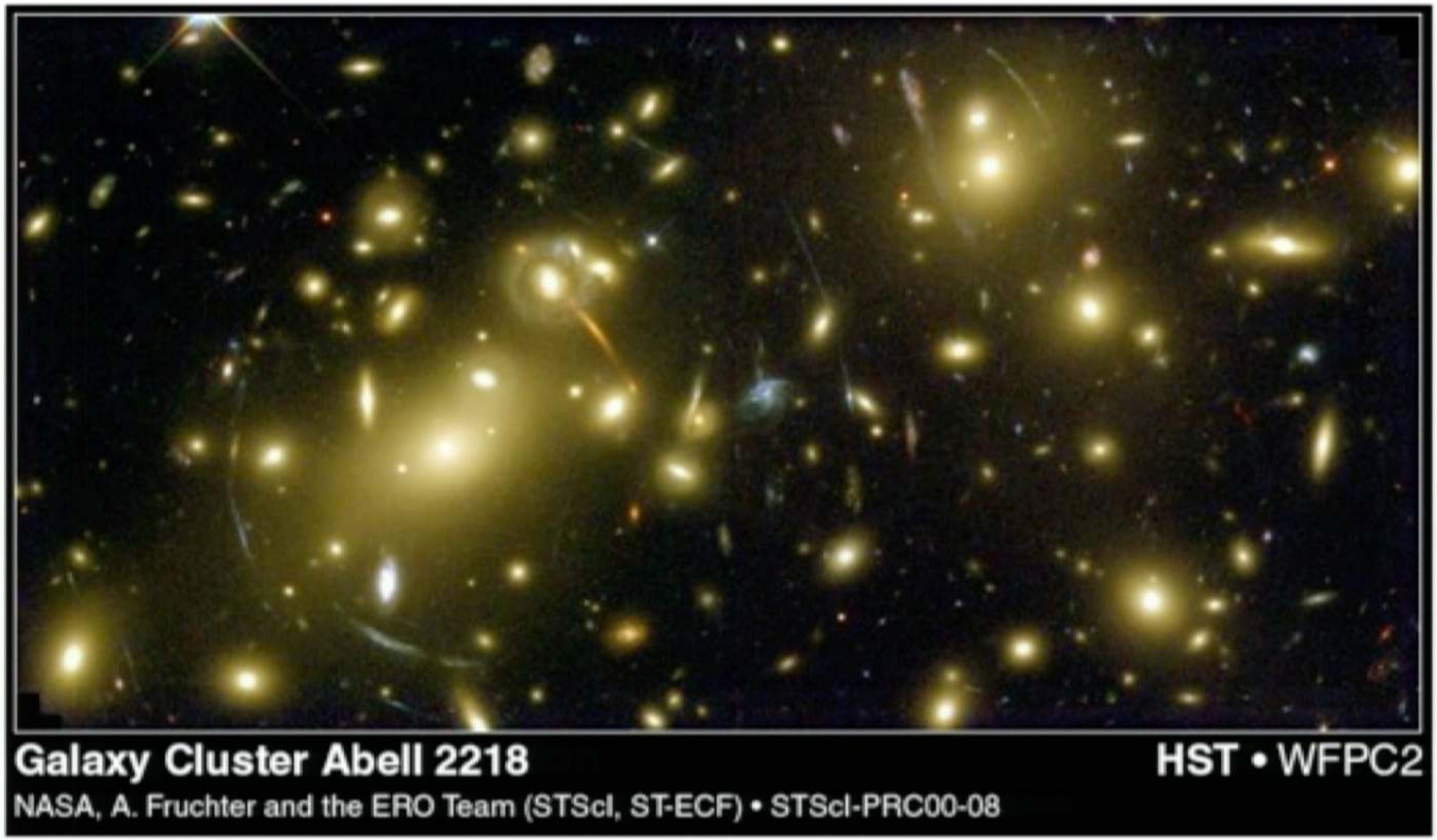
Title: 13/14 PSI - Cosmology Review - Lecture 8

