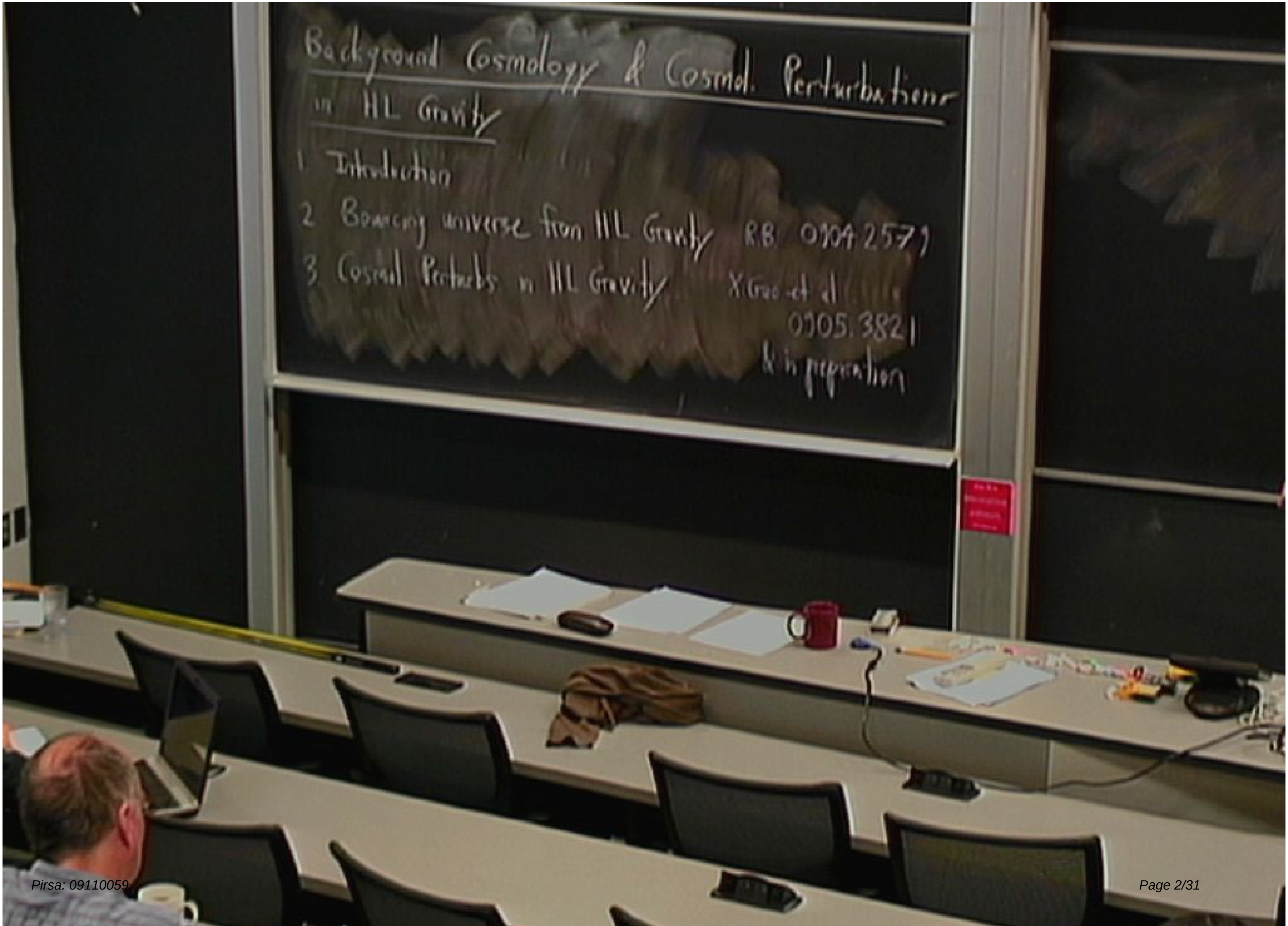
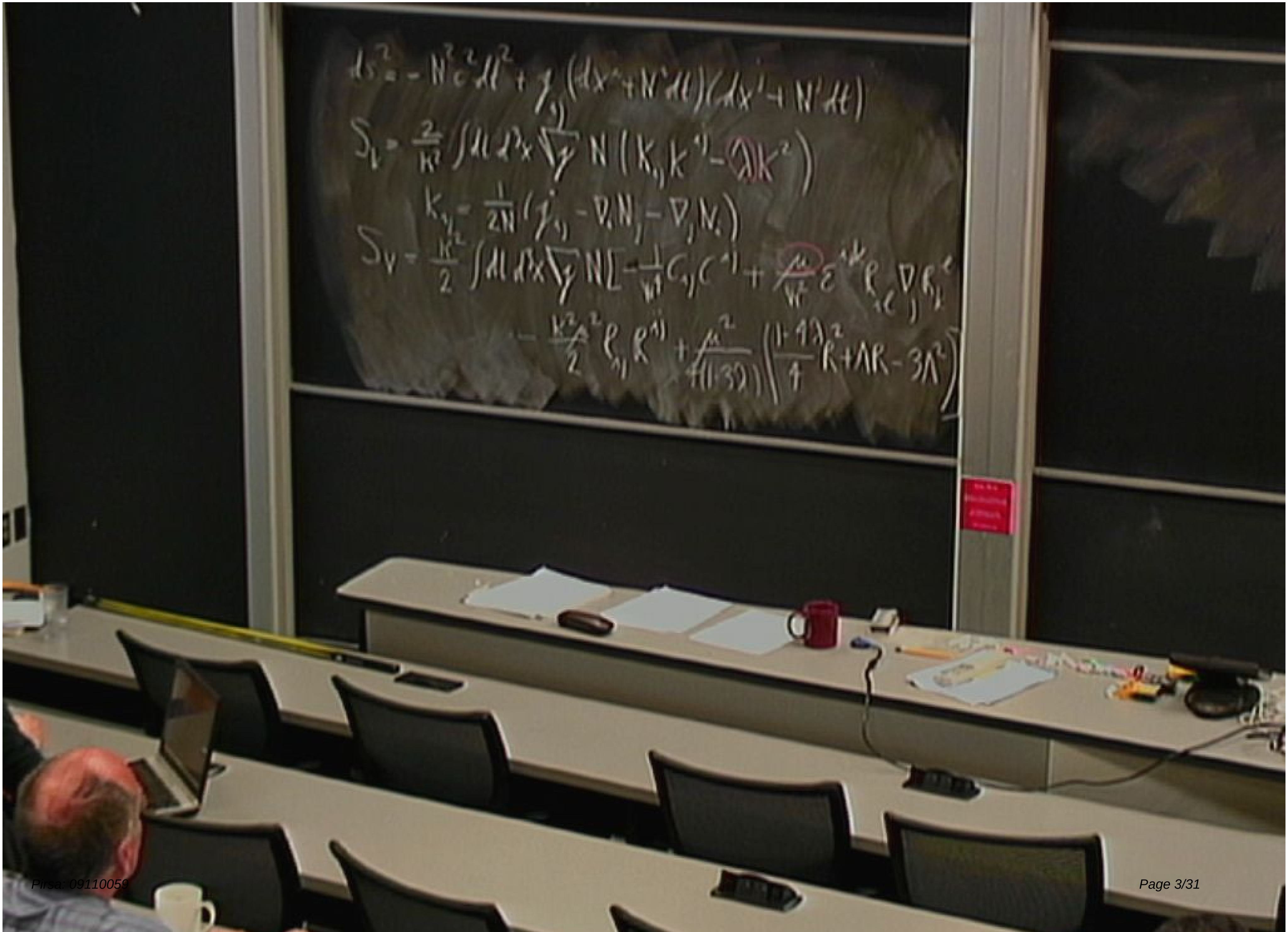
Title: Background Cosmology and Cosmological Perturbations in Horava-Lifshitz Gravity

