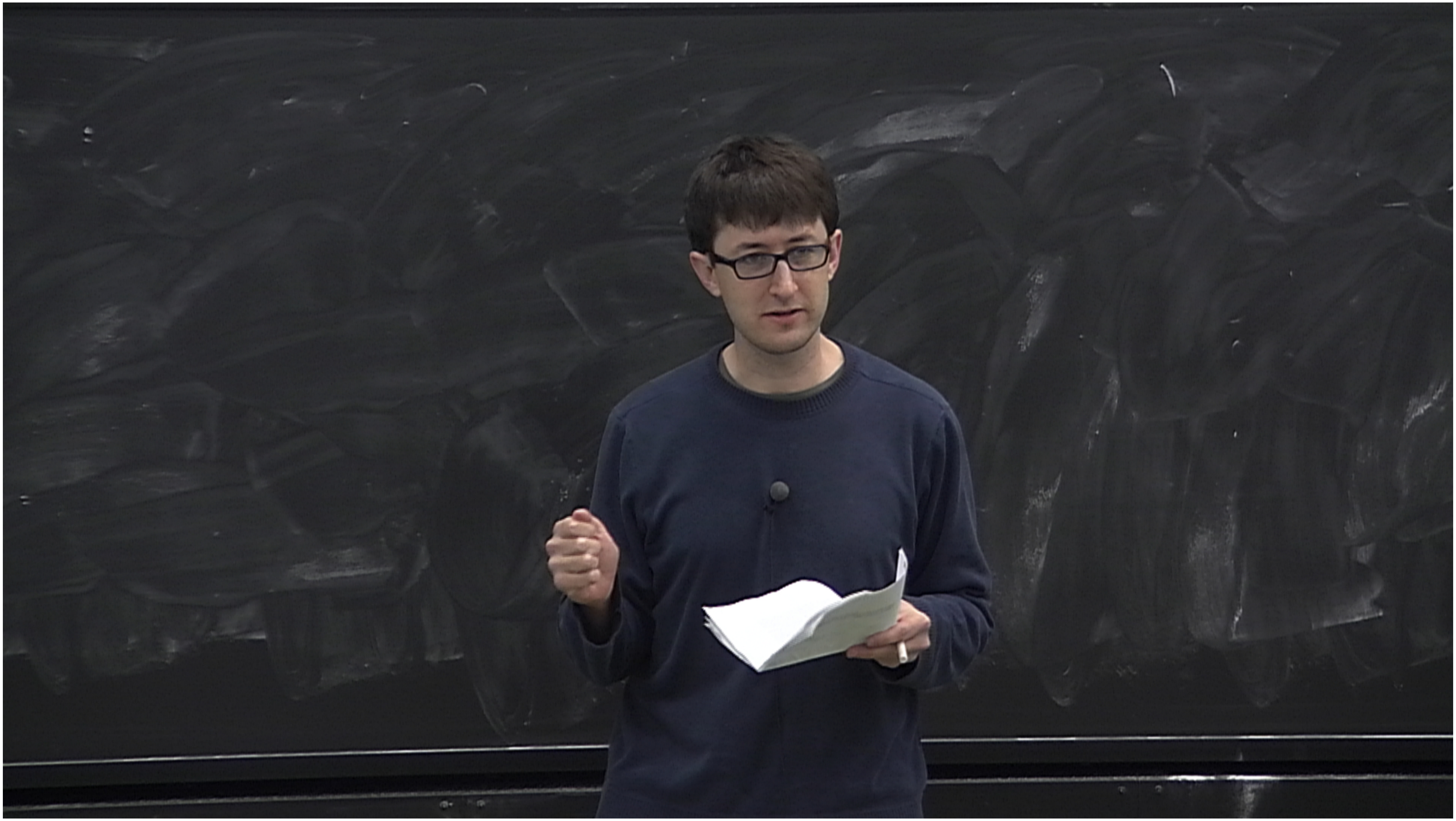
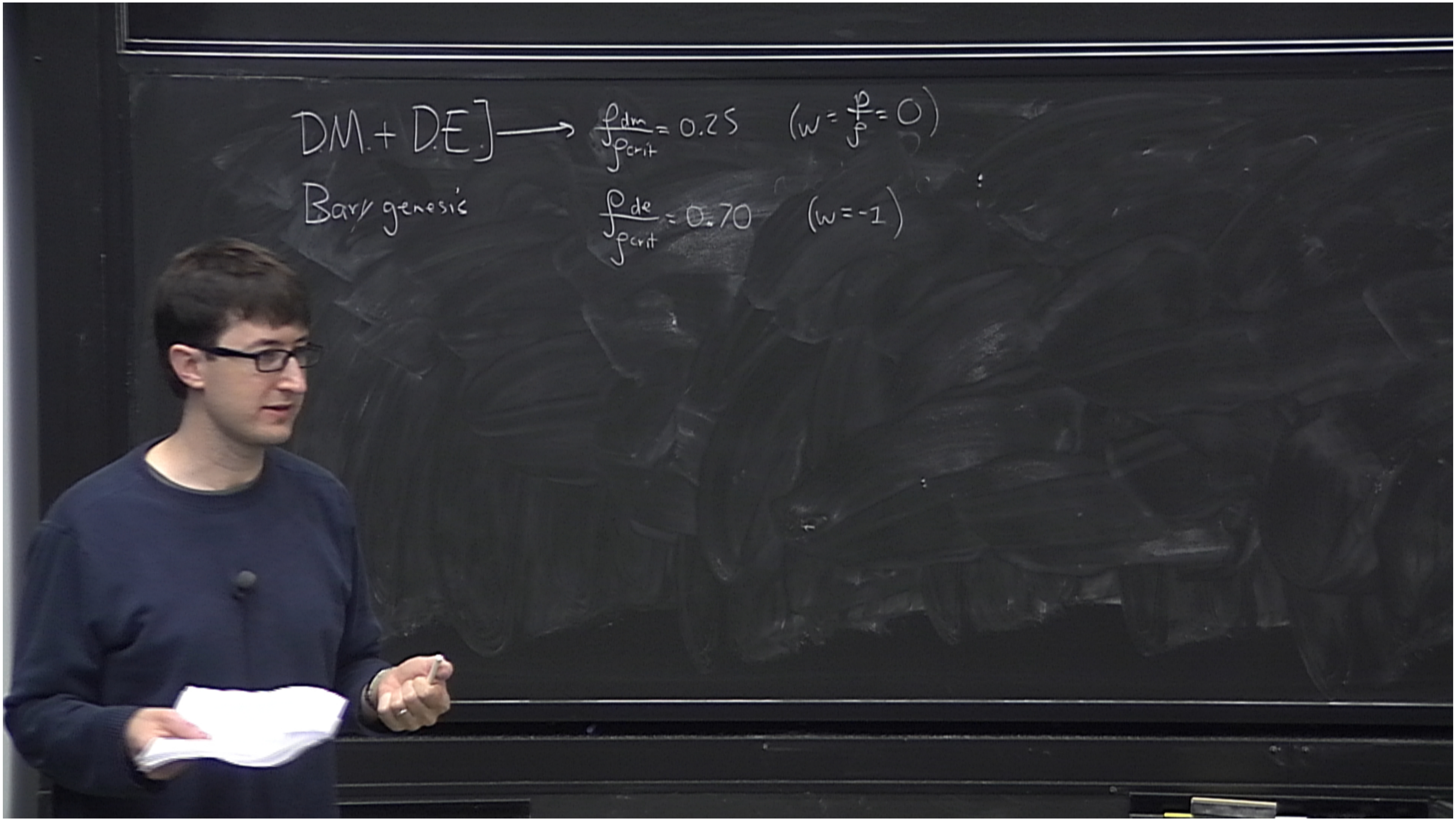
Title: Cosmology (Review) - Lecture 12

