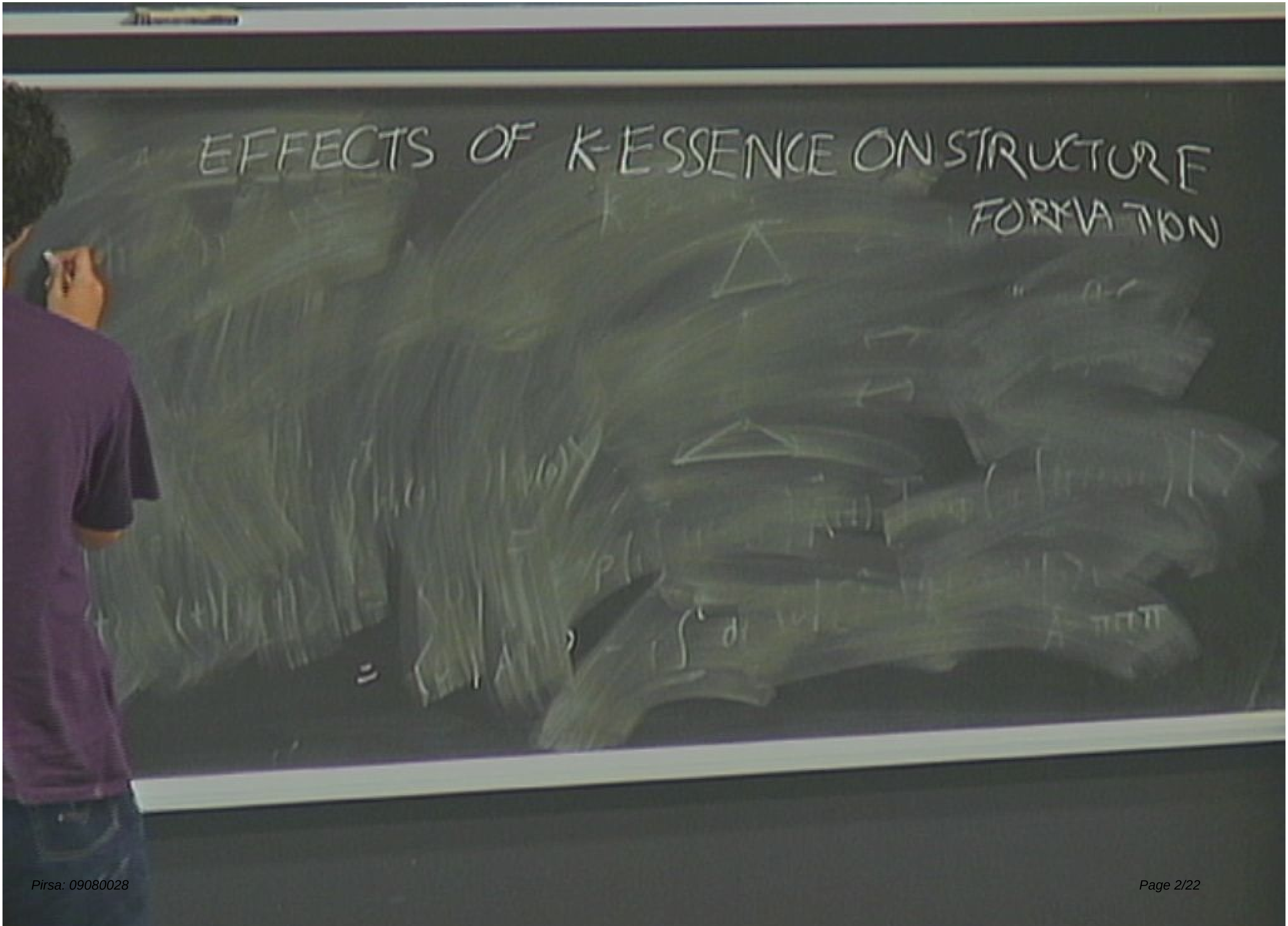
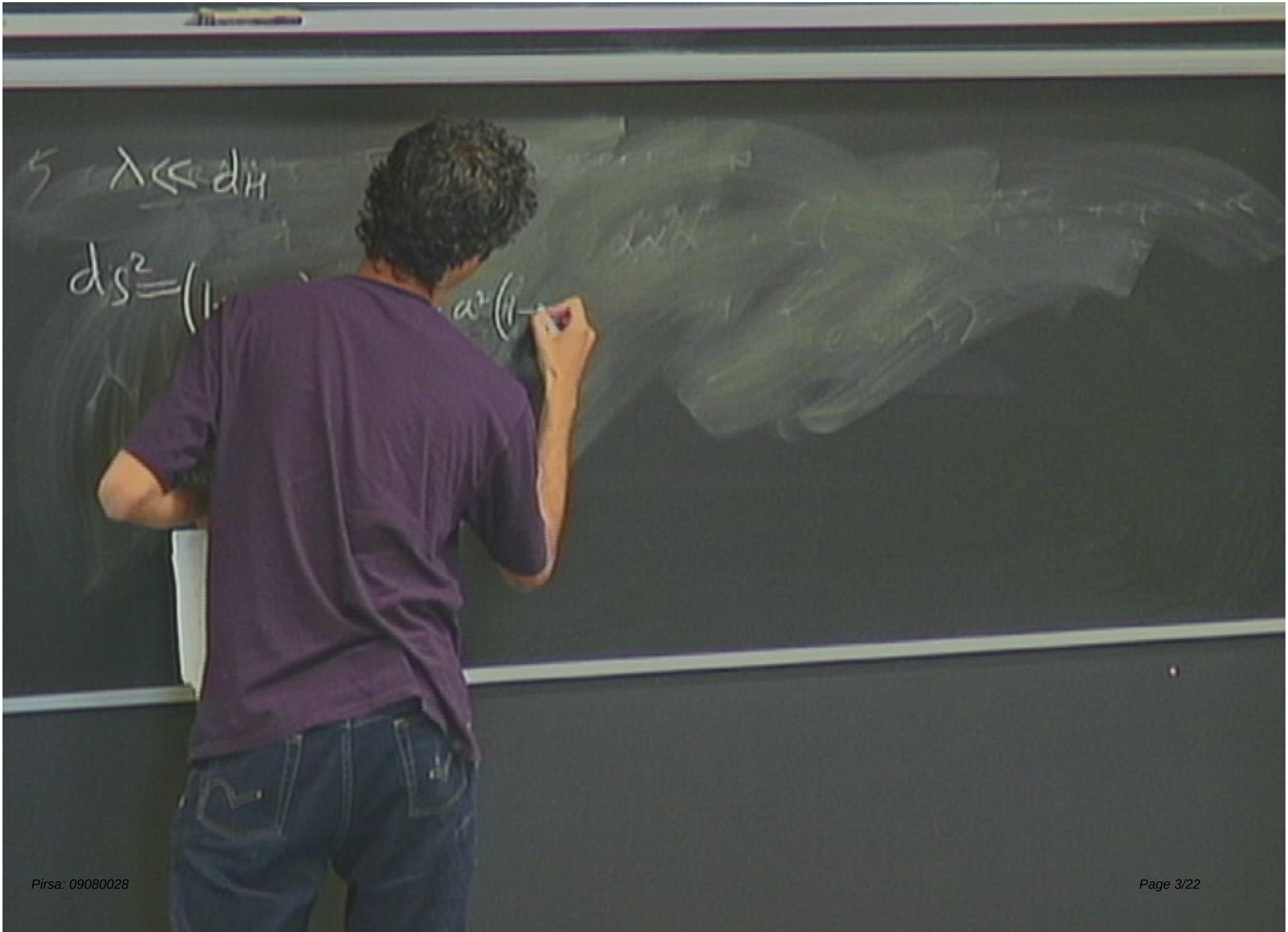
Title: Undergrad Research Project Talk