Date: Feb 07, 2014 11:30 AM

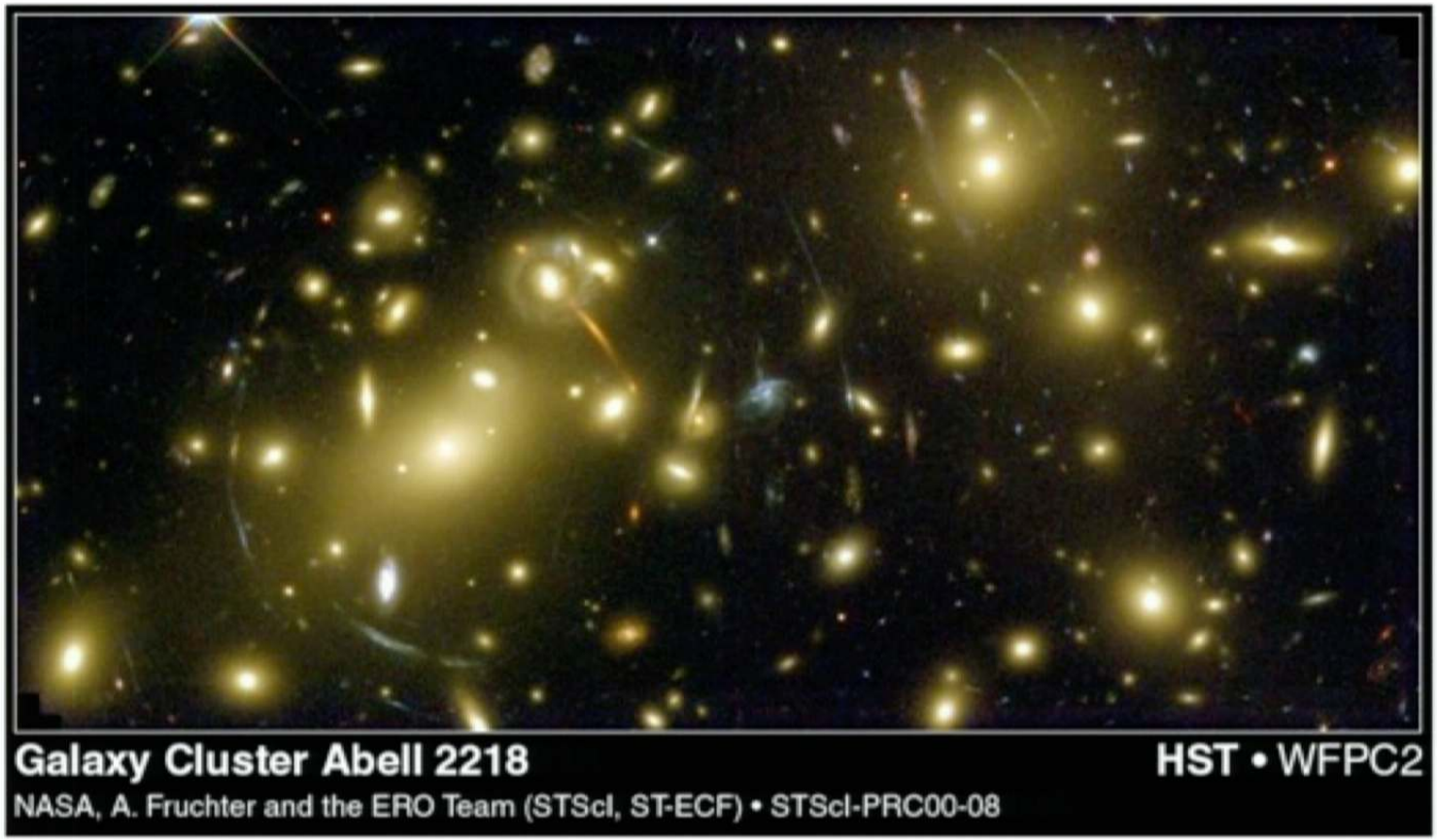