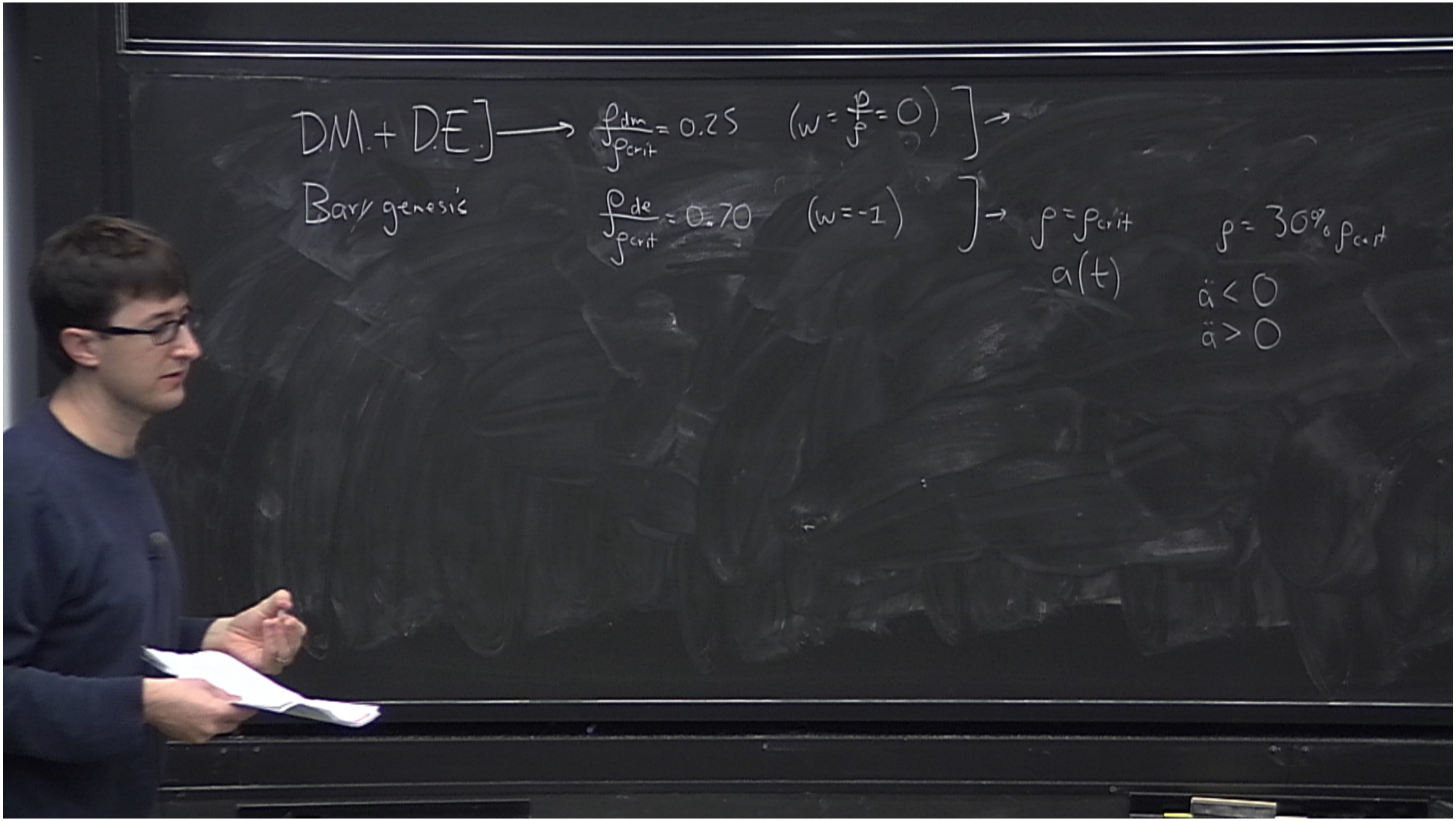
Date: Feb 08, 2012 11:30 AM

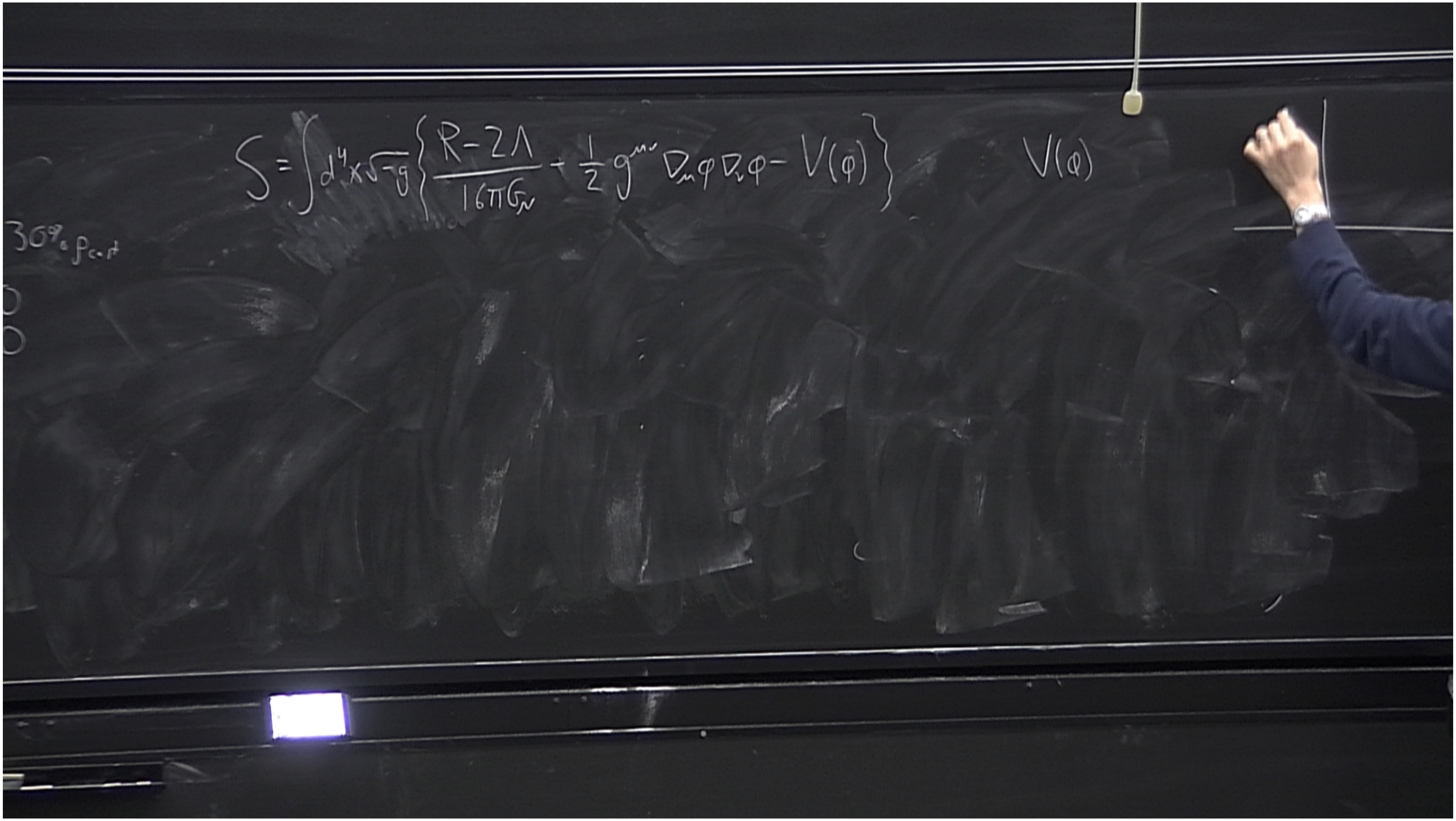
URL: http://pirsa.org/12020028

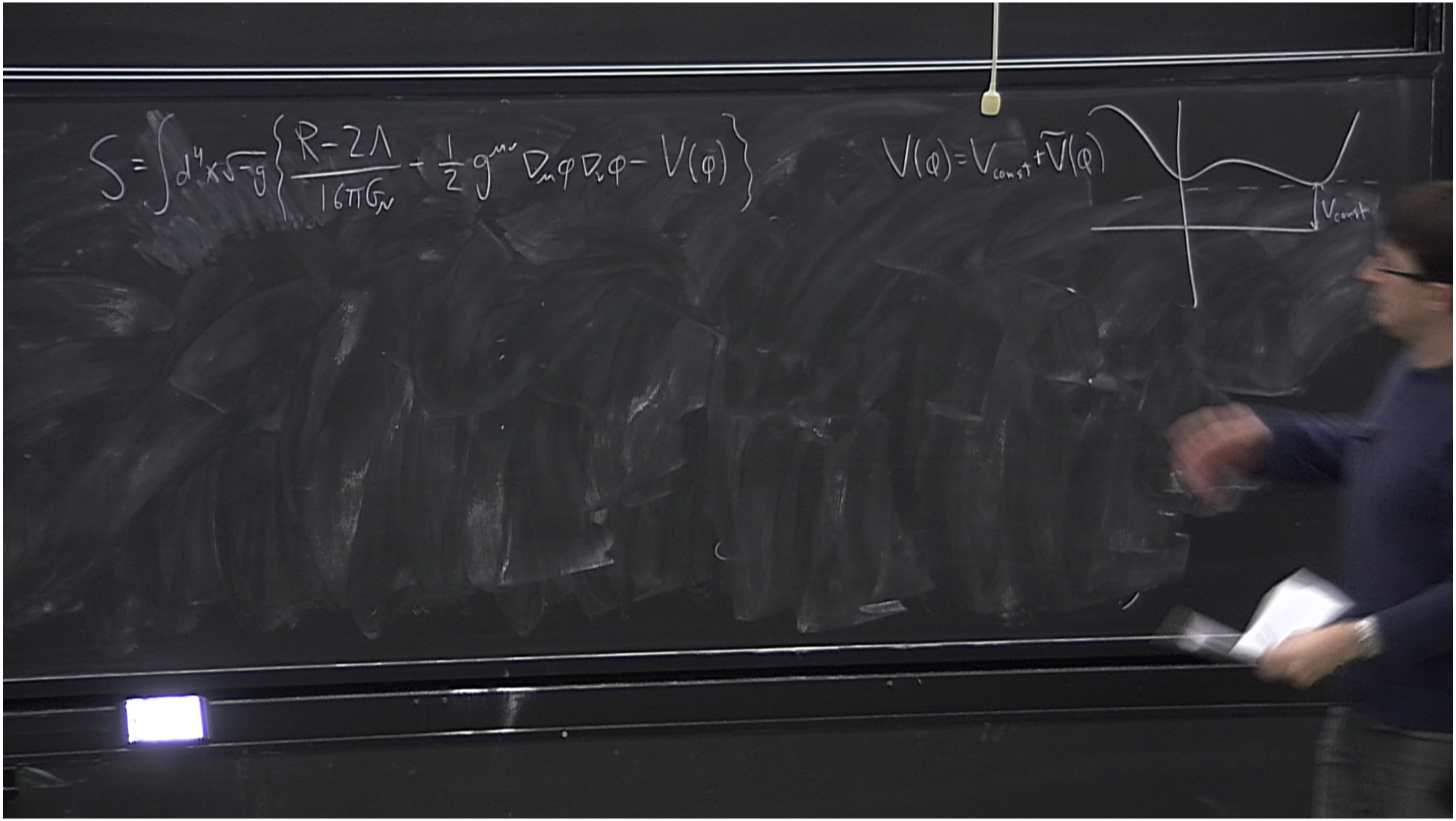
Abstract:

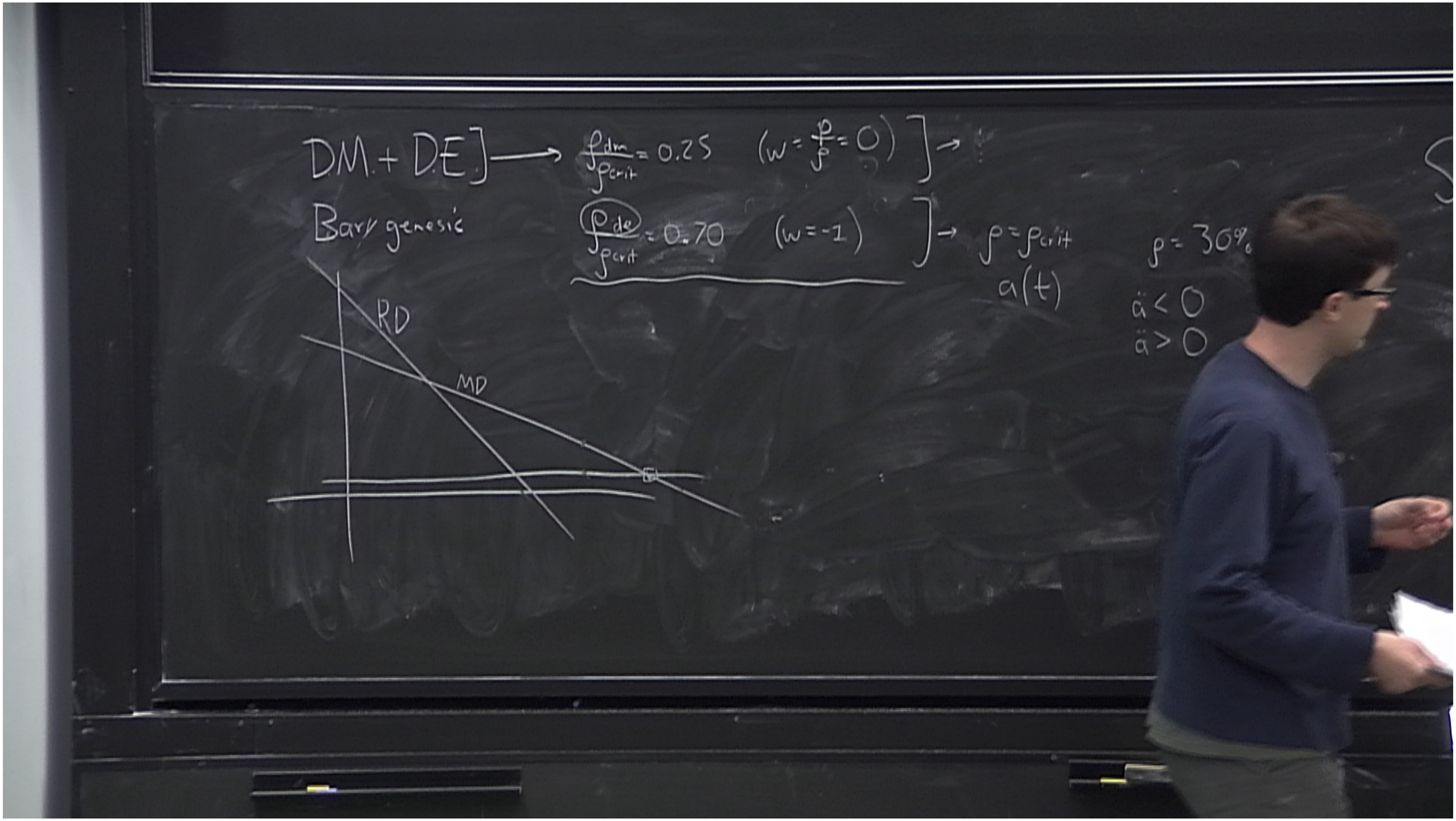


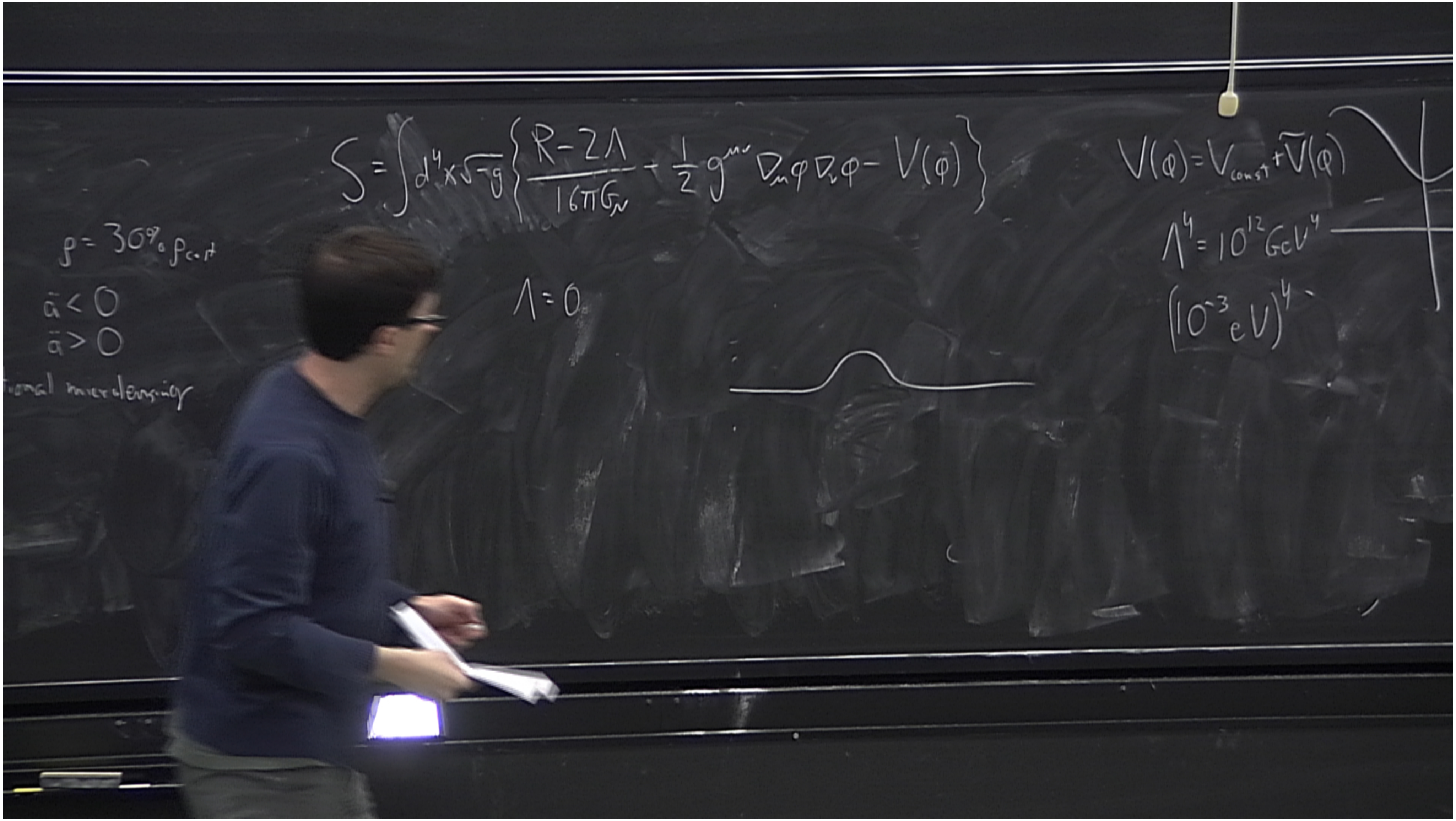

DM + DE] → ρdm / ρcrit = 0.25 (w = p/ρ = 0)
Bary genesis
ρde / ρcrit = 0.70 (w = -1)


DM + DE
ρdm / ρcrit = 0.25
(w = p/ρ = 0)
Barygenesis
ρde / ρcrit = 0.70
(w = -1)
ρ = ρcrit
a(t)
ρ = 30% ρcrit
ä < 0
ä > 0