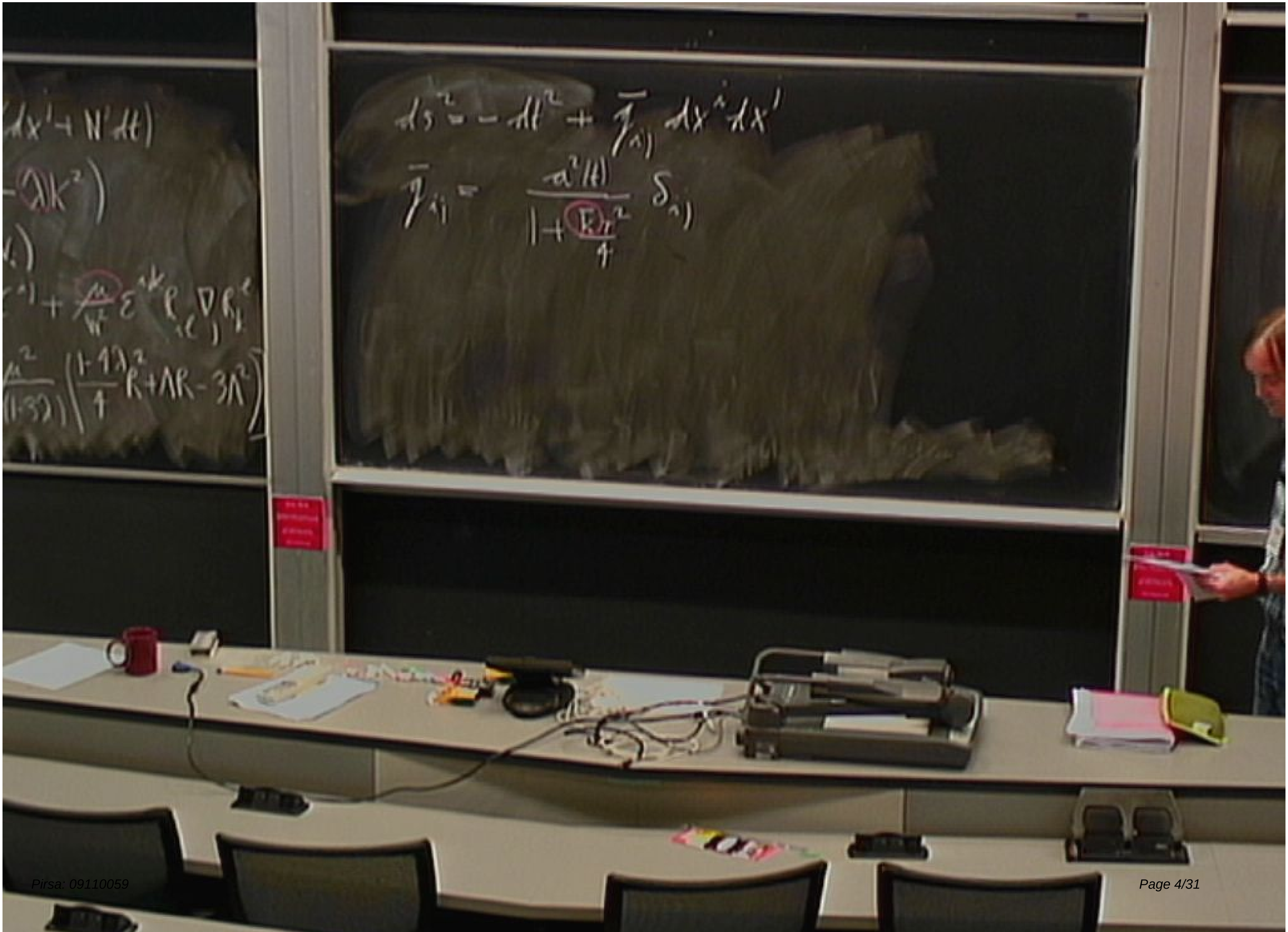
Date: Nov 09, 2009 02:00 PM

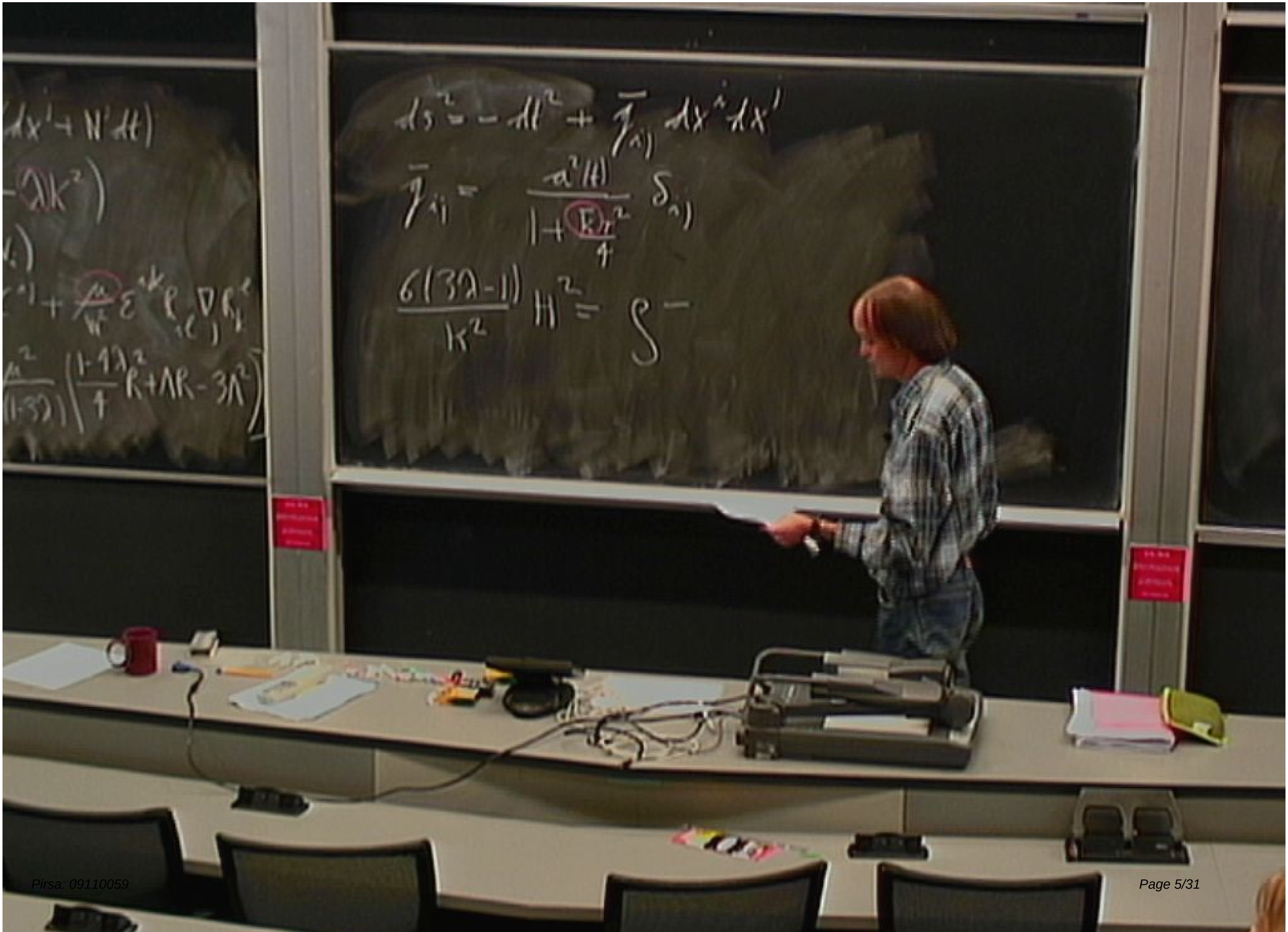
URL: http://pirsa.org/09110059

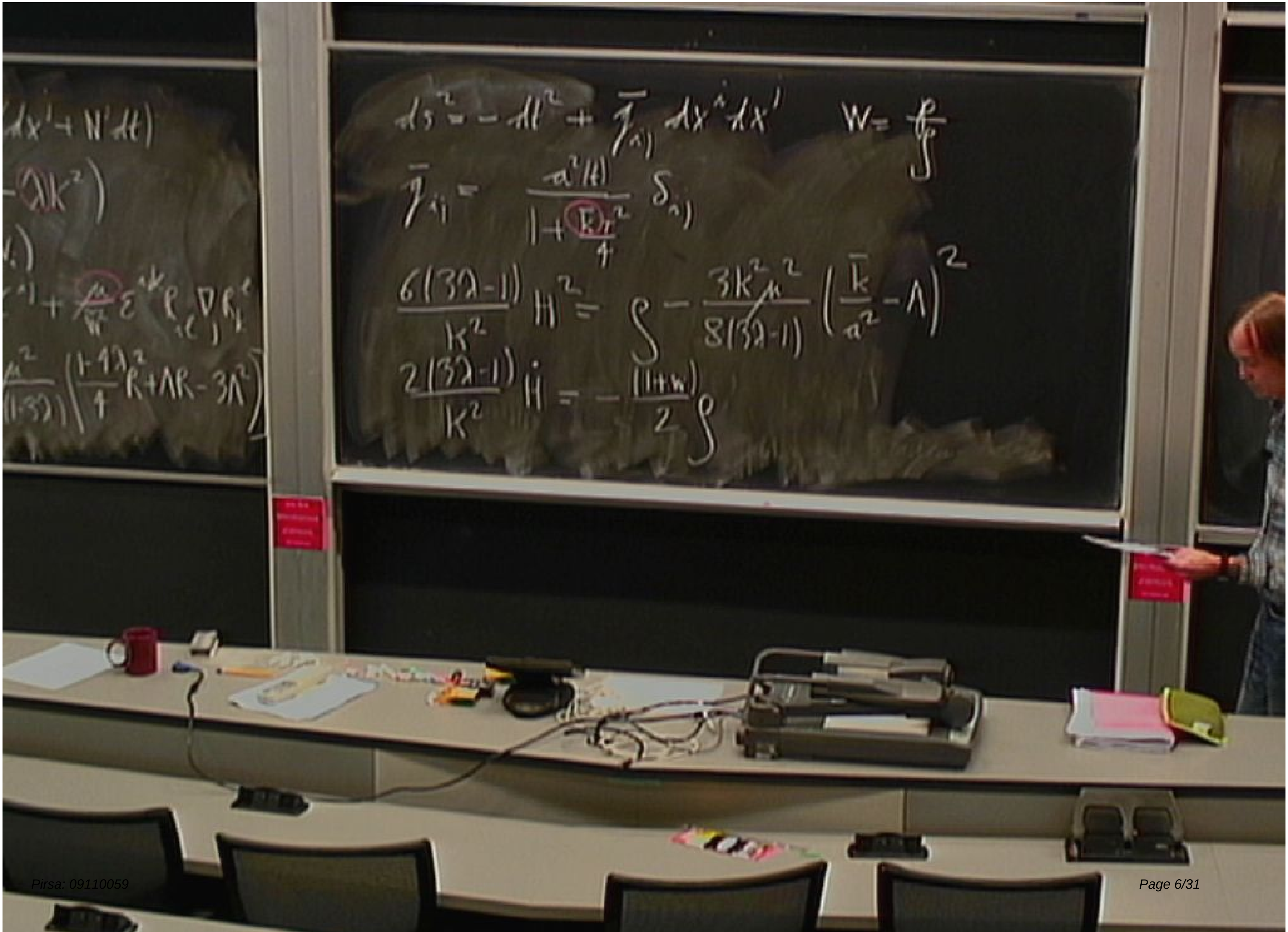
Abstract:


Background Cosmology & Cosmol. Perturbations
in HL Gravity
1. Introduction
2 Bouncing universe from HL Gravity R.B. 0904.2579
3 Cosmol. Perturbs. in HL Gravity X.Gao et al
0905.3821
& in preparation

