Title: Cosmology Review - Lecture 4

Date: Jan 27, 2011 11:30 AM

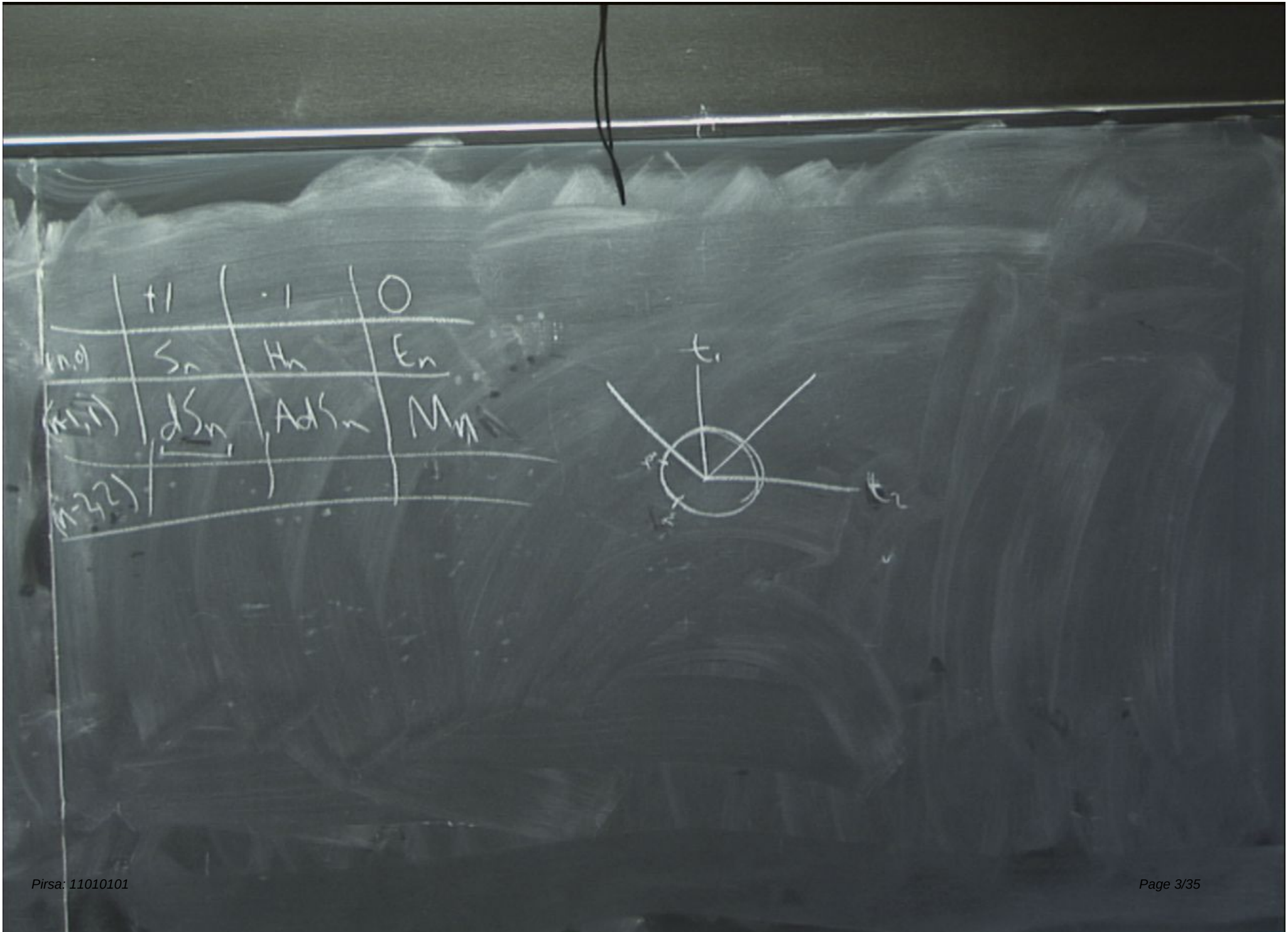
URL: http://pirsa.org/11010101

Abstract:

n-dim (p,q) , $K = \pm, 0$, ρ

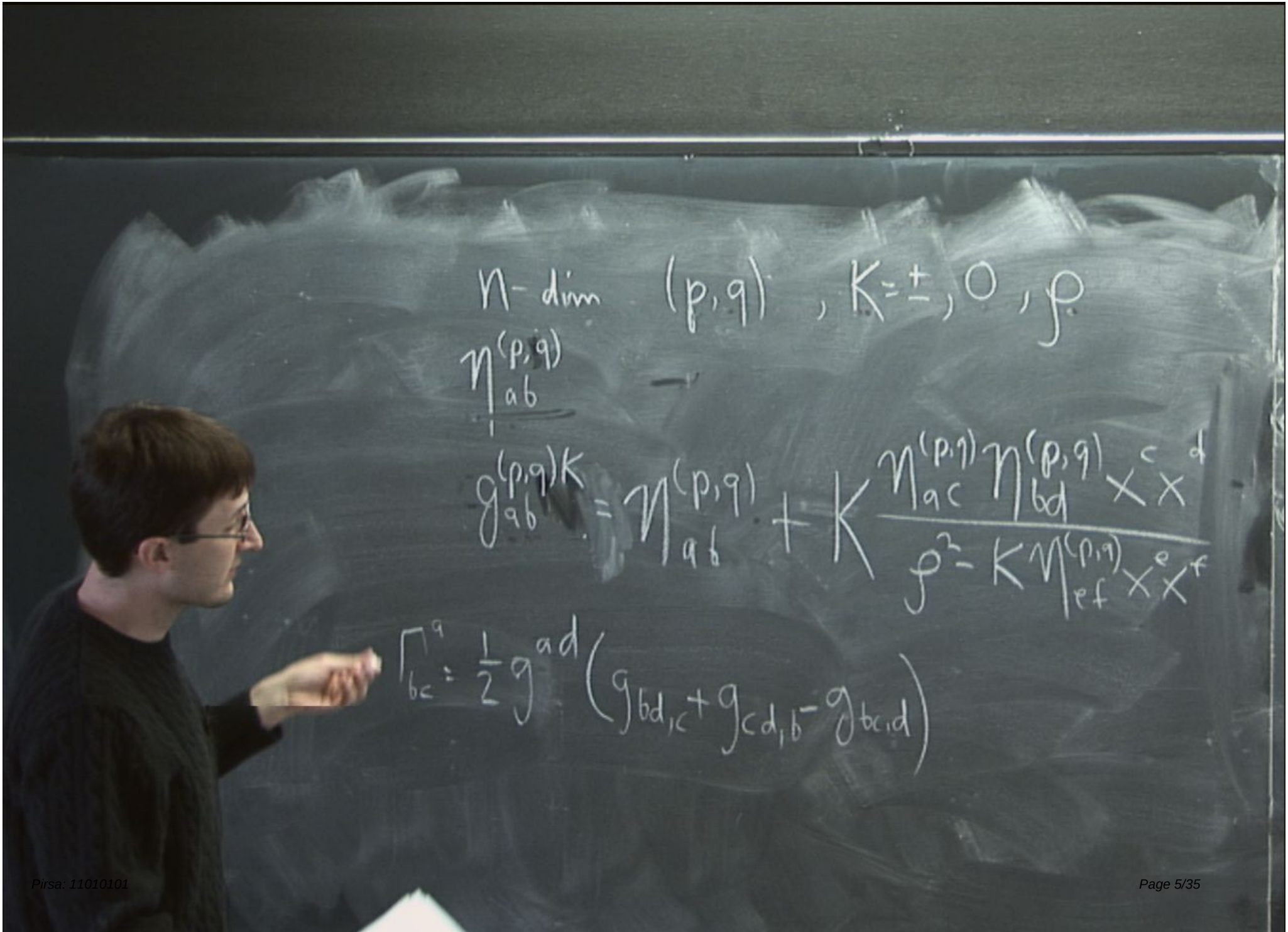
$\eta^{(p,q)}_{ab}$

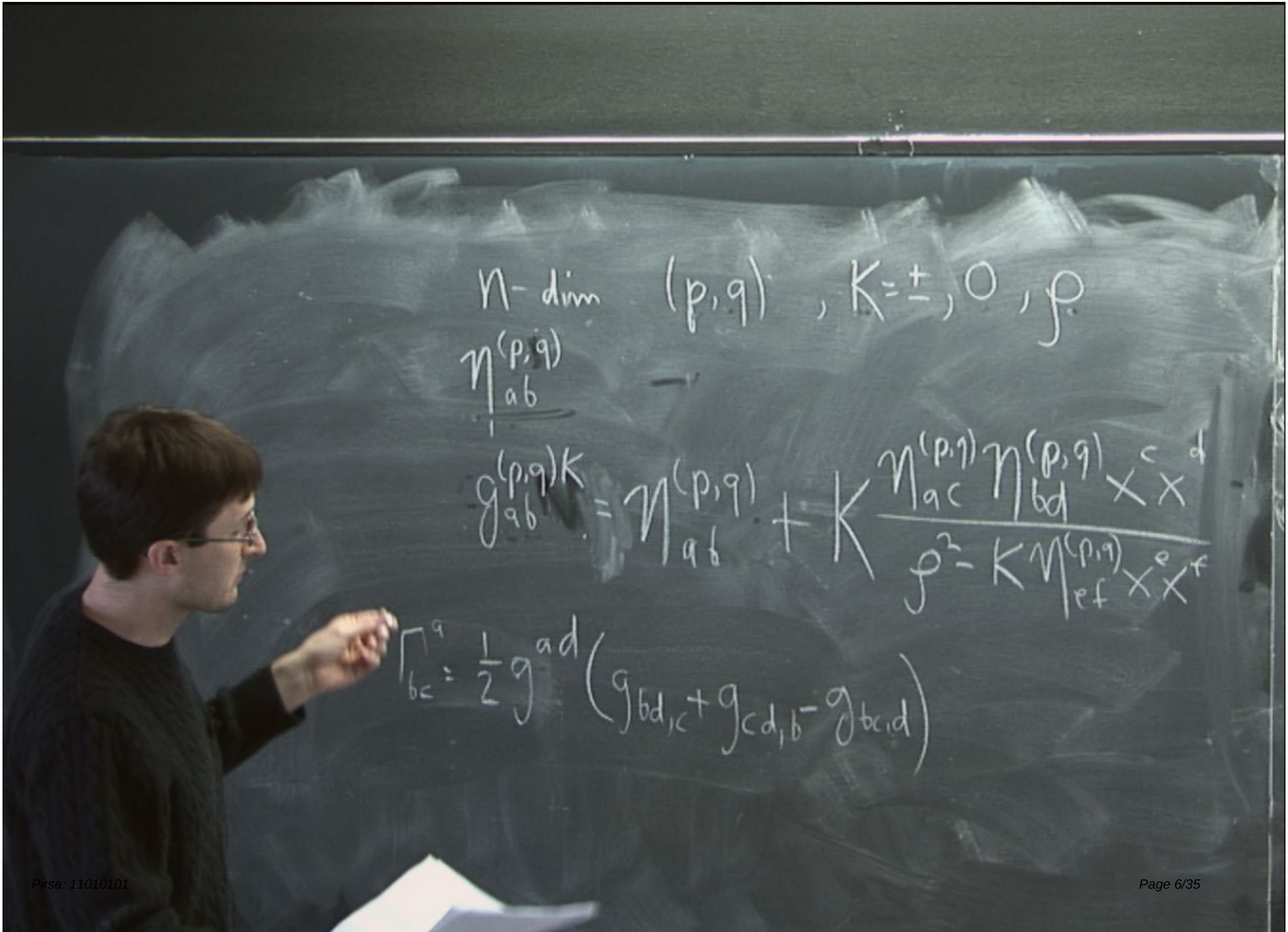
$$g^{(p,q)K}_{ab} = \eta^{(p,q)}_{ab} + K \frac{\eta^{(p,q)}_{ac}\eta^{(p,q)}_{bd} x^c x^d}{\rho^2 - K \eta^{(p,q)}_{ef} x^e x^f}$$