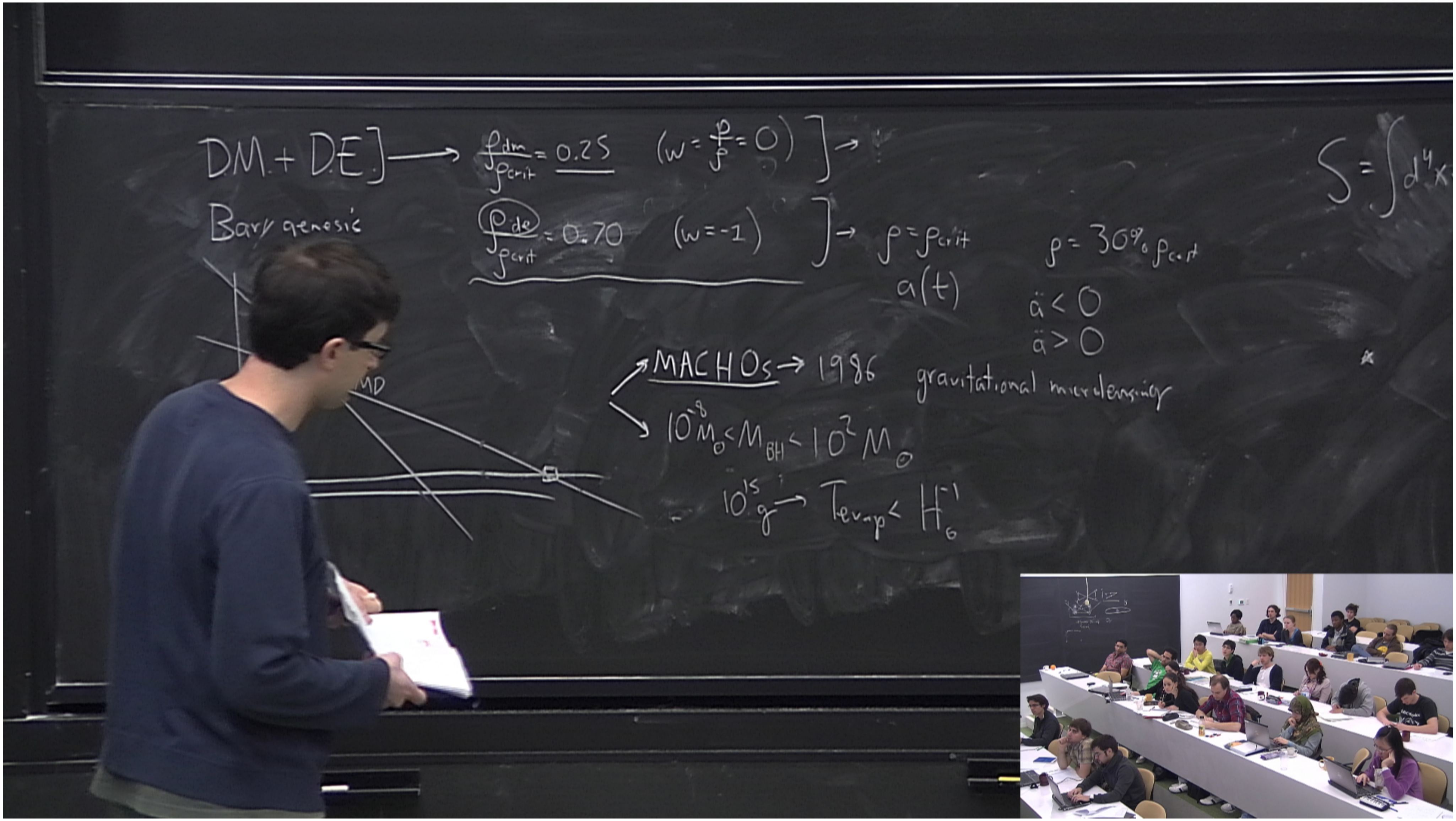

$S = \int d^4x \sqrt{-g} \left\{ \frac{R - 2\Lambda}{16\pi G_N} - \frac{1}{2} g^{\mu\nu} \nabla_\mu \varphi \nabla_\nu \varphi - V(\varphi) \right\}$
$V(\varphi)$
30% ρ_{crit}

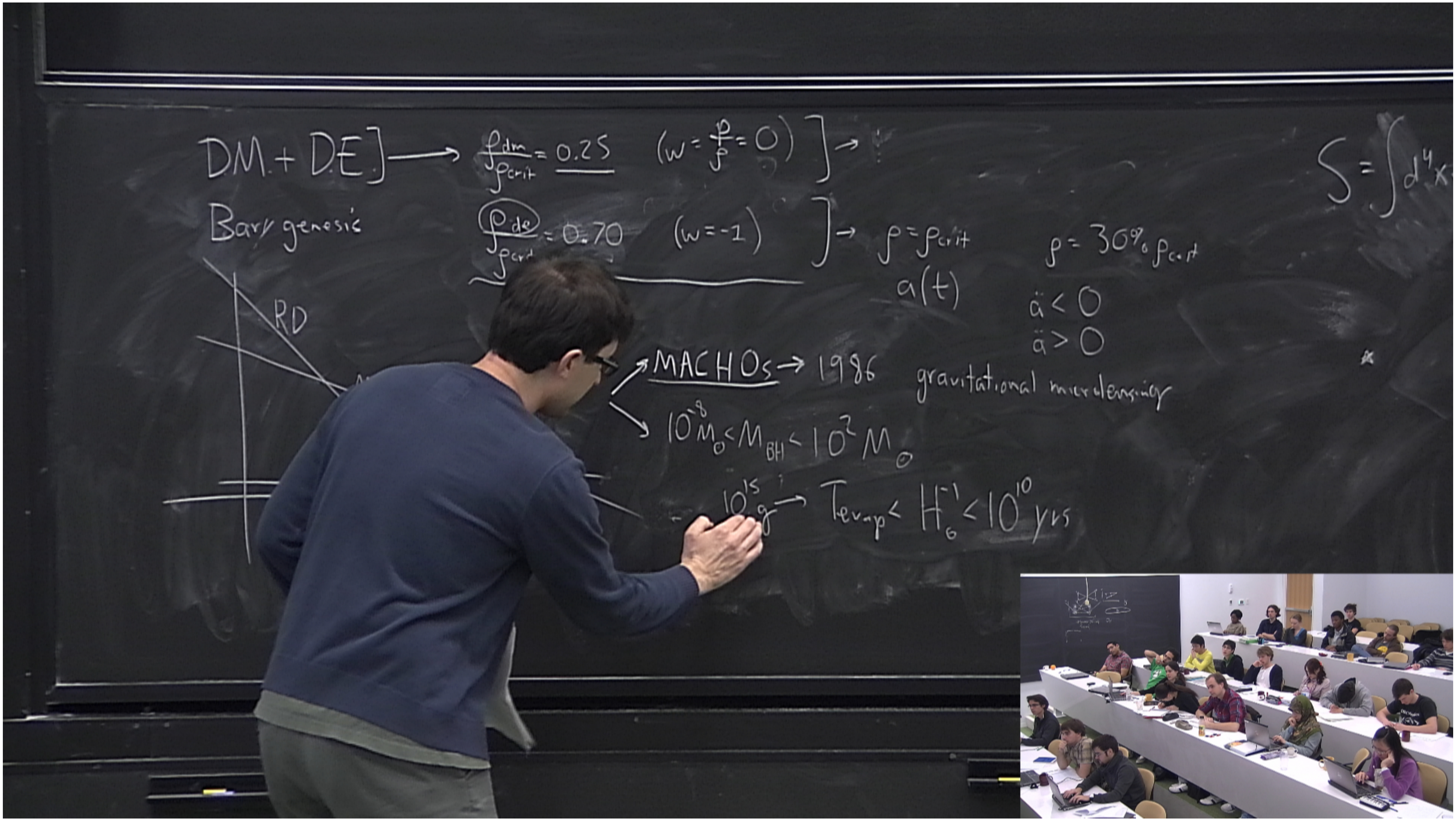

$S = \int d^4x \sqrt{-g} \left\{ \frac{R - 2\Lambda}{16\pi G_N} - \frac{1}{2} g^{\mu\nu} \nabla_\mu \varphi \nabla_\nu \varphi - V(\varphi) \right\}$
$V(\varphi) = V_{const} + \tilde{V}(\varphi)$
V_{const}

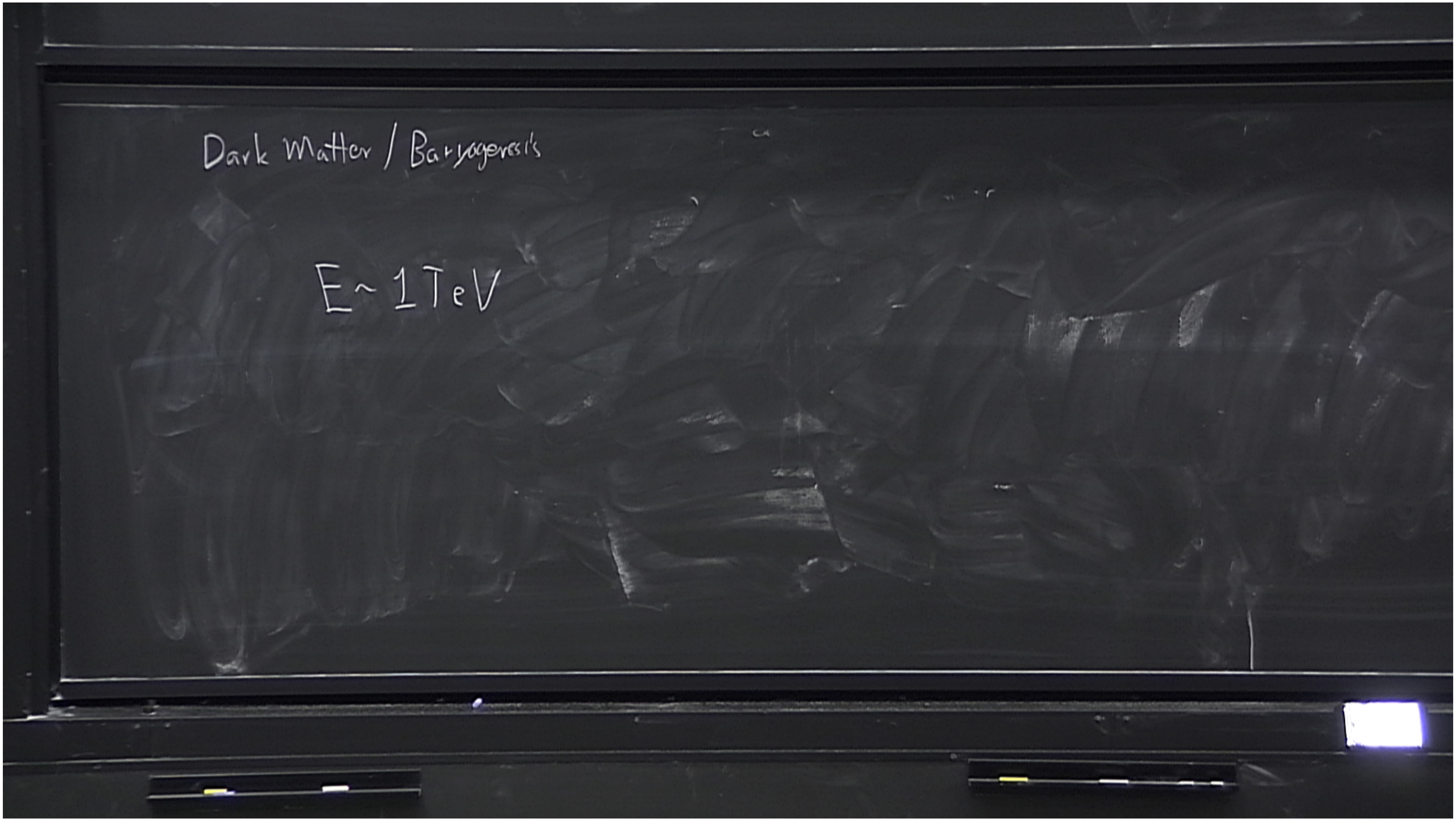

DM + DE
$\frac{\rho_{dm}}{\rho_{crit}} = 0.25$ $(w = \frac{p}{\rho} = 0)$
Barygenesis
$\frac{\rho_{de}}{\rho_{crit}} = 0.70$ $(w = -1)$
$\rho = \rho_{crit}$
$a(t)$
$\rho = 30\%$
$\ddot{a} < 0$
$\ddot{a} > 0$
RD
MD