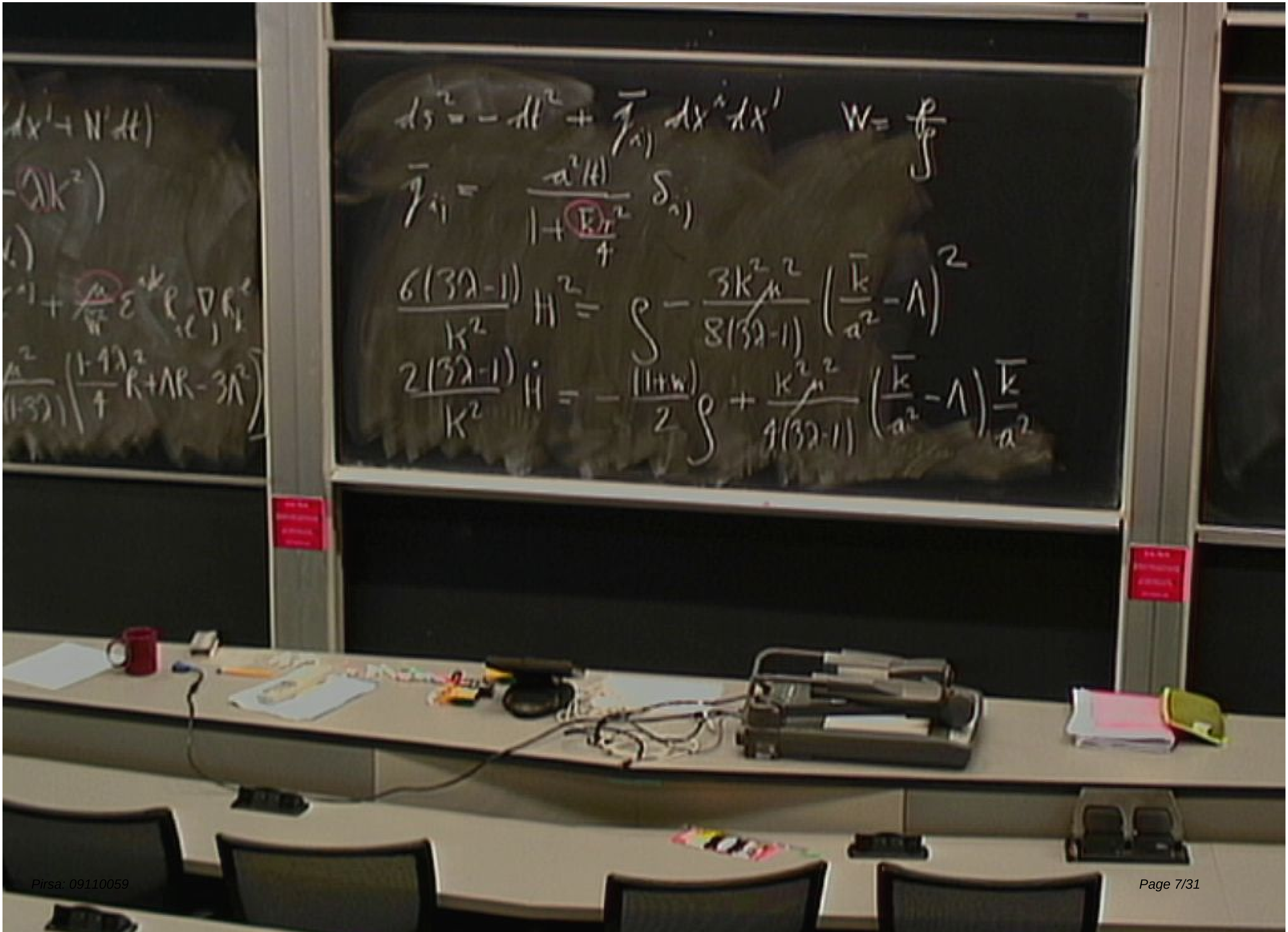



$ds^2 = -dt^2 + \bar{g}_{ij} dx^i dx^j$
$\bar{g}_{ij} = \frac{a^2(t)}{1 + \frac{k r^2}{4}} \delta_{ij}$


$ds^2 = -dt^2 + \bar{g}_{ij} dx^i dx^j$
$\bar{g}_{ij} = \frac{a^2(t)}{1+\frac{kr^2}{4}} \delta_{ij}$
$\frac{6(3\lambda-1)}{\kappa^2} H^2 = \rho -$



