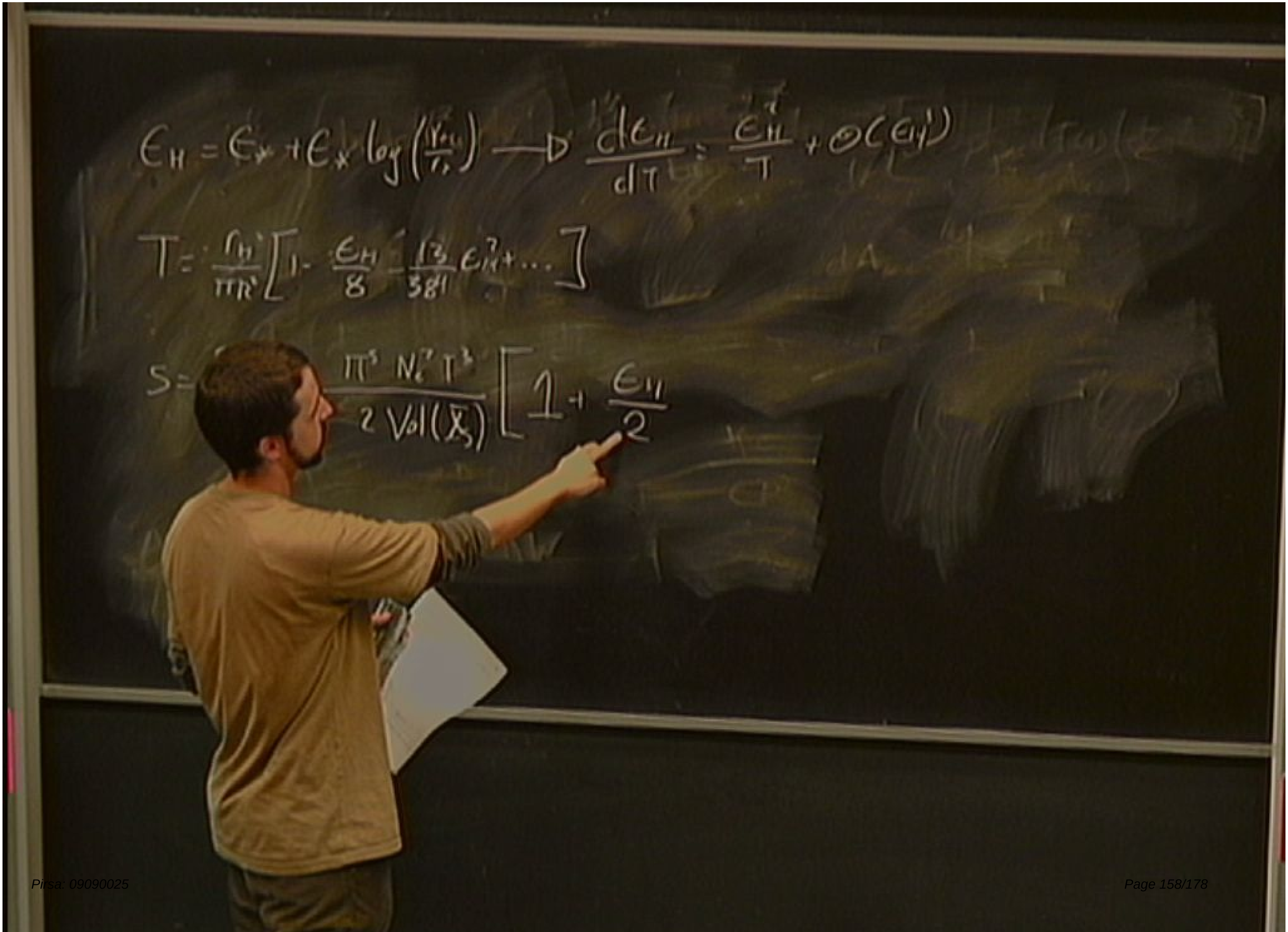
$$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$$

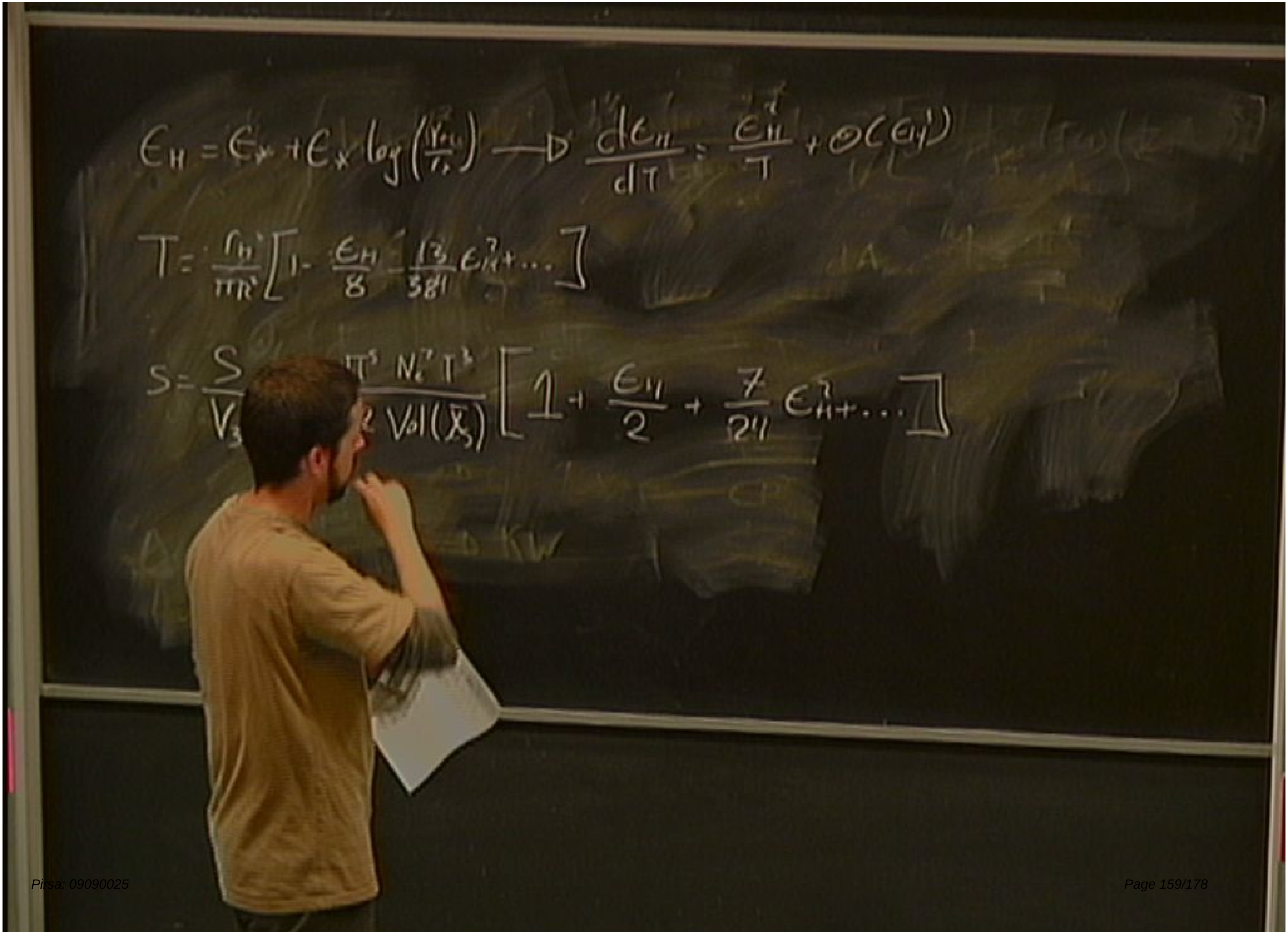
$$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{d\tau} = \frac{\epsilon_H}{\tau} + \mathcal{O}(\epsilon_H^2)$$