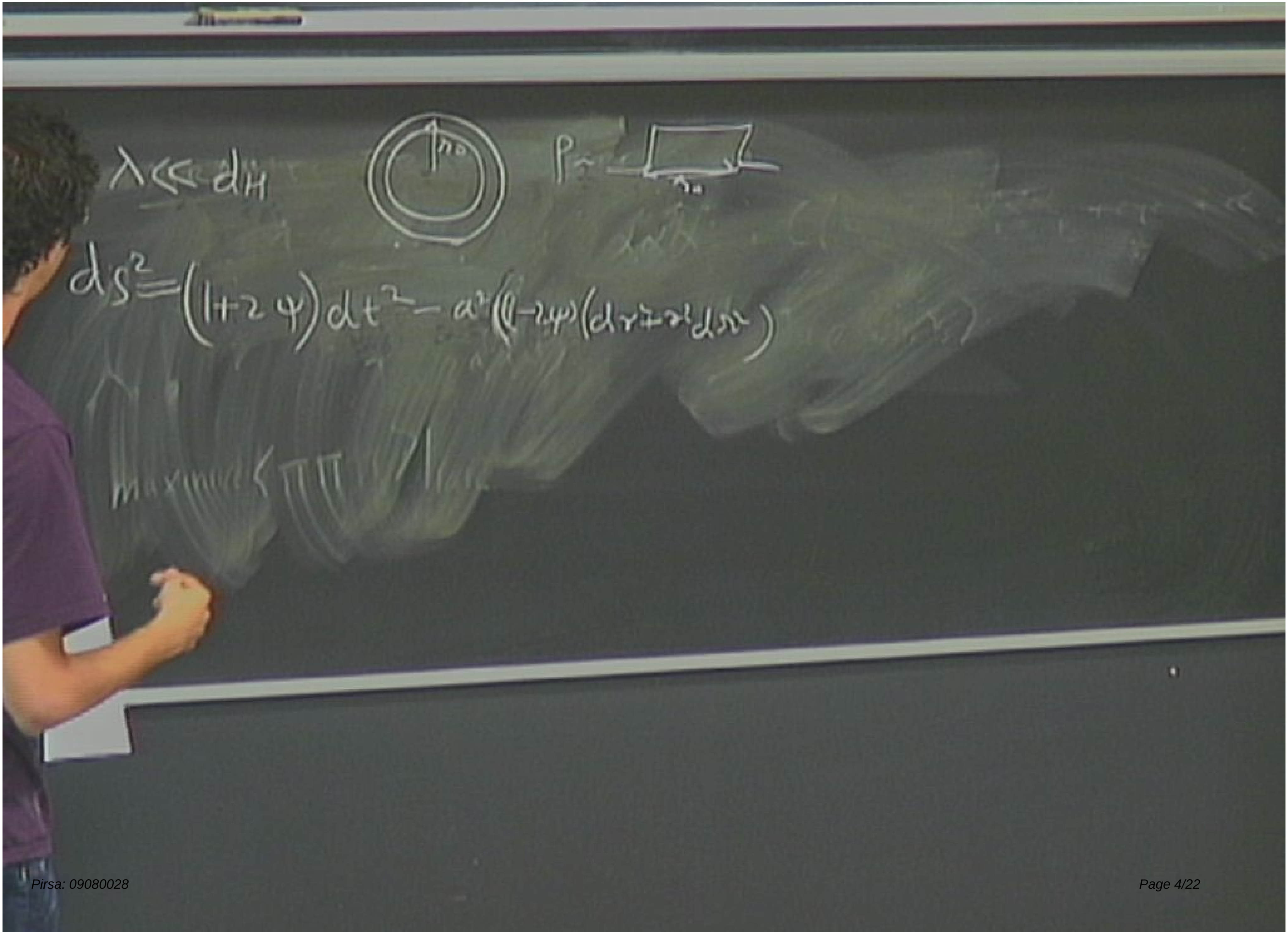
Date: Aug 06, 2009 03:00 PM

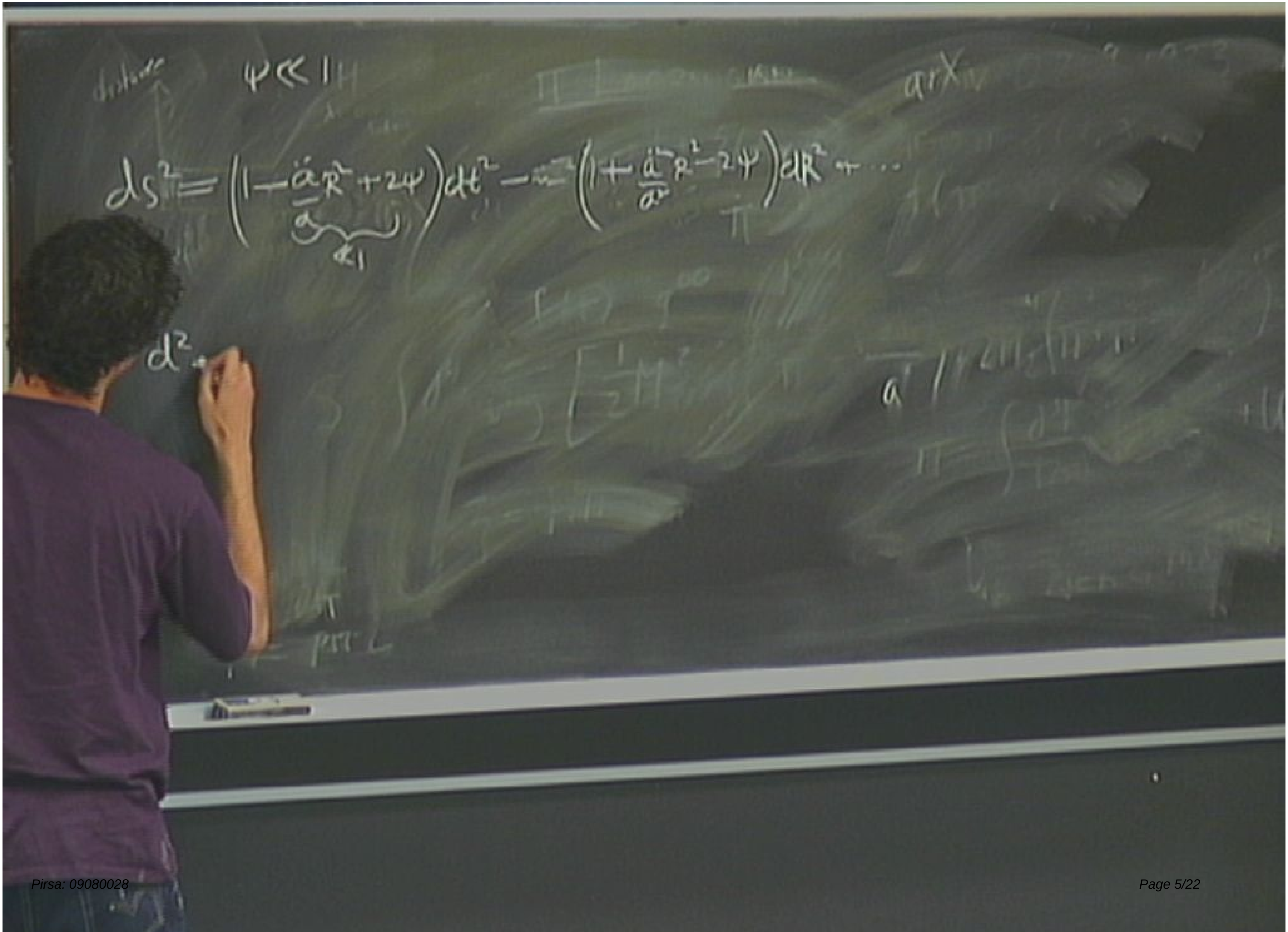
URL: http://pirsa.org/09080028

Abstract:


EFFECTS OF K-ESSENCE ON STRUCTURE
FORMATION


λ<<d_H


$\lambda \ll d_H$
r_0
$\rho \sim$
$ds^2 = (1+2\psi)dt^2 - a^2((1-2\psi)(dr^2 + r^2 d\Omega^2))$