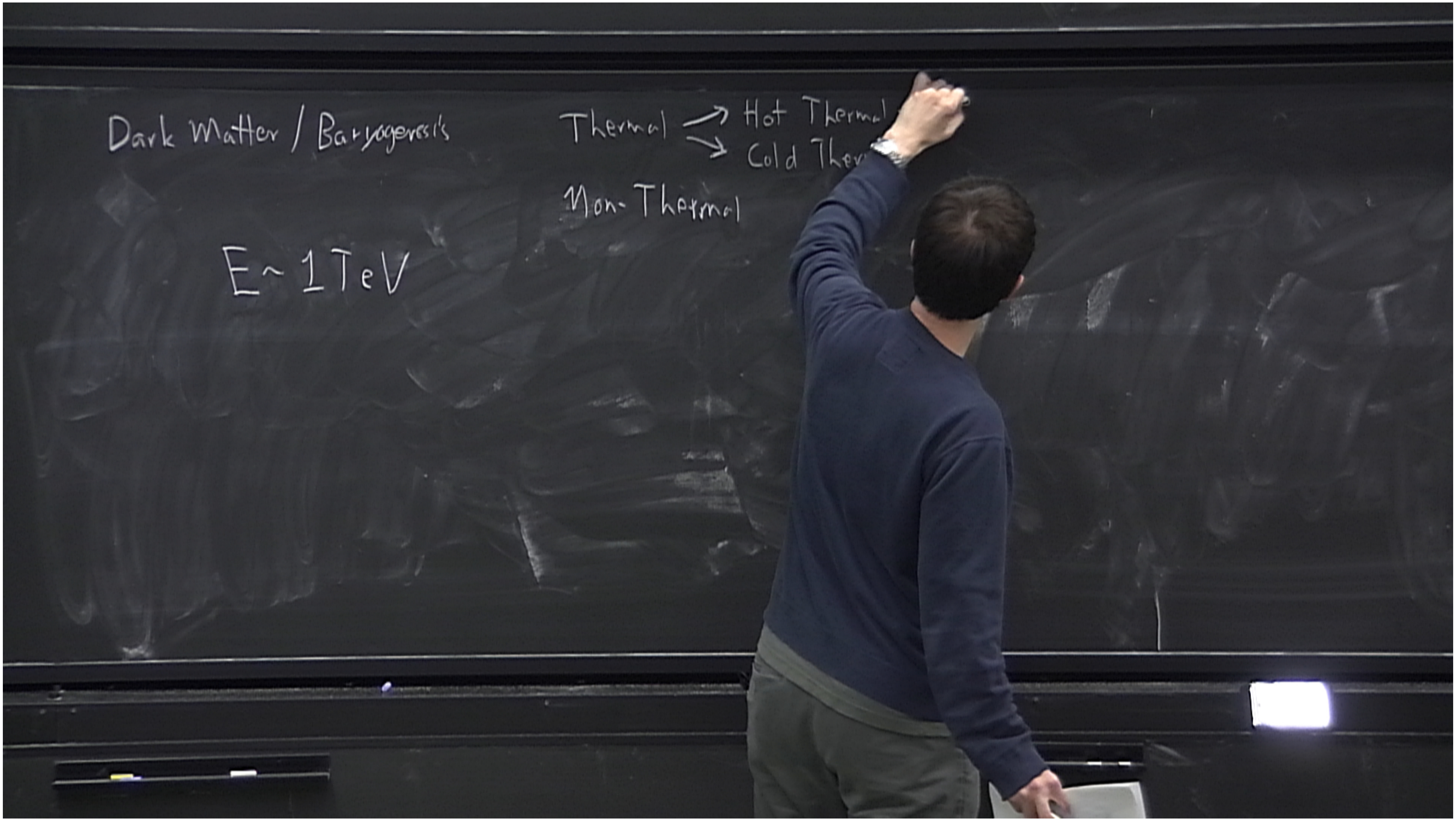


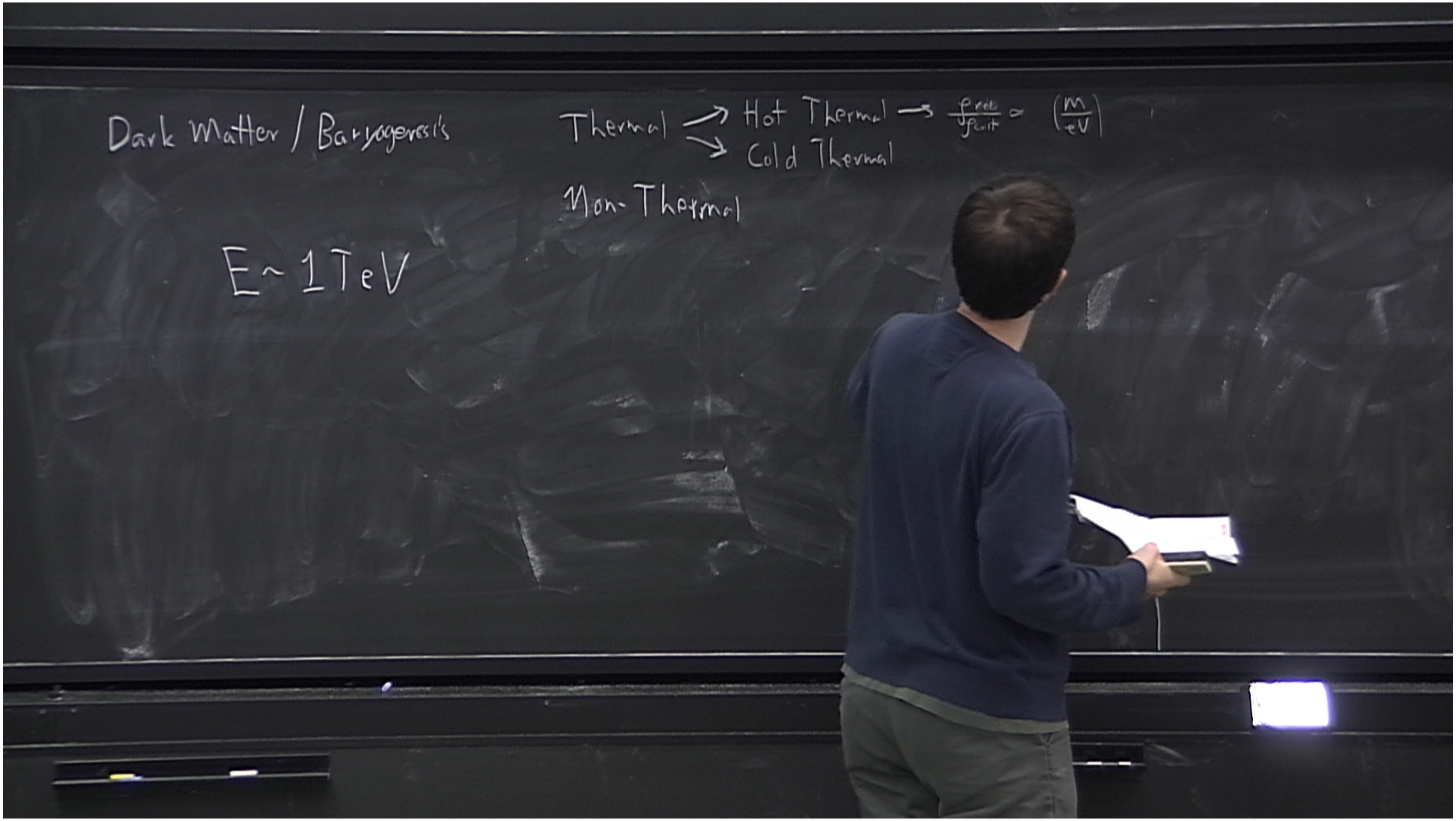
$S = \int d^4x \sqrt{-g} \left\{ \frac{R - 2\Lambda}{16\pi G_N} + \frac{1}{2} g^{\mu\nu} D_\mu \varphi D_\nu \varphi - V(\varphi) \right\}$
$V(\varphi) = V_{const} + \tilde{V}(\varphi)$
$\rho = 30\%\ \rho_{crit}$
$\Lambda^4 = 10^{12}\ GeV^4$
$\ddot{a} < 0$
$\Lambda = 0$
$(10^{-3}\ eV)^4$
$\ddot{a} > 0$

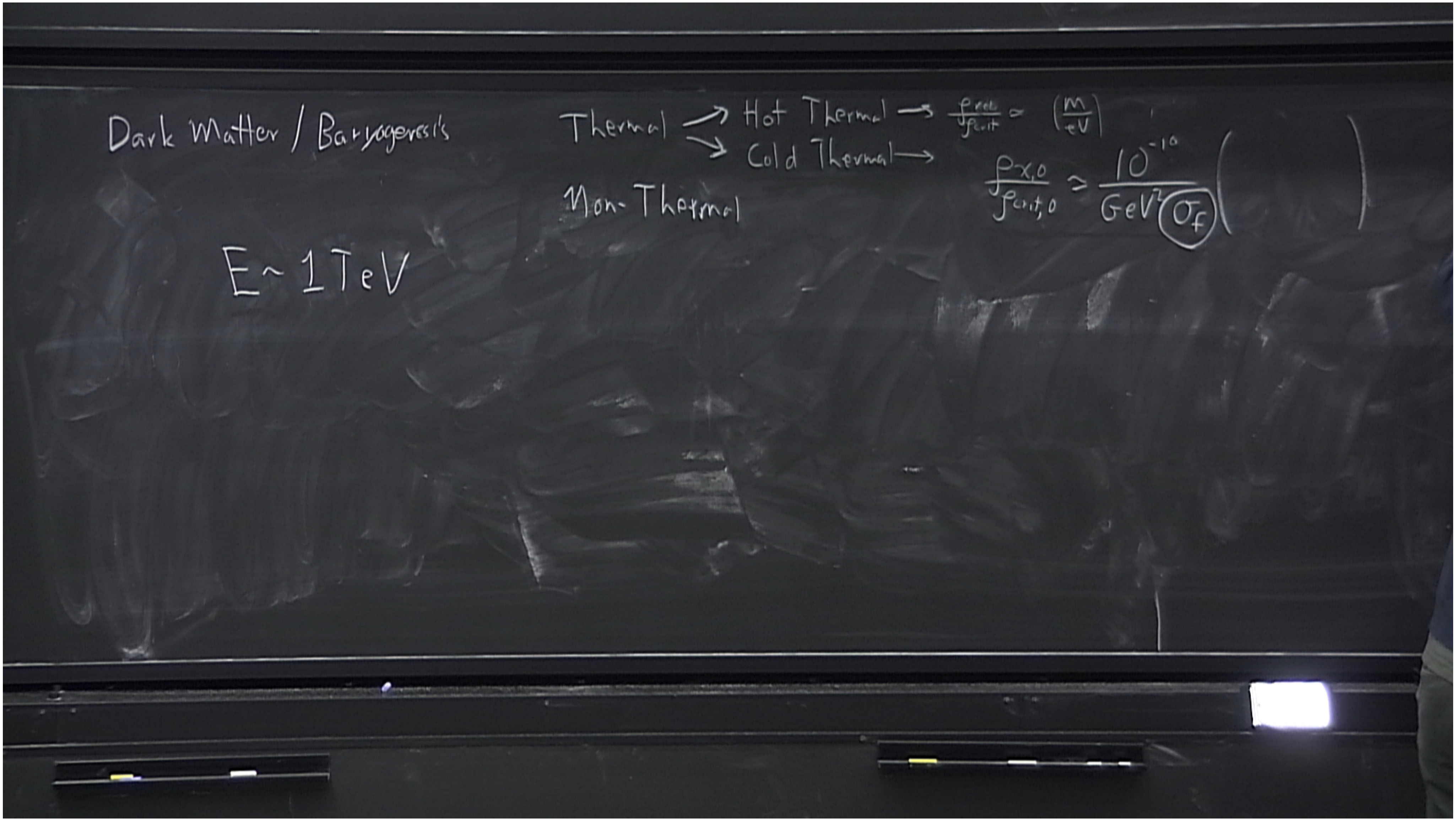

DM + DE
ρdm / ρcrit = 0.25
(w = p/ρ = 0)
Barygenesis
ρde / ρcrit = 0.70
(w = -1)
ρ = ρcrit
a(t)
ρ = 30% ρcrit
ä < 0
ä > 0
MACHOs → 1986
gravitational microlensing
10^-8 M☉ < M_BH < 10^2 M☉
10^15 g → T_evap < H0^-1
S = ∫ d^4x

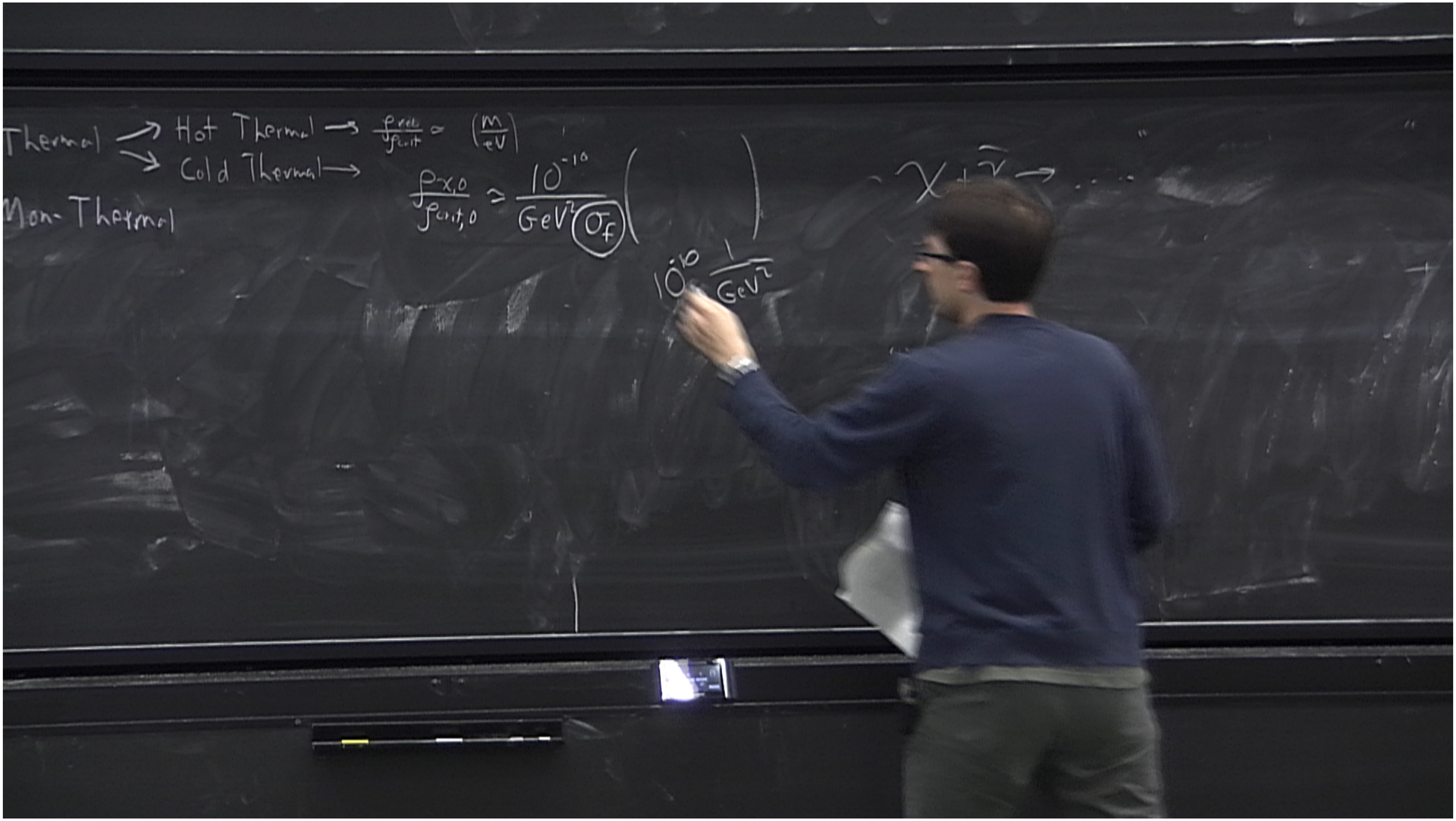

DM + DE
Barygenesis
RD
MACHOs → 1986 gravitational microlensing
10^-8 M_⊙ < M_BH < 10^2 M_⊙
10^15 g → T_evap < H_0^-1 < 10^10 yrs
ρ_dm / ρ_crit = 0.25 (w = p/ρ = 0)
ρ_de / ρ_crit = 0.70 (w = -1)
ρ = ρ_crit
a(t)
ρ = 30% ρ_crit
ä < 0
ä > 0
S = ∫d^4x