URL: http://pirsa.org/14020014

Abstract:



Galaxy Cluster Abell 2218 **HST • WFPC2**

NASA, A. Fruchter and the ERO Team (STScI, ST-ECF) • STScI-PRC00-08



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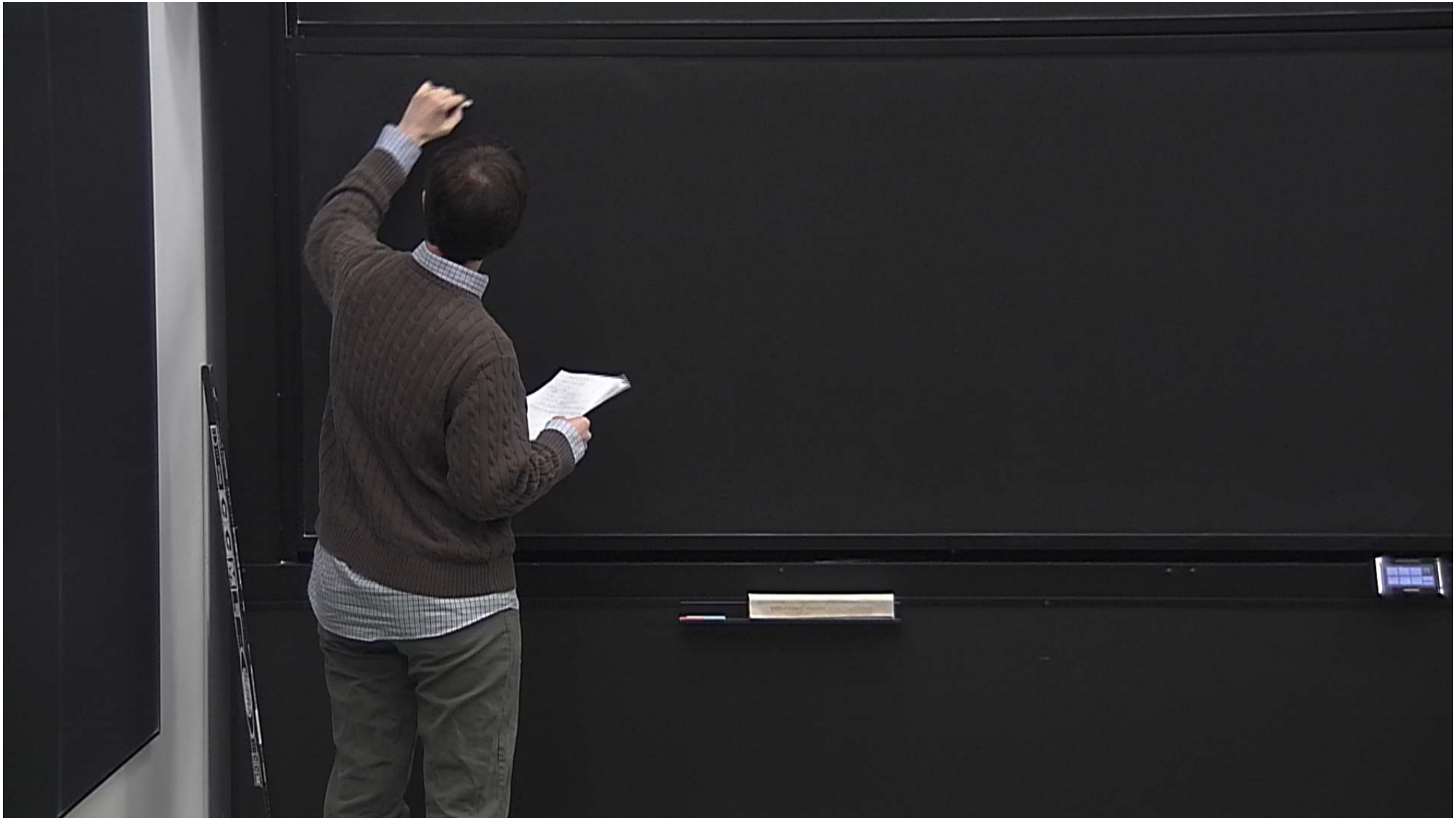