ψ ≪ 1
arX
ds² = (1 − ä/a R² + 2ψ) dt² − (1 + ȧ²/a² R² − 2ψ) dR² + ...
≪ 1
d²

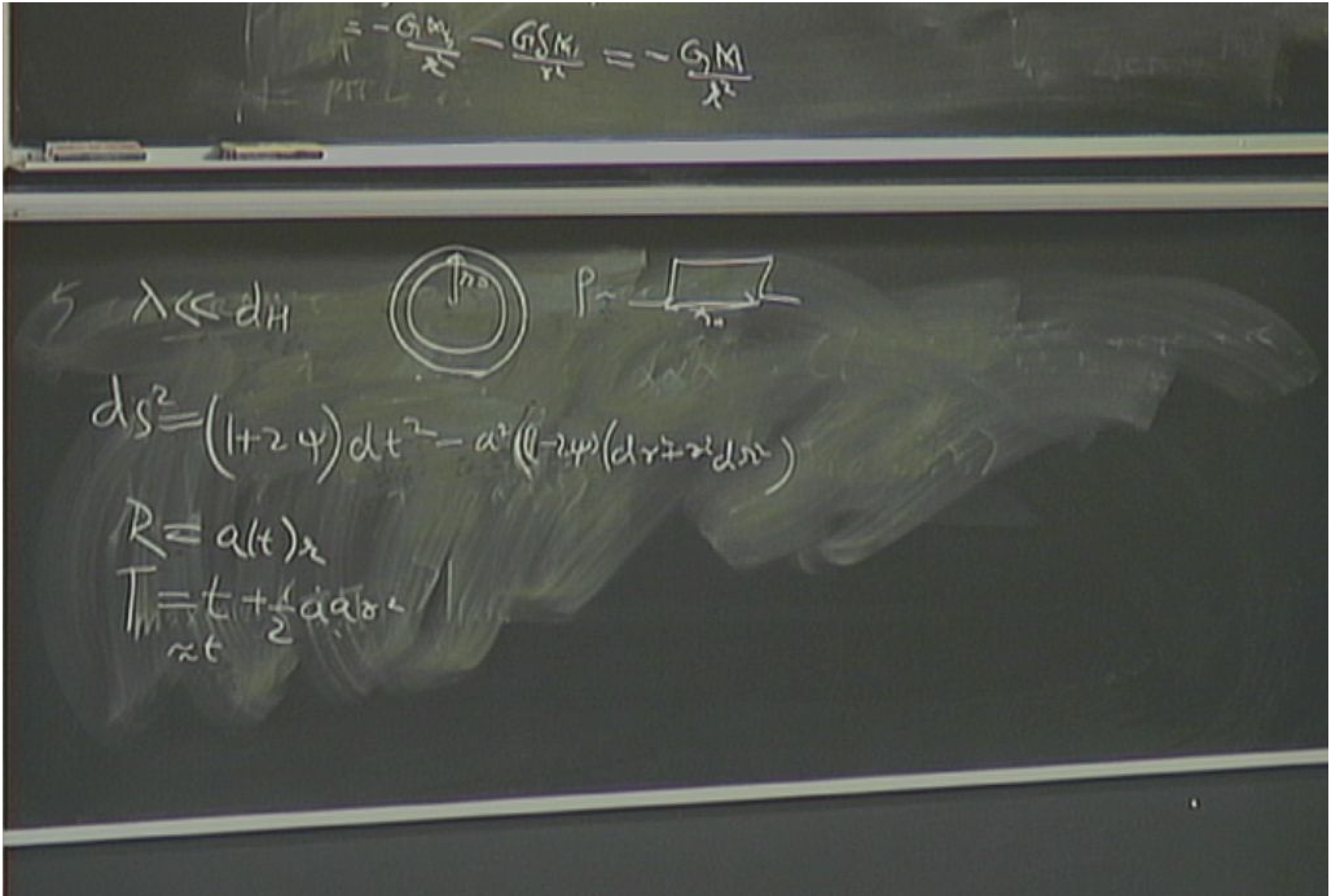
distance $\psi \ll 1$

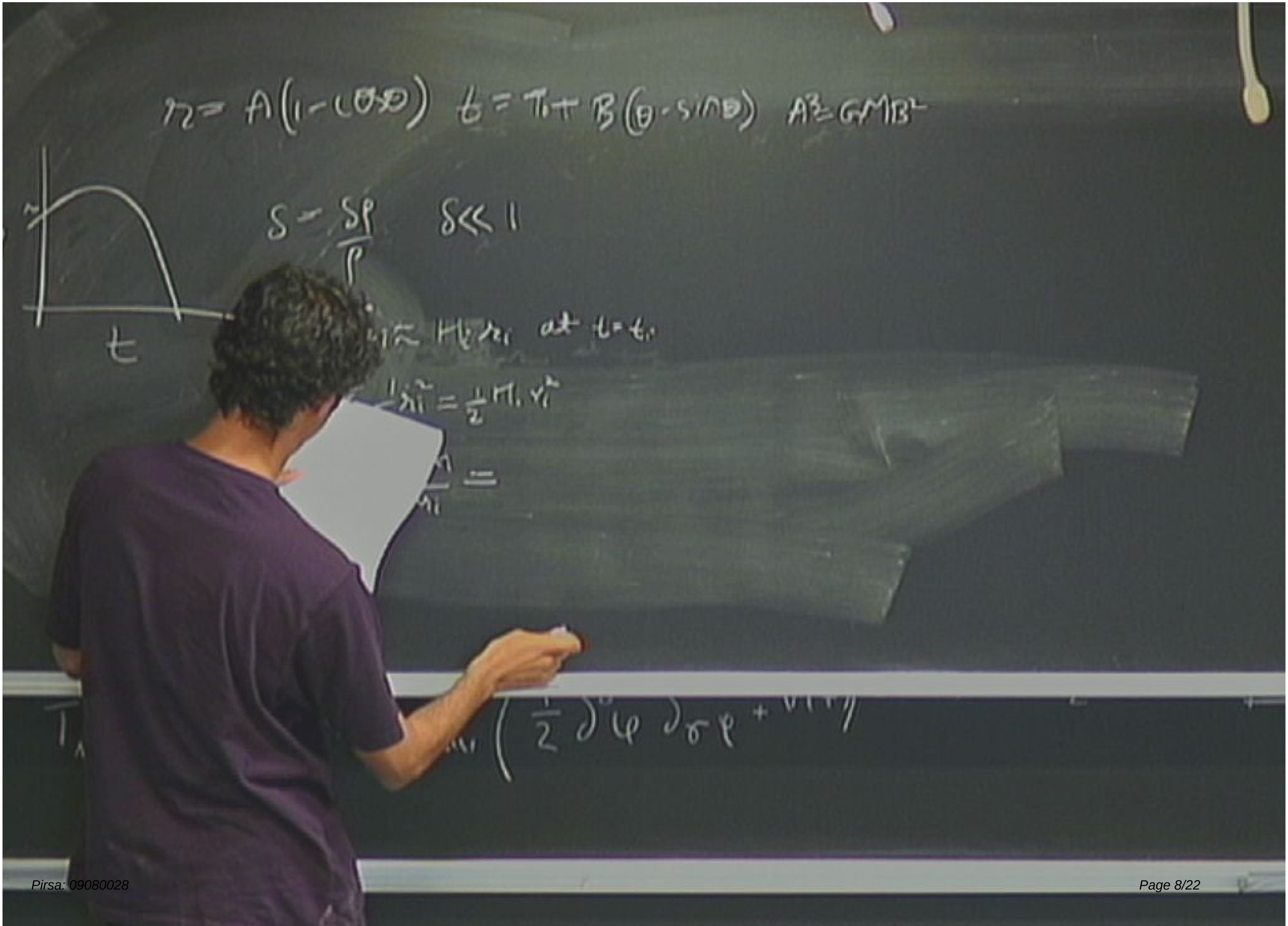
arXiv

$$ds^2 = \Big(1 - \underbrace{\frac{\ddot a}{a} R^2}_{\ll 1} + 2\psi\Big) dt^2 - \Big(1 + \frac{\dot a^2}{a^2} R^2 - 2\psi\Big) dR^2 + \cdots$$

$$\phi = -\frac{1}{2}\frac{\ddot a}{a} R^2 + \psi$$

$$\frac{d^2 r}{dt^2} = -\nabla\phi = \frac{2\pi G}{3}(\rho + 3p) + \psi$$


= −GM_b/r² − GδM/r² = −GM/r²
5 λ ≪ d_H
r_0
ρ ~
r_0
ds² = (1+2ψ)dt² − a²((1−2ψ)(dr² + r²dΩ²))
R = a(t)r
T = t + ½ȧar²
≈ t


r = A(1 - cos θ) t = T + B(θ - sin θ) A³ = GMB²
δ = δρ/ρ δ << 1
t

$E = -\frac{1}{2} K_i \delta_i$

INFLATION

FRW $\quad ds^2 = -dt^2 + a^2(t)\left[\frac{dr^2}{1-kr^2} + d\Omega^2\right]$