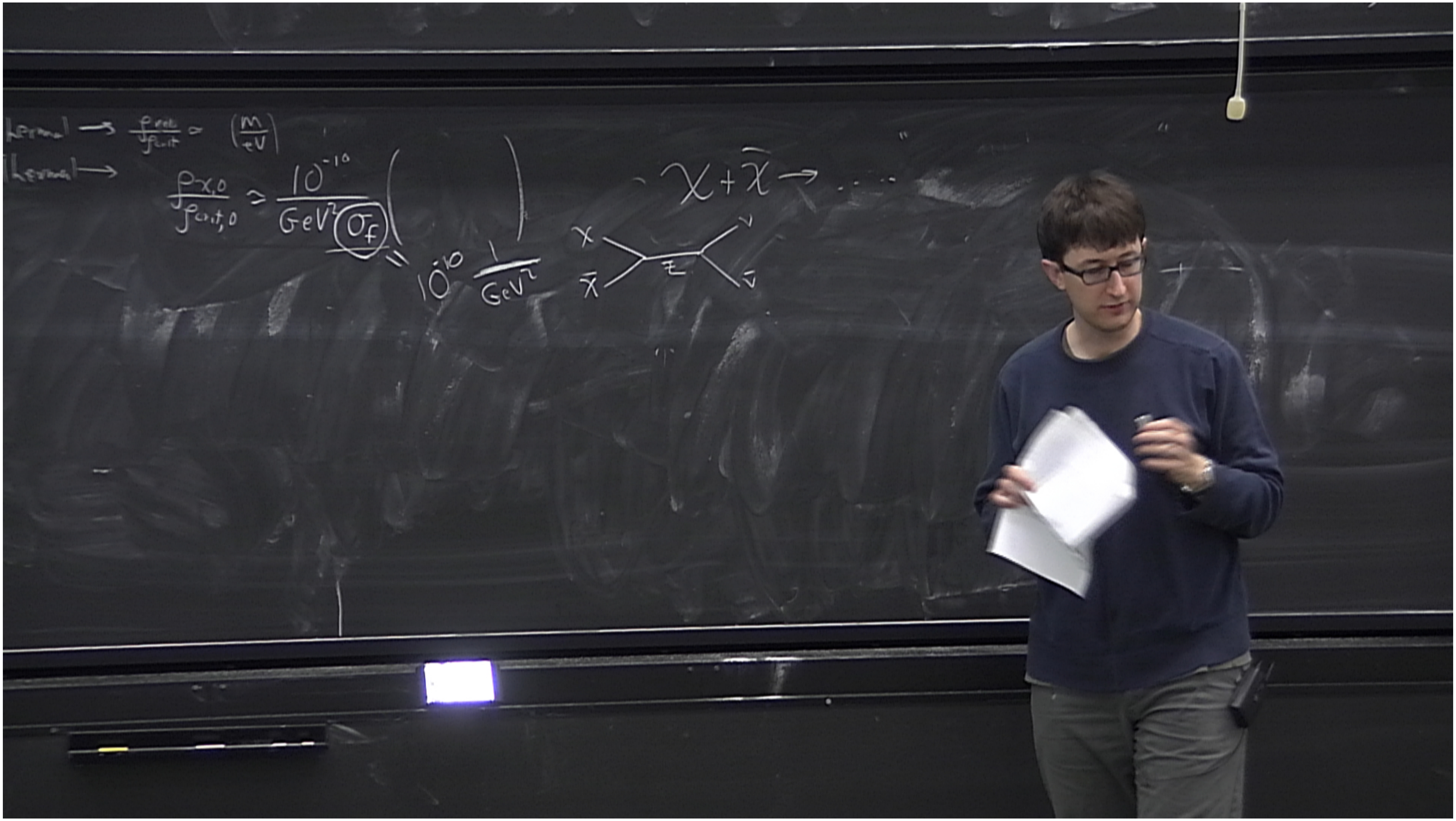

Dark Matter / Baryogenesis
E ~ 1 TeV

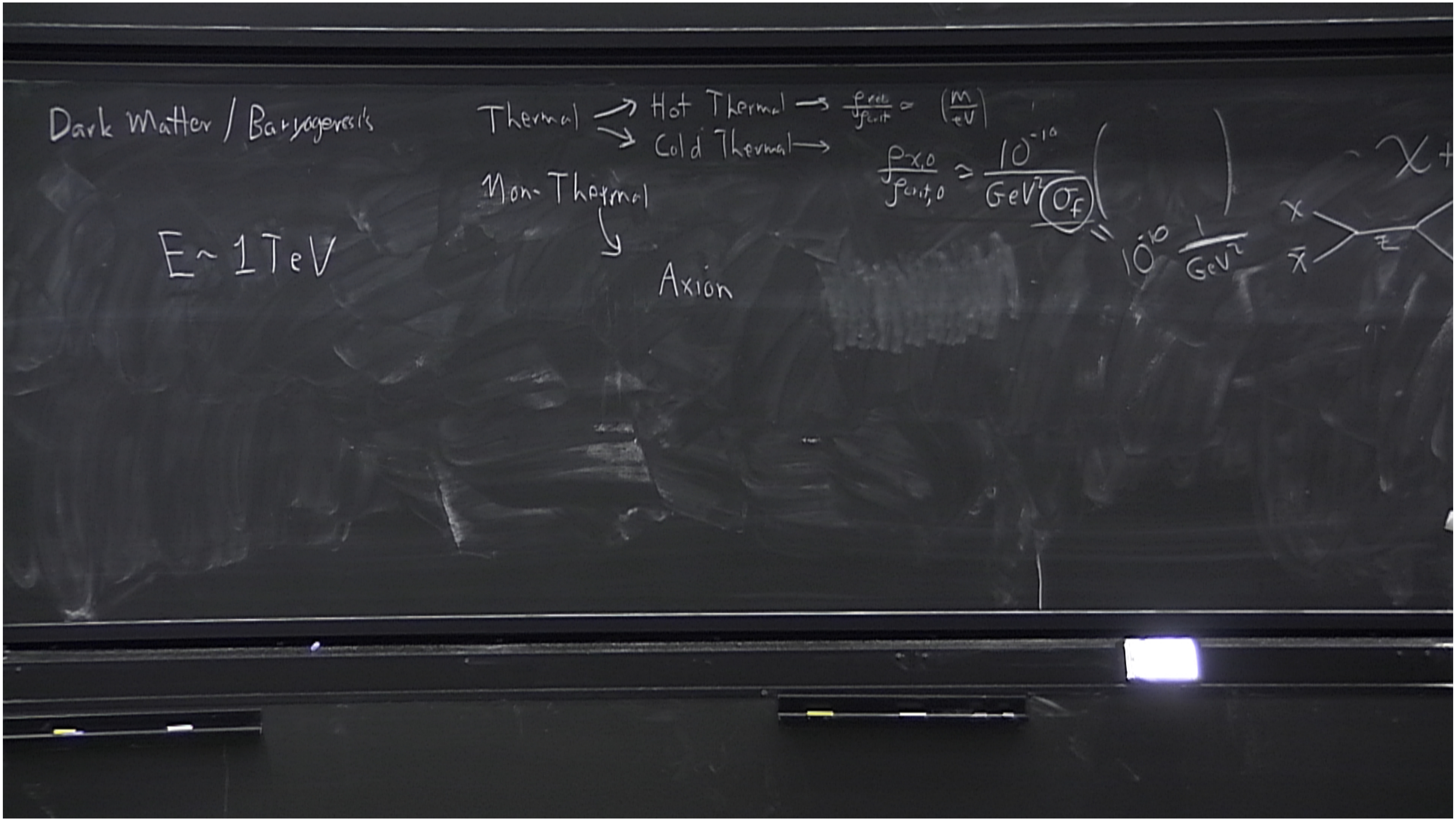

Dark Matter / Baryogenesis
Thermal
Hot Thermal
Cold Ther
Non-Thermal
E ~ 1 TeV


Dark Matter / Baryogenesis
Thermal
Hot Thermal
ρrelic / ρcrit ∝ (m / eV)
Cold Thermal
Non-Thermal
E ~ 1 TeV

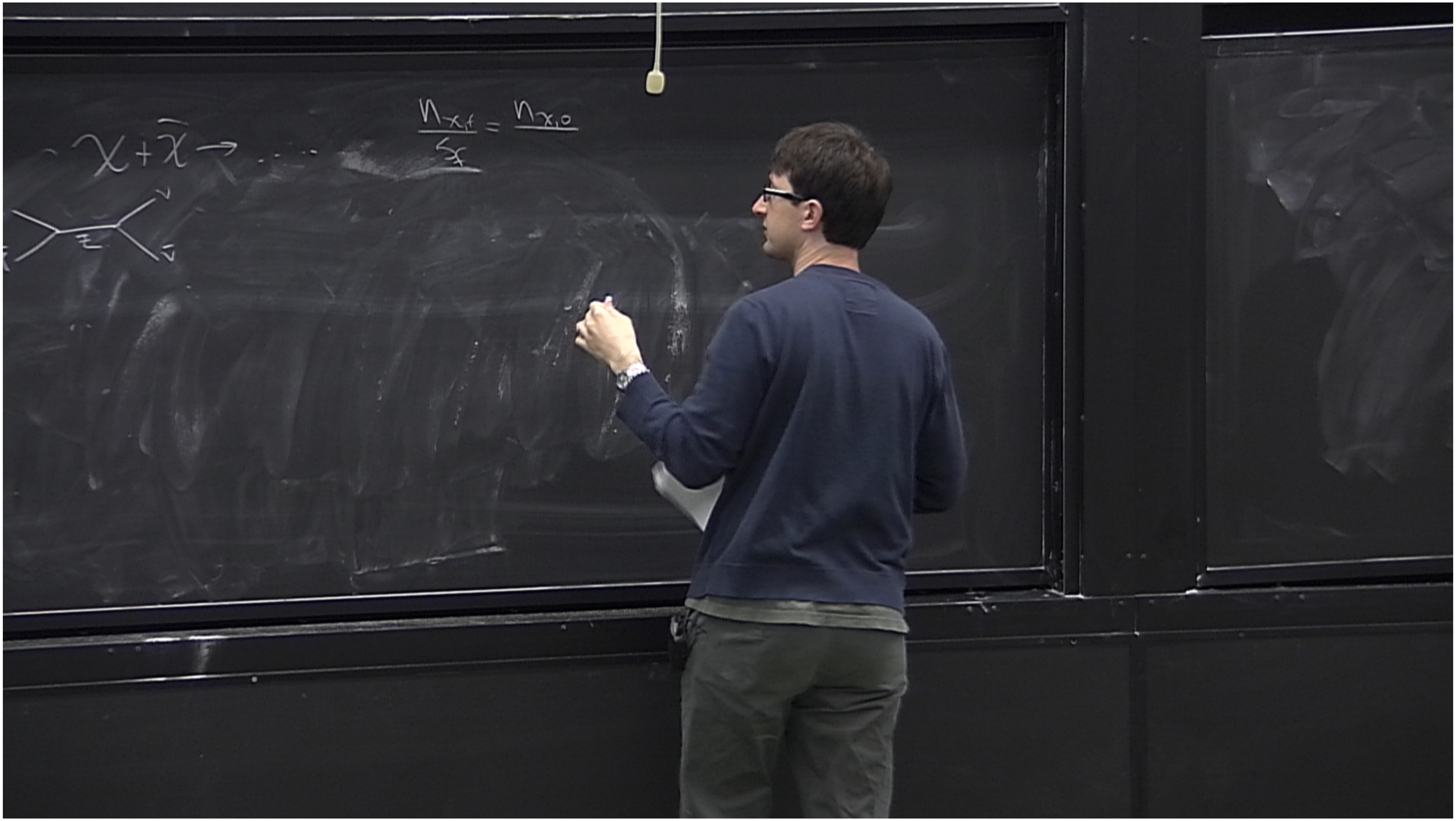

Dark Matter / Baryogenesis
Thermal
Hot Thermal → ρ_rel / ρ_crit ≈ (m / eV)
Cold Thermal →
Non-Thermal
ρ_χ,0 / ρ_crit,0 ≈ 10^-10 / GeV^2 σ_f
E ~ 1 TeV