$ds^2 = -dt^2 + \bar{g}_{ij}\, dx^i dx^j$
$W = \frac{p}{\rho}$
$\bar{g}_{ij} = \frac{a^2(t)}{1+\frac{k r^2}{4}}\, \delta_{ij}$
$\frac{6(3\lambda-1)}{\kappa^2} H^2 = \rho - \frac{3\kappa^2 \mu^2}{8(3\lambda-1)}\left(\frac{k}{a^2}-\Lambda\right)^2$
$\frac{2(3\lambda-1)}{\kappa^2} \dot{H} = -\frac{(1+w)}{2}\rho$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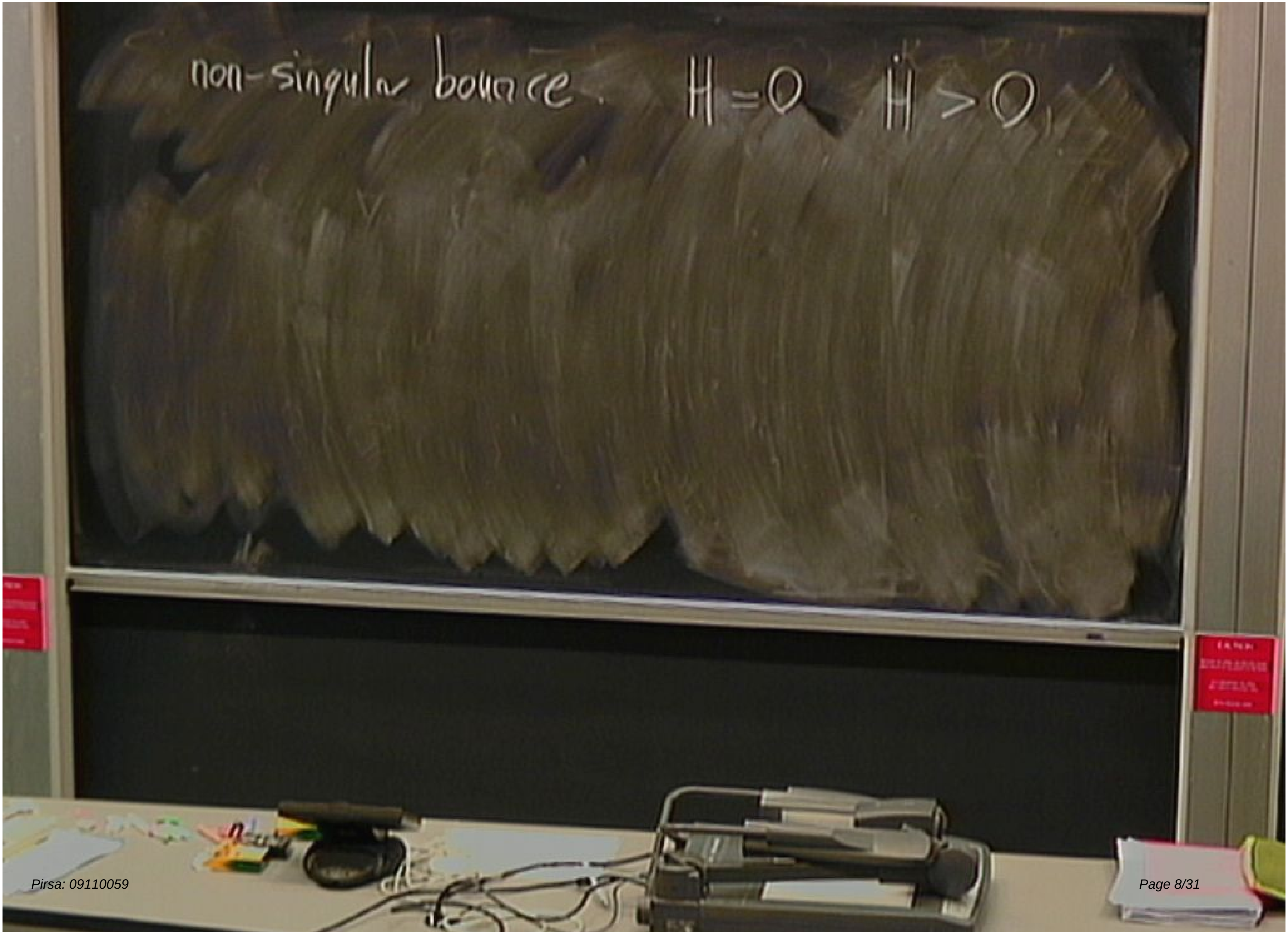
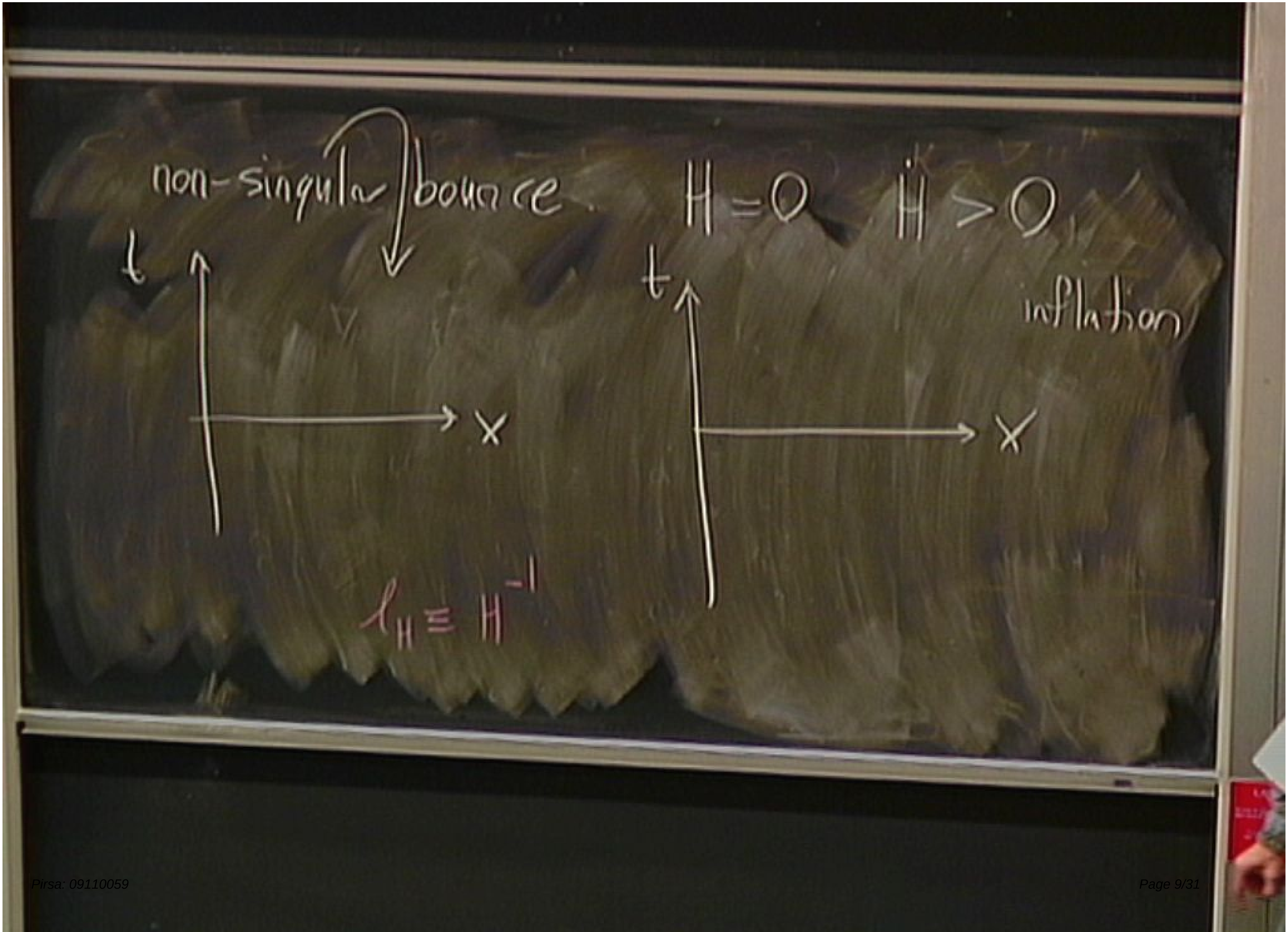
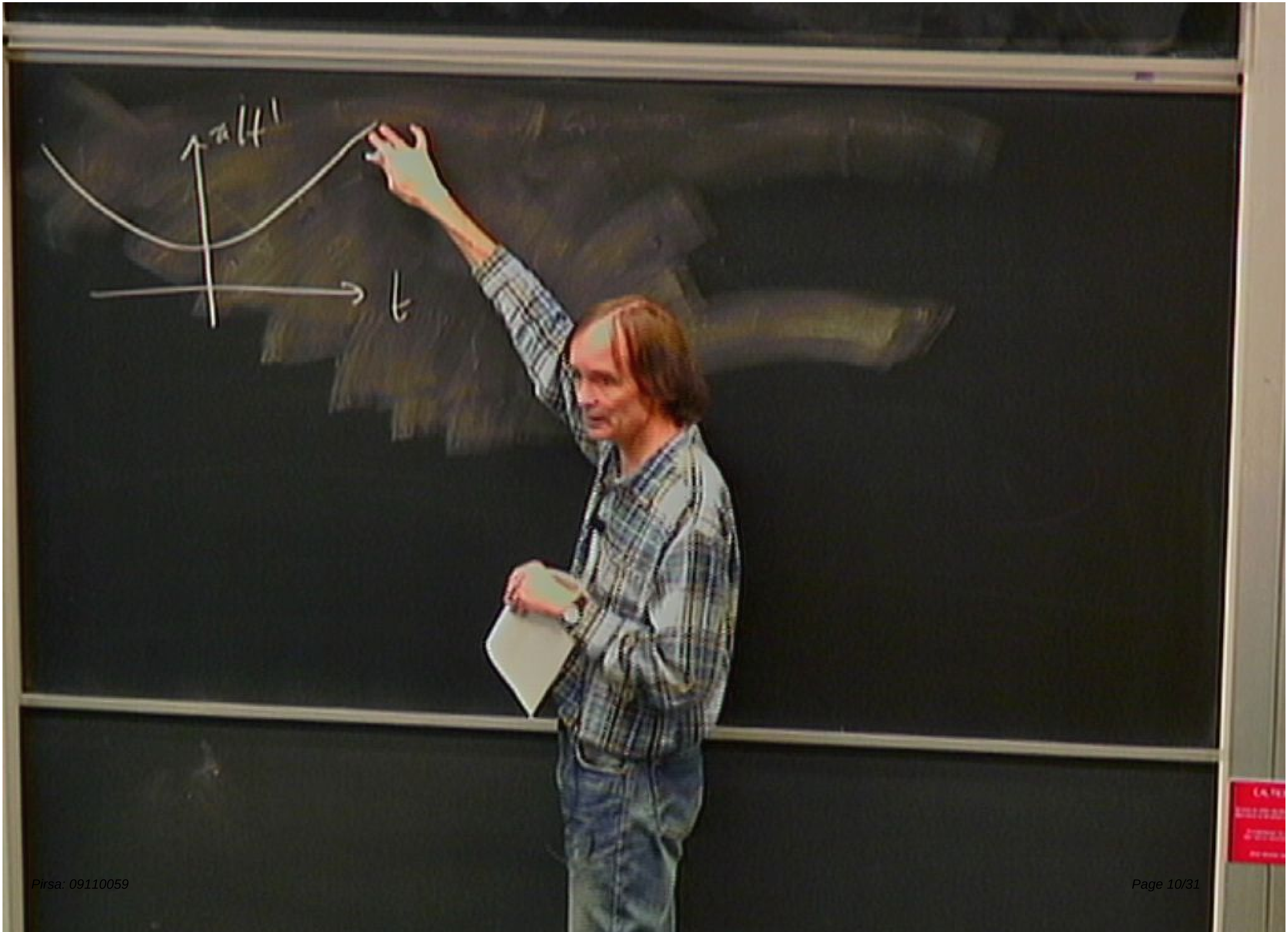
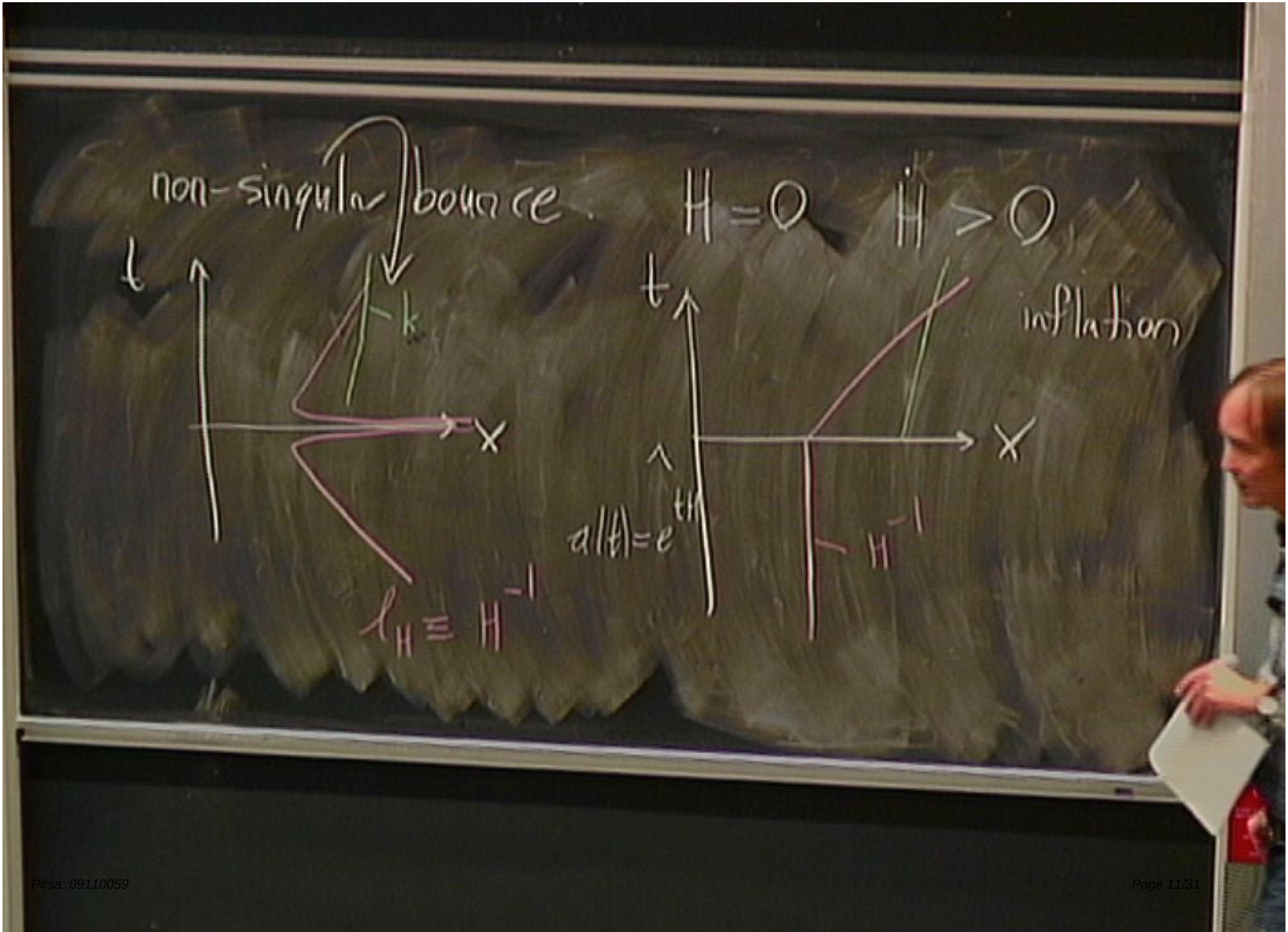
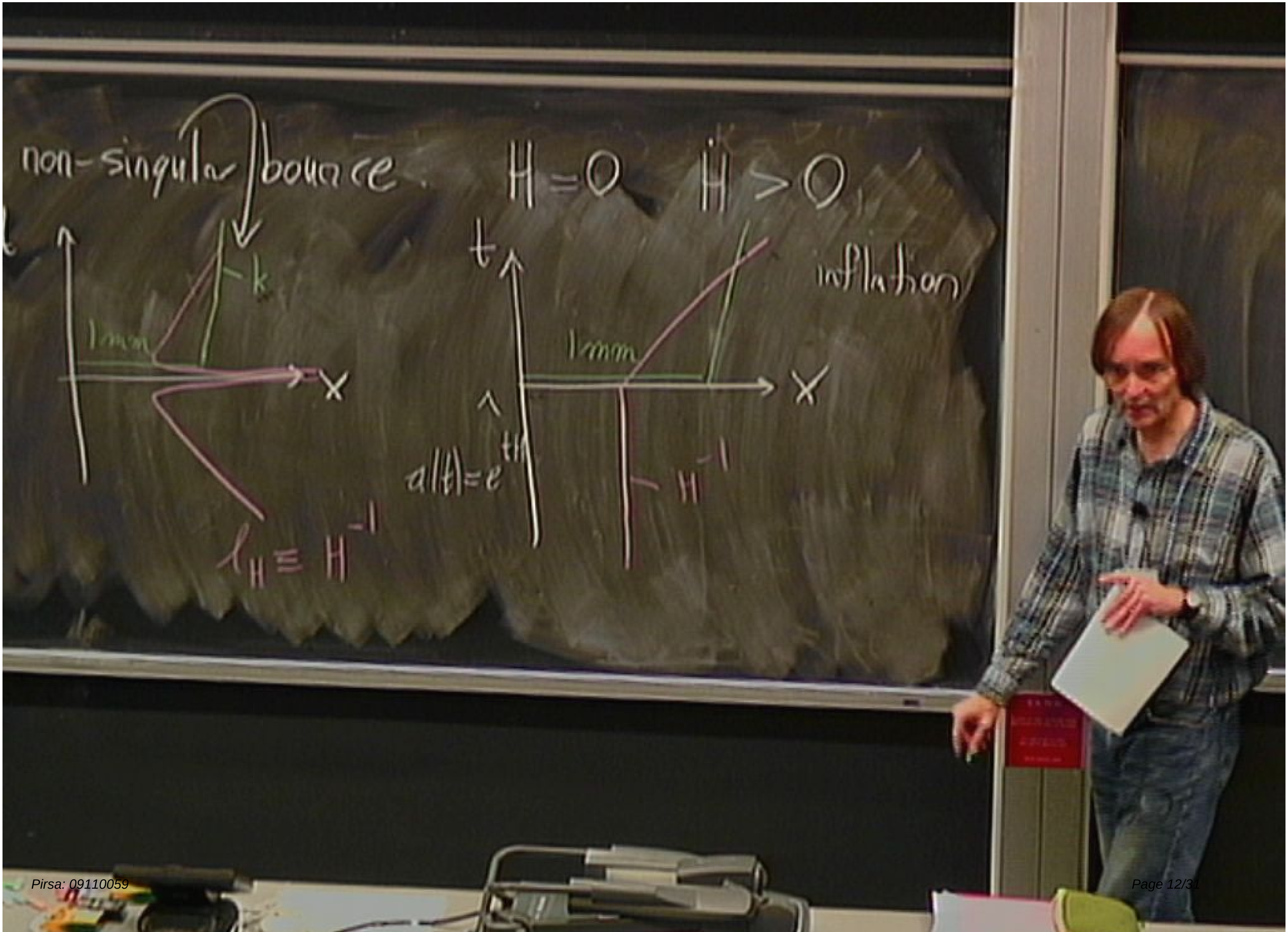
$\frac{2(3\lambda-1)}{\kappa^2}\dot{H} = -\frac{(1+w)}{2}\rho + \frac{\kappa^2\mu^2}{4(3\lambda-1)}\left(\frac{k}{a^2}-\Lambda\right)\frac{k}{a^2}$