+1
-1
0
S_n
H_n
E_n
dS_n
AdS_n
M_n
t_1
t_2

	+1	-1	0
(n,0)	S_n	H_n	E_n
(n-1,1)	dS_n	AdS_n	M_n
(n-2,2)			

$$R_{abcd} = \frac{K}{\rho^2}\left(g_{ac}g_{bd} - g_{ad}g_{bc}\right)$$


n - dim (p, q) , K = ±, 0 , ρ
$\eta^{(p,q)}_{ab}$
$g^{(p,q)K}_{ab} = \eta^{(p,q)}_{ab} + K\frac{\eta^{(p,q)}_{ac}\eta^{(p,q)}_{bd}x^c x^d}{\rho^2 - K\eta^{(p,q)}_{ef}x^e x^f}$
$\Gamma^a_{bc} = \frac{1}{2}g^{ad}\left(g_{bd,c} + g_{cd,b} - g_{bc,d}\right)$


n - dim (p, q) , K = ±, 0 , ρ
$\eta^{(p,q)}_{ab}$
$g^{(p,q)K}_{ab} = \eta^{(p,q)}_{ab} + K\frac{\eta^{(p,q)}_{ac}\eta^{(p,q)}_{bd}x^c x^d}{\rho^2 - K\eta^{(p,q)}_{ef}x^e x^f}$
$\Gamma^a_{bc} = \frac{1}{2}g^{ad}\left(g_{bd,c} + g_{cd,b} - g_{bc,d}\right)$

n-dim (p,q) , $K = \pm, 0$, ρ

$g^{ab} g_{bc} = \delta^a_c$ $\quad \eta^{(p,q)}_{ab}$

$$g^{(p,q)K}_{ab} = \eta^{(p,q)}_{ab} + K \frac{\eta^{(p,q)}_{ac} \eta^{(p,q)}_{bd} x^c x^d}{\rho^2 - K \eta^{(p,q)}_{ef} x^e x^f}$$

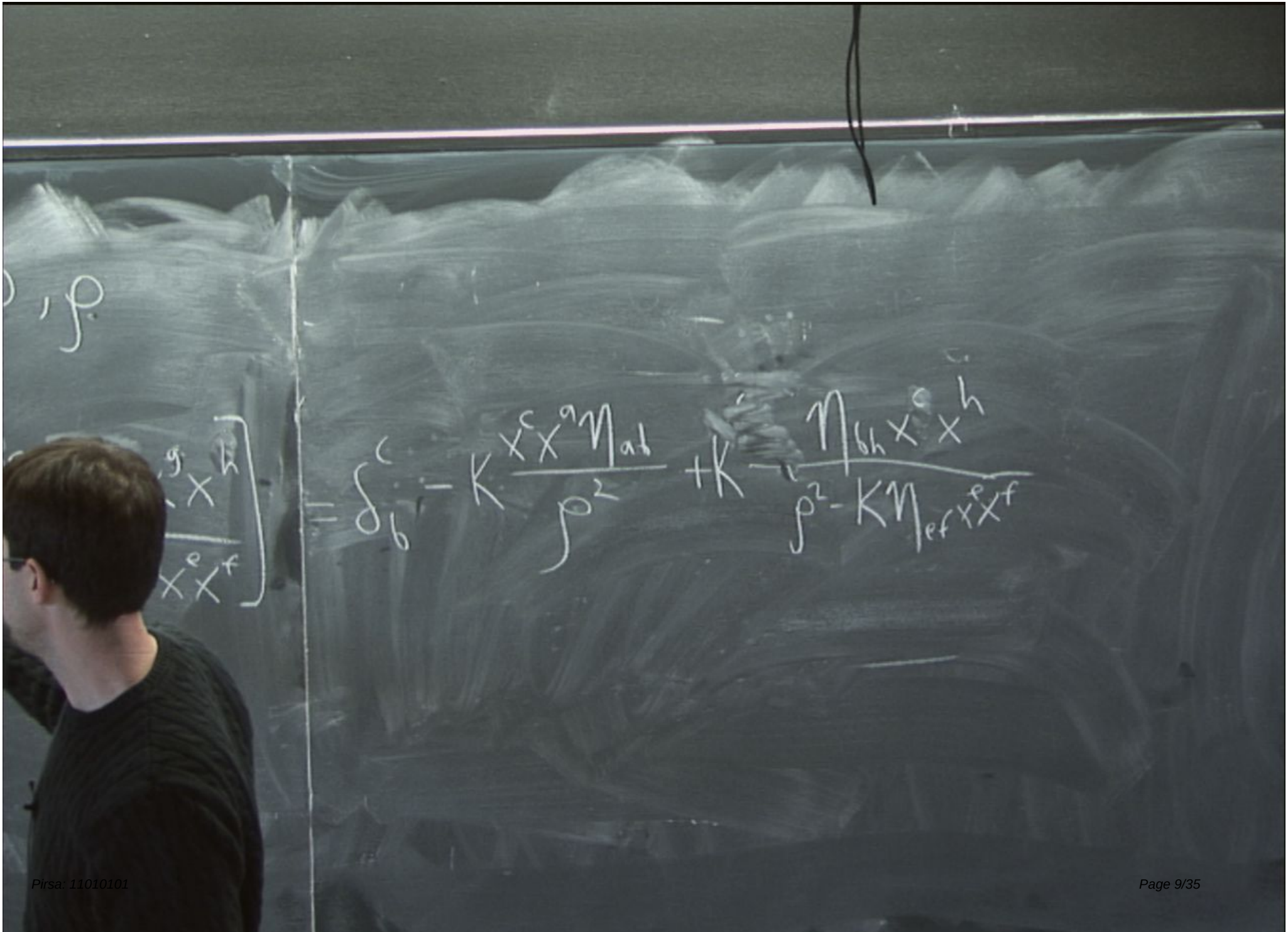
$$\Gamma^a_{bc} = \frac{1}{2} g^{ad} \left(g_{bd,c} + g_{cd,b} - g_{bc,d} \right)$$

n-dim (p,q) , $K = \pm, 0$, ρ

$g^{ca} g_{ab} = \delta^c_b$ $\quad \eta^{(p,q)}_{ab}$

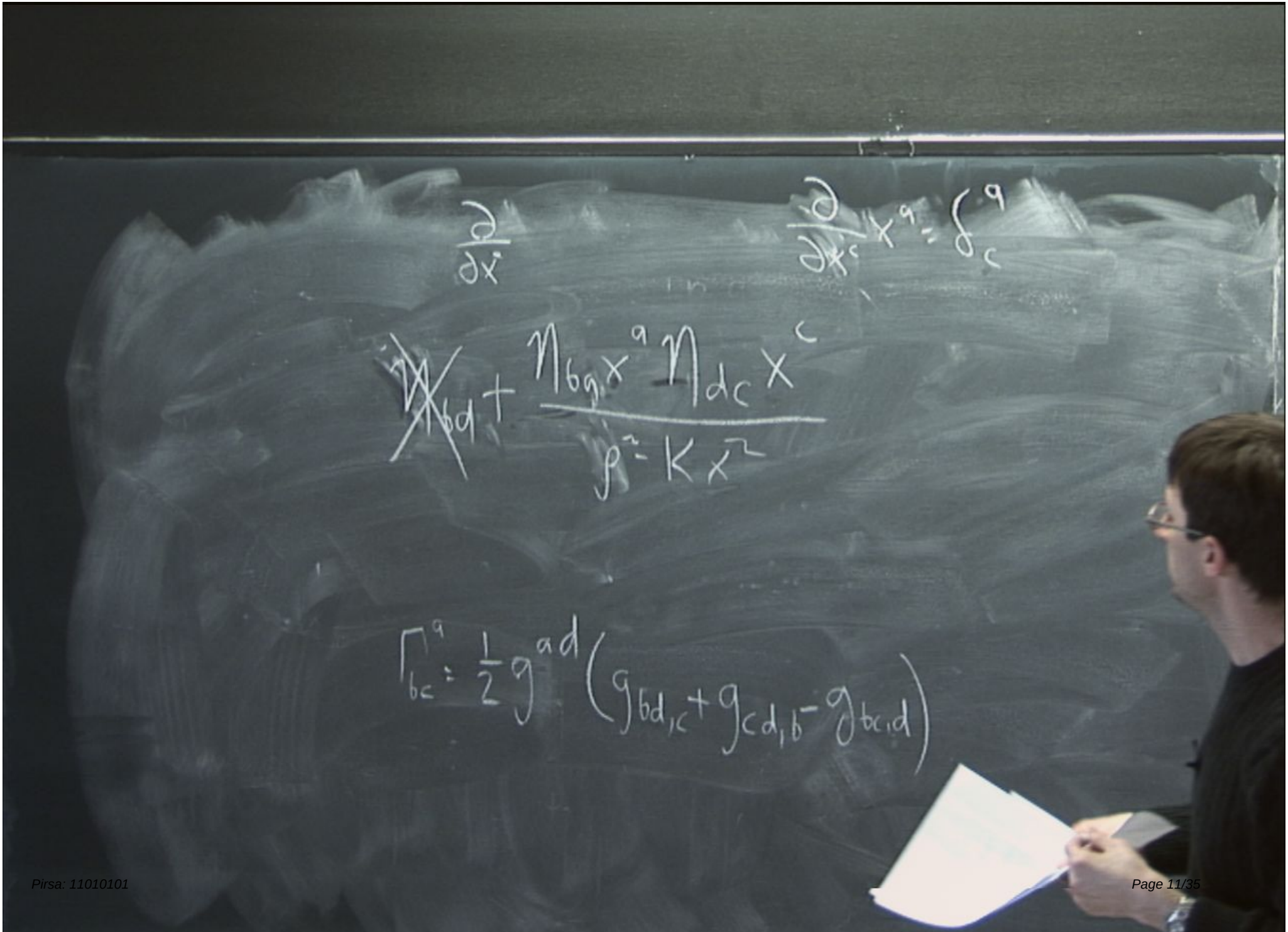
$$\left(\eta^{ca} - K\frac{x^c x^a}{\rho^2}\right)\left[\eta_{ab} + K\frac{\eta_{ac}\eta_{bd}x^c x^d}{\rho^2 - K\eta_{ef}x^e x^f}\right]$$

$$\Gamma^a_{bc} = \frac{1}{2} g^{ad}\left(g_{bd,c} + g_{cd,b} - g_{bc,d}\right)$$


ρ
$= \delta^c_b - K\frac{x^c x^a \eta_{ab}}{\rho^2} + K\frac{\eta_{bh} x^c x^h}{\rho^2 - K\eta_{ef}x^e x^f}$

$$x^2 = \eta_{ab} x^a x^b$$

$$\frac{\partial x^c}{\partial x^b} = \delta^c_b - K\frac{x^c x^a \eta_{ab}}{\rho^2} + K\frac{\eta_{bh} x^c x^h}{\rho^2 - K x^2} + \frac{\eta_{gh} x^g x^h x^c x^b}{\rho^2(\rho^2 - K x^2)}$$


$\frac{\partial}{\partial x^a}$
$\frac{\partial}{\partial x^c} x^q = \delta^q_c$
$\eta_{bd} + \frac{\eta_{bq} x^q \eta_{dc} x^c}{\rho^2 = K x^2}$
$\Gamma^q_{bc} = \frac{1}{2} g^{ad} \left(g_{bd,c} + g_{cd,b} - g_{bc,d} \right)$

$$\frac{\partial}{\partial x^c}\qquad \frac{\partial}{\partial x^c}x^a = \delta^a_c$$

$$\eta_{bd,c} + \left(\frac{\eta_{ba}x^a\eta_{de}x^e}{\rho^2 - Kx^2}\right)_{,c} = \frac{\eta_{ba}\delta^a_c\eta_{de}x^e + \eta_{ba}x^a\eta_{de}\delta^e_c}{\rho^2 - Kx^2}$$

$$\Gamma^a_{bc} = \frac{1}{2}g^{ad}\left(g_{bd,c} + g_{cd,b} - g_{bc,d}\right)$$

$$x^e + \frac{\eta_{ba}x^a\eta_{dc}}{Kx^2} - \frac{\eta_{ba}x^a\eta_{de}x^e}{(\vec{p}\cdot Kx^2)^2}(-K)2x^h\eta_{ch}$$