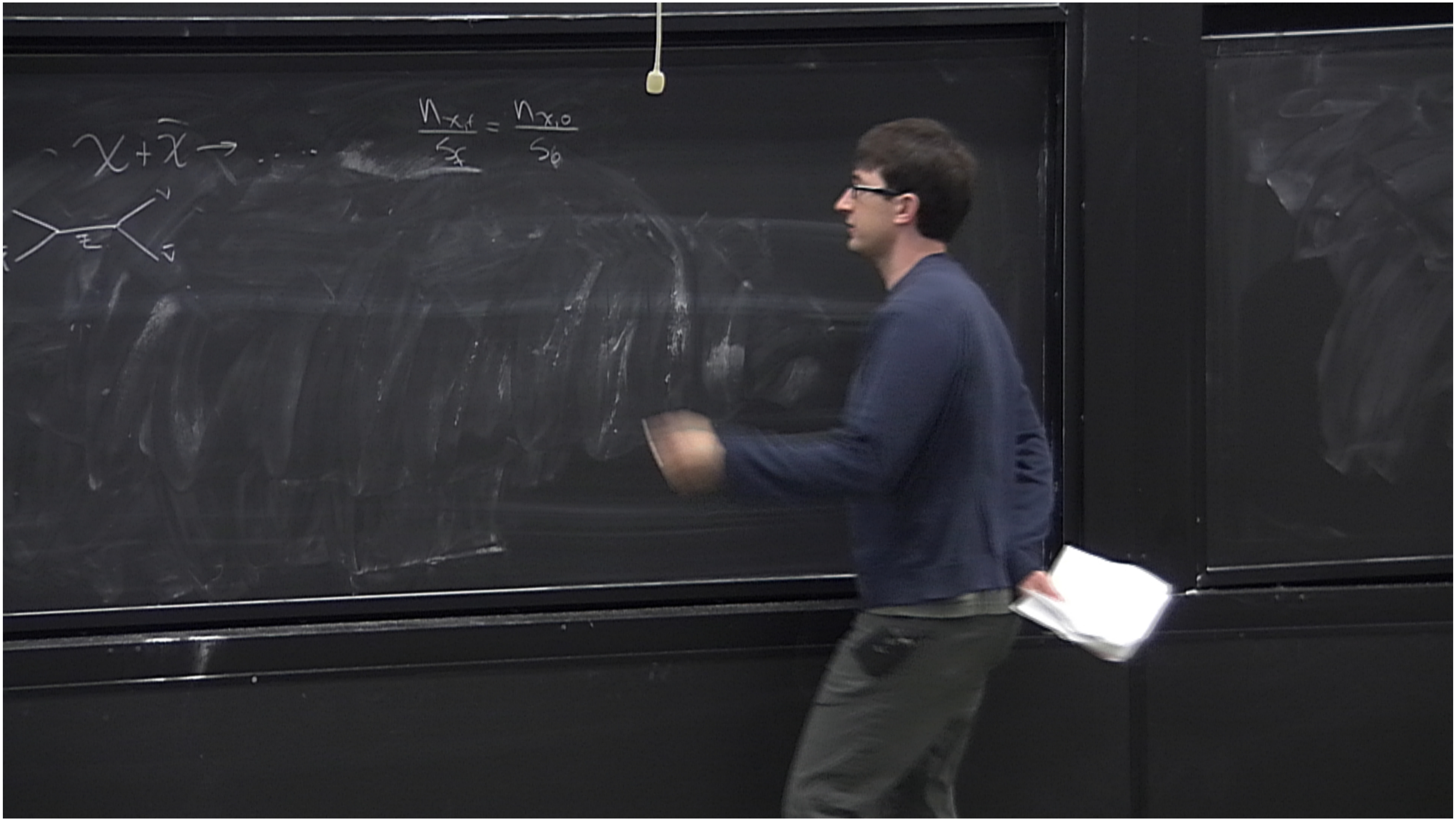

Thermal → Hot Thermal →
→ Cold Thermal →
Non-Thermal

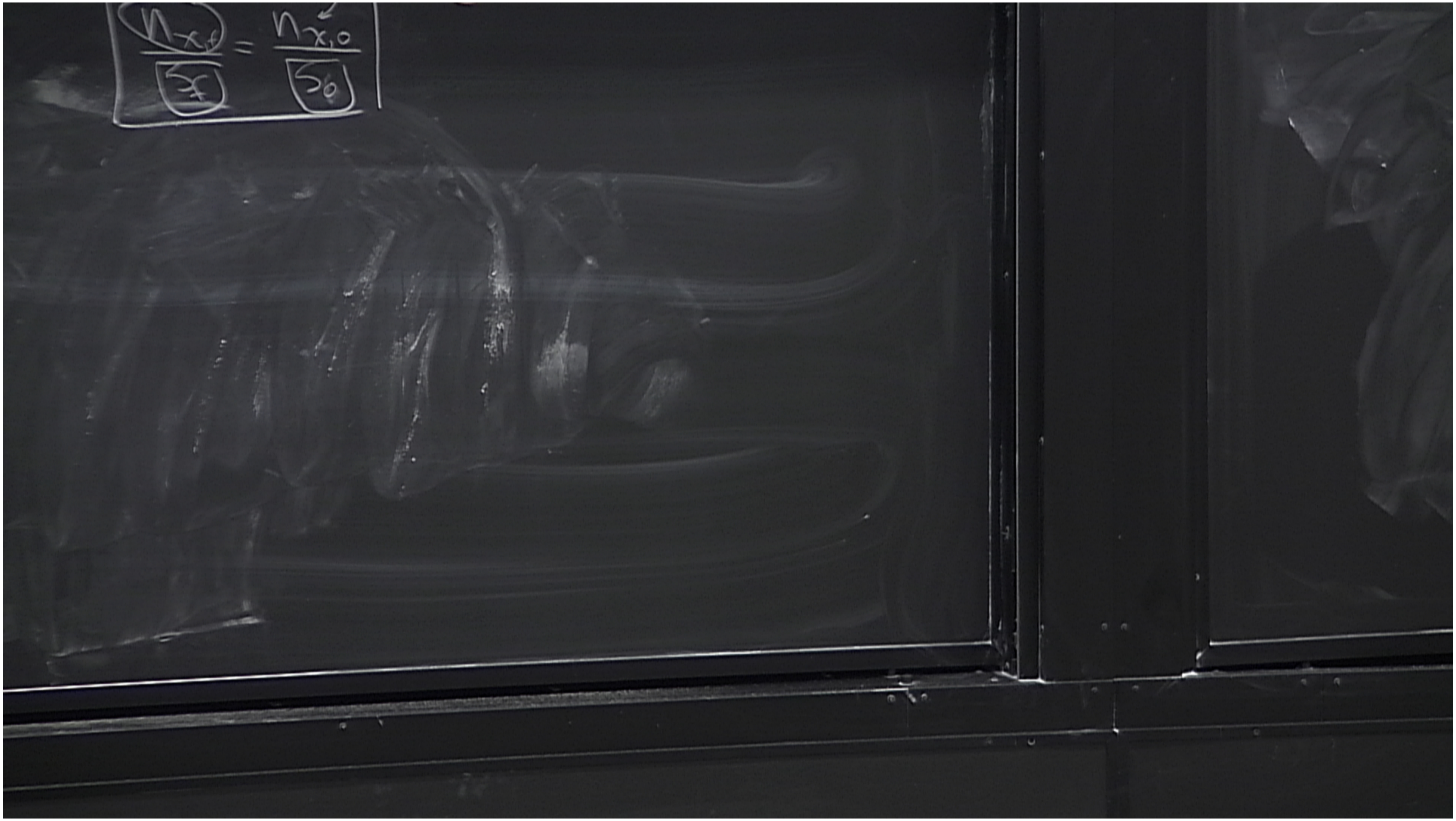


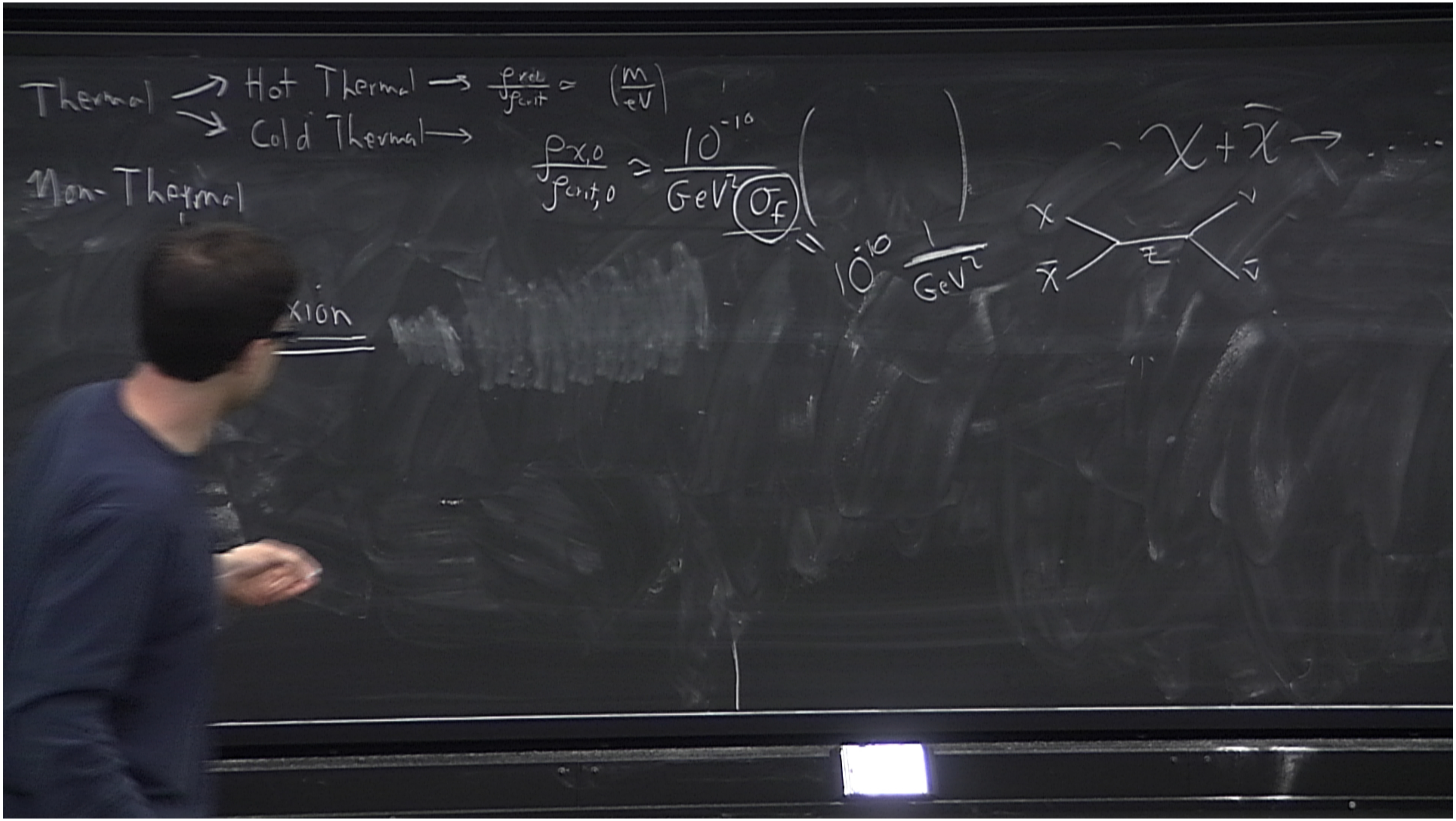


Dark Matter / Baryogenesis
Thermal
Hot Thermal
Cold Thermal
Non-Thermal
Axion
E ~ 1 TeV
$\frac{\rho_{\chi,0}}{\rho_{crit,0}} \simeq \frac{10^{-10}}{GeV^2 \sigma_f}$
$10^{-10} \frac{1}{GeV^2}$