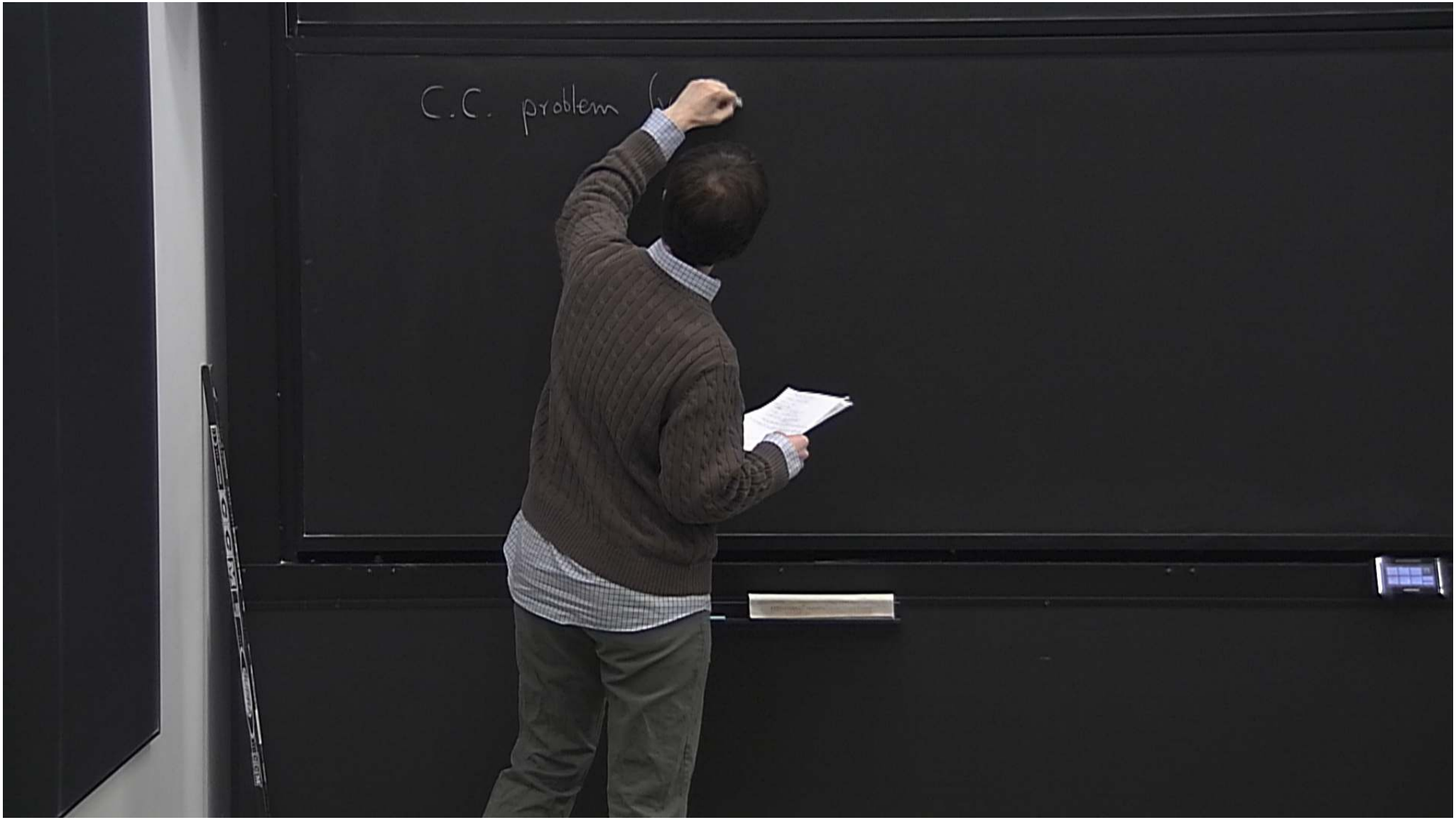
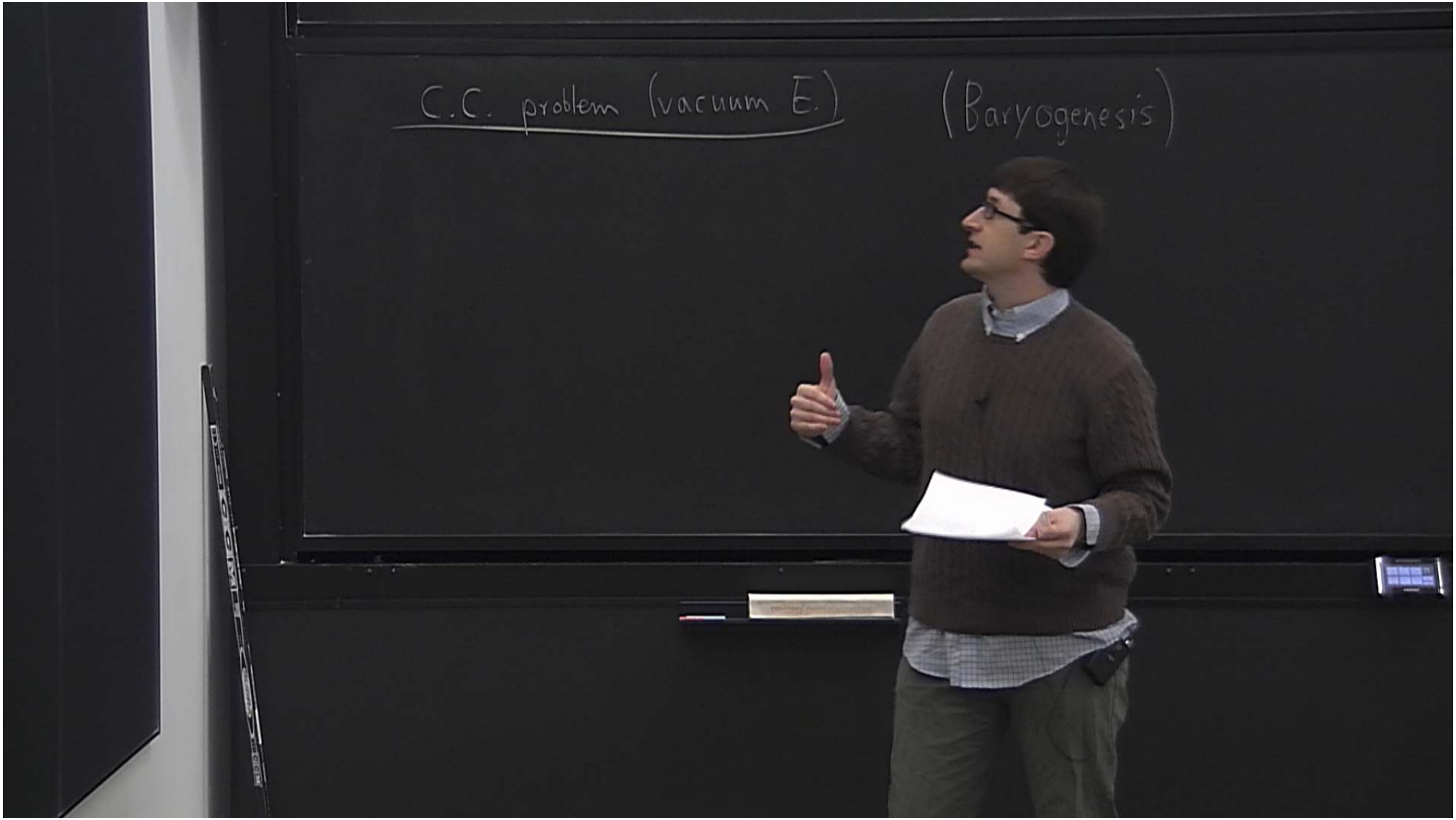