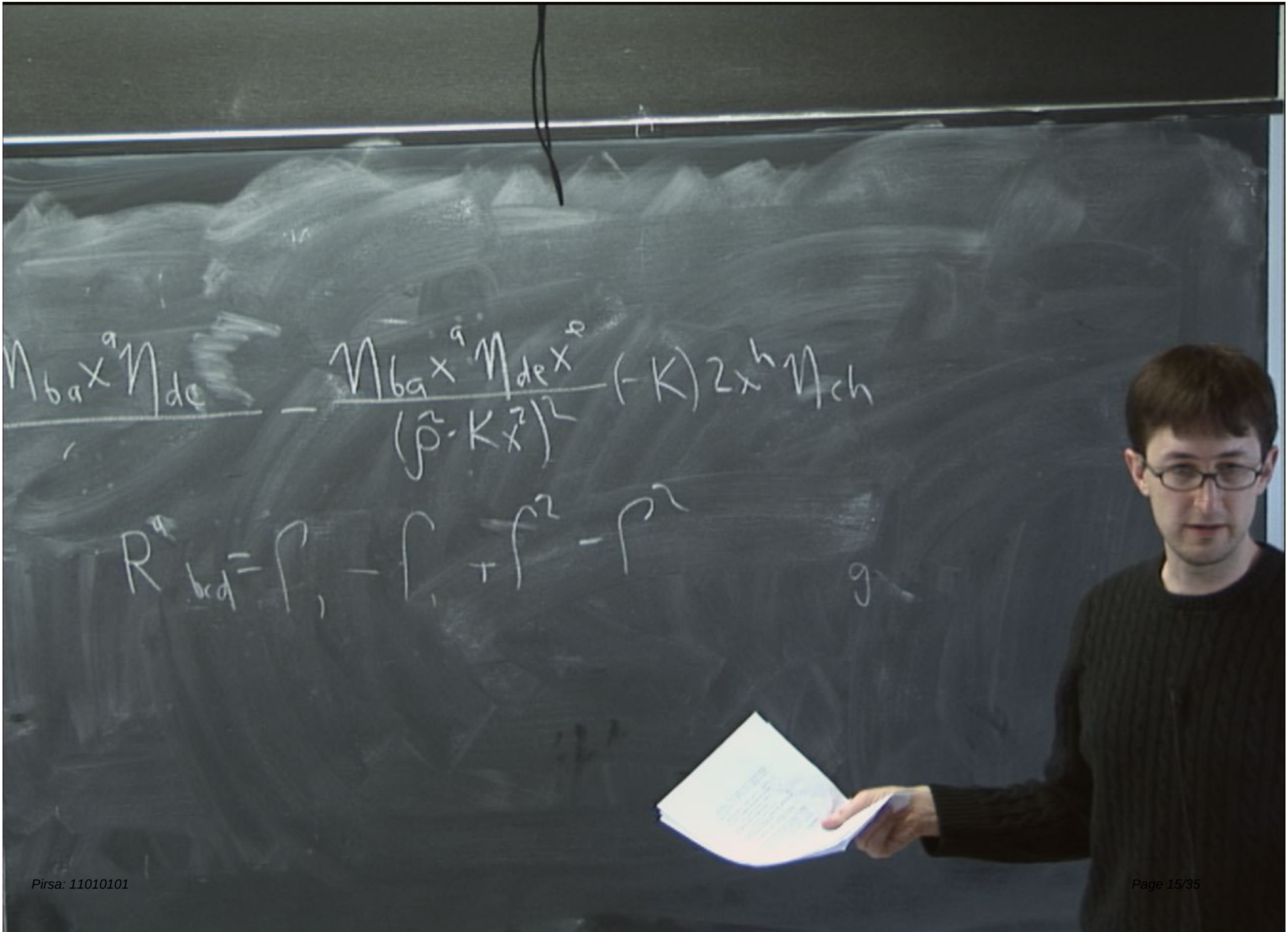
$$\frac{\partial}{\partial x^c}x^g x^h \eta_{gh} = 2x^h\eta_{ch}$$

$$\frac{\partial}{\partial x^c} \qquad \frac{\partial}{\partial x^c} x^a = \delta^a_c$$

$$\cancel{\eta_{bd}} + \left(\frac{\eta_{ba} x^a \eta_{de} x^e}{\rho^2 - K x^2} \right)_{,c} = \frac{\eta_{bc} \eta_{de} x^e + \eta_{ba} x^a \eta_{de}}{\rho^2 - K x^2}$$

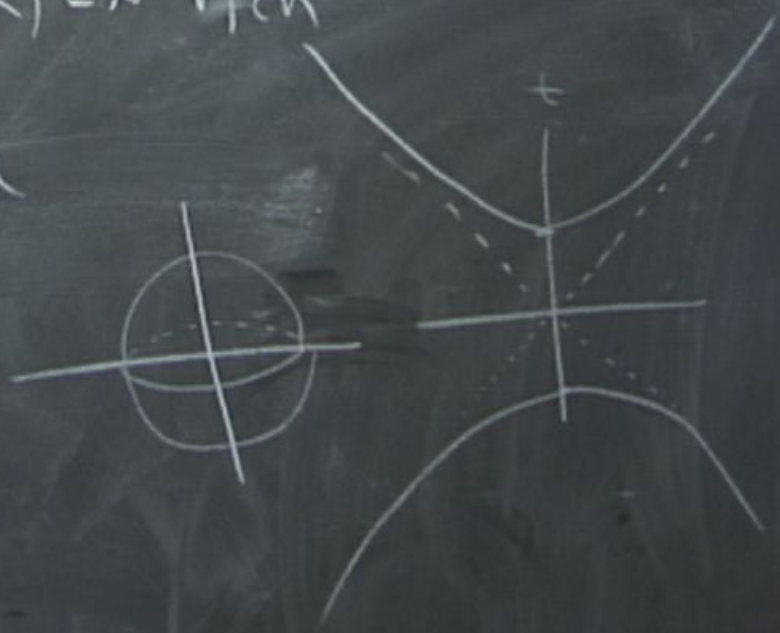
$$R^a{}_{bcd} =$$

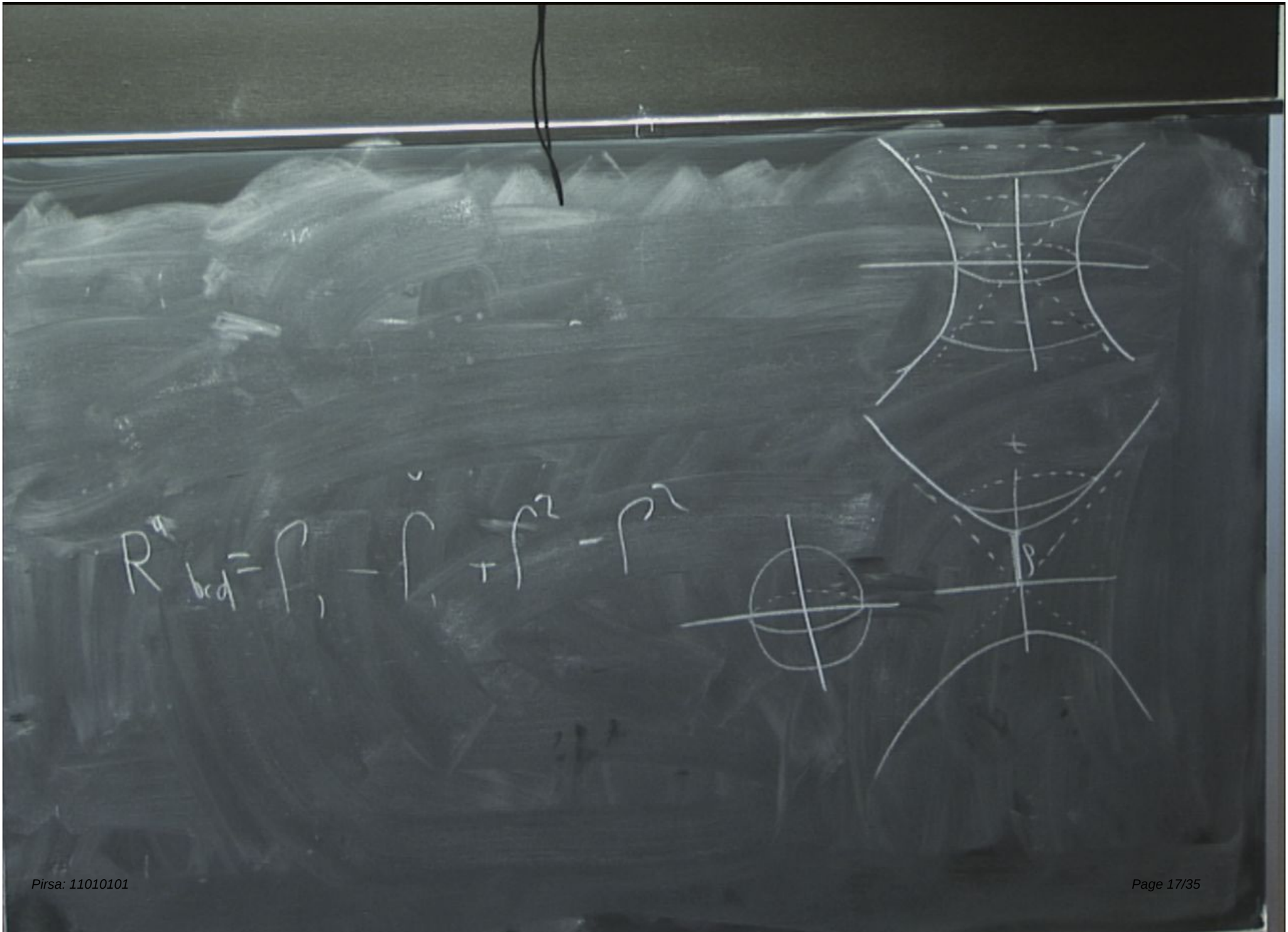
$$\Gamma^a_{bc} = \frac{1}{2} g^{ad} \left(g_{bd,c} + g_{cd,b} - g_{bc,d} \right) = K \frac{x^a}{\rho^2} \frac{g^{(p,q)K}_{bc}}{}$$

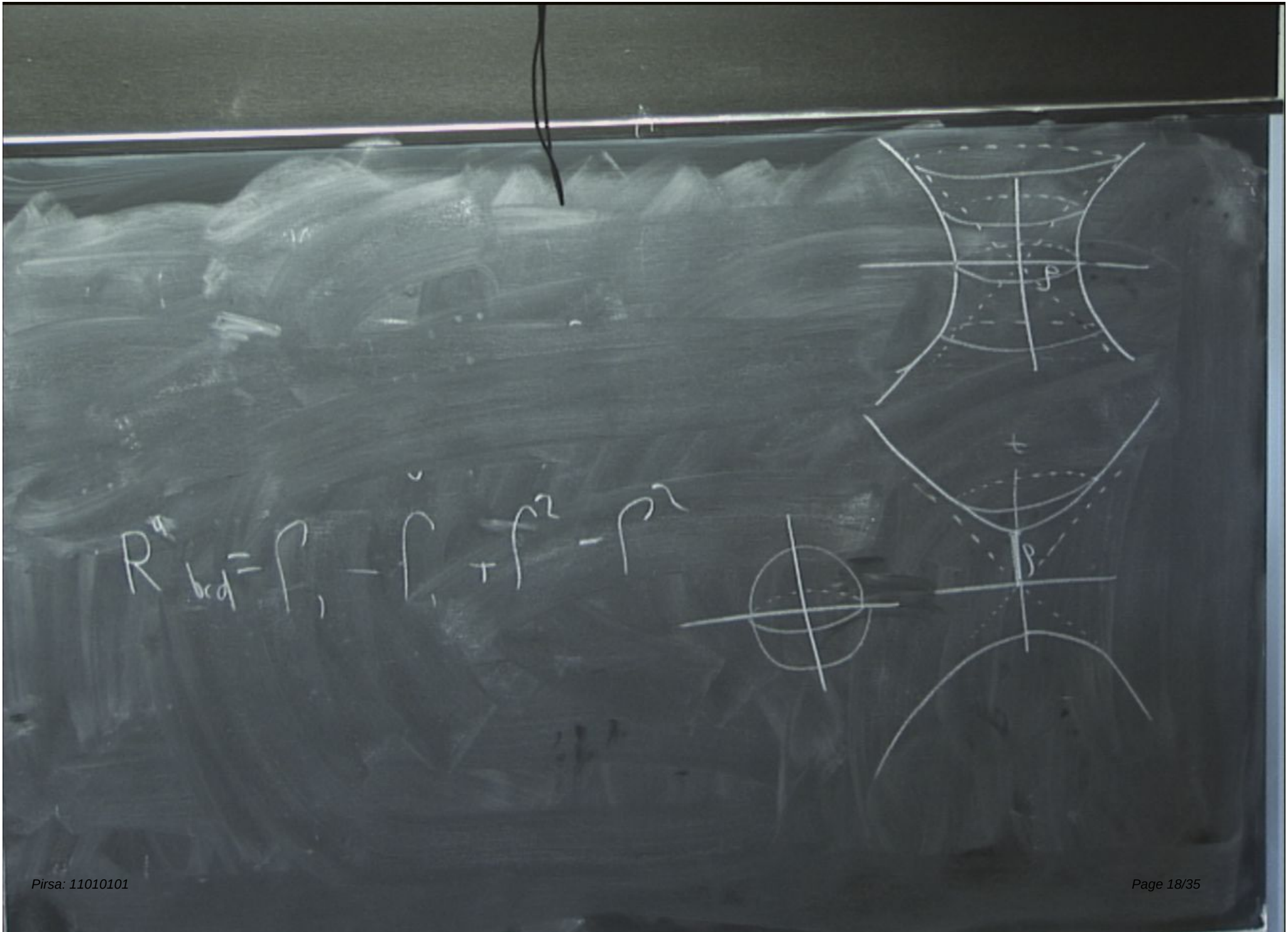

$\eta_{ba}x^a\eta_{dc} - \frac{\eta_{ba}x^a\eta_{dc}x^c}{(\tilde{\rho}\cdot Kx^2)^2}(-K)2x^h\eta_{ch}$
$R^q{}_{bcd} = \Gamma_{,} - \Gamma_{,} + \Gamma^2 - \Gamma^2$
g