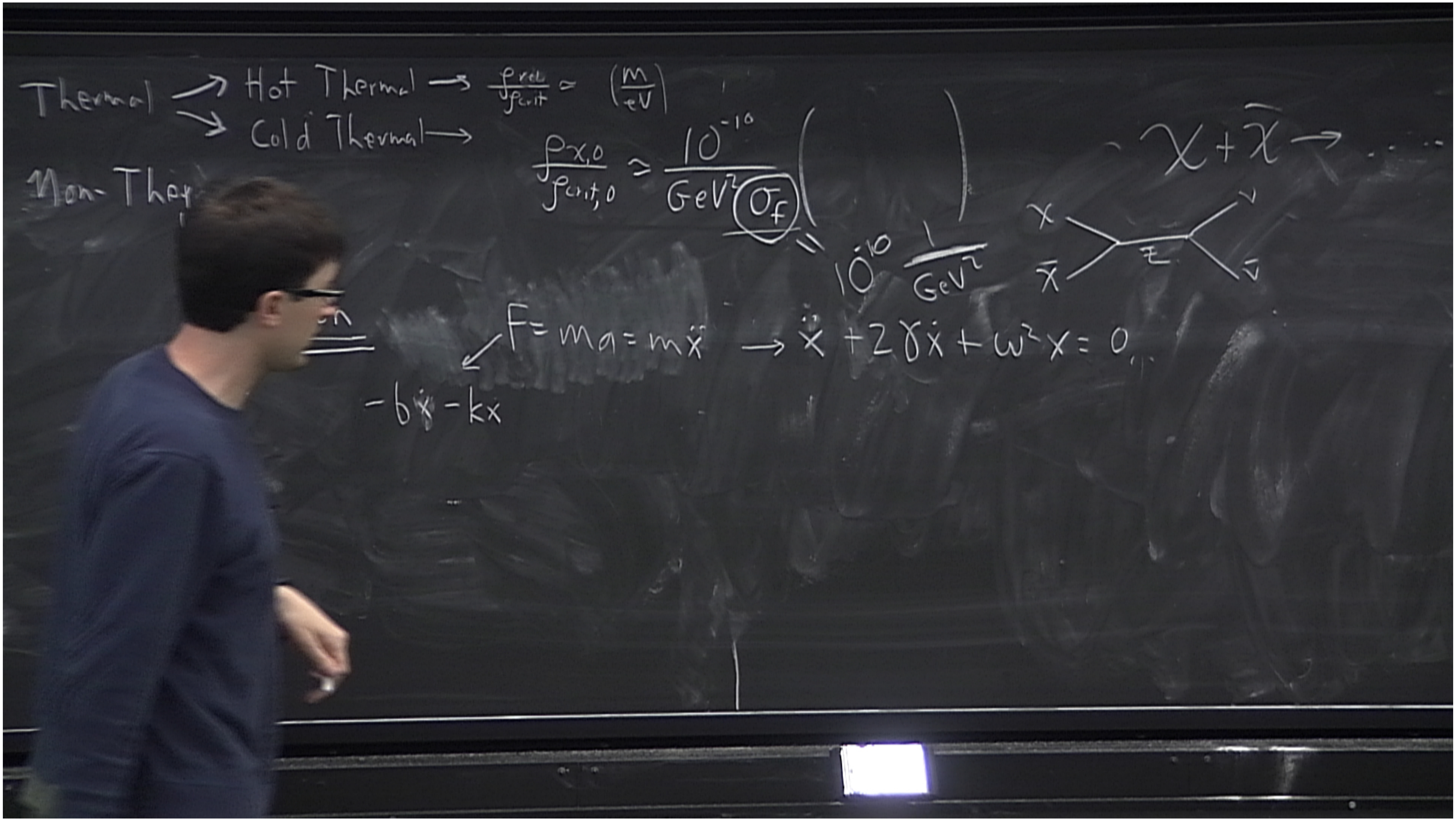

χ + χ̄ → . . .
n_{χ,f} / s_f = n_{χ,0}

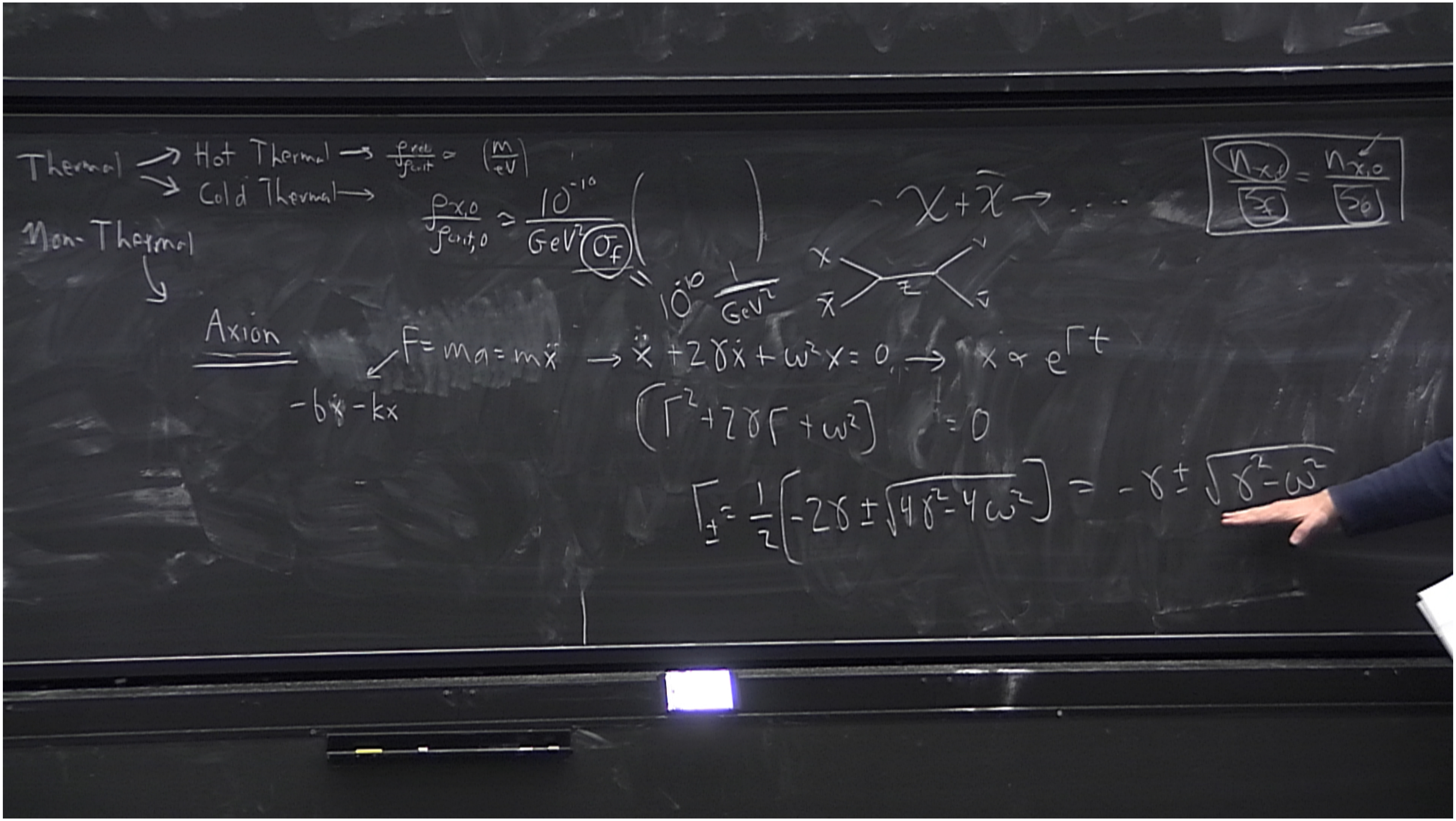

$\chi + \bar{\chi} \rightarrow \ldots$
$\frac{n_{\chi,f}}{s_f} = \frac{n_{\chi,0}}{s_0}$

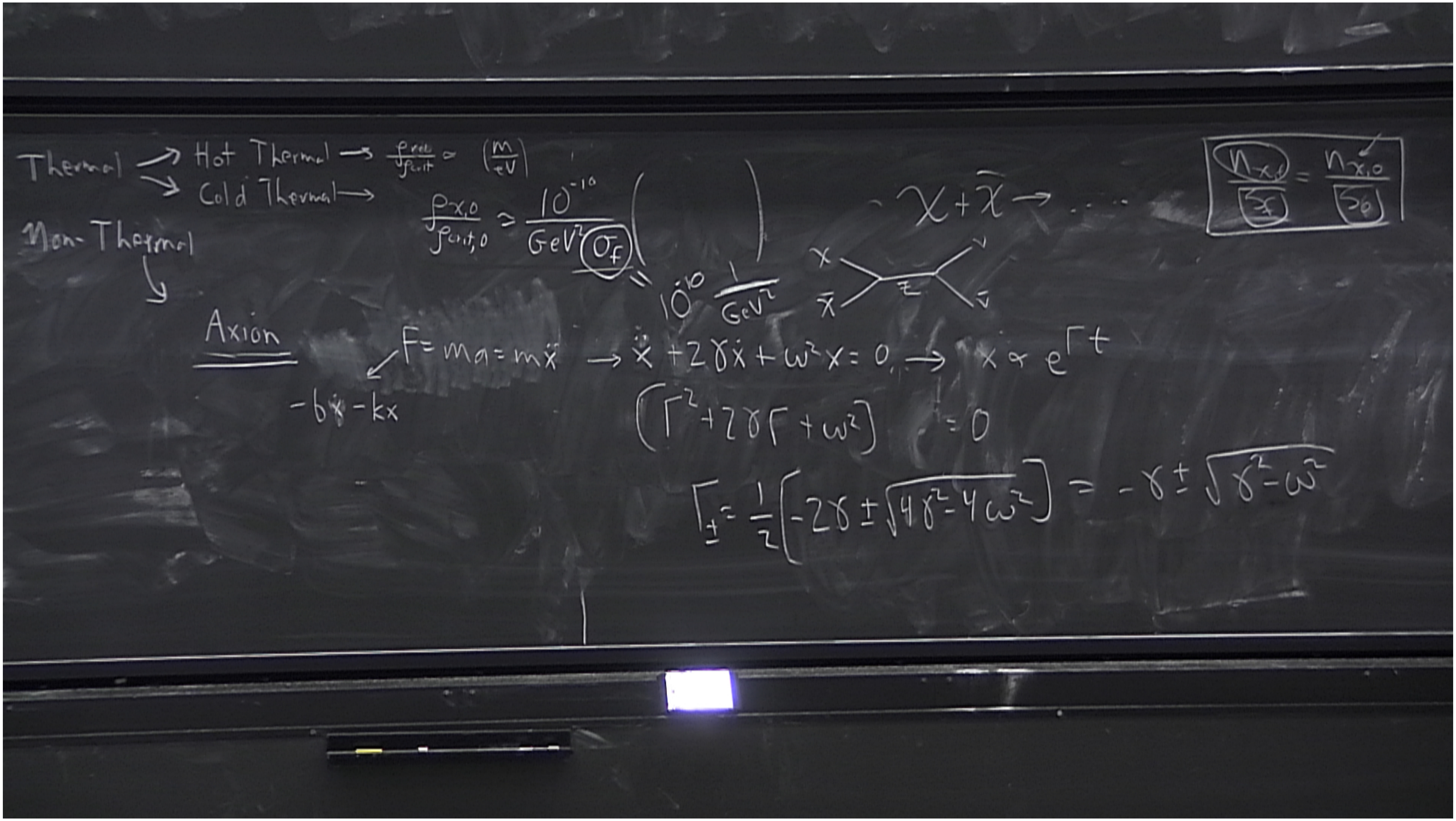

$\frac{n_{x,f}}{s_f} = \frac{n_{x,0}}{s_0}$

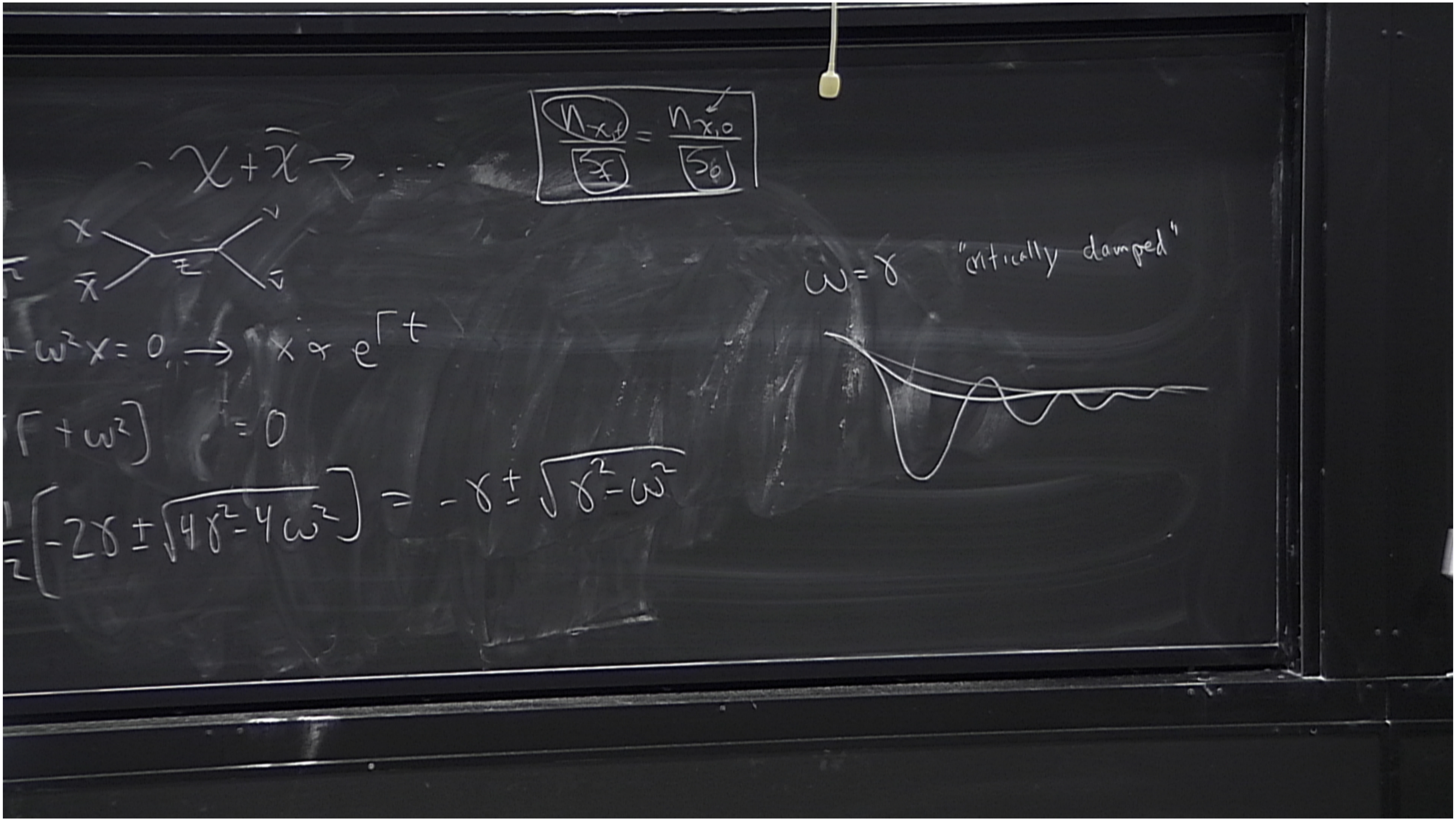


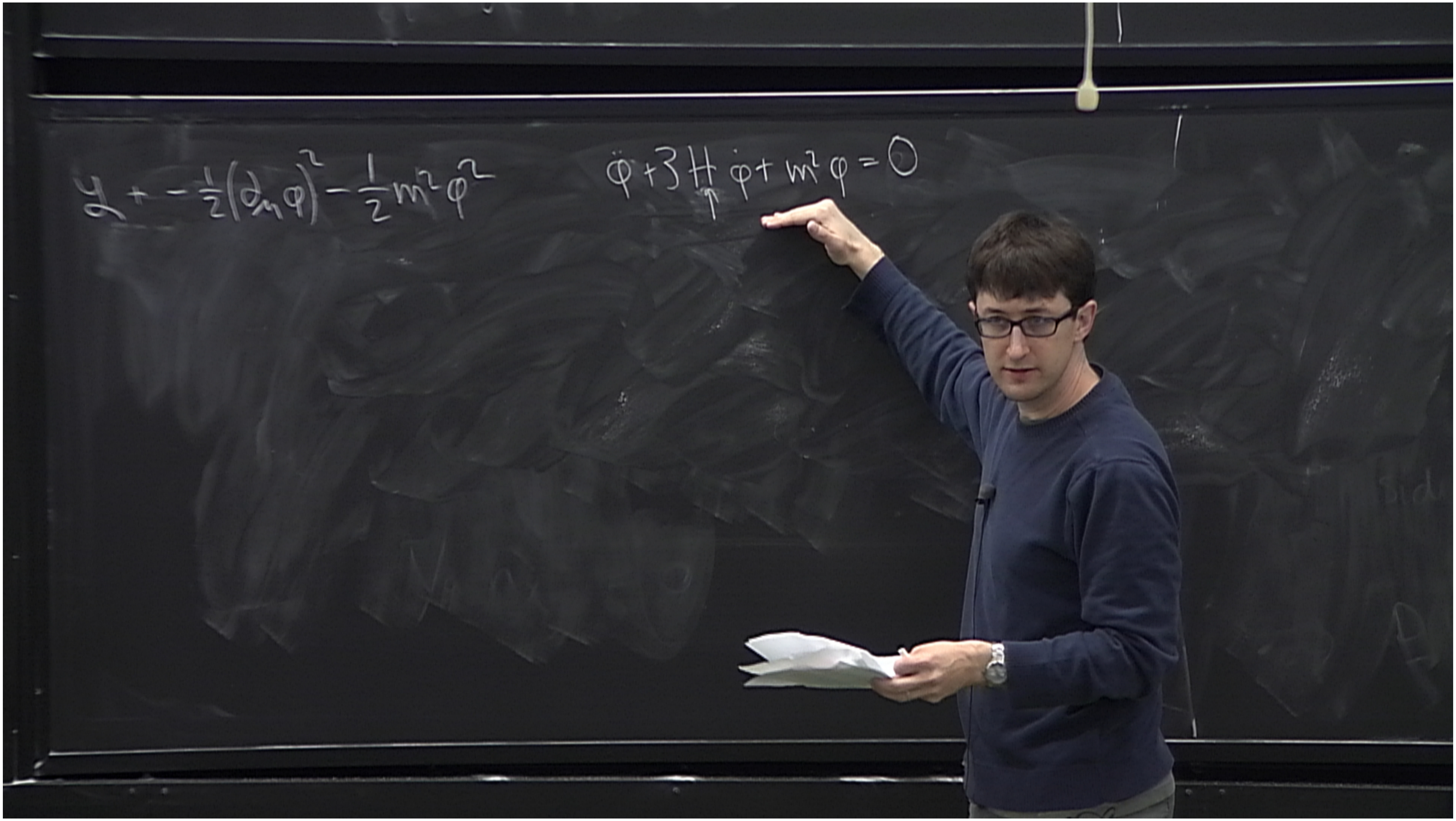
Thermal → Hot Thermal → ρrel / ρcrit ≃ (m / eV)
→ Cold Thermal →
Non-Thermal
xion
ρχ,0 / ρcrit,0 ≃ 10^-10 / GeV² σf
= 10^-10 1 / GeV²
χ + χ̄ → . . .
χ
χ̄
Z
ν
ν̄