FRIEDMANN $\quad \left(\frac{\dot a}{a}\right)^2 = \frac{8\pi G\rho}{3} - \frac{k}{a^2} \qquad \frac{\ddot a}{a} = -\frac{4\pi G}{3}(\rho + 3p)$

$\frac{p}{\rho} < -\frac{1}{3}$

$a = e^{Ht} \qquad H = \text{constant} \qquad \nabla_\mu T_\nu{}^\mu = 0$

H^{-1} = Hubble radius $\qquad \rho = \text{constant}$

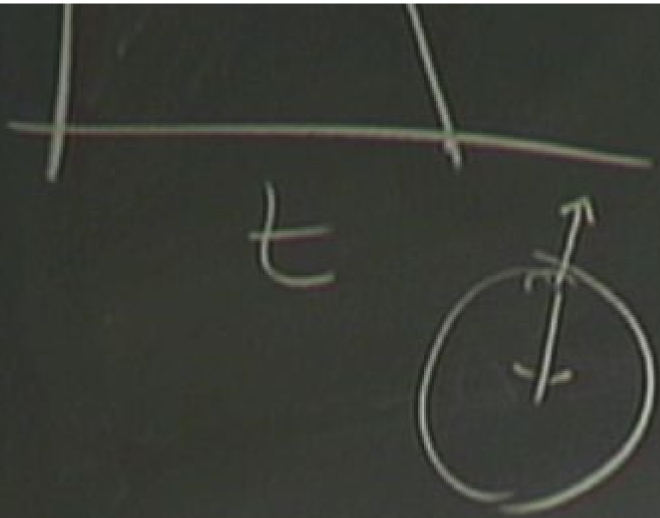
$\rho = -p$

$S_M = \int d^4x \sqrt{-g}\left(\frac{1}{2} g^{\mu\nu} \partial_\mu\varphi\, \partial_\nu\varphi - V(\varphi)\right)$

$T_{\mu\nu} = \partial_\mu\varphi\, \partial_\nu\varphi - g_{\mu\nu}\left(\frac{1}{2}\partial^\sigma\varphi\, \partial_\sigma\varphi + V(\varphi)\right)$

$\rho = \frac{\dot\varphi^2}{2} + V(\varphi)$

$p = \frac{\dot\varphi^2}{2} - V(\varphi)$.