non-singular bounce. $H=0$ $\dot{H}>0$

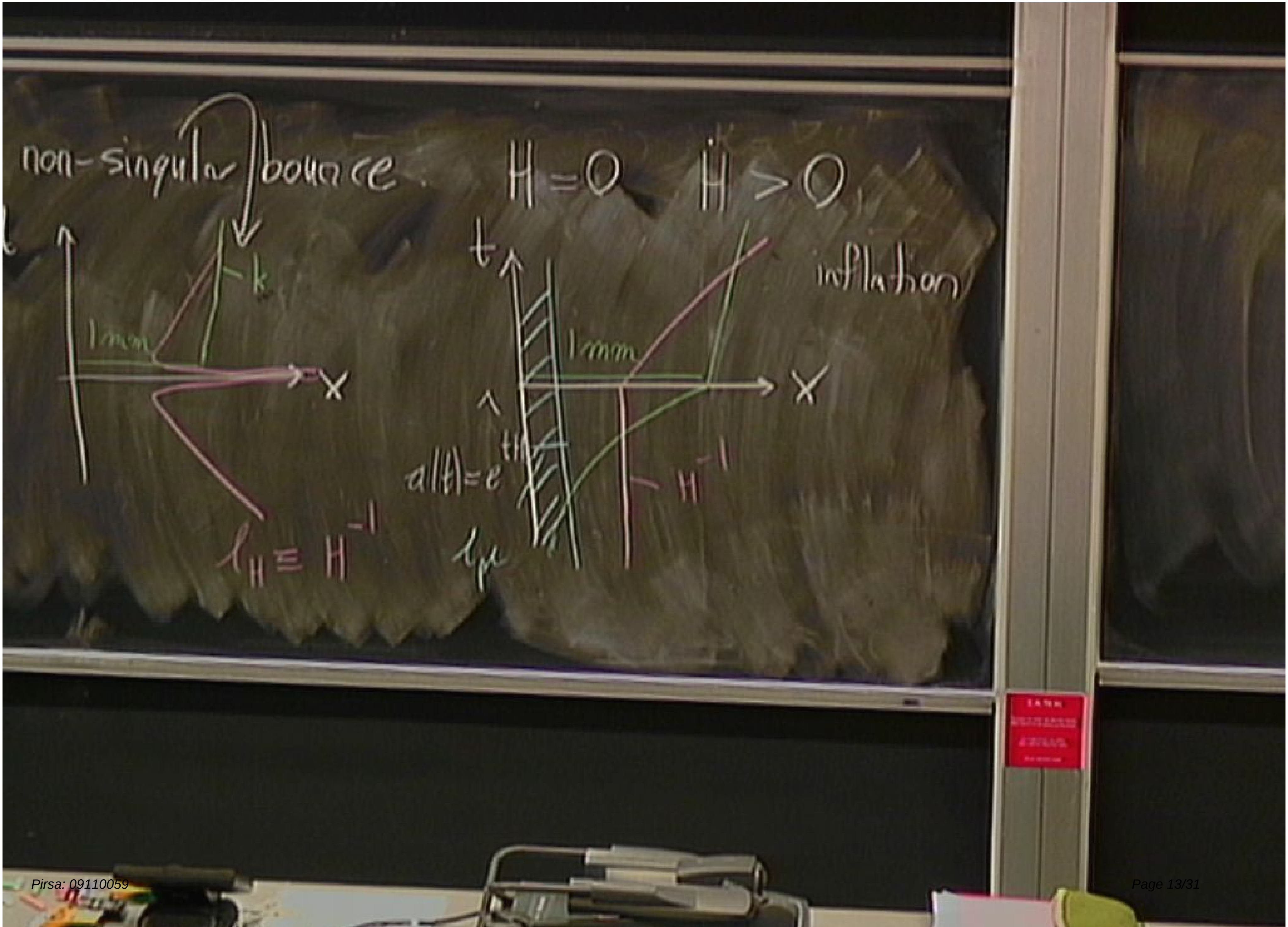

non-singular bounce
t
x
H = 0   Ḣ > 0
t
inflation
x
l_H ≡ H^-1

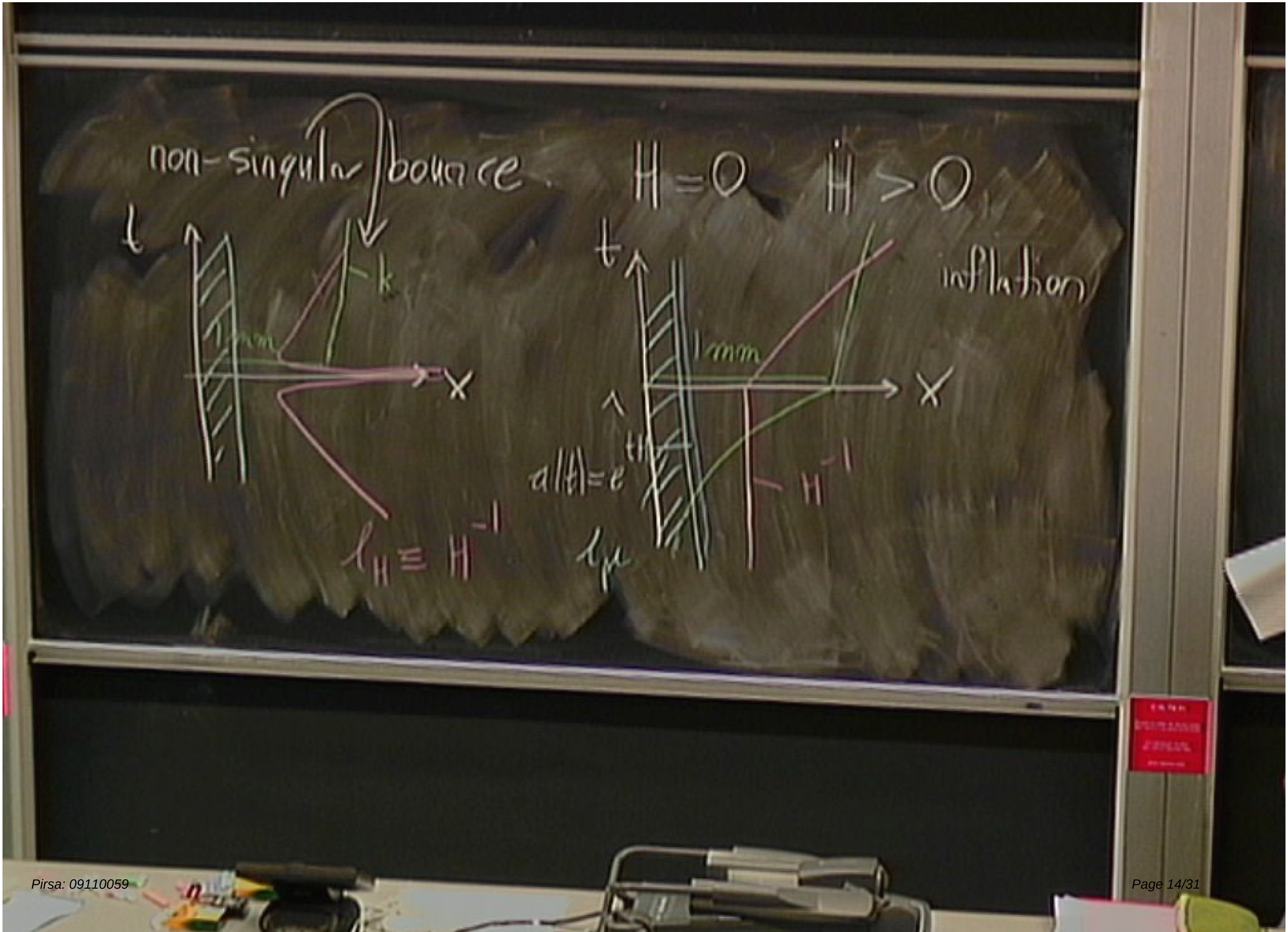


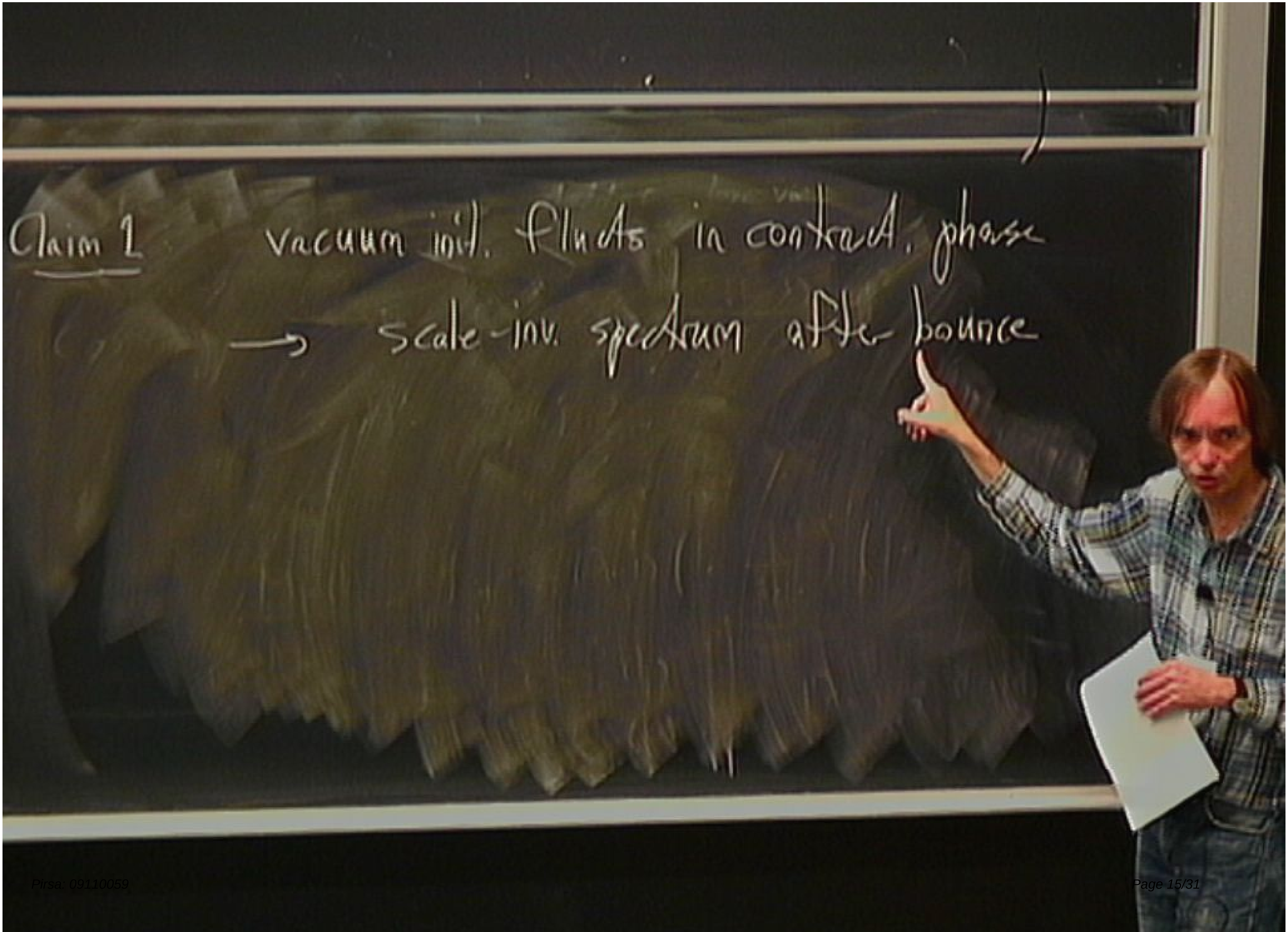

non-singular bounce
H = 0   Ḣ > 0
t
k
x
$\ell_H \equiv H^{-1}$
t
inflation
x
$a(t) = e^{tH}$
H^{-1}