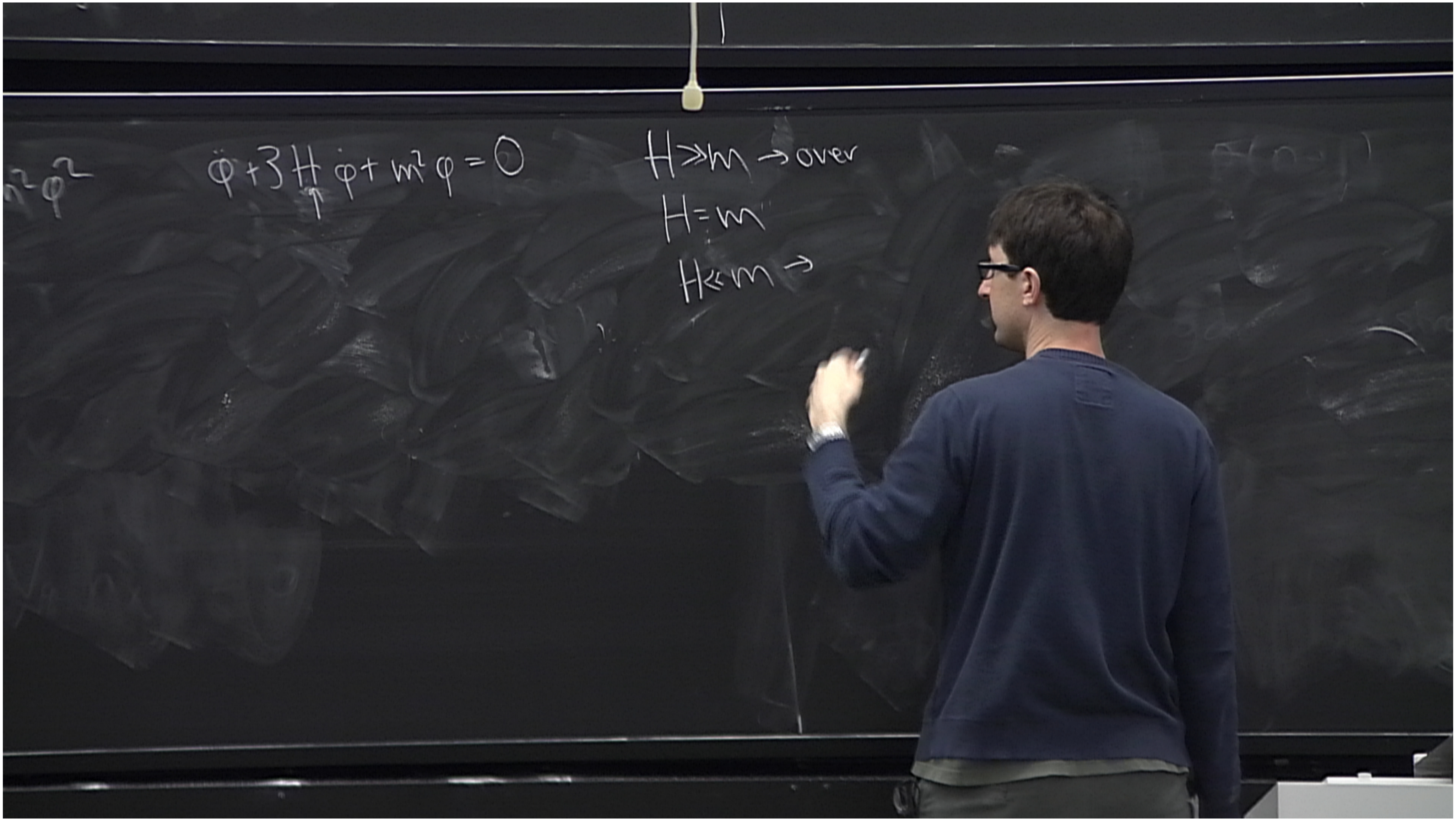

Thermal → Hot Thermal →
Cold Thermal →
F = ma = mẍ → ẍ + 2γẋ + ω²x = 0
-bẋ - kx
χ + χ̄ →
GeV²

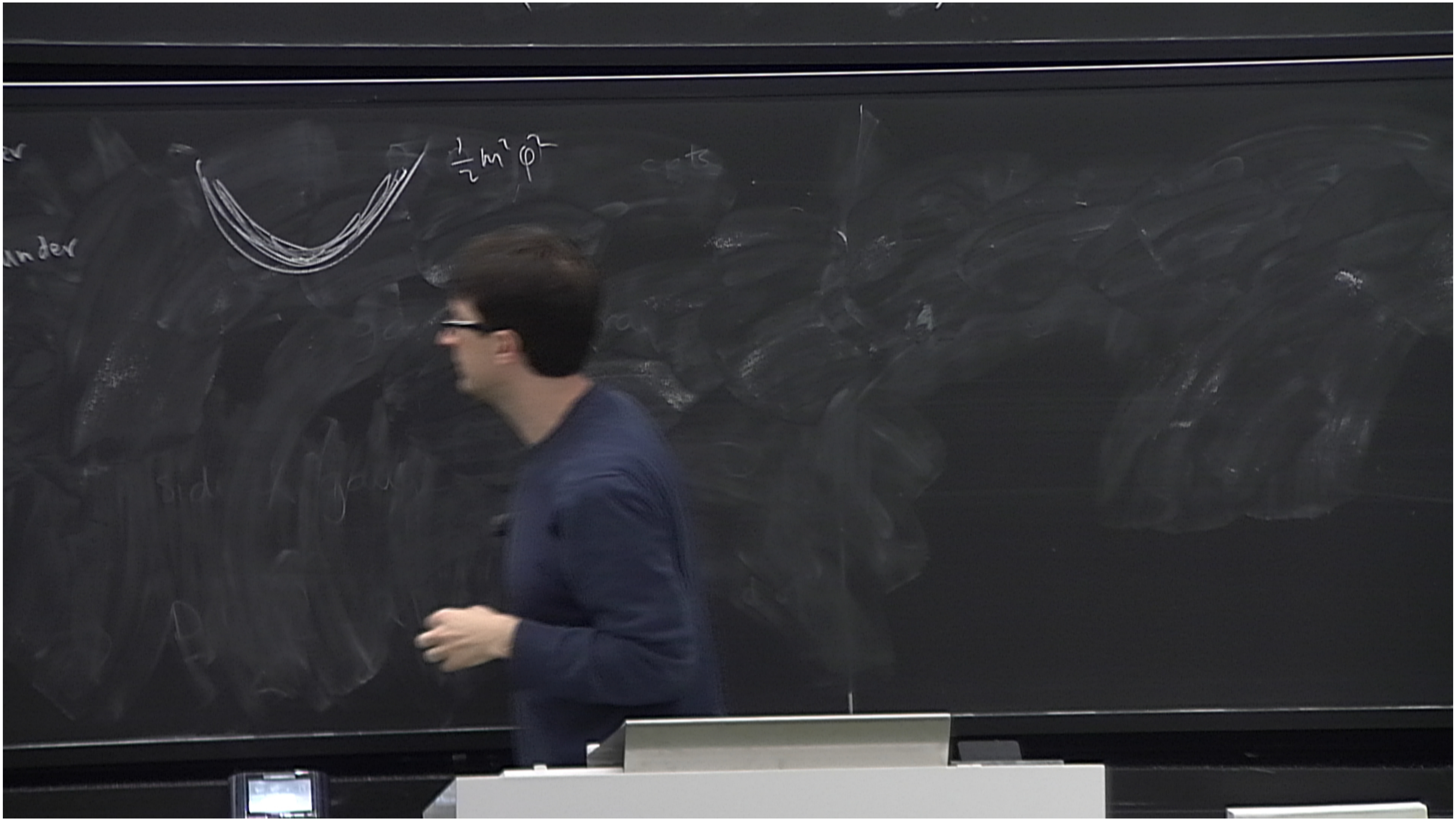

Thermal → Hot Thermal → $\rho_{rel}/\rho_{crit} \simeq (m/eV)$
→ Cold Thermal →
Non-Thermal
Axion
$\rho_{\chi,0}/\rho_{crit,0} \simeq \frac{10^{-10}}{GeV^2 \sigma_f}$
$10^{-10} \frac{1}{GeV^2}$
$\chi + \bar{\chi} \to \ldots$
$\frac{n_{\chi,f}}{s_f} = \frac{n_{\chi,0}}{s_0}$
$F = ma = m\ddot{x} \to \ddot{x} + 2\gamma\dot{x} + \omega^2 x = 0 \to x \propto e^{\Gamma t}$
$-b\dot{x} - kx$
$(\Gamma^2 + 2\gamma\Gamma + \omega^2) = 0$
$\Gamma_\pm = \frac{1}{2}\left(-2\gamma \pm \sqrt{4\gamma^2 - 4\omega^2}\right) = -\gamma \pm \sqrt{\gamma^2 - \omega^2}$

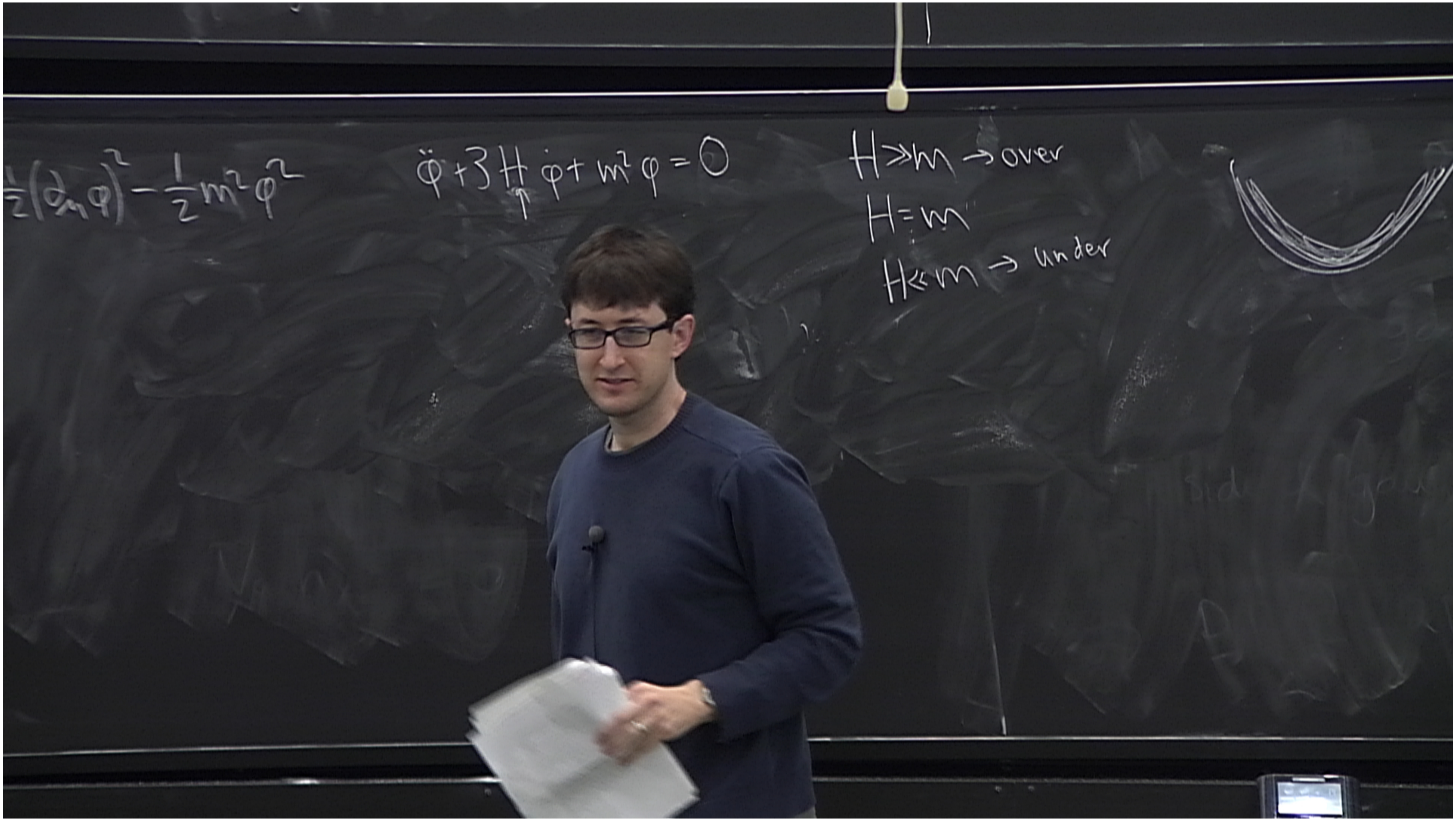

Thermal → Hot Thermal → ρ_rel / ρ_crit ≃ (m / eV)
→ Cold Thermal →
Non-Thermal
Axion
ρ_χ,0 / ρ_crit,0 ≃ 10^-10 / (GeV² σ_f)
= 10^-10 1/GeV²
χ + χ̄ → . . . .
χ χ̄ Z ν ν̄
n_χ,0 / s_f = n_χ,0 / s_0
F = ma = mẍ → ẍ + 2γẋ + ω²x = 0 → x ∝ e^Γt
−bẋ − kx
(Γ² + 2γΓ + ω²) = 0
Γ± = 1/2 (−2γ ± √(4γ² − 4ω²)) = −γ ± √(γ² − ω²)


ω = γ
"critically damped"


$\mathcal{L} = -\frac{1}{2}(\partial_\mu \varphi)^2 - \frac{1}{2} m^2 \varphi^2$
$\ddot{\varphi} + 3H\dot{\varphi} + m^2 \varphi = 0$


$\ddot{\varphi} + 3H\dot{\varphi} + m^2\varphi = 0$
$H \gg m \to$ over
$H = m$
$H \ll m \to$


$\frac{1}{2}m^2\phi^2$
under


H≫m → over
H=m
H≪m → under