$\dot{r}\ \gamma =$

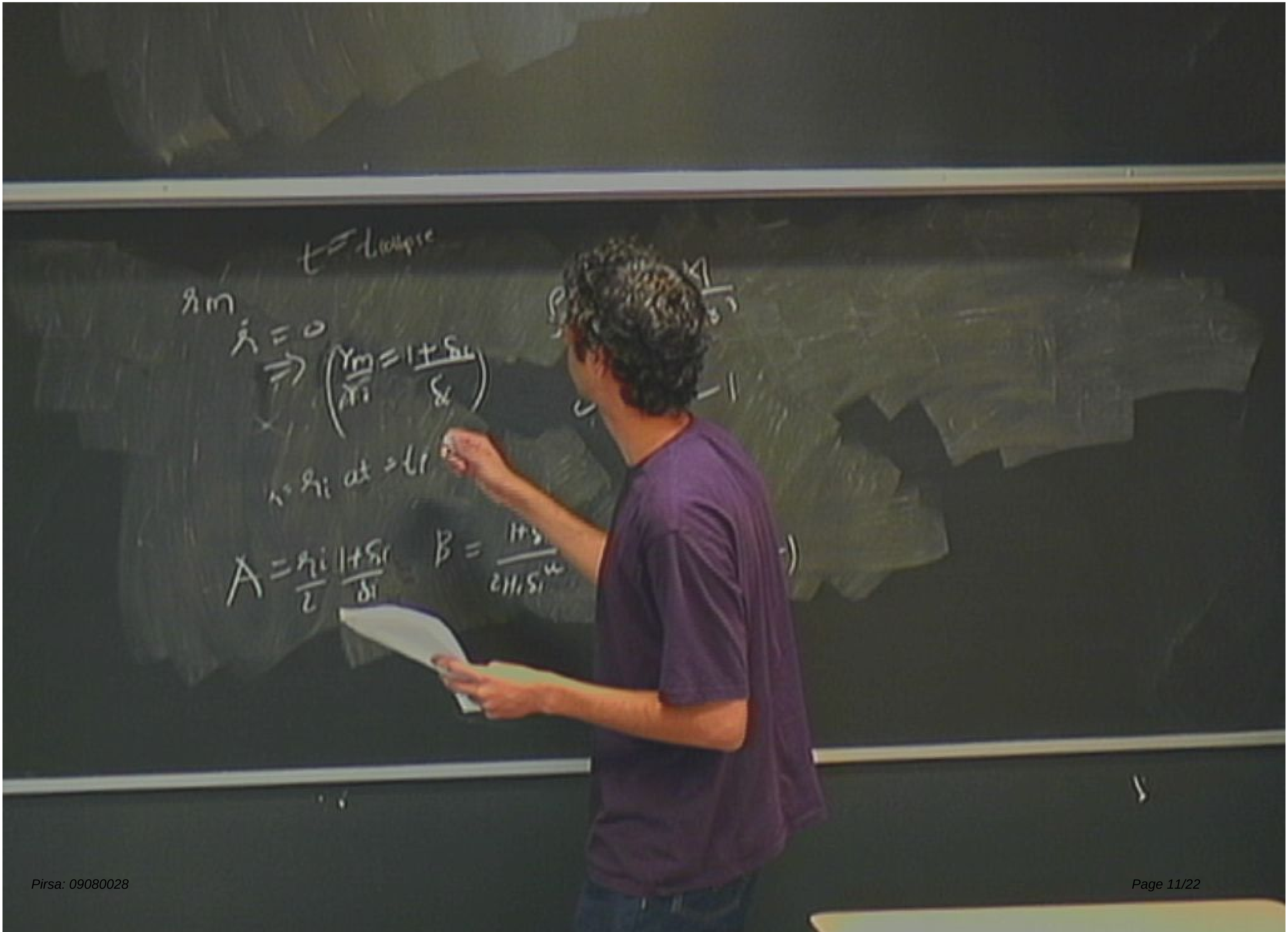
$\dot{r}_i \simeq H_i r_i$ at $t = t_i$

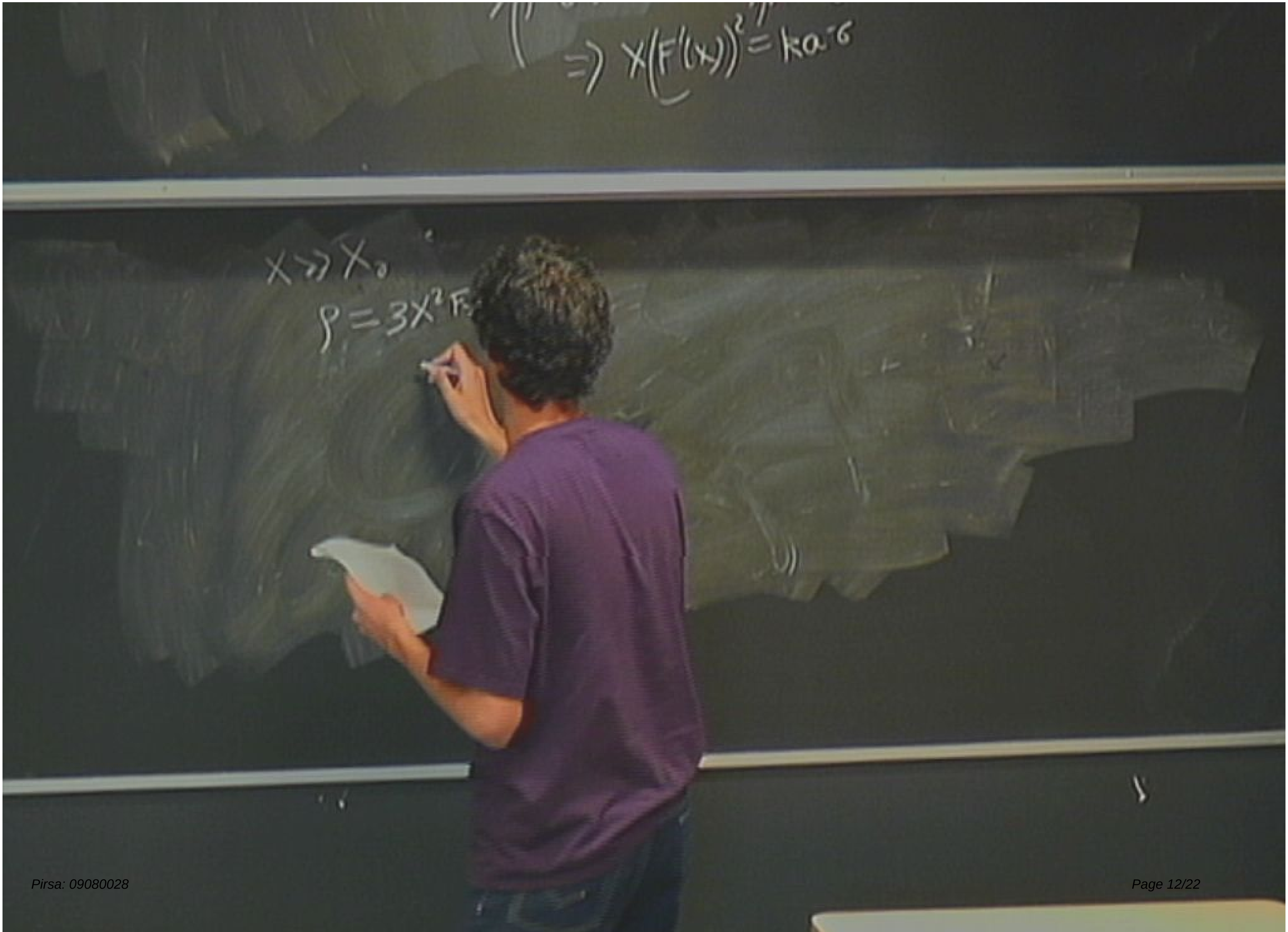
$K_i = \frac{1}{2}\dot{r}_i^2 = \frac{1}{2}H_i^2 r_i^2$