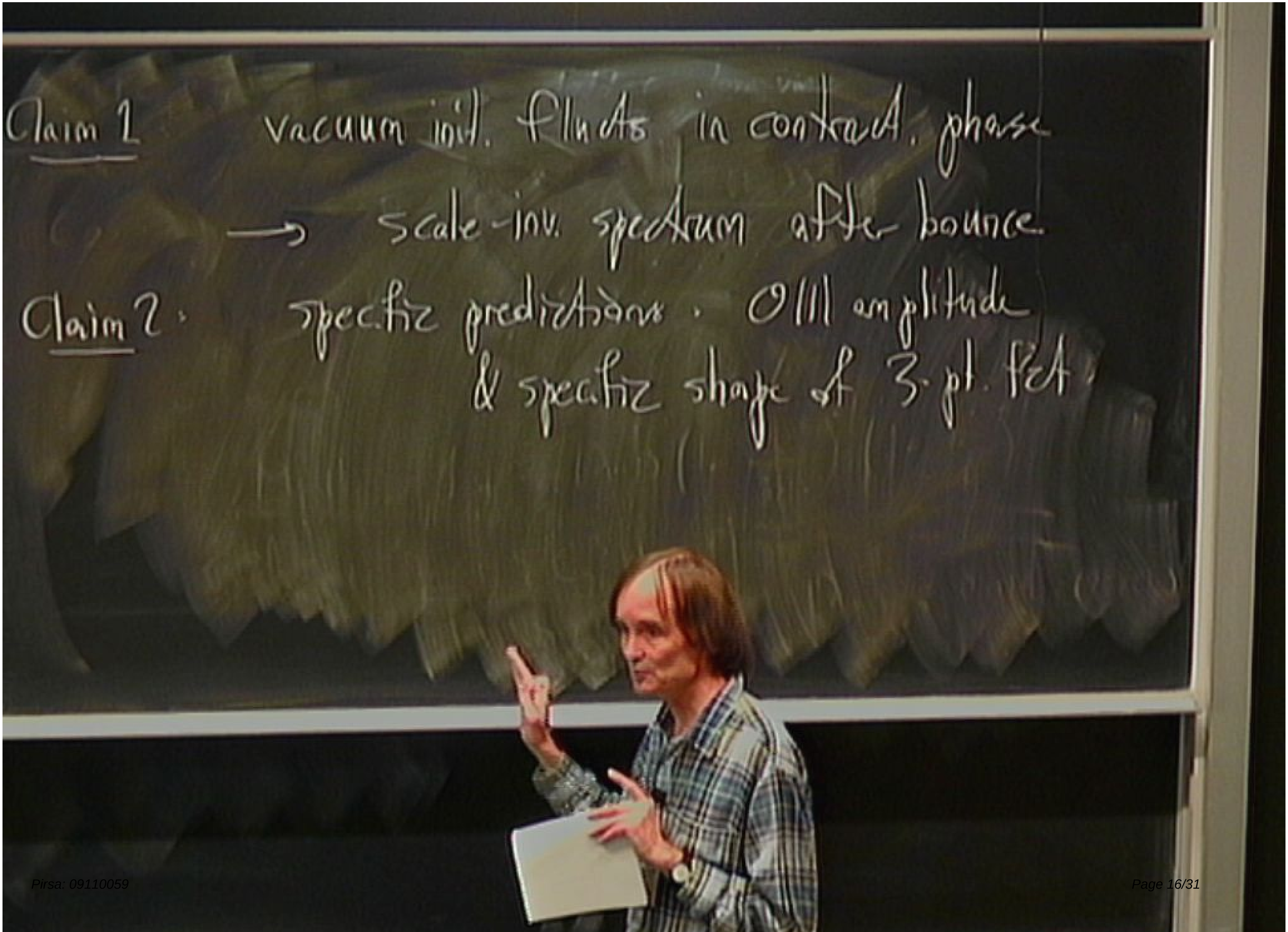


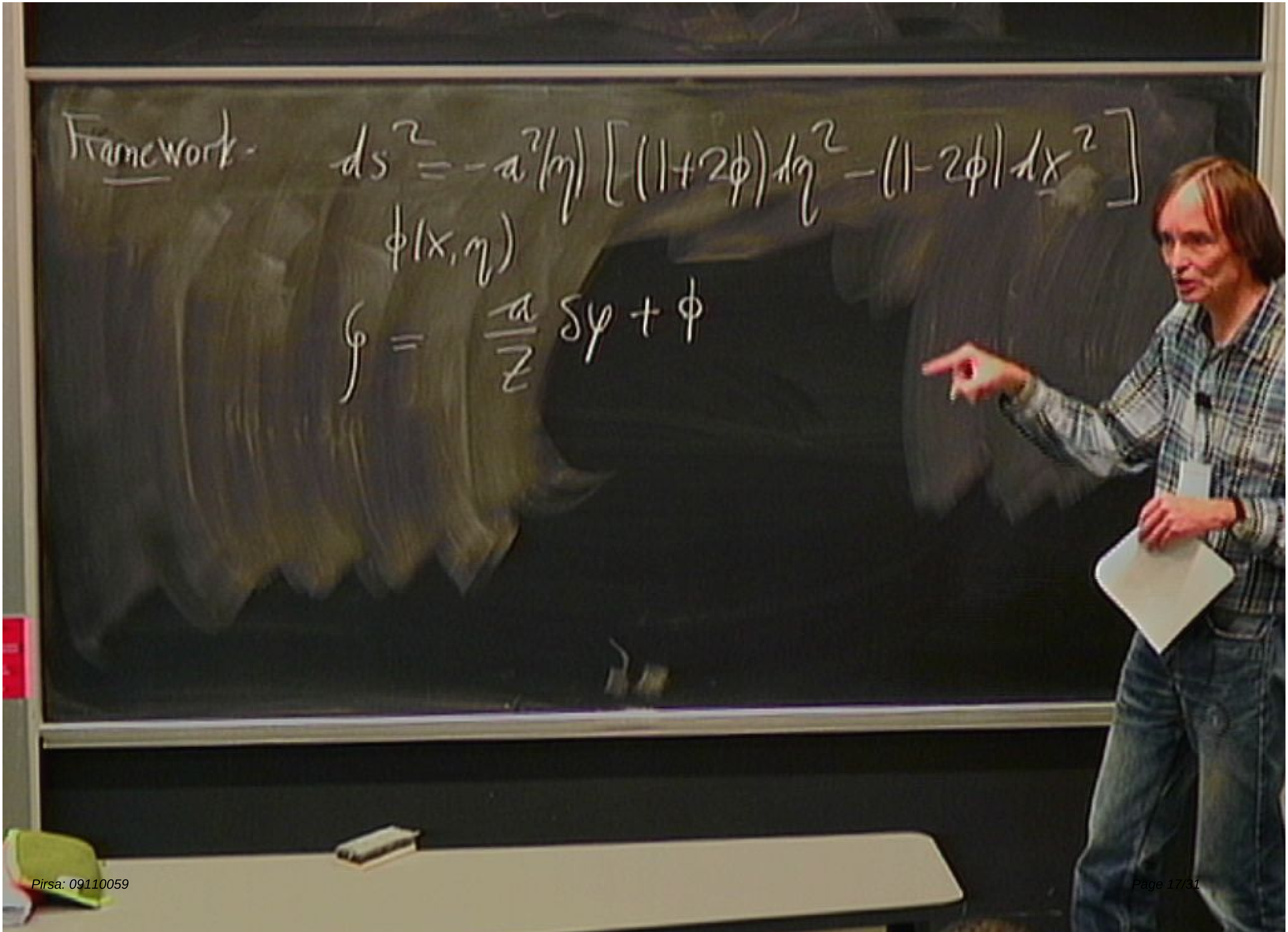
non-singular bounce
H=0 Ḣ>0
t
k
1mm
x
$l_H \equiv H^{-1}$
$a(t)=e^{tH}$
H^{-1}
inflation


non-singular bounce
$H=0$ $\dot{H}>0$
inflation
t
k
1mm
x
$a(t)=e^{Ht}$
H^{-1}
$l_H \equiv H^{-1}$
l_μ


non-singular bounce
t
k
1mm
x
$l_H \equiv H^{-1}$
$H = 0$
$\dot{H} > 0$
t
inflation
1mm
x
$a(t) = e^{tH}$
H^{-1}
l_μ


Claim 1 vacuum init. flucts in contract. phase
→ scale-inv. spectrum after bounce


Claim 1 vacuum init. flucts in contract. phase
→ scale-inv. spectrum after bounce
Claim 2: specific predictions: O(1) amplitude
& specific shape of 3-pt. fct