$$\frac{\eta_{ba}x^a\eta_{dc}}{} - \frac{\eta_{ba}x^a\eta_{de}x^e}{(\tilde{\rho}\cdot Kx^2)^2}(-K)2x^h\eta_{ch}$$

$$R^a{}_{bcd} = \Gamma_1 - \Gamma_1 + \Gamma^2 - \Gamma^2$$




$R^a{}_{bcd} = \Gamma_{,} - \Gamma_{,} + \Gamma^2 - \Gamma^2$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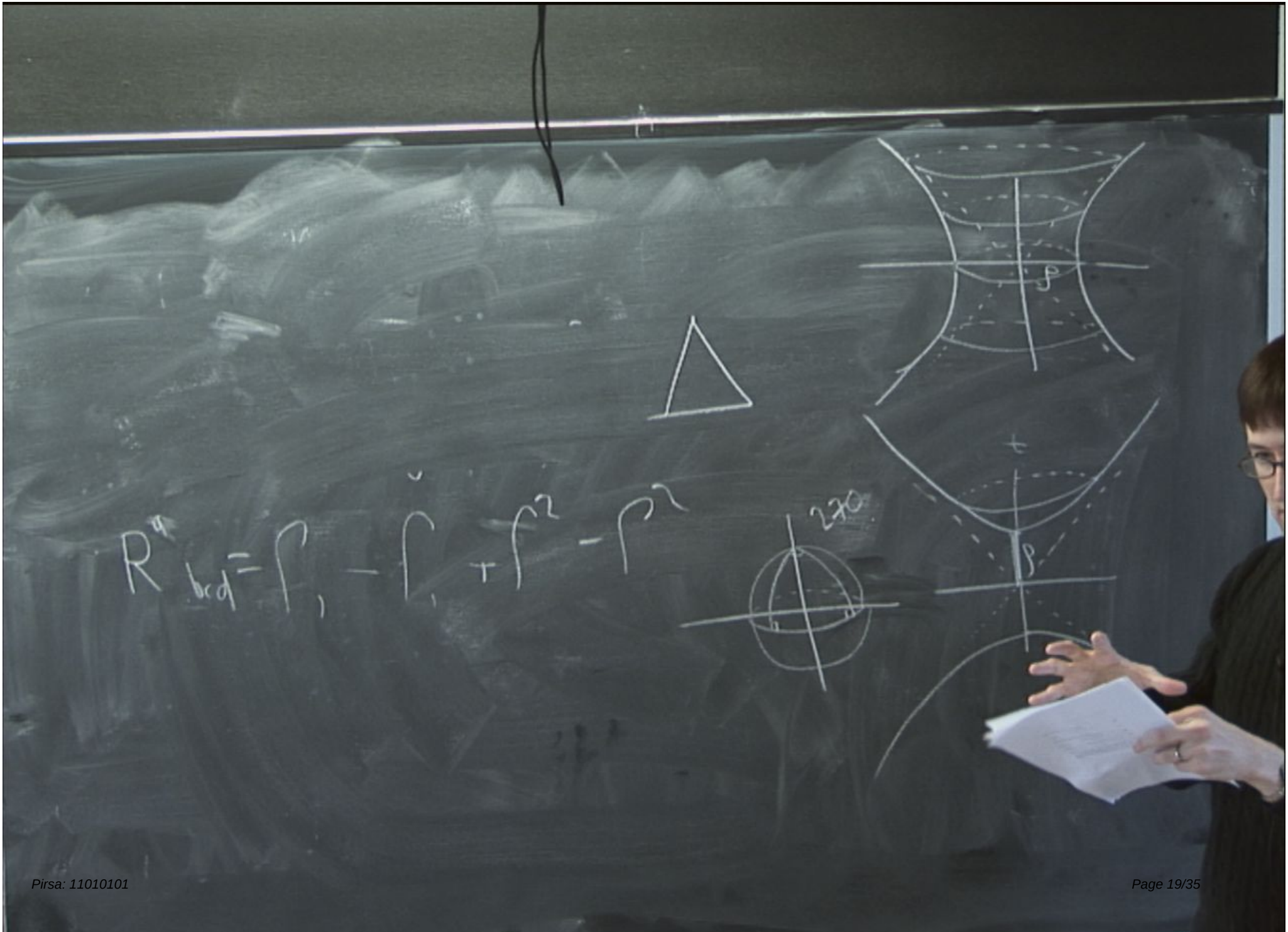
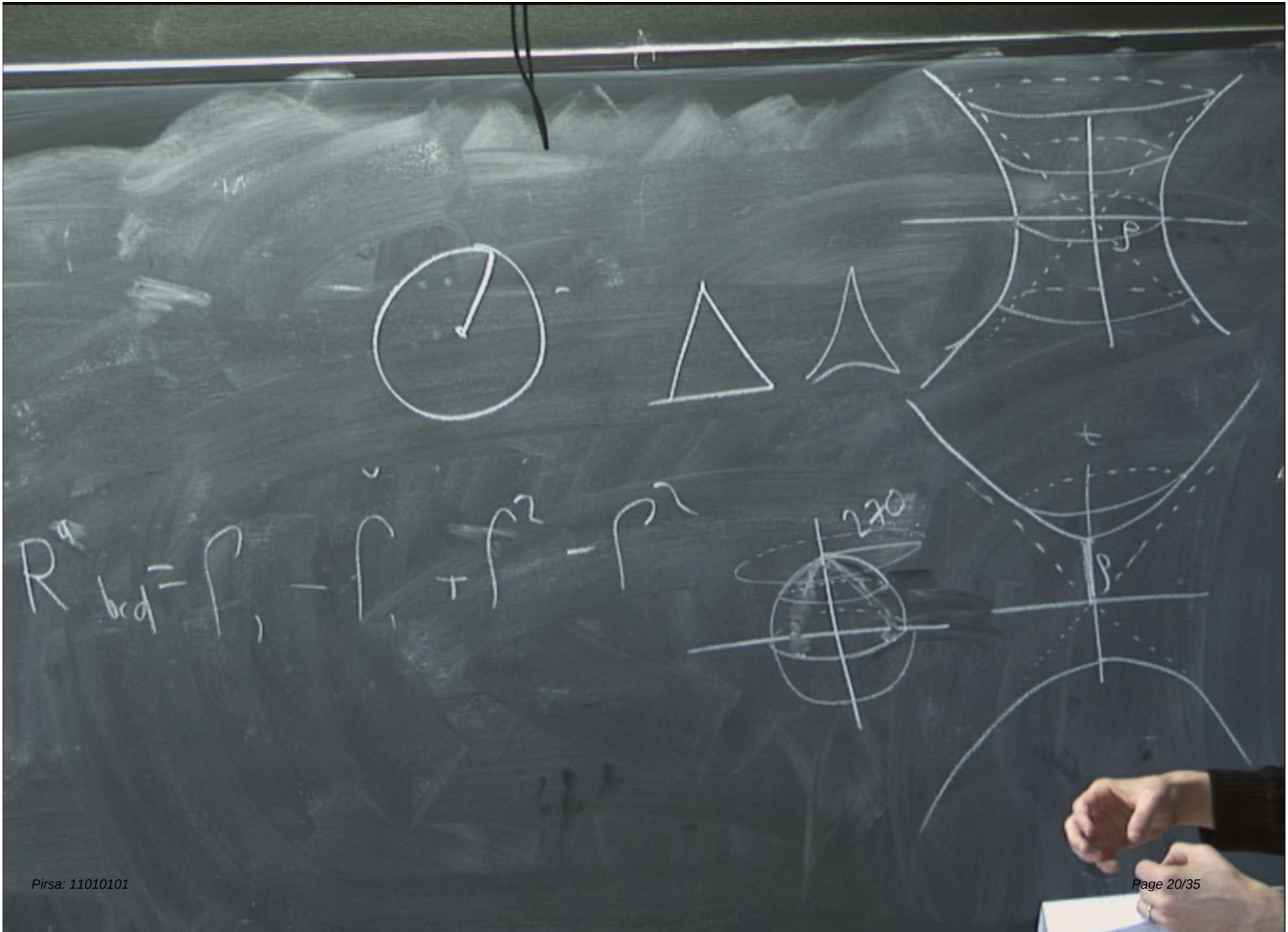
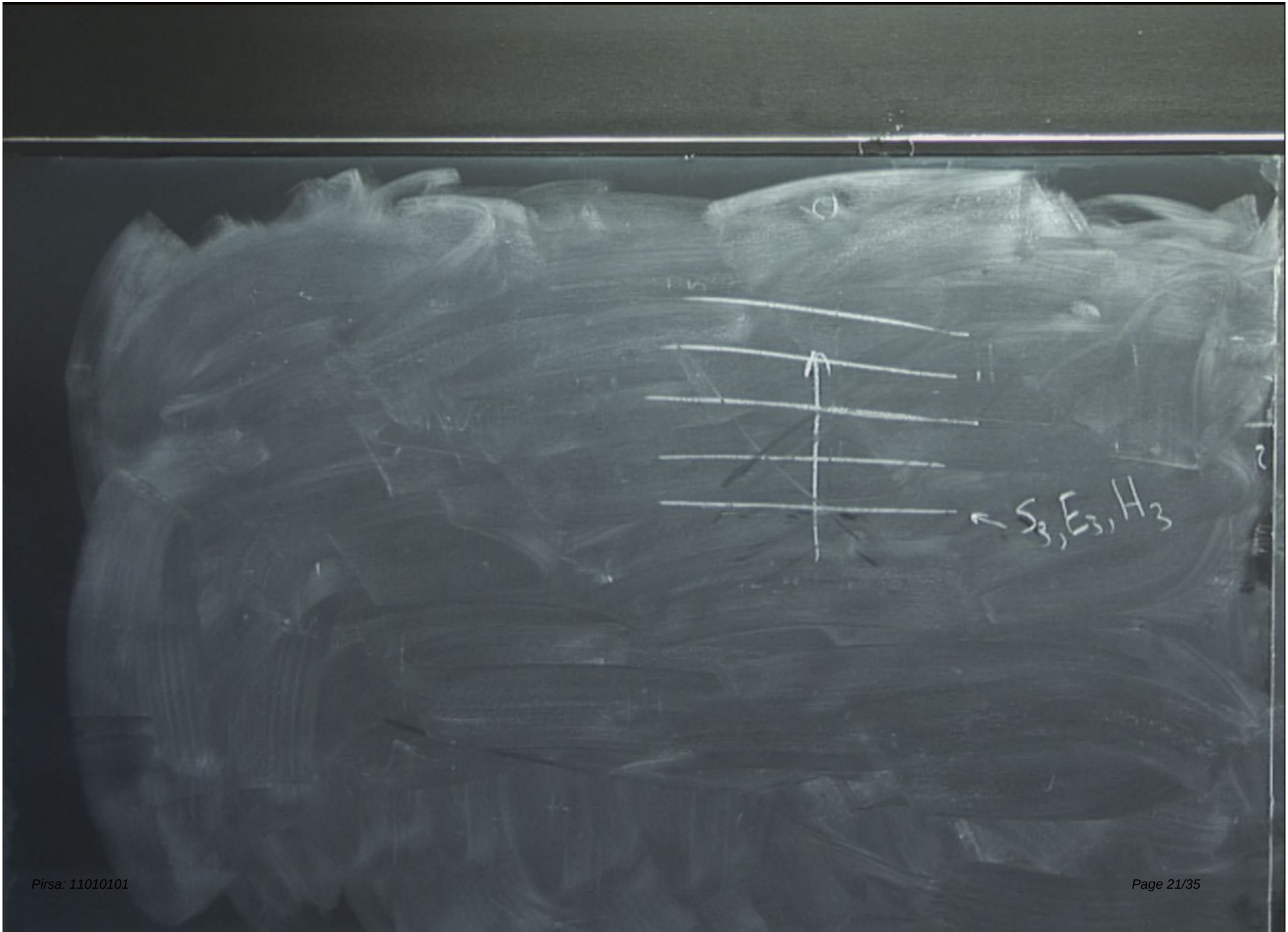
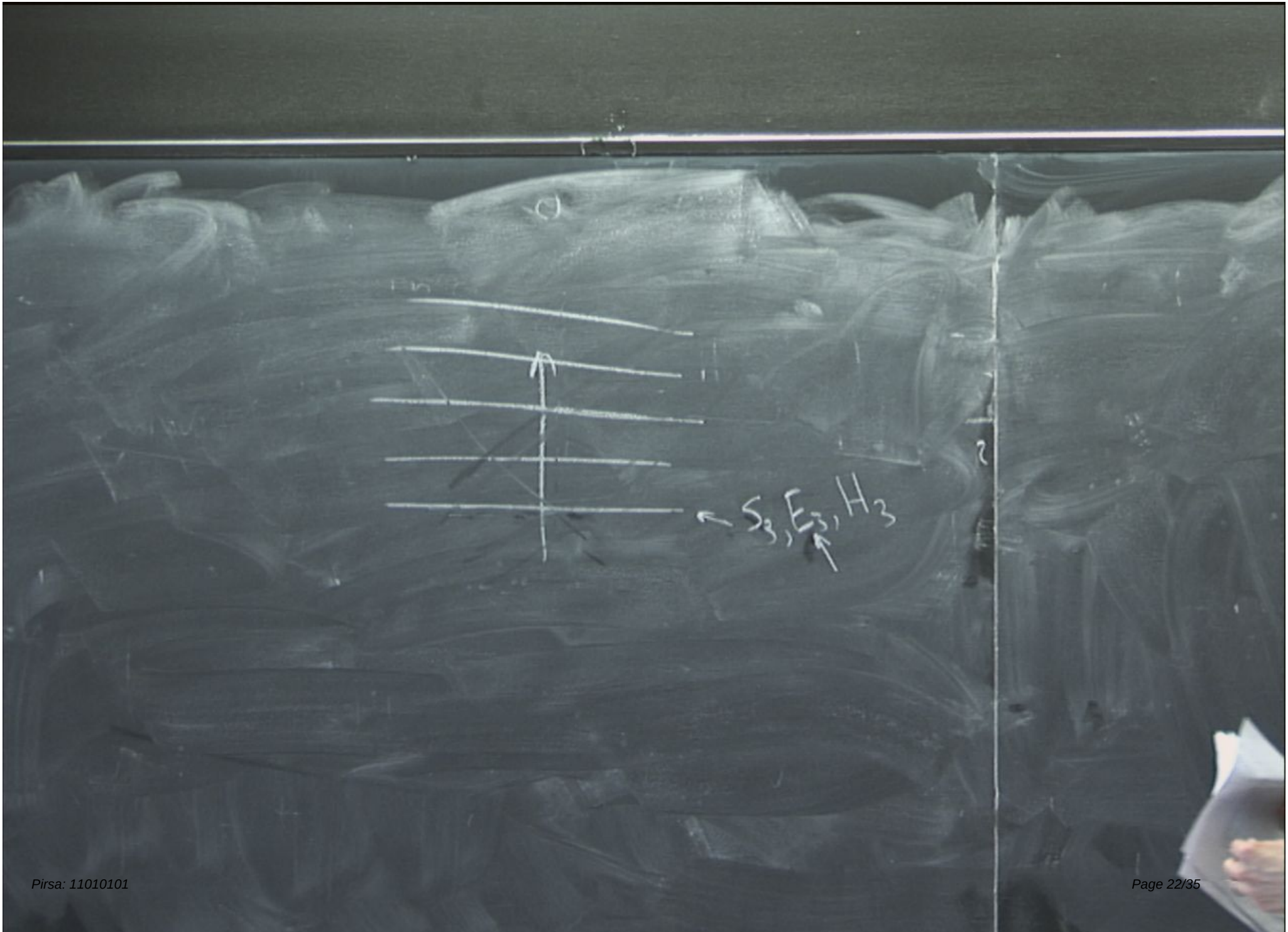
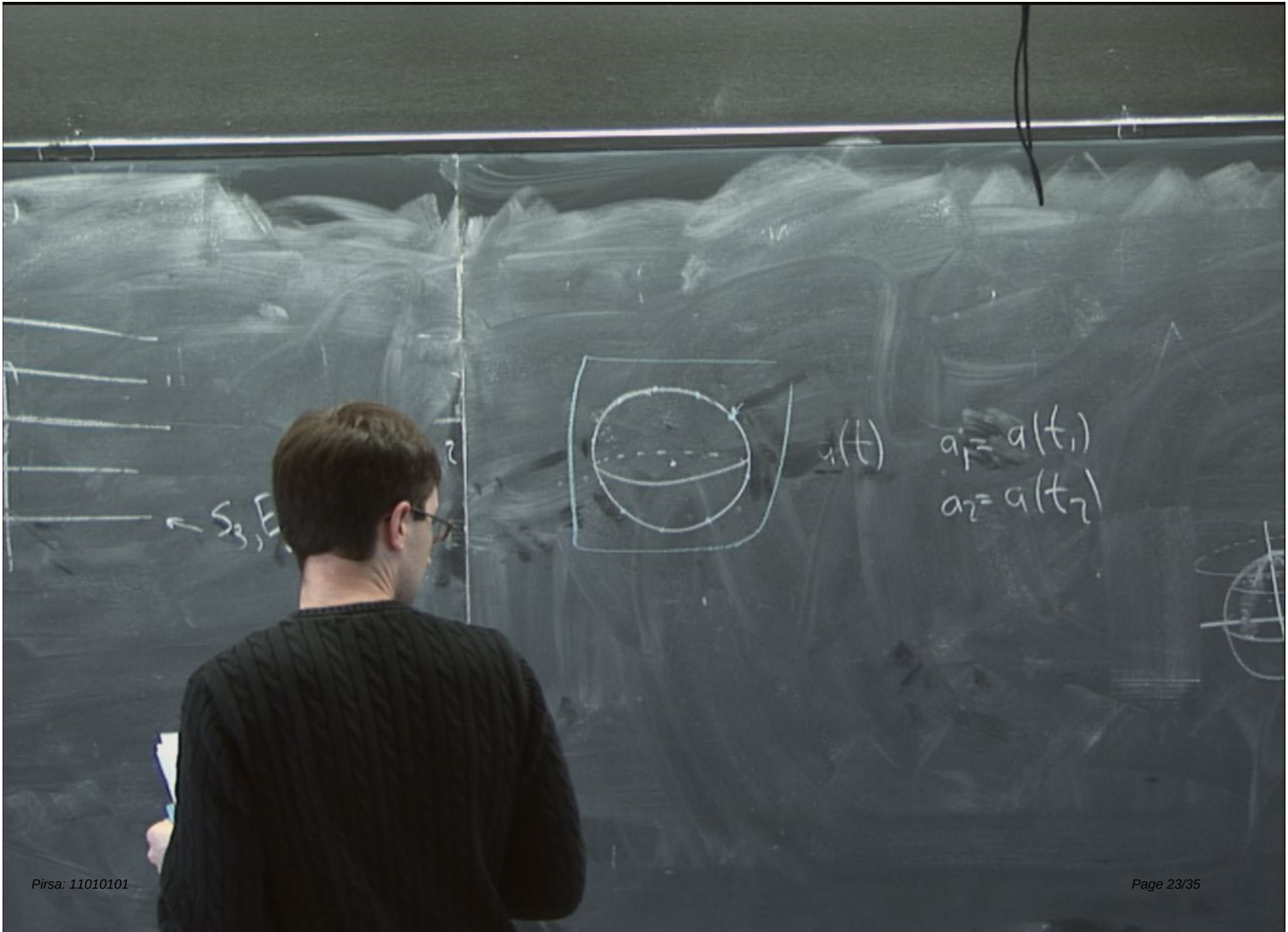
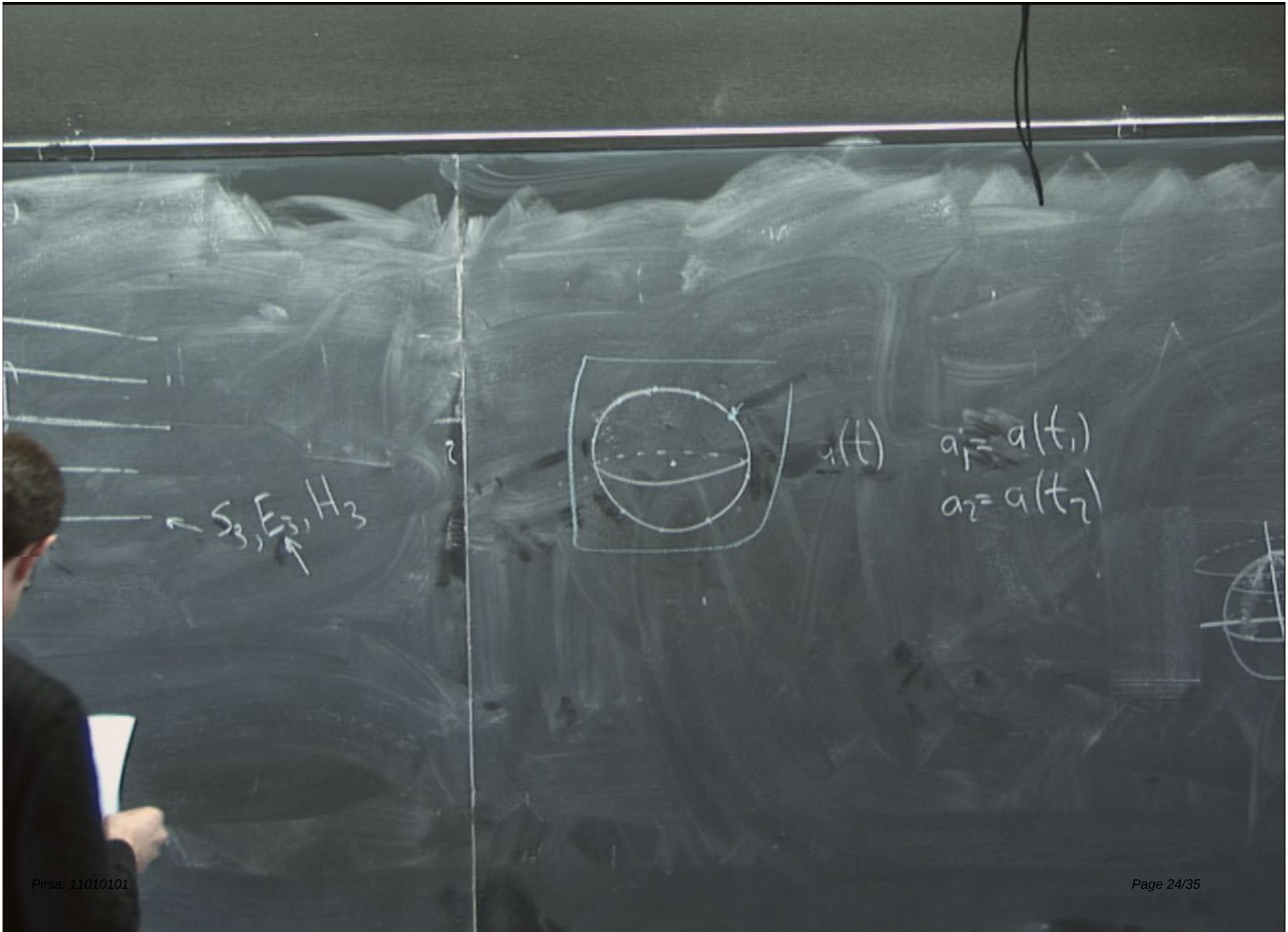