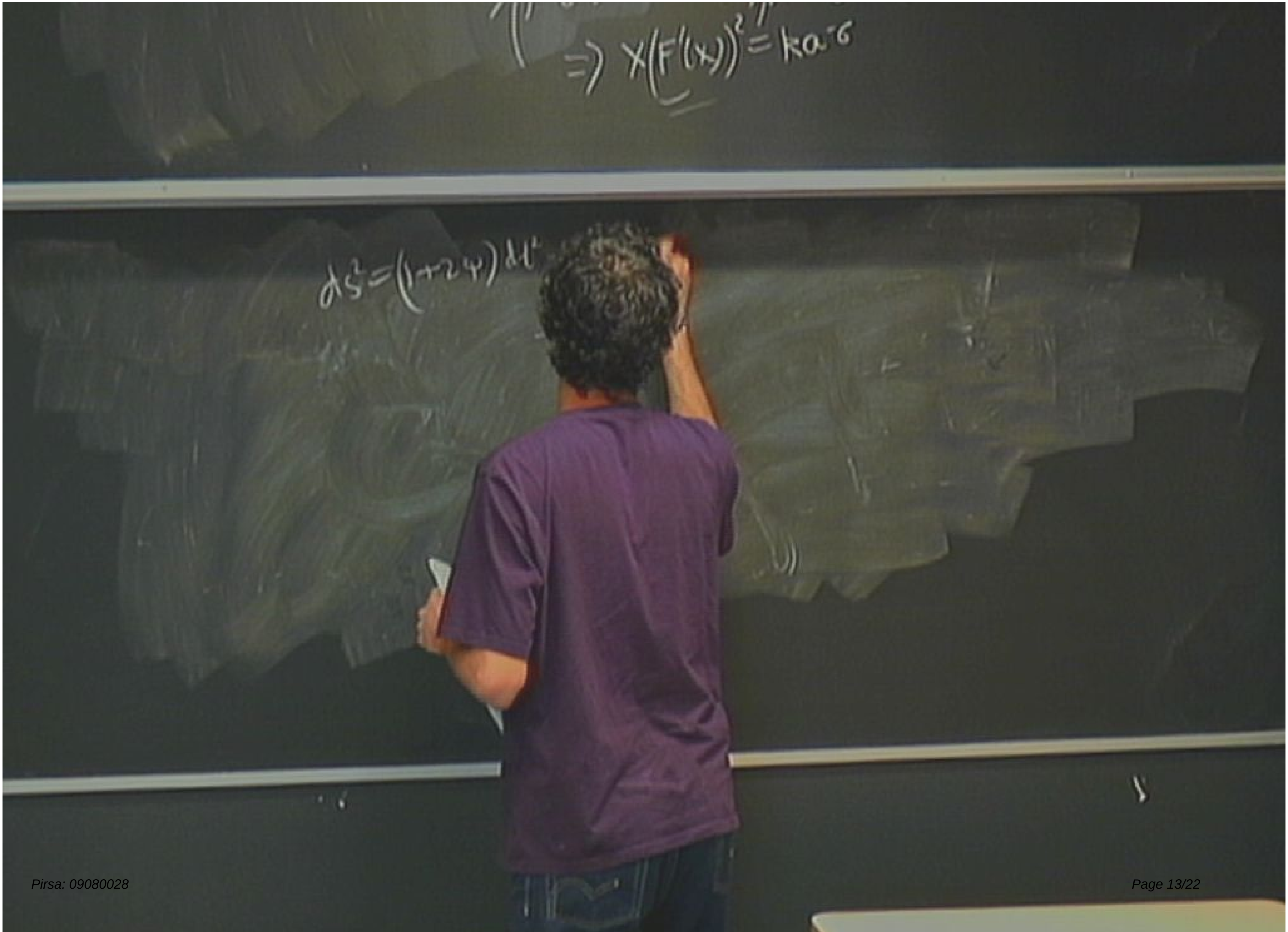
$U_i = \frac{GM}{r_i} = K_i(1+\delta_i)$