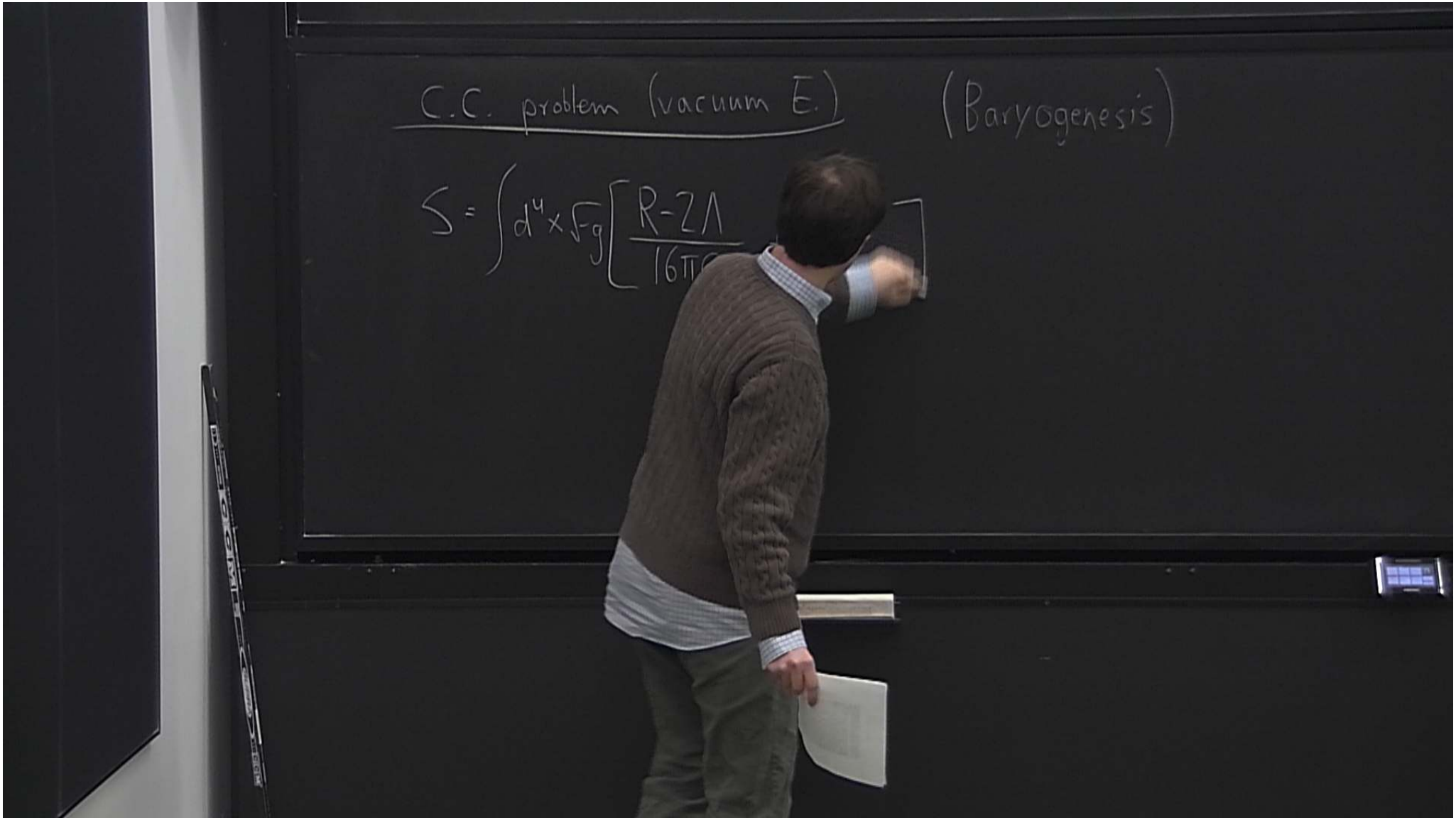
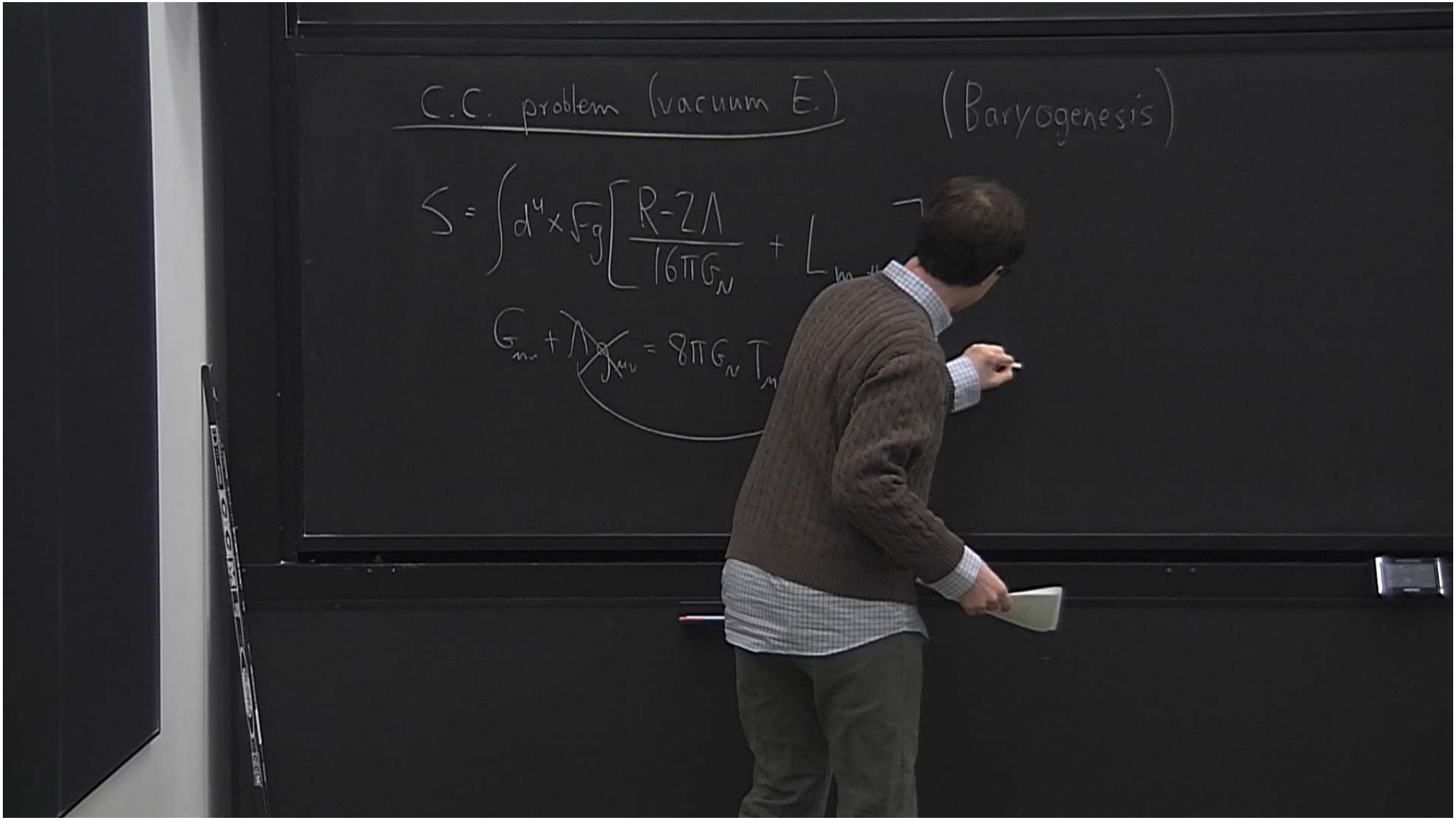