$R^a{}_{bcd} = \Gamma_{,} - \Gamma_{,} + \Gamma^2 - \Gamma^2$
270

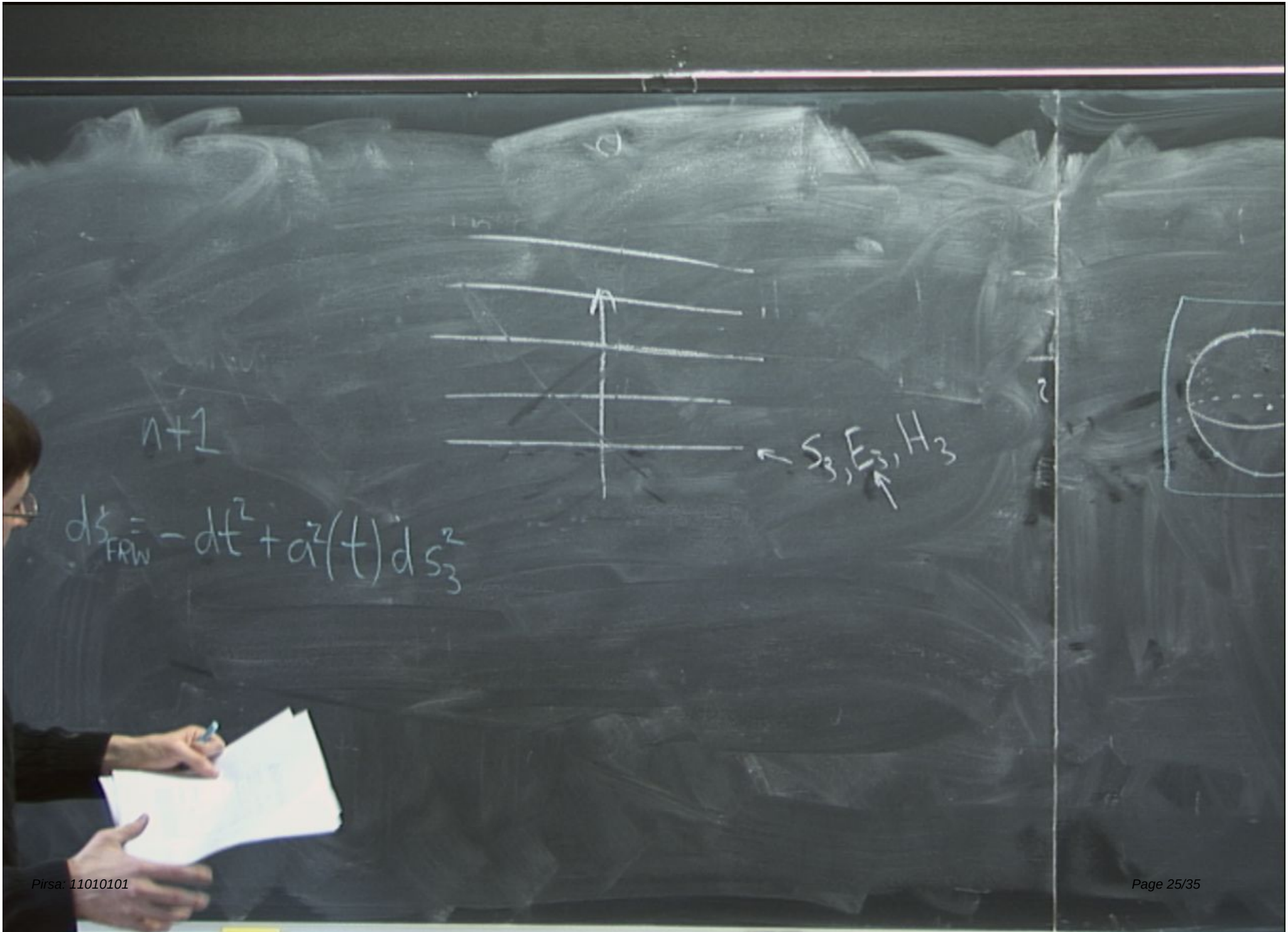

$R^{a}{}_{bcd} = \Gamma_{,} - \Gamma_{,} + \Gamma^{2} - \Gamma^{2}$
270

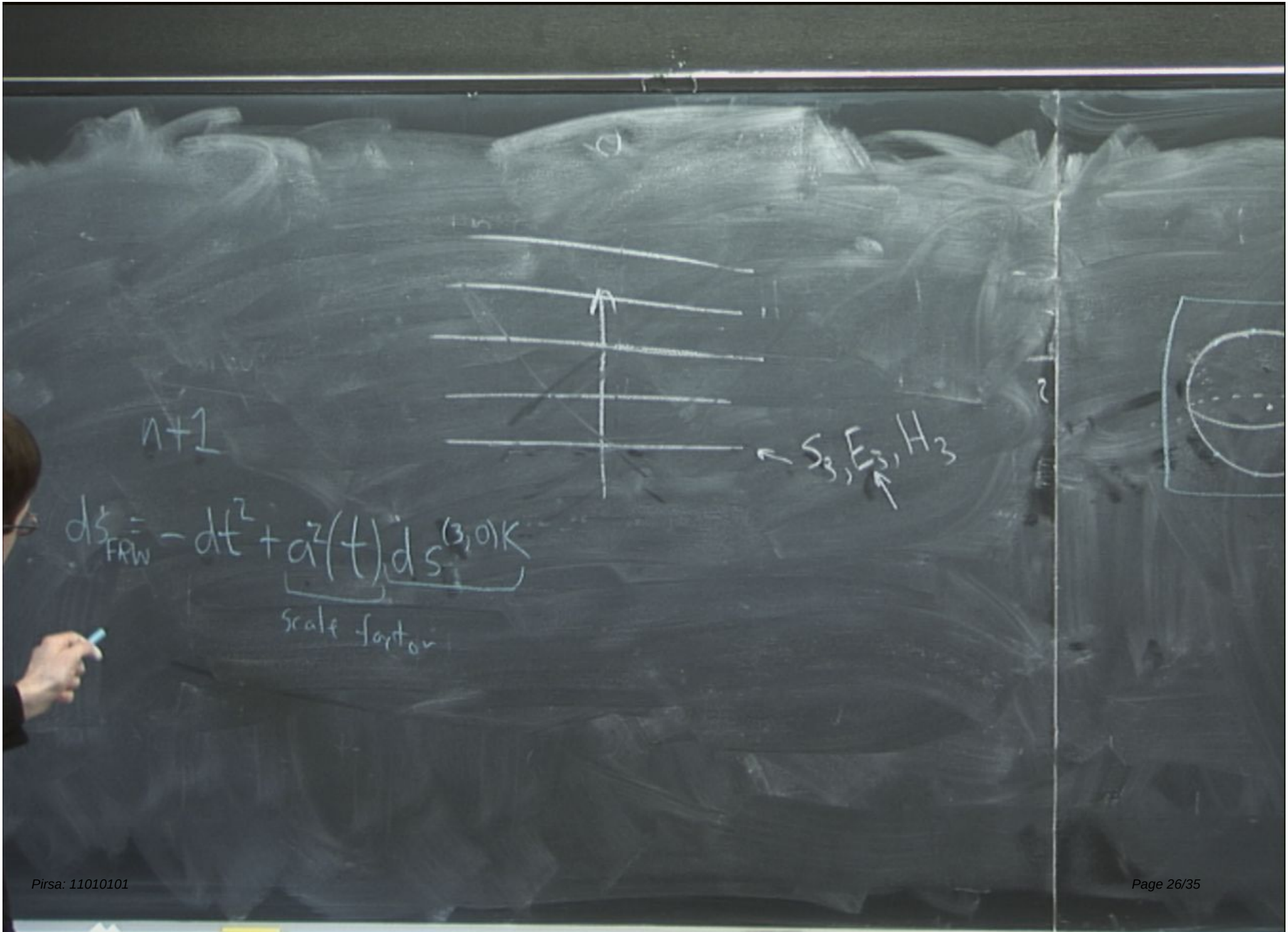

S_3, E_3, H_3

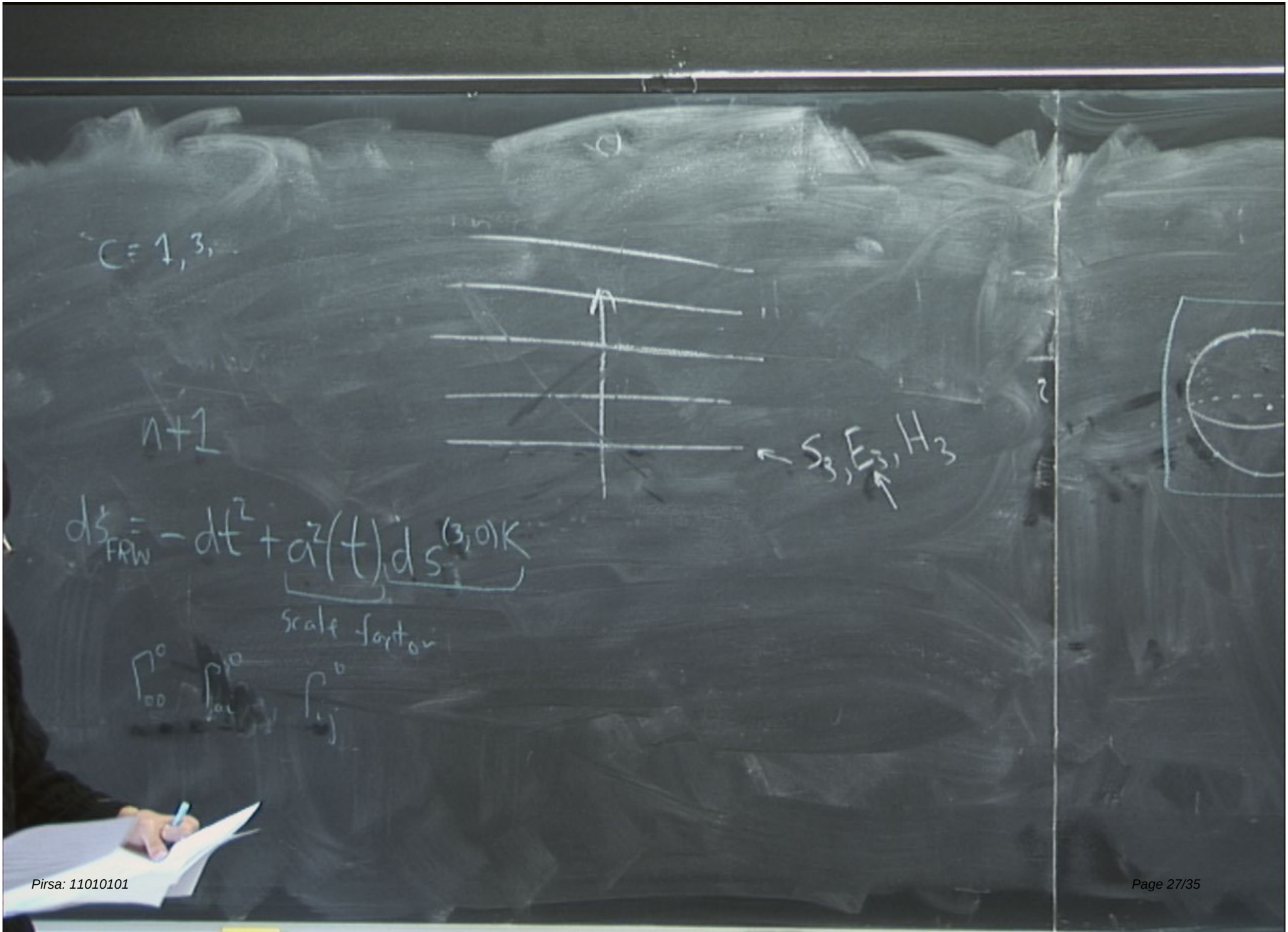

S_3, E_3, H_3


$a_1 = a(t_1)$
$a_2 = a(t_2)$

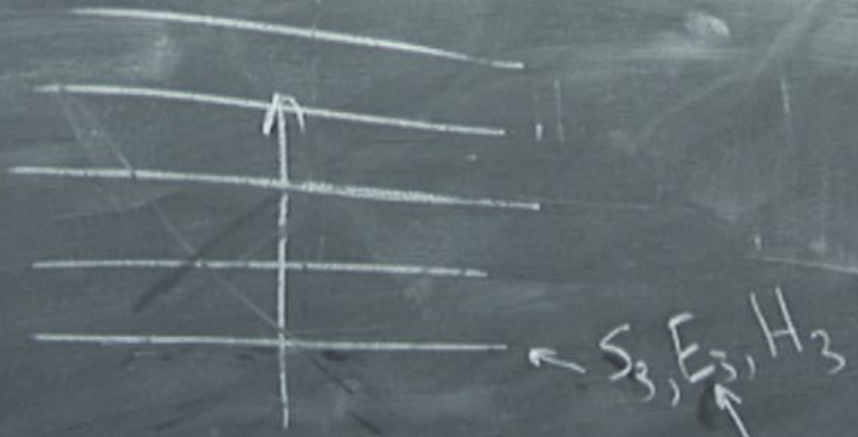

S_3, E_3, H_3
$a_1(t)$
$a_1 = a(t_1)$
$a_2 = a(t_2)$


n+1
S_3, E_3, H_3
$ds^2_{FRW} = -dt^2 + a^2(t) ds_3^2$


n+1
S_3, E_3, H_3
$ds^2_{FRW} = -dt^2 + a^2(t)\, ds^{(3,0)K}$
scale factor


C = 1, 3,
n+1
S_3, E_3, H_3
$ds^2_{FRW} = -dt^2 + a^2(t)\, ds^{(3,0)K}$
scale factor