Framework.
ds² = −a²(η) [(1+2ϕ) dη² − (1−2ϕ) dx²]
ϕ(x, η)
ζ = −a/Z δφ + ϕ

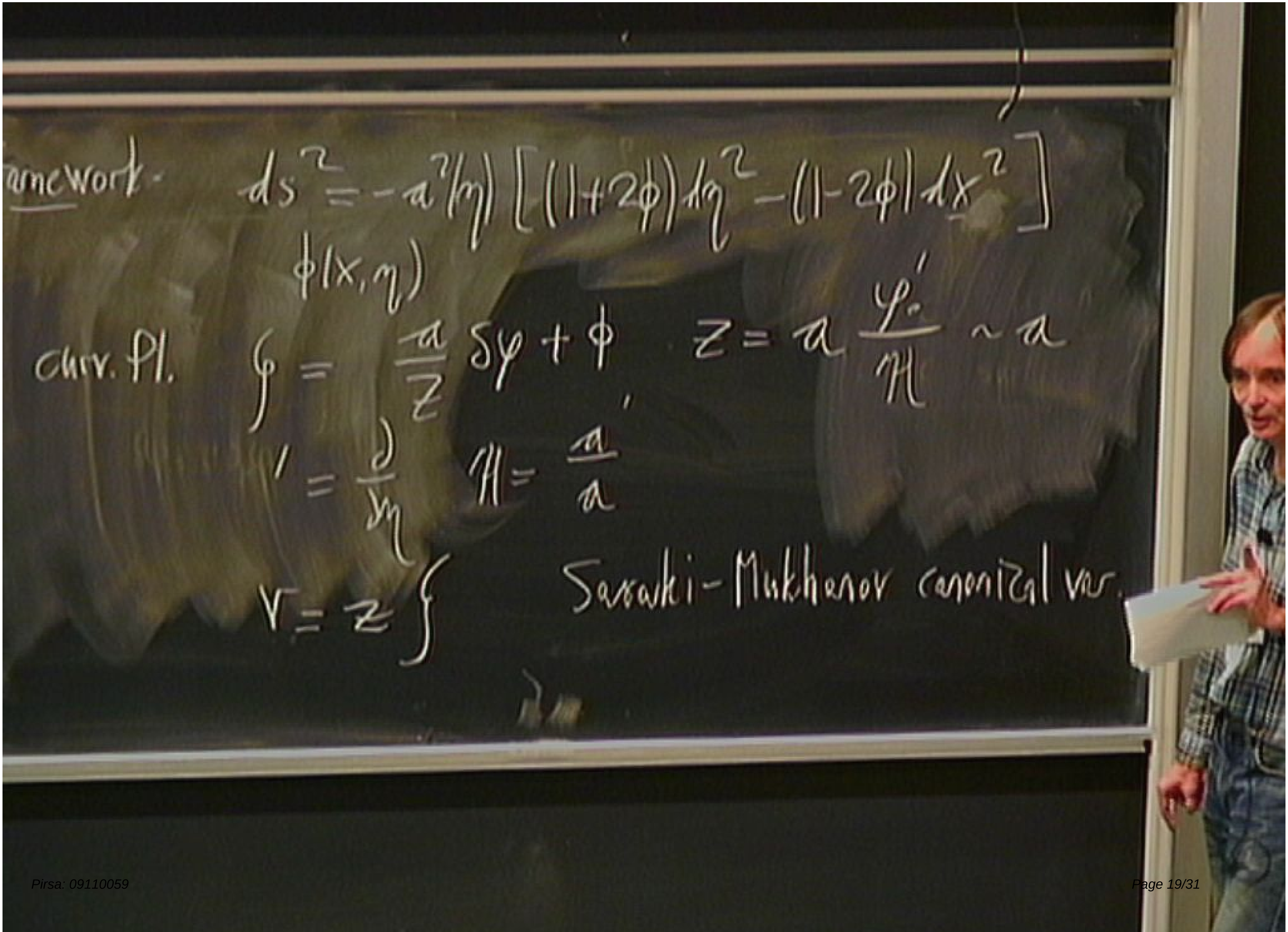
Framework:

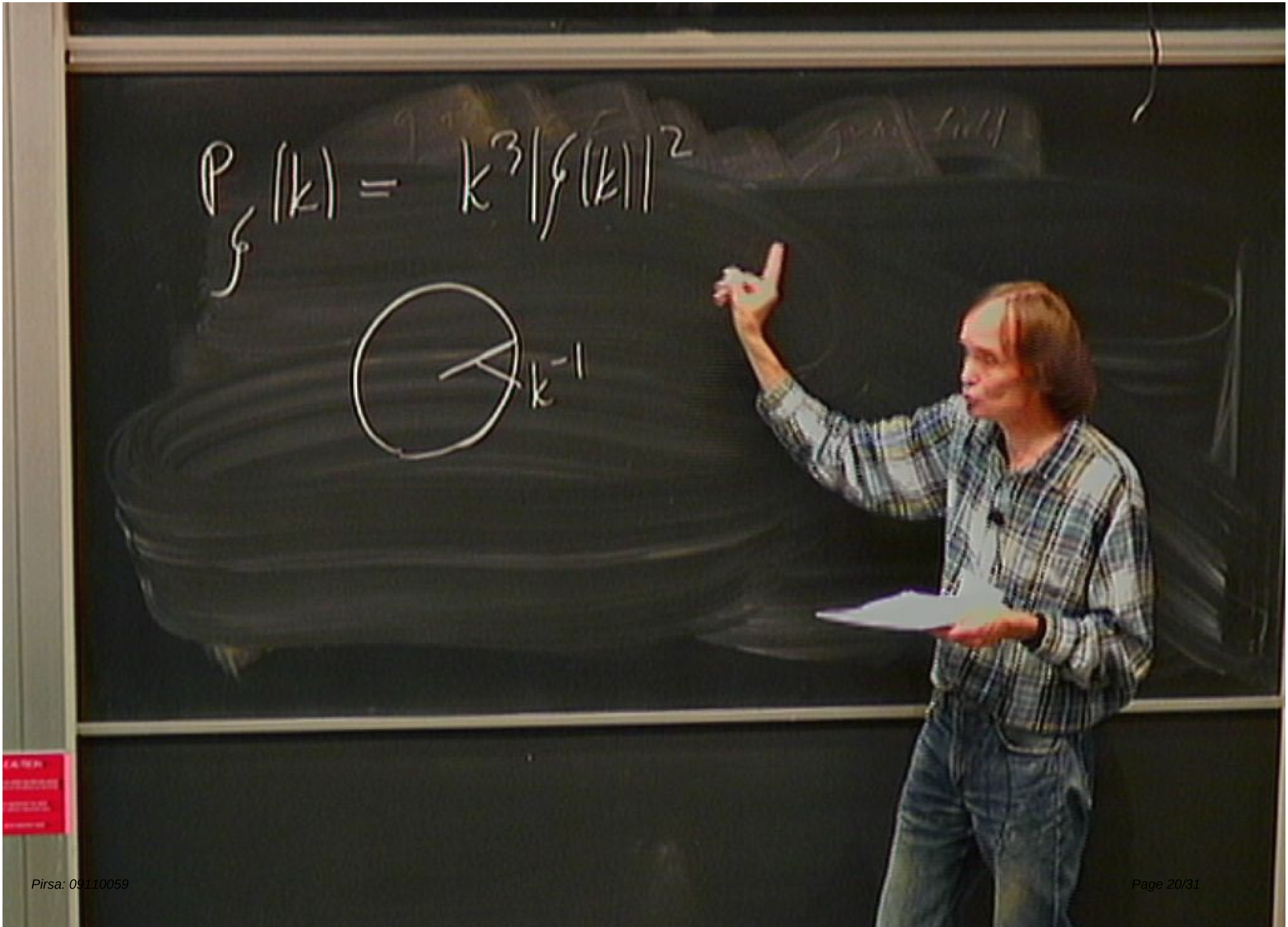
$$ds^2 = -a^2(\eta)\left[(1+2\phi)d\eta^2 - (1-2\phi)dx^2\right]$$

$$\phi(x,\eta)$$

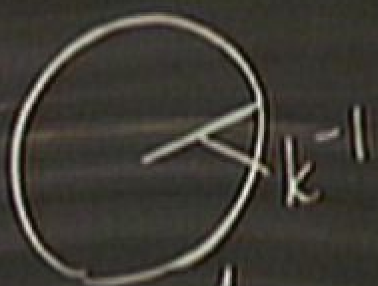
$$\zeta = \frac{a}{z}\delta\varphi + \phi \qquad z = a\frac{\varphi_0'}{\mathcal{H}}$$

$$' = \frac{\partial}{\partial\eta} \qquad \mathcal{H} = \frac{a'}{a}$$


amework.
$ds^2 = -a^2(\eta)\left[(1+2\phi)d\eta^2 - (1-2\phi)dx^2\right]$
$\phi(x,\eta)$
curv. Pl.
$\zeta = \frac{a}{Z}\delta\varphi + \phi$
$Z = a\frac{\varphi_0'}{\mathcal{H}} \sim a$
$' = \frac{\partial}{\partial\eta}$
$\mathcal{H} = \frac{a'}{a}$
$v = z\zeta$
Sasaki-Mukhanov canonical var.


$P_\zeta(k) = k^3 |\zeta(k)|^2$
k^{-1}

$$P_\zeta(k) = k^3|\zeta(k)|^2 \sim k^0$$ scale-inv



vacuum spectrum

$$P_\zeta(k) \sim k^3 k^{-1} \sim k^2$$

$$v_k'' + \left(k^2 - \frac{z''}{z}\right) v_k = 0$$

H^2

expanding : $v_k \sim z \Rightarrow \zeta_k \sim \text{const}$

$$S_{tot} = S_k + S_V + S_{matter}$$

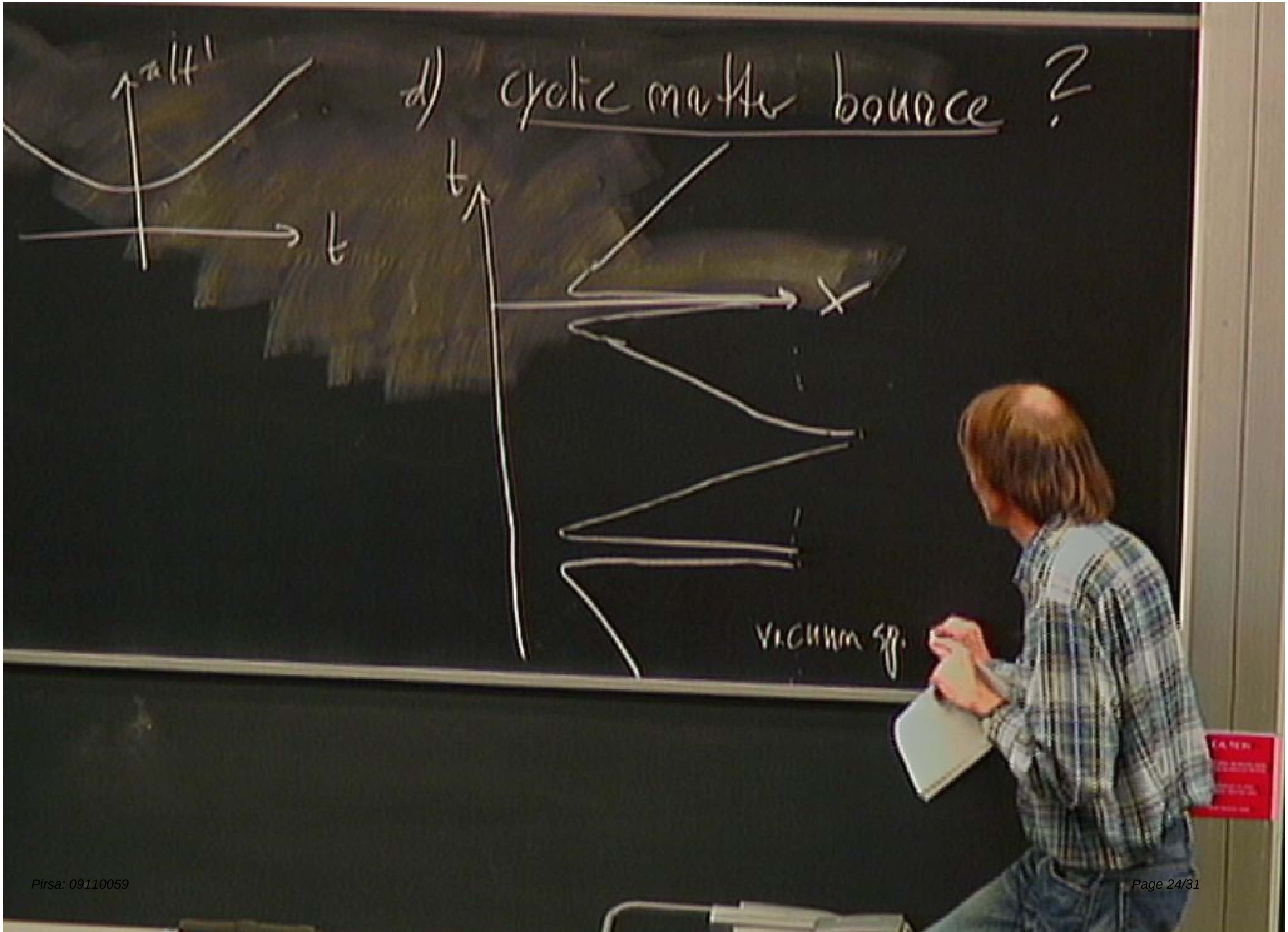
$$v_k'' + \left(k^2 - \frac{z''}{z}\right) v_k = 0$$

H^2

expanding: $v_k \sim z \Rightarrow \zeta_k \sim \text{const}$

contract. matter $v_k \sim z^{-1/2} \to \zeta_k \sim z^{-3/2}$

$$S_{tot} = S_k + S_V + S_{matter}$$


d) cyclic matter bounce ?
t
x
vacuum sp.