$$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{381}\epsilon_H^2 + \dots\right]$$

$$s = \frac{S}{V_3}$$


$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H^2}{T} + O(\epsilon_H^3)$
$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$
$\frac{S}{V_3} = \pi^3 N_c^2 T^3$


$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H^2)$
$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$
$S = \frac{\pi^3 N_c^2 T^3}{2 \mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2}\right.$


$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H^2}{T} + O(\epsilon_H^3)$
$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$
$s = \frac{S}{V_3}$
$\pi^5 N_c^2 T^3$
$\mathrm{Vol}(X_5)$
$\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$

$$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

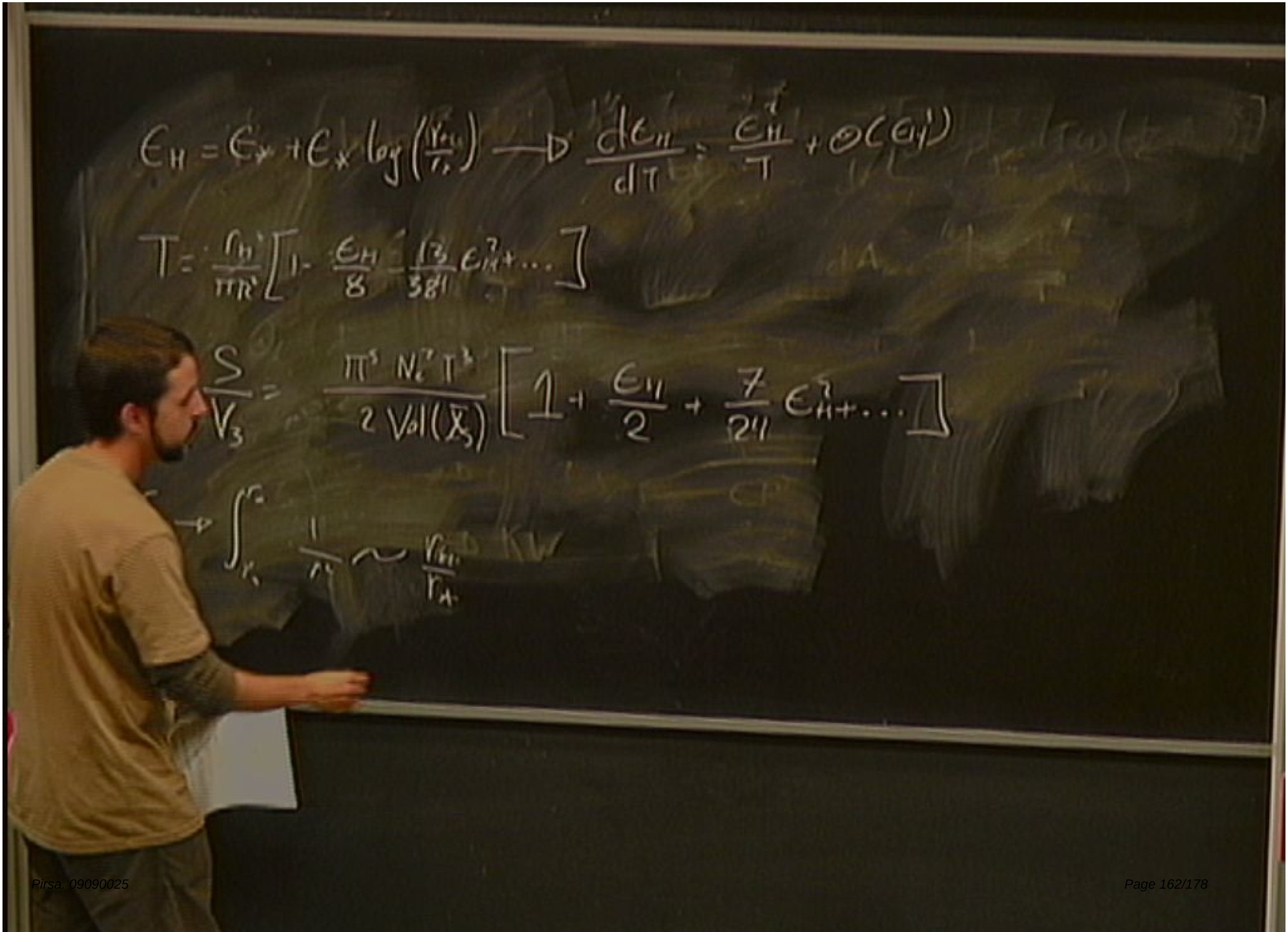
$$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$$

$$s = \frac{S}{V_3} = \frac{\pi^5 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$$

$$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{d\tau} = \frac{\epsilon_H^2}{\tau} + O(\epsilon_H^3)$$