$C = 1, 3,$



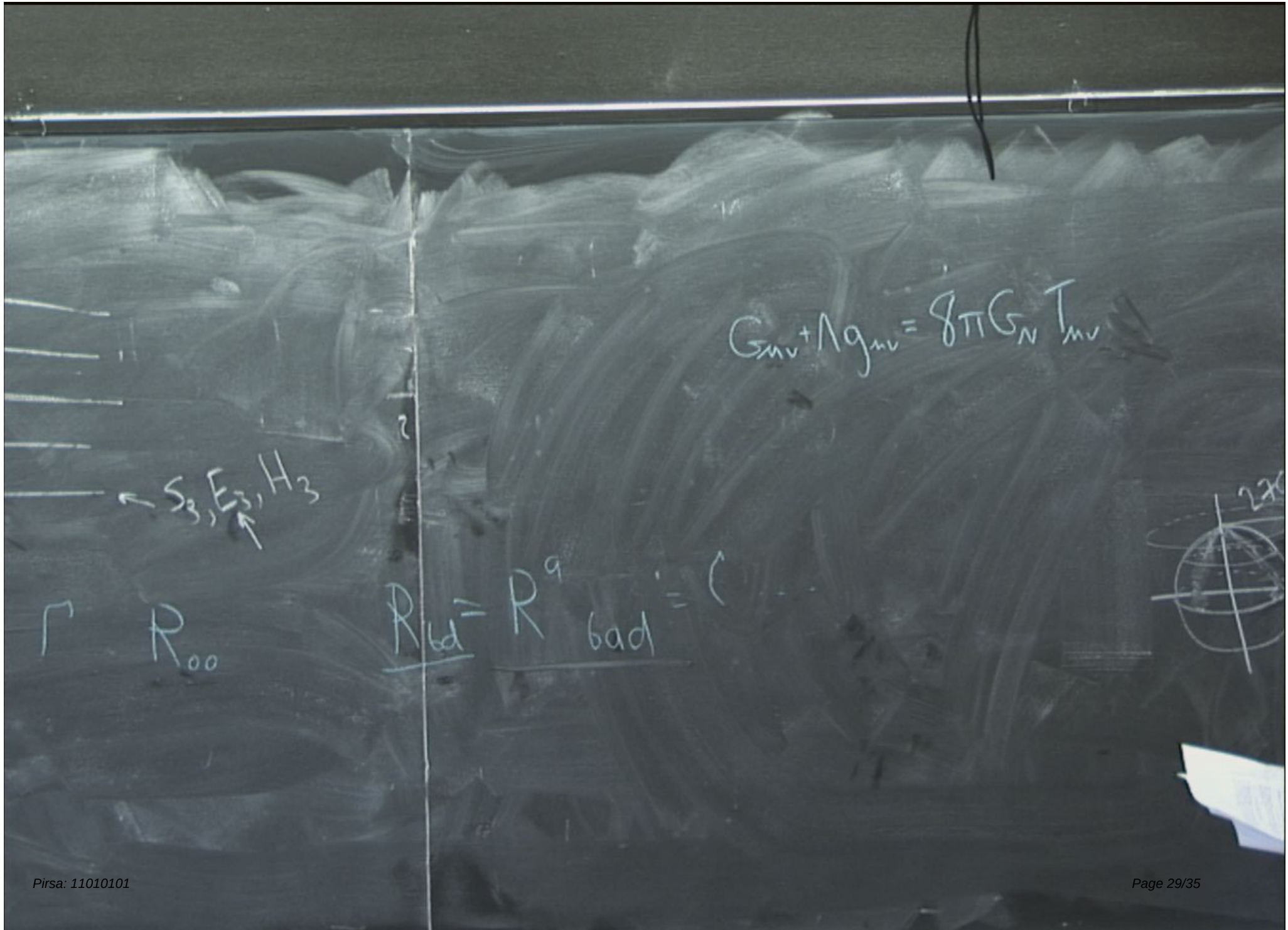
$n+1$

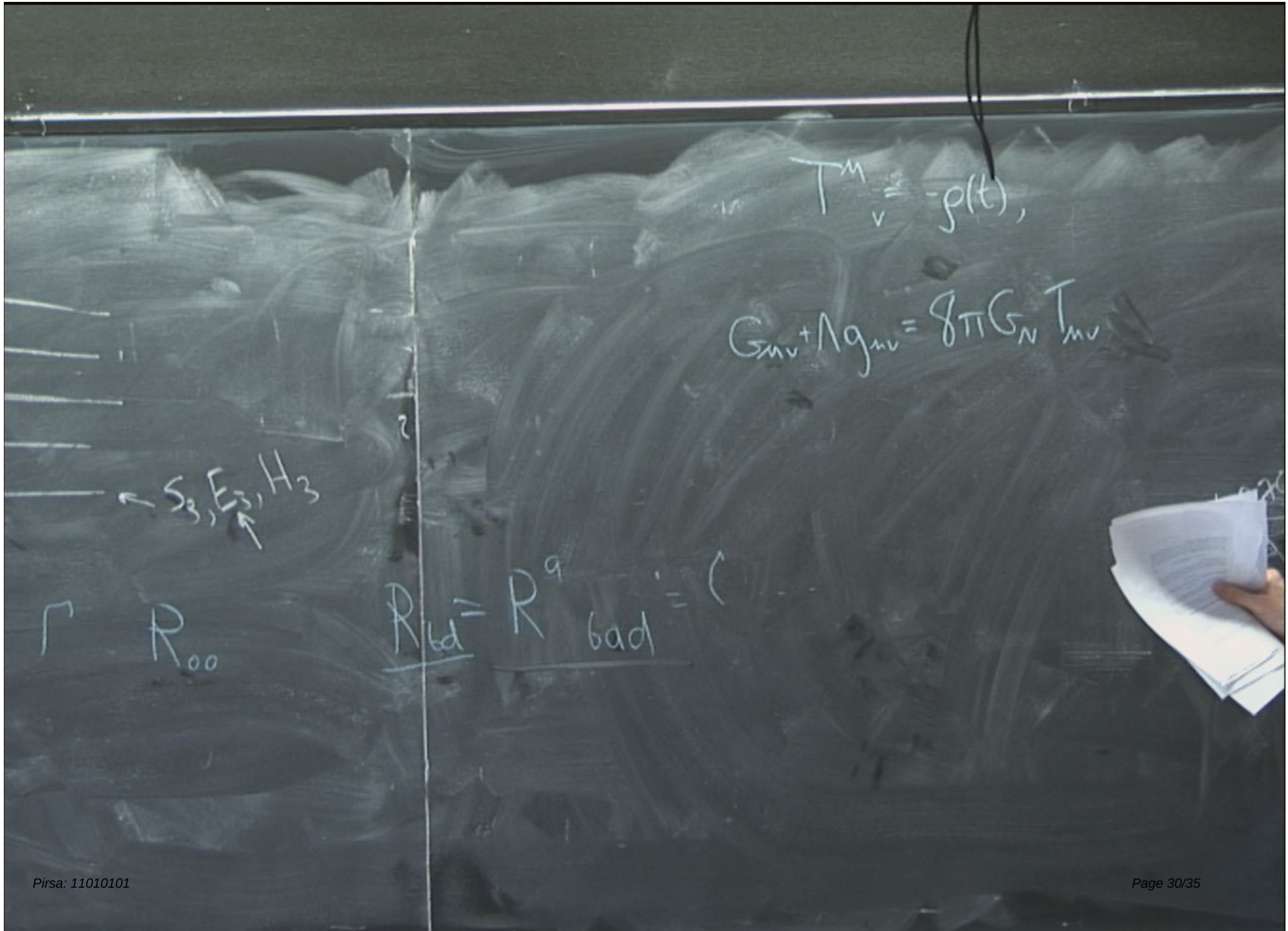
$$ds^2_{FRW} = -dt^2 + \underbrace{a^2(t)\, ds^{(3,0)K}}_{\text{scale factor}}$$

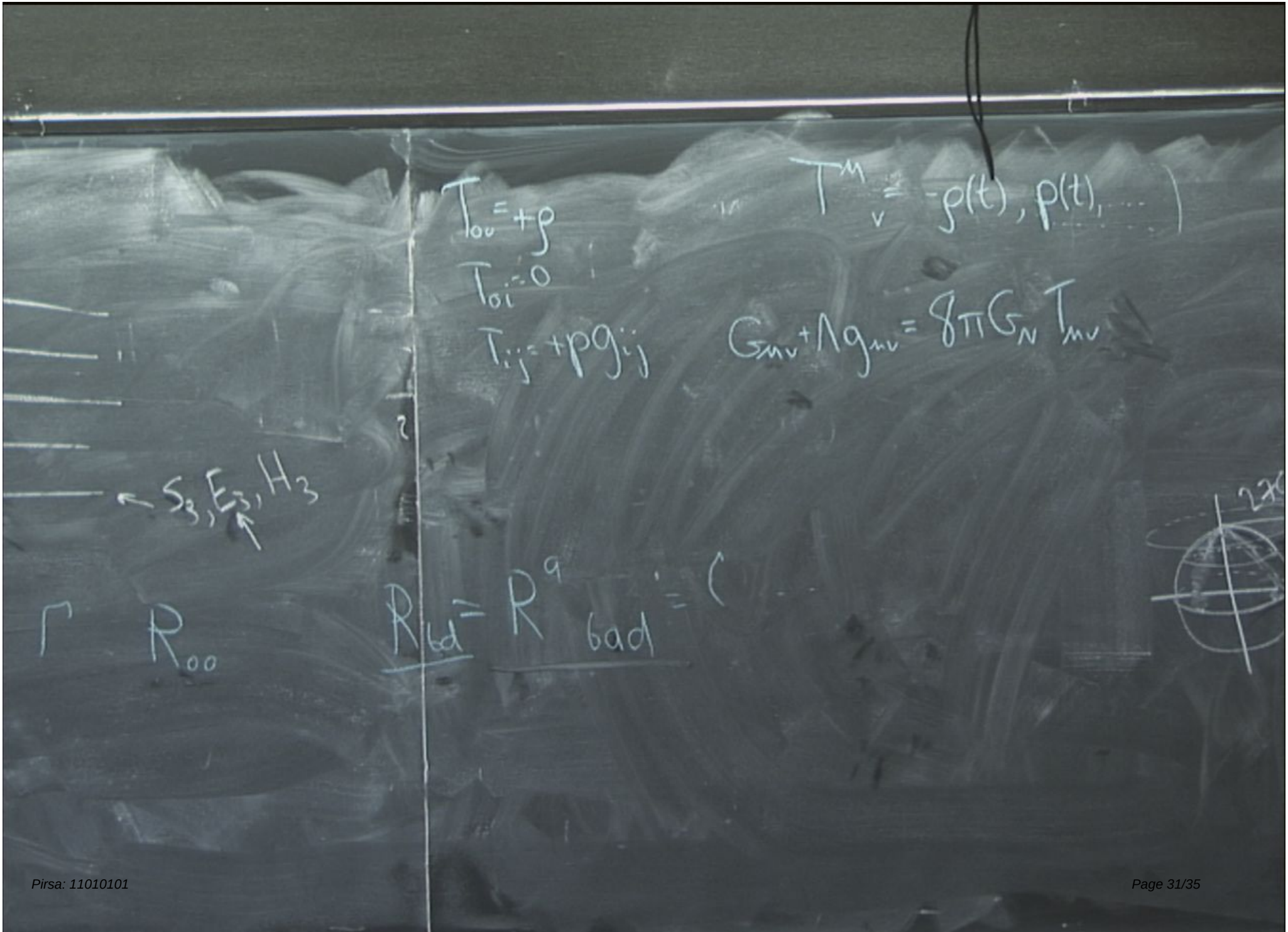
Γ R_{00}

R^a_{bcd}

Γ^0_{00} Γ^0_{0i} Γ^0_{ij}


$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$
S_3, E_3, H_3
R_{00}
$R_{bd} = R^{a}{}_{bad} = ($


$T^{\mu}_{\ \nu} = -\rho(t)$,
$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$
S_3, E_3, H_3
R_{00}
$R_{ijkl} = R^{9}_{\ ijkl} = C$


$T_{00} = +\rho$
$T_{0i} = 0$
$T_{ij} = +p g_{ij}$
$T^{\mu}_{\ \nu} = -\rho(t), p(t), \ldots)$
$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$
S_3, E_3, H_3
R_{00}
$R_{bd} = R^{a}_{\ bad} = ($
270