Claim 1 vacuum init. flucts in contract. phase

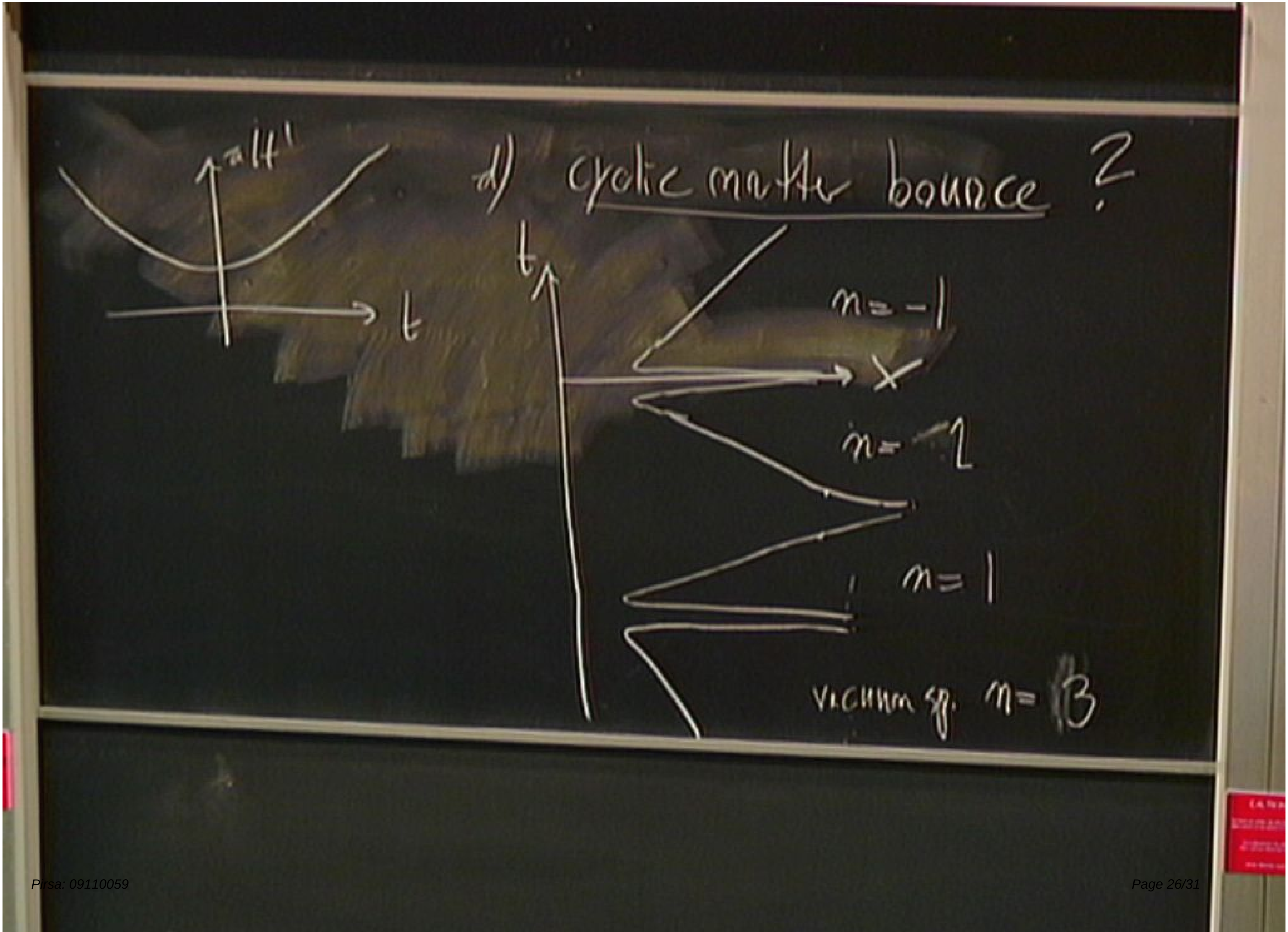
$\longrightarrow$ scale-inv. spectrum after bounce

Claim 2: specific predictions: $O(1)$ amplitude

& specific shape of 3-pt. fct.

$$P_\xi(k) \sim k^{n-1}$$

$\phi(x,\eta)$


a(t)
t
d) cyclic matter bounce ?
t
n = -1
x
n = 2
n = 1
vacuum sp.

Formalism

$$\delta g_{00} = -2\phi \qquad \phi(x,t)$$

$$\delta g_{0i} = a^2 B_{,i} \qquad B(x,t)$$

$$\delta g_{ij} = a^2\left(\psi \delta_{ij} + E_{,ij}\right) \qquad \psi(x,t) \quad E(x,t)$$

$$\delta\varphi(x,t)$$

5 DOF

scalar
radiation

GR

5 DOF

−2 GDF

−1 no anisotropic stress

−1 energy constraint

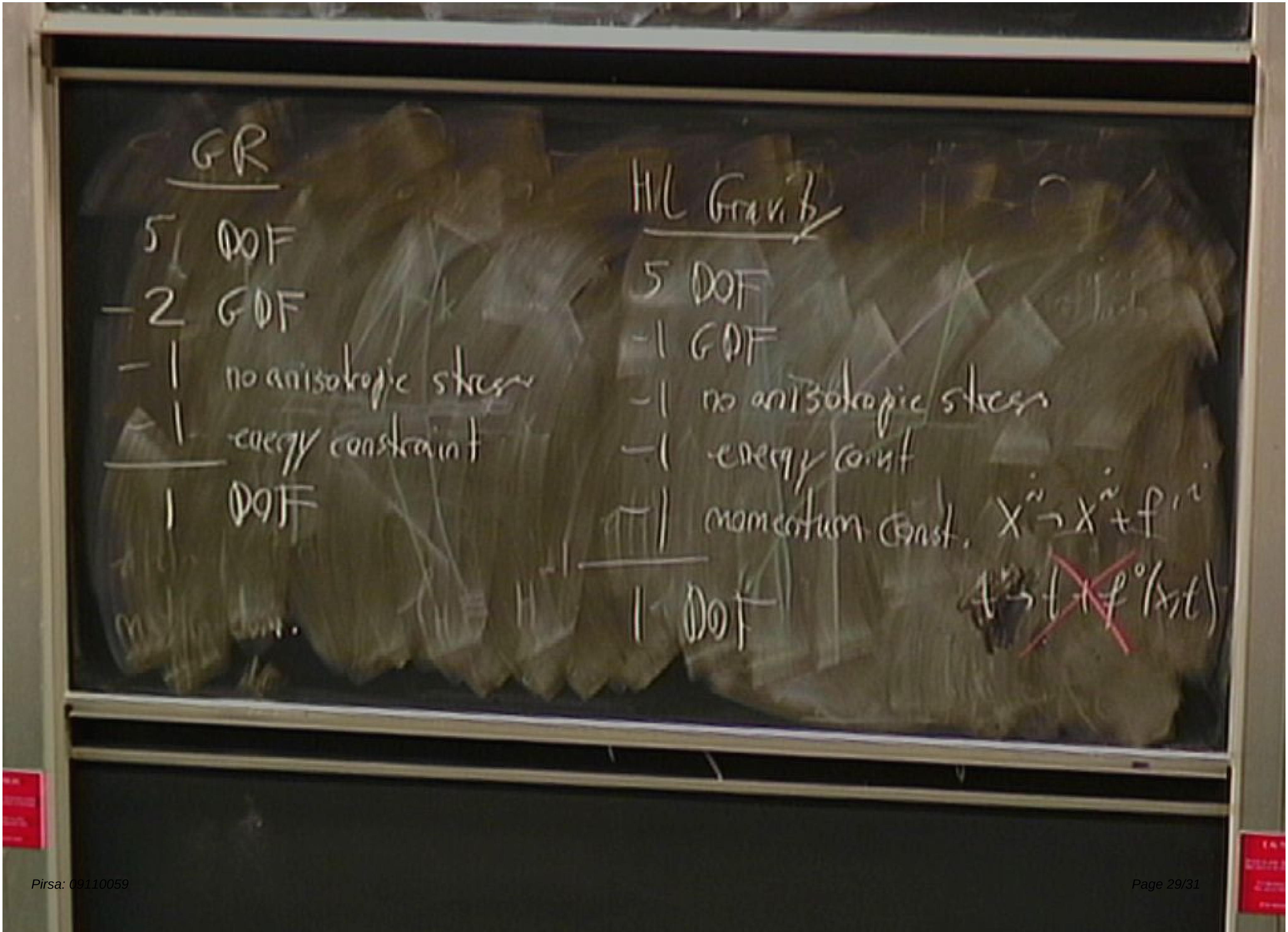
1 DOF

HL Gravity

5 DOF

$x^i \to x^i + f^i$

$t \to t + \cancel{f}^0(x,t)$


GR
5 DOF
−2 GDF
−1 no anisotropic stress
−1 energy constraint
1 DOF
HL Gravity
5 DOF
−1 GDF
−1 no anisotropic stress
−1 energy const
−1 momentum const. $x^i \to x^i + f^i$
$t \to t + \cancel{f^0(x,t)}$
1 DOF

step 1: gauge choice $E=0$

step 2: $\phi =$

$$B = \frac{f(\psi, \delta\varphi)}{32H^2(3\lambda-1) - 4K^2(\lambda-1)\dot{\varphi}_0^2}$$

→ scale- … after bounce

Claim 2: specific predictions: O(1) amplitude & specific shape of 3-pt. fct.

$$P_\xi(k) \sim k^{n-1}$$