$E = -K_i\delta_i$

INFLATION




⇒ x(F'(x))² = ka⁻⁶
x ≫ x₀
ρ = 3x²F



⇒ X(F'(X))² = ka⁻⁶
ds² = (1+2ψ)dt²

$$\Rightarrow X(F'(X))^2 = ka^{-6}$$

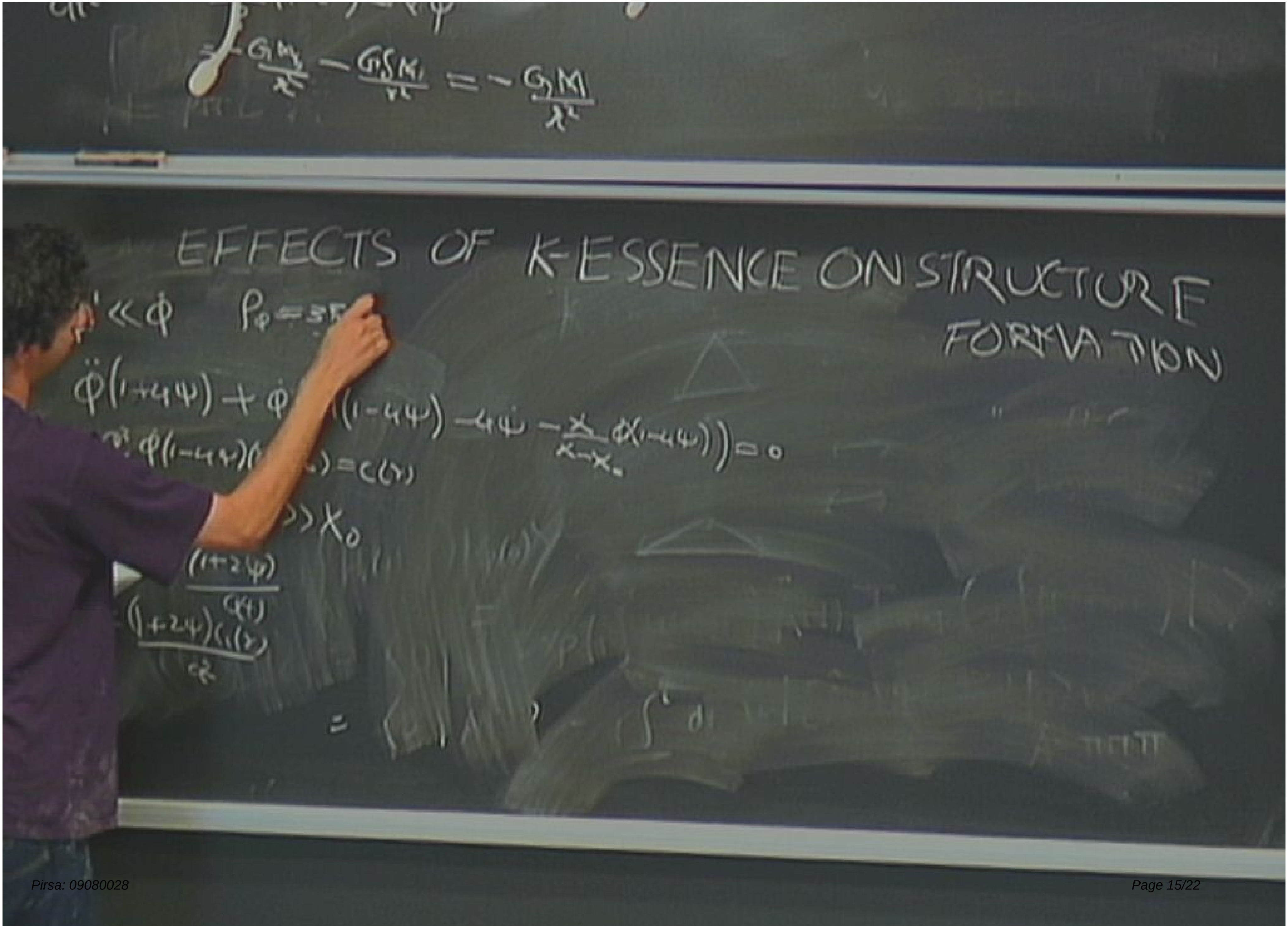
$$ds^2 = (1+2\psi)dt^2 - (1-2\psi)a^2(dr^2 + r^2 d\Omega^2)$$

$$X = \frac{1}{2}(1-2\psi)\dot{\phi}^2 - \frac{1}{2}(1+2\psi)\phi'^2 \qquad X = \frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi$$

$R \to a(t)r$

$$\ddot{\phi}(1-4\psi) + \dot{\phi}\left(3H(1-4\psi) - 4\dot{\psi} + \frac{1}{F'}\frac{\partial F'}{\partial t}(1-4\psi)\right) - \phi'' - \left(\frac{2}{r} + \frac{1}{F'}\frac{\partial F'}{\partial r}\right)\phi' = 0$$

$$\nabla^2\psi = 4\pi G(\delta\rho_m + \delta\rho_\phi)$$


EFFECTS OF K-ESSENCE ON STRUCTURE FORMATION

$$-\frac{G m_1}{r^2} - \frac{G \delta M_1}{r^2} = -\frac{G M}{r^2}$$

EFFECTS OF K-ESSENCE ON STRUCTURE FORMATION

$\varphi' \ll \dot{\varphi}$ $\quad \rho_\varphi = 3\bar{F}_0 X^2 =$

$$\ddot{\varphi}(1+4\Psi) + \dot{\varphi}\left(3H(1-4\Psi) - 4\dot{\Psi} - \frac{\dot{X}}{X - X_0}\,\dot{\varphi}(1-4\Psi)\right) = 0$$

$$a^3 \dot{\varphi}(1-4\Psi)(X - X_0) = C(r)$$

$$X \simeq \frac{1-2\Psi}{2}\dot{\varphi}^2 \qquad X \gg X_0$$

$$\dot{\varphi} = \frac{C(r)(1+2\Psi)}{\varphi(t)}$$

$$\frac{(\ldots\Psi)C_1(r)}{a^3}$$

$$= -\frac{G m_1}{r^2} - \frac{G \zeta M_1}{r^2} = -\frac{G M}{r^2}$$

EFFECTS OF K-ESSENCE ON STRUCTURE FORMATION

$\phi' \ll \dot{\phi}$ $\quad \rho_\phi = 3 F_{,X} X^2 - \boxed{\frac{C_2(x)(1+4\psi)}{a^4}}$

$$\ddot{\phi}(1+4\psi) + \dot{\phi}\left(3H(1-4\psi) - 4\dot{\psi} - \frac{X}{X-X_0}\dot{\phi}(1-4\psi)\right) = 0$$

$a^3 \dot{\phi}(1-4\psi)(X-X_0) = C(r)$

$X \simeq \frac{1-2\psi}{2}\dot{\phi}^2 \quad X \gg X_0$

$\dot{\phi} = C(r)\frac{(1+2\psi)}{a^3}$

$X = (1+2\psi)\frac{C_1(r)}{a^6}$

ψ_1

$=$

$$-\frac{GM_2}{r^2} - \frac{GSM_1}{r^2} = -\frac{GM}{r^2}$$

EFFECTS OF K-ESSENCE ON STRUCTURE FORMATION

$\phi' \ll \dot\phi \qquad \rho_\phi = 3F_{,X}X^2 = \boxed{\frac{C_2(x)(1+4\psi)}{a^4}}$

$$\ddot\phi(1+4\psi) + \dot\phi\left(3H(1-4\psi) - 4\dot\psi - \frac{\dot X}{X-X_0}\dot\phi(1-4\psi)\right) = 0$$