$T_{00} = +\rho$

$T_{0i} = 0$

$T_{ij} = +p g_{ij}$

$T^{\mu}_{\ \nu} = -\rho(t), p(t), \ldots)$

$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$

$$H^2 = \frac{16\pi G_N \rho + 2\Lambda}{n(n-1)} - \frac{k}{a^2}$$

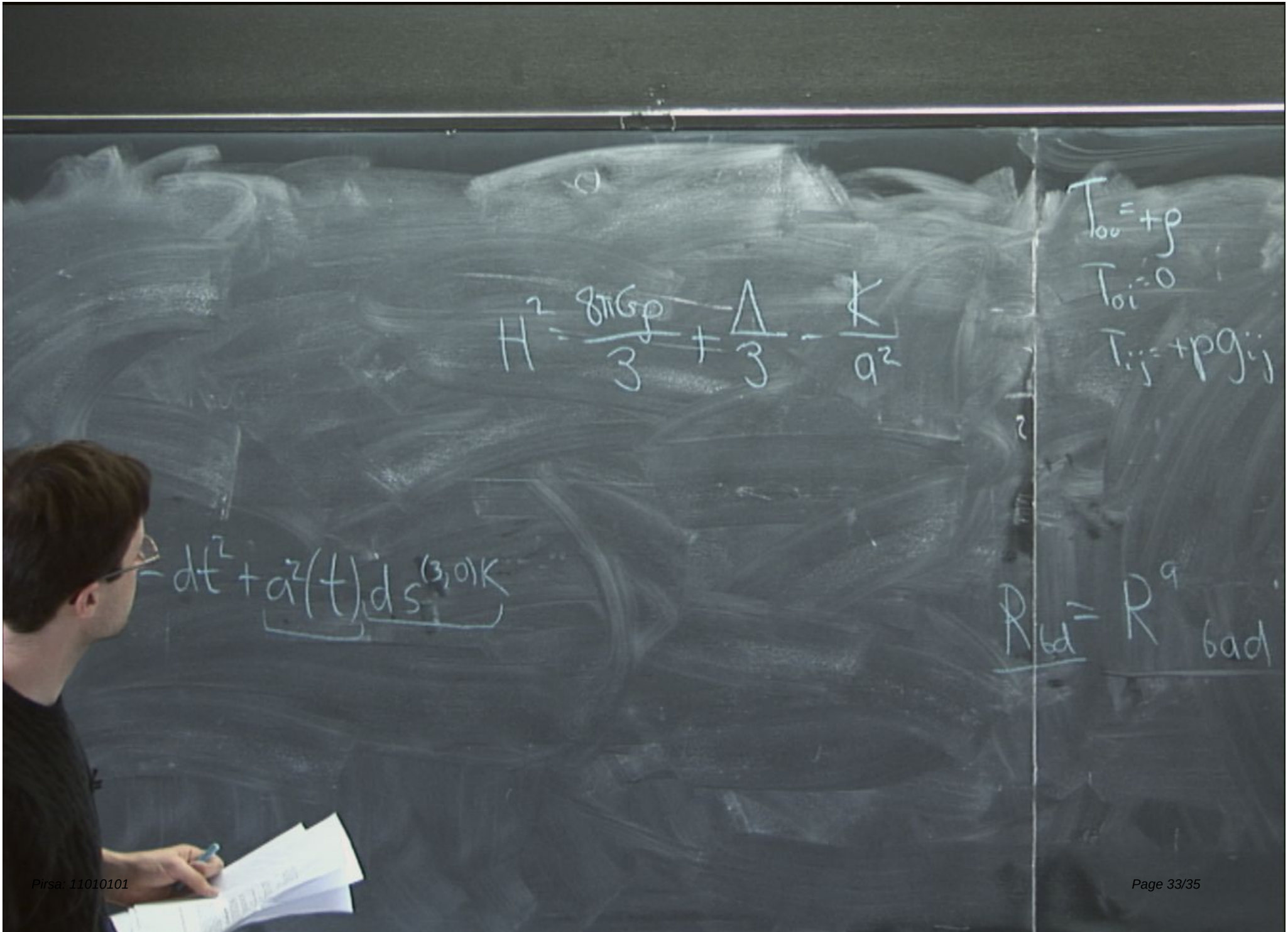
$$\dot{\rho} = -nH(\rho + p)$$

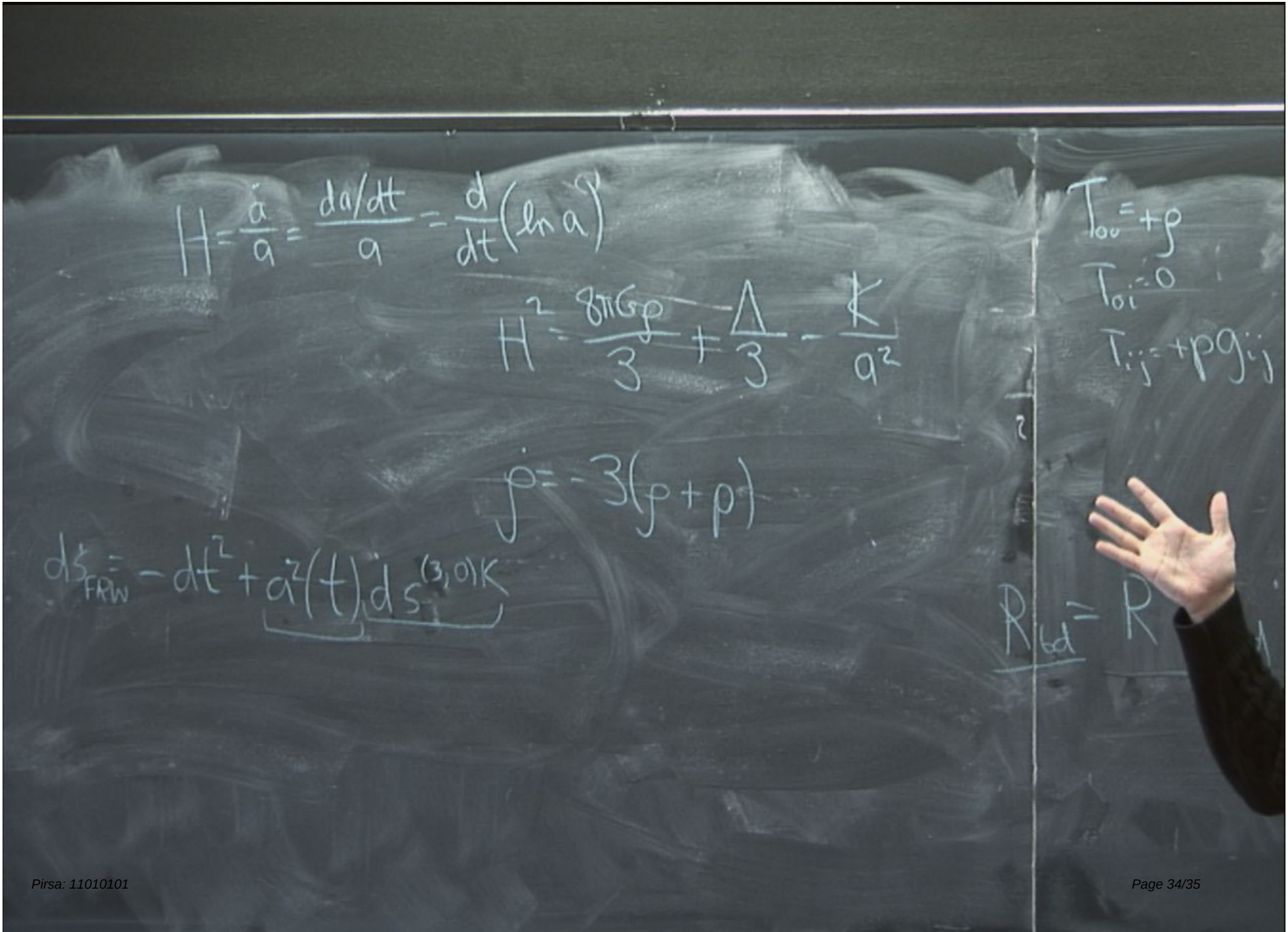
$\leftarrow S_3, E_3, H_3$

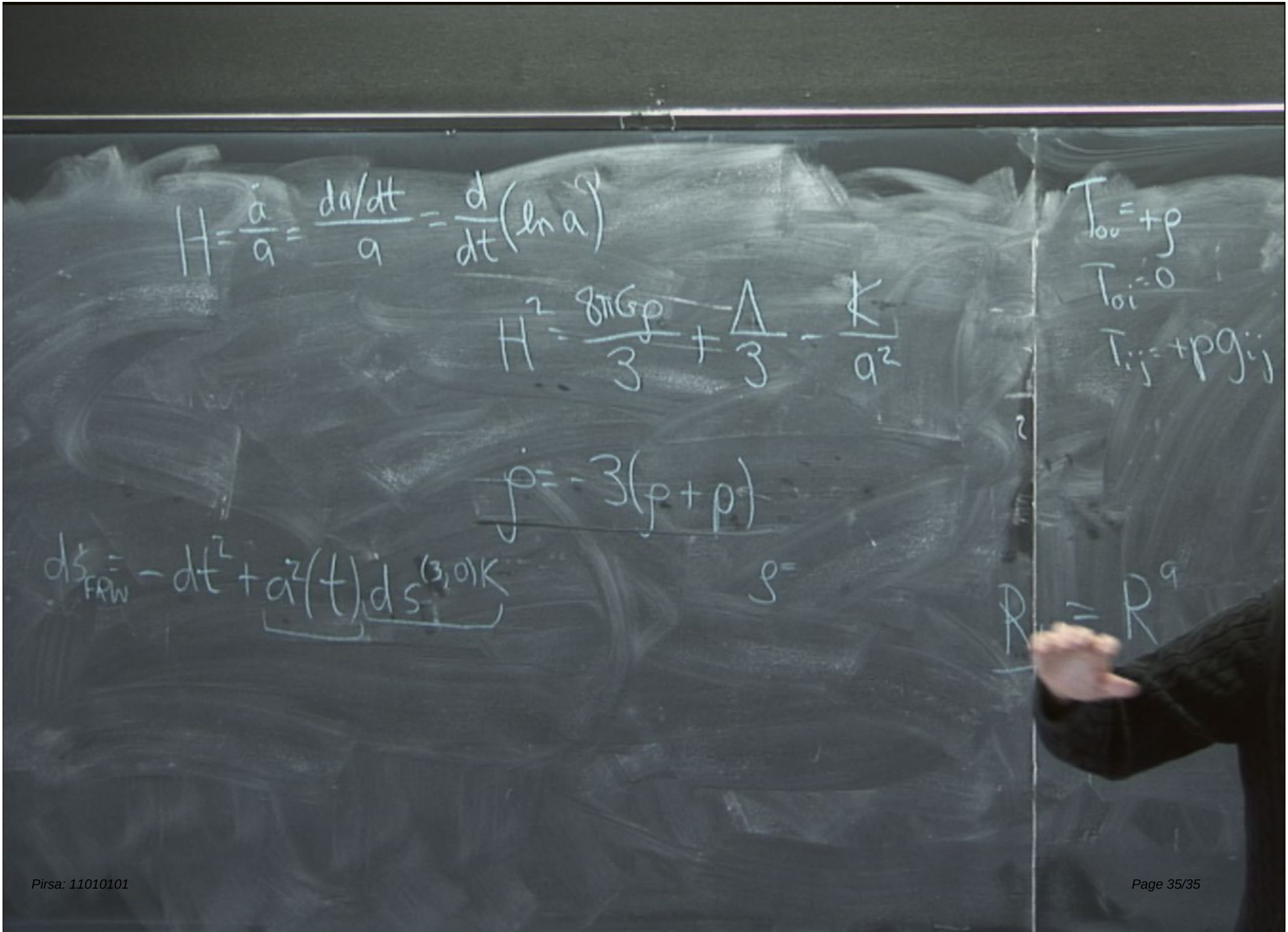
R_{00}

$R_{bd} = R^{a}_{\ bad} =$

270


$H^2 = \frac{8\pi G\rho}{3} + \frac{\Lambda}{3} - \frac{k}{a^2}$
$T_{00} = +\rho$
$T_{0i} = 0$
$T_{ij} = +p g_{ij}$
$= -dt^2 + a^2(t)\, ds^2_{(3,0)K}$
$R_{bd} = R^{a}{}_{bad}$


$H = \frac{\dot{a}}{a} = \frac{da/dt}{a} = \frac{d}{dt}(\ln a)$
$H^2 = \frac{8\pi G\rho}{3} + \frac{\Lambda}{3} - \frac{k}{a^2}$
$\dot{\rho} = -3(\rho + p)$
$ds^2_{FRW} = -dt^2 + a^2(t)\, ds^2_{(3,0)K}$
$T_{00} = +\rho$
$T_{0i} = 0$
$T_{ij} = +p g_{ij}$
$R_{\mu\nu} = R$


$H = \frac{\dot{a}}{a} = \frac{da/dt}{a} = \frac{d}{dt}(\ln a)$
$H^2 = \frac{8\pi G\rho}{3} + \frac{\Lambda}{3} - \frac{k}{a^2}$
$\dot{\rho} = -3(p+\rho)$
$ds^2_{FRW} = -dt^2 + a^2(t)\, ds^2_{(3,0)K}$
$T_{00} = +\rho$
$T_{0i} = 0$
$T_{ij} = +p g_{ij}$
$R = R^9$