$$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$$

$$s = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$$

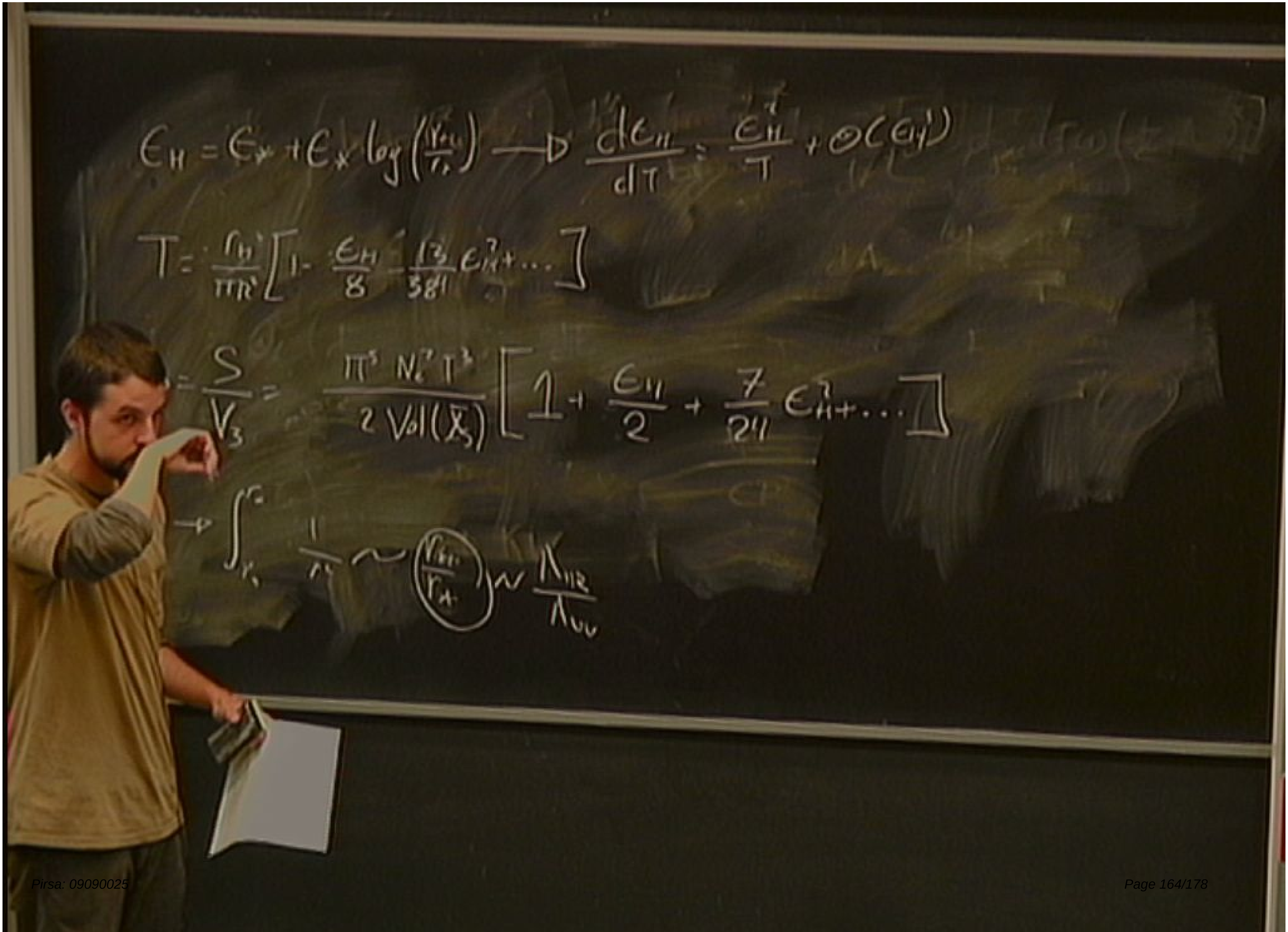

$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H^2)$
$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$
$\frac{S}{V_3} = \frac{\pi^5 N_c^2 T^3}{2\,Vol(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$

$$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_{+H}}{r_+}\right) \longrightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H^2}{T} + O(\epsilon_H^3)$$

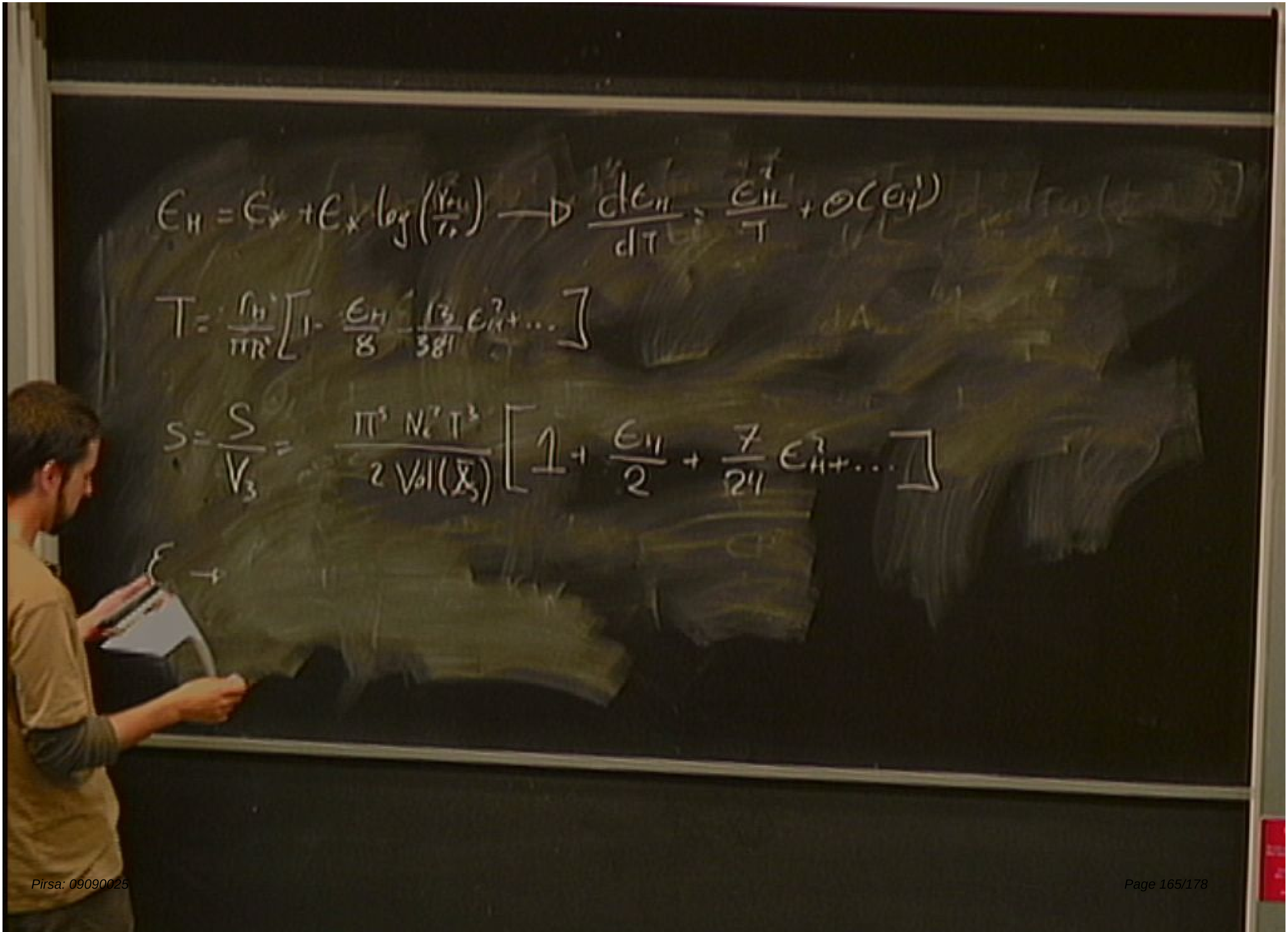
$$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$$

$$s = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$$

$$\epsilon \to \int_{r_+}^{r_H} \frac{1}{r^2} \sim \frac{r_{+H}}{r_+}$$



$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H^2}{T} + O(\epsilon_H^3)$
$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$
$= \frac{S}{V_3} = \frac{\pi^5 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$
$\rightarrow \int_{r_0}^{r_H} \frac{1}{r^4} \sim \frac{r_H}{r_A} \sim \frac{\Lambda_{IR}}{\Lambda_{UV}}$


$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_H}{r_*}\right) \longrightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H^2}{T} + \mathcal{O}(\epsilon_H^3)$
$T = \frac{r_H}{\pi R^2}\left[1 - \frac{\epsilon_H}{8} - \frac{13}{384}\epsilon_H^2 + \dots\right]$
$s = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$
$\xi \to$

$-F$

$$\frac{(\mathcal{E}-3P)}{T^4} \propto \epsilon_H^2 \Rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H^2}{T} + \mathcal{O}(\epsilon_H^3)$$

$$s = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$$

$$\mathcal{E} \rightarrow$$

$-F$

$$\frac{(\mathcal{E}-3P)}{T^4} \propto \epsilon_H^2 \quad \to \quad \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H^2)$$

$$s = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$$

$\mathcal{E} \to$

$-F$

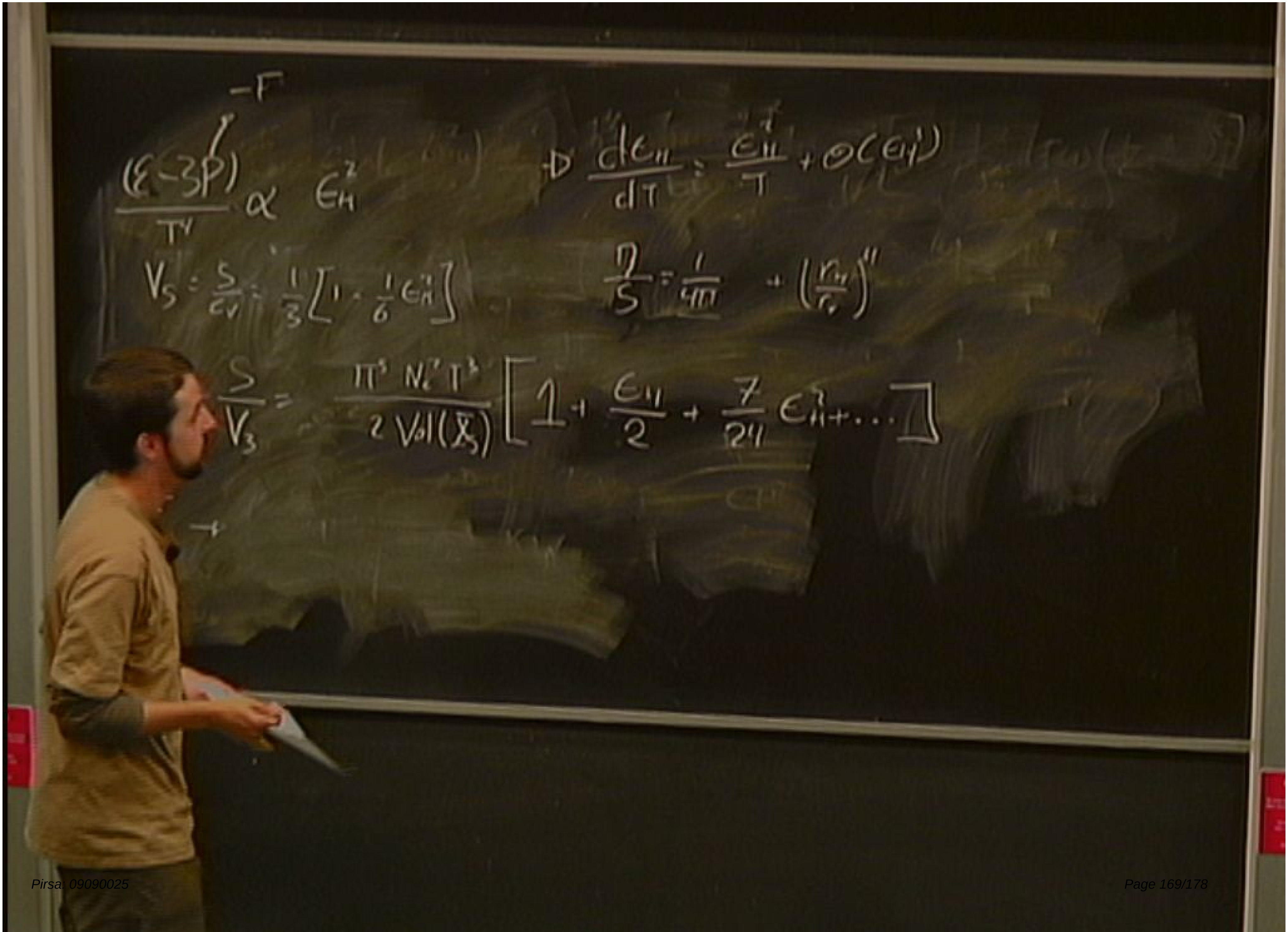
$$\frac{(\mathcal{E}-3P)}{T^4} \propto \epsilon_H^2$$

$$\Rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H^2)$$

$$v_s = \frac{s}{c_V} = \frac{1}{3}\left[1 - \frac{1}{6}\epsilon_H^2\right]$$

$$s = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$$

$\mathcal{E} \to$


$-F$
$\frac{(\mathcal{E}-3P)}{T^4} \propto \epsilon_H^2$
$\Rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H^2}{T} + O(\epsilon_H^3)$
$V_s = \frac{S}{C_V} = \frac{1}{3}\left[1 - \frac{1}{6}\epsilon_H^2\right]$
$\frac{\eta}{s} = \frac{1}{4\pi} + \left(\frac{r_H}{r_0}\right)^4$
$\frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$

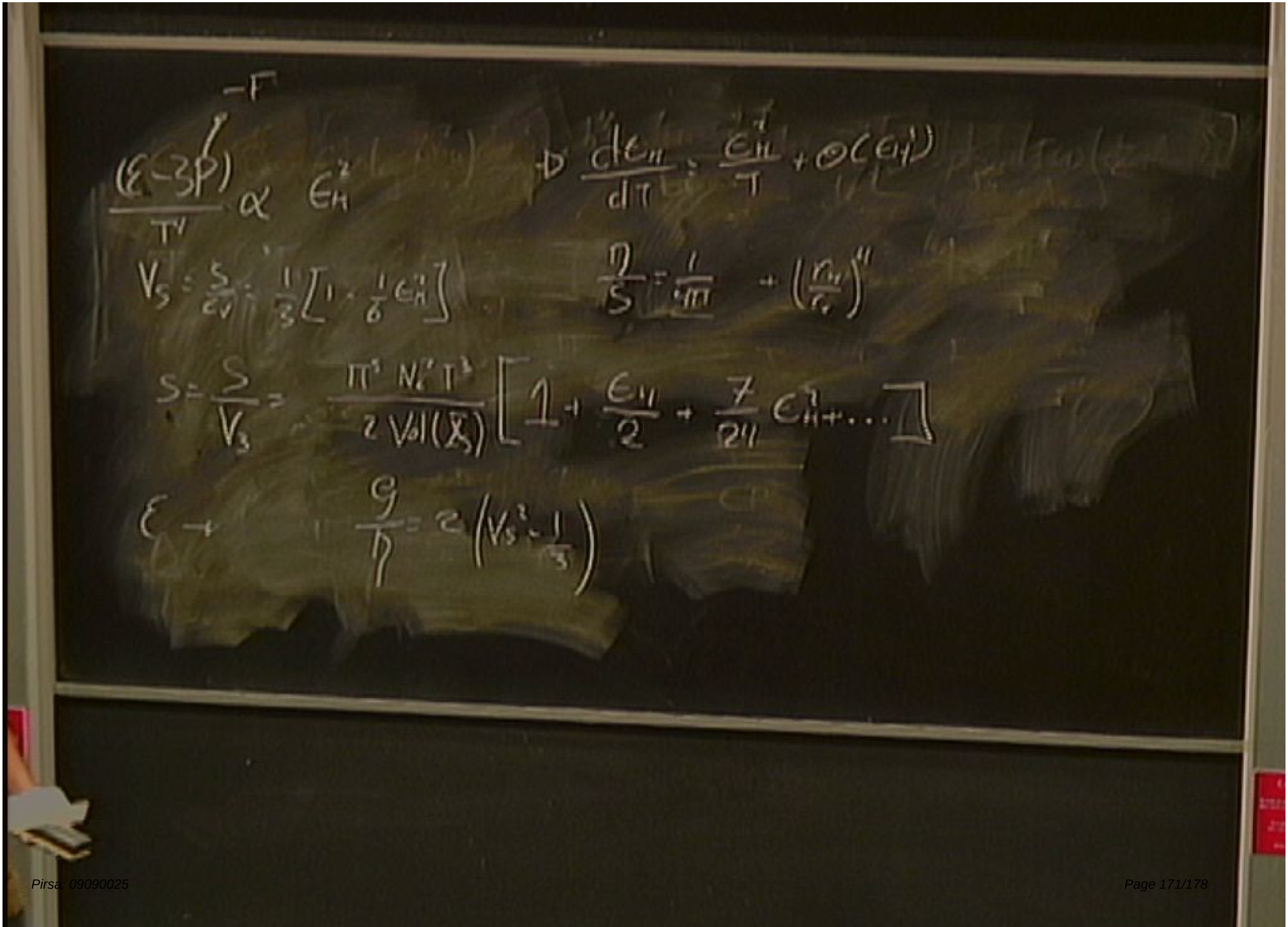
$-F$

$$\frac{(\mathcal{E}-3P)}{T^4} \propto \epsilon_H^2 \quad \to \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H^3)$$

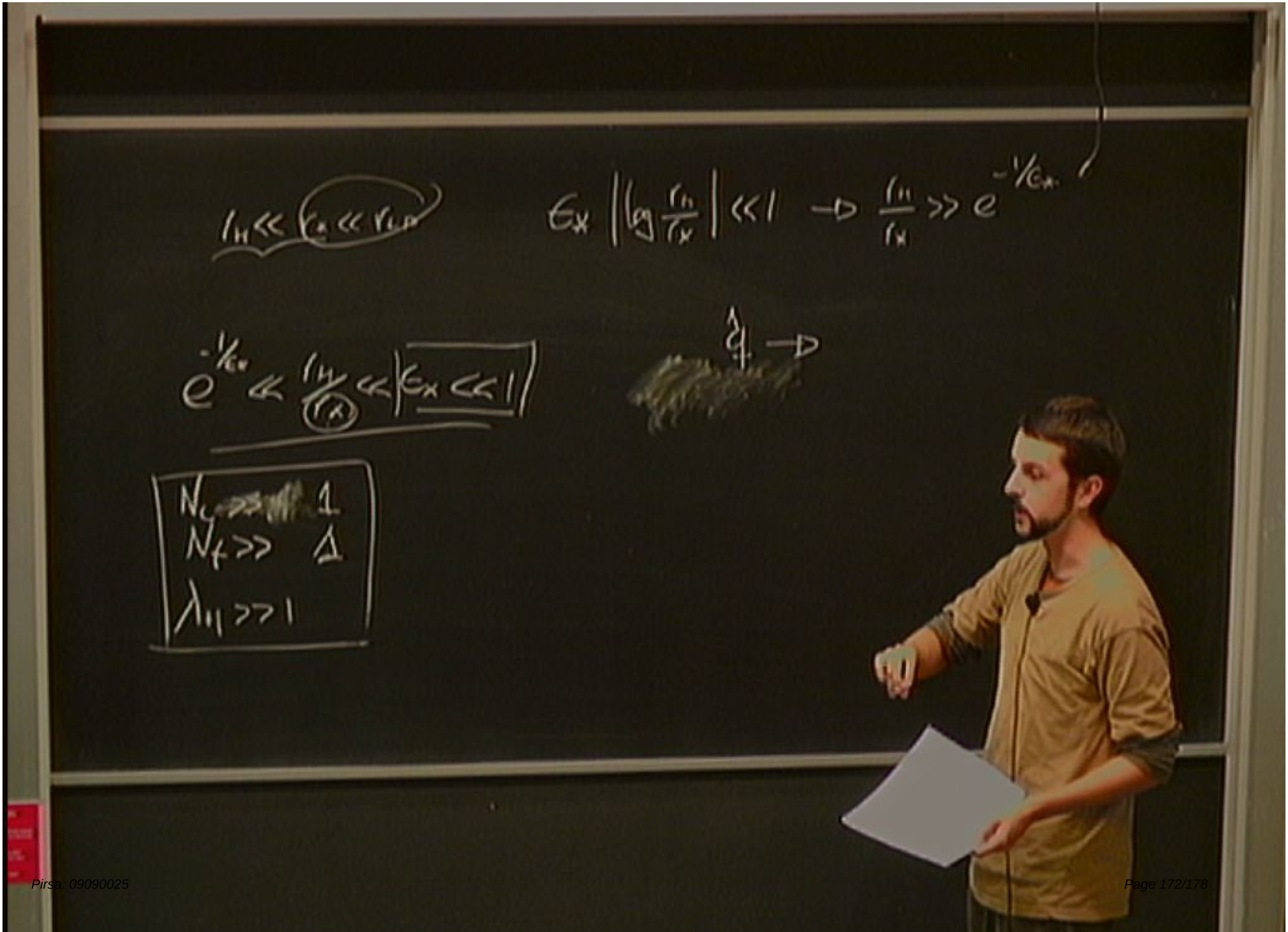
$$V_s = \frac{S}{c_V} = \frac{1}{3}\left[1 - \frac{1}{6}\epsilon_H^2\right] \qquad \frac{\eta}{s} = \frac{1}{4\pi} + \left(\frac{r_H}{r_0}\right)^4$$

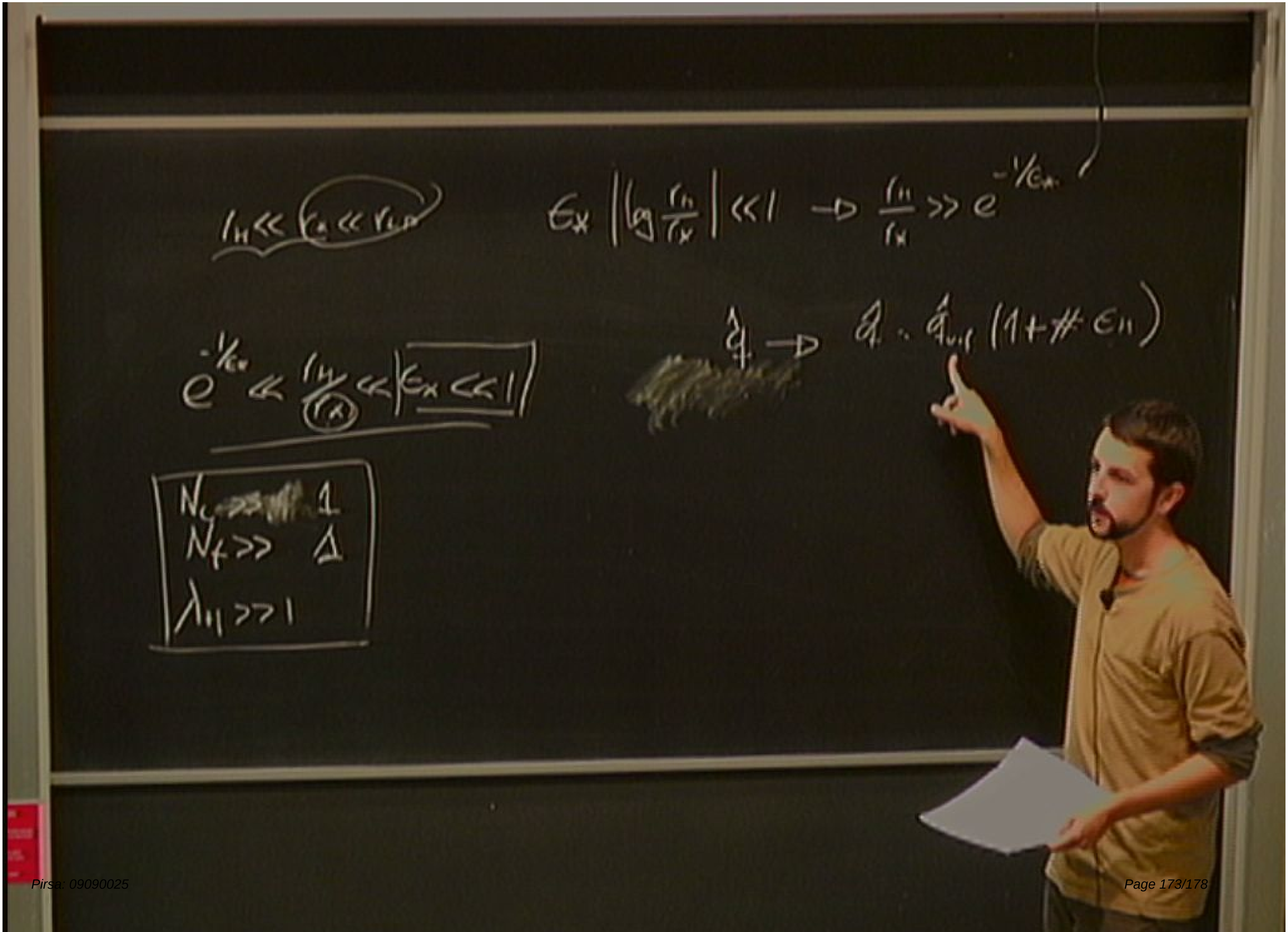
$$s = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$$

$$\mathcal{E} \to \qquad \frac{\zeta}{\eta} = 2\left(V_s^2 - \frac{1}{3}\right)$$



$-F$
$\frac{(\mathcal{E}-3P)}{T^4} \propto \epsilon_H^2$
$\frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H^2)$
$V_s = \frac{S}{C_V} = \frac{1}{3}\left[1 - \frac{1}{6}\epsilon_H^2\right]$
$\frac{\eta}{S} = \frac{1}{4\pi}$
$s = \frac{S}{V_3} = \frac{\pi^2 N_c^2 T^3}{2\,\mathrm{Vol}(X_5)}\left[1 + \frac{\epsilon_H}{2} + \frac{7}{24}\epsilon_H^2 + \dots\right]$
$\mathcal{E} \to$
$\frac{\zeta}{\eta} = 2\left(V_s^2 - \frac{1}{3}\right)$


$r_H \ll r_* \ll r_{UV}$
$\epsilon_* \left|\log \frac{r_H}{r_*}\right| \ll 1 \to \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$
$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \epsilon_* \ll 1$
$N_c \gg 1$
$N_f \gg 1$
$\lambda_H \gg 1$


$r_H \ll r_* \ll r_{UV}$
$\epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \rightarrow \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$
$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \boxed{\epsilon_* \ll 1}$
$N_c \gg 1$
$N_f \gg 1$
$\lambda_H \gg 1$

$$\underbrace{r_H \ll r_*} \ll r_{LP}$$

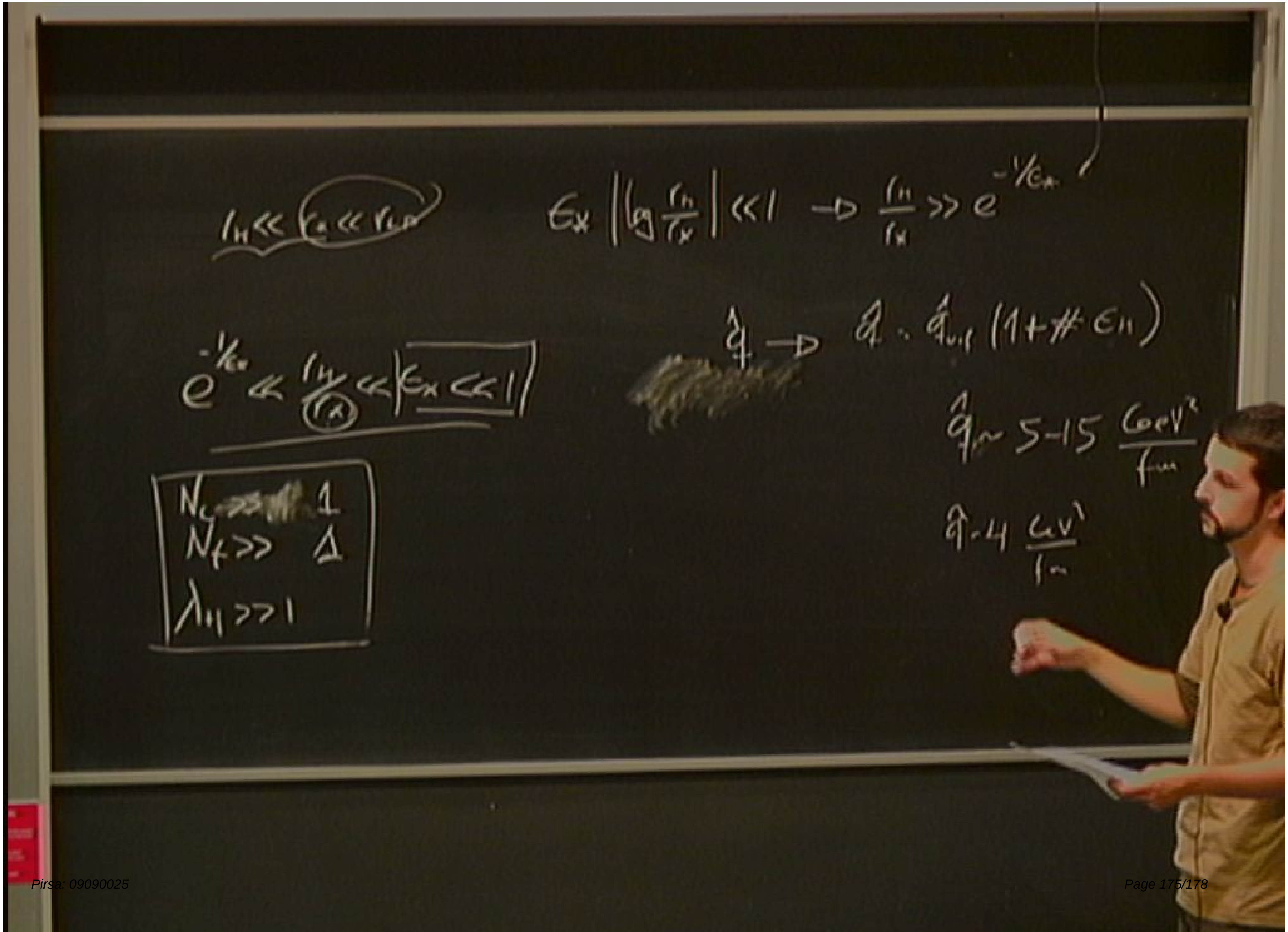
$$\epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \longrightarrow \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$$

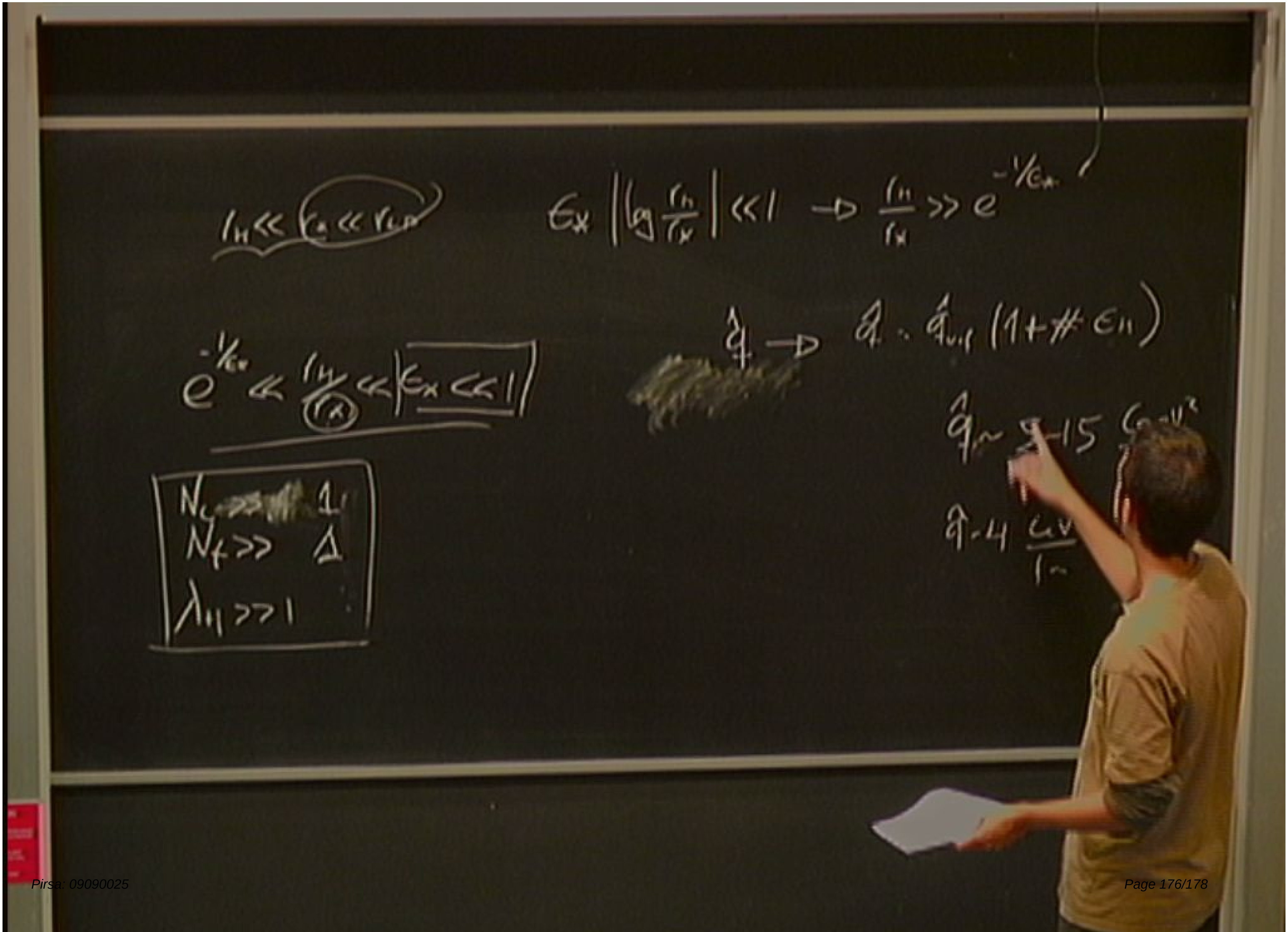
$$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \boxed{\epsilon_* \ll 1}$$

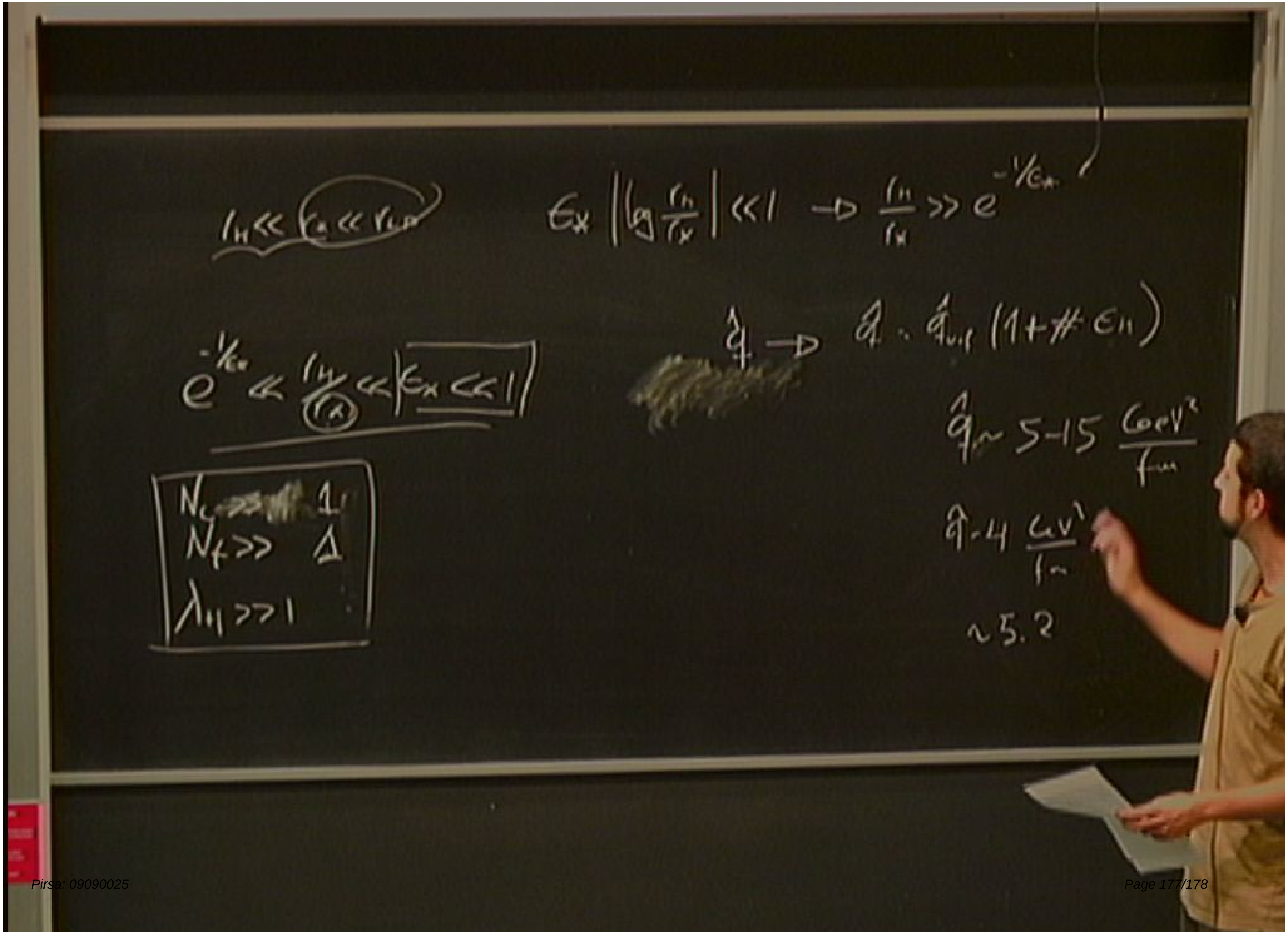
$$\hat q \longrightarrow \hat q \sim \hat q_{vis} \left(1 + \# \epsilon_H\right)$$

$$\hat q \sim 5\text{–}15 \; \frac{GeV^2}{fm}$$

$$\boxed{\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_H \gg 1 \end{array}}$$


$r_H \ll r_* \ll r_{UV}$
$\epsilon_* \left|\log \frac{r_H}{r_*}\right| \ll 1 \to \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$
$\hat{q} \to \hat{q} = \hat{q}_{N=4}(1 + \# \epsilon_H)$
$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \boxed{\epsilon_* \ll 1}$
$N_c \gg 1$
$N_f \gg 1$
$\lambda_H \gg 1$
$\hat{q}_{fit} \sim 5\text{-}15 \ \frac{GeV^2}{fm}$
$\hat{q} \sim 4 \ \frac{GeV^2}{fm}$





$r_H \ll r_* \ll r_{UV}$
$\epsilon_* \left|\log \frac{r_H}{r_*}\right| \ll 1 \to \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$
$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \epsilon_* \ll 1$
$\hat{q} \to \hat{q} \sim \hat{q}\,(1 + \#\,\epsilon_H)$
$\hat{q} \sim 5\text{-}15\ \frac{GeV^2}{fm}$
$\hat{q} \sim 4\ \frac{GeV^2}{fm}$
~ 5.2
$N_c \gg 1$
$N_f \gg 1$
$\lambda_H \gg 1$

$r_H \ll r_* \ll r_{UV}$

$\epsilon_* \left| \log \frac{r_H}{r_*} \right| \ll 1 \to \frac{r_H}{r_*} \gg e^{-1/\epsilon_*}$

$e^{-1/\epsilon_*} \ll \frac{r_H}{r_*} \ll \boxed{\epsilon_* \ll 1}$

$$\boxed{\begin{array}{l} N_c \gg 1 \\ N_f \gg \Delta \\ \lambda_H \gg 1 \end{array}}$$

$\hat{q} \to \hat{q} = \hat{q}_{UV}(1 + \# \epsilon_H)$

$\hat{q} \sim 5\text{-}15 \frac{GeV^2}{fm}$

$\hat{q} \sim 4 \frac{GeV^2}{fm}$

~ 5.2