$a^3\dot\phi(1-4\psi)(X-X_0) = C(x)$

$X \approx \frac{1-2\psi}{2}\dot\phi^2 \qquad X \gg X_0 \qquad X = \frac{1}{2}g_{\mu\nu}\partial^\mu\phi\,\partial^\nu\phi$

$\dot\phi = C(x)\frac{(1+2\psi)}{a^{(4)}}$

$X = \frac{(1+2\psi)C_1(x)}{a^2}$

$$\nabla^2 \psi = 4\pi G\left(\delta\rho_\varphi + \delta\rho_m\right)$$

$$\rho_\varphi = \rho_\varphi(t) + \delta\rho_{\varphi 0}\left(\frac{a_i}{a}\right)^4 \Theta(r_0 - r)\left(1 + 4\left(\psi - \psi(r_0)\right)\right) + 4\,\frac{\rho_{\varphi 0}}{a^4}\left(\psi(r,t) - \psi(r,t_i)\right)$$

$$\rho_\varphi = \rho_\varphi(t) + \delta\rho_{\varphi 0}\left(\frac{a_i}{a}\right)^4 \Theta(r_0 - r)\left(1 + 4(\psi - \psi(r_0 t))\right) + 4\frac{\rho_\varphi}{a^4}\left(\psi(r,t) - \psi(r,t)\right)$$

$r < r_0$

$$\psi(r,t) = -\frac{4\pi G}{3}\rho_m r^2 - \frac{G}{r}\int_0^r 4\pi r'^2 [\;\;]\, dr'$$

$8\pi G = 1$

$r \leq r_0$

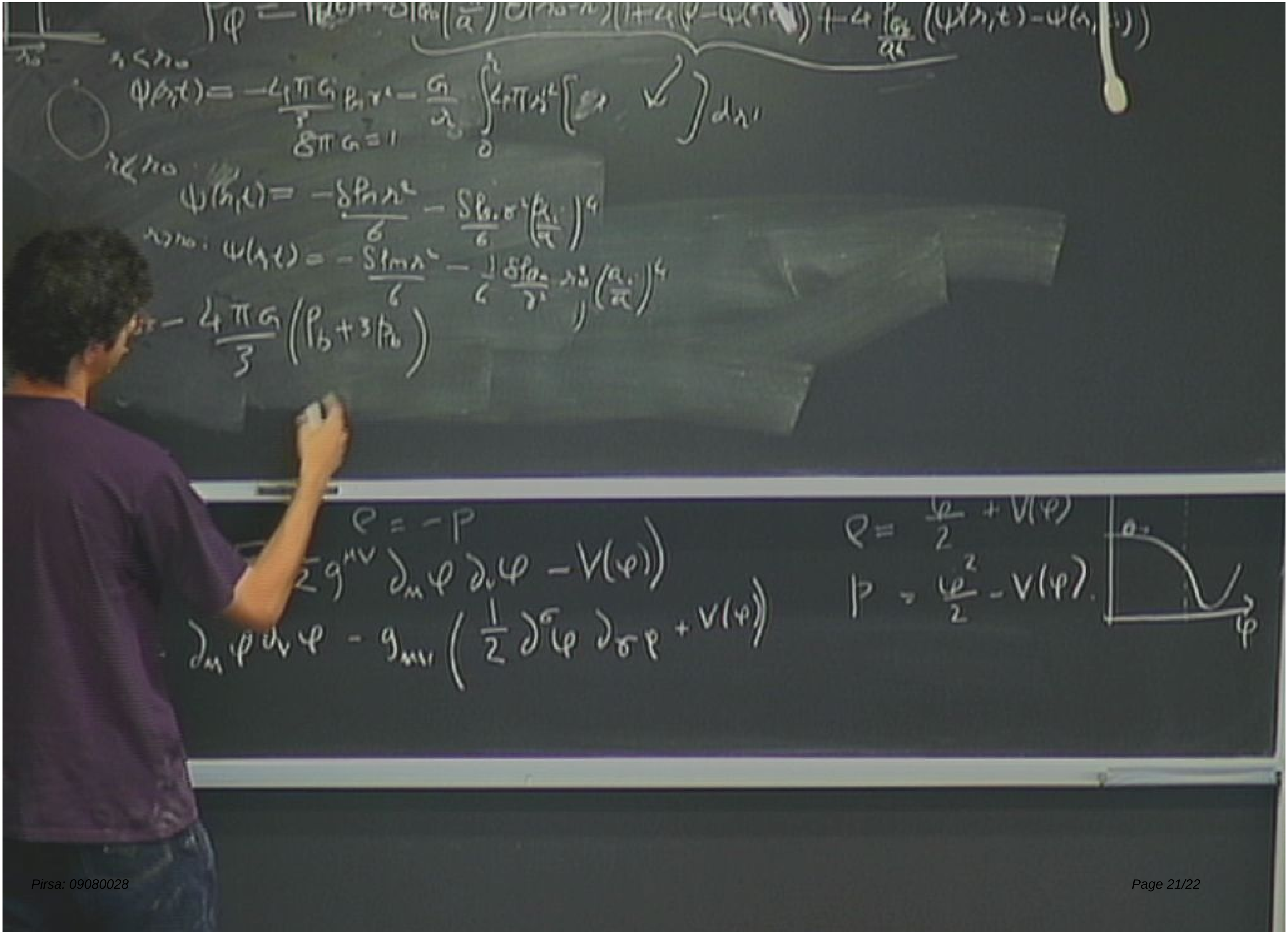
$$\psi(r,t) = -\frac{\delta\rho_m r^2}{6} - \frac{\delta\rho_{\varphi 0}\, r^2}{6}\left(\frac{a_i}{a}\right)^4$$

$r > r_0$:

$$\psi(r,t) = -\frac{\delta\rho_m r^2}{6} - \frac{1}{6}\frac{\delta\rho_{\varphi 0}}{r}\, r_0^3\left(\frac{a_i}{a}\right)^4$$

$$\partial_\mu \varphi\, \partial_\nu \varphi - g_{\mu\nu}\left(\frac{1}{2}\partial^\sigma \varphi\, \partial_\sigma \varphi + V(\varphi)\right)$$

φ



$\rho = -P$
$\rho = \frac{\dot\varphi^2}{2} + V(\varphi)$
$P = \frac{\dot\varphi^2}{2} - V(\varphi)$
$-\frac{4\pi G}{3}(\rho_b + 3P_b)$
$8\pi G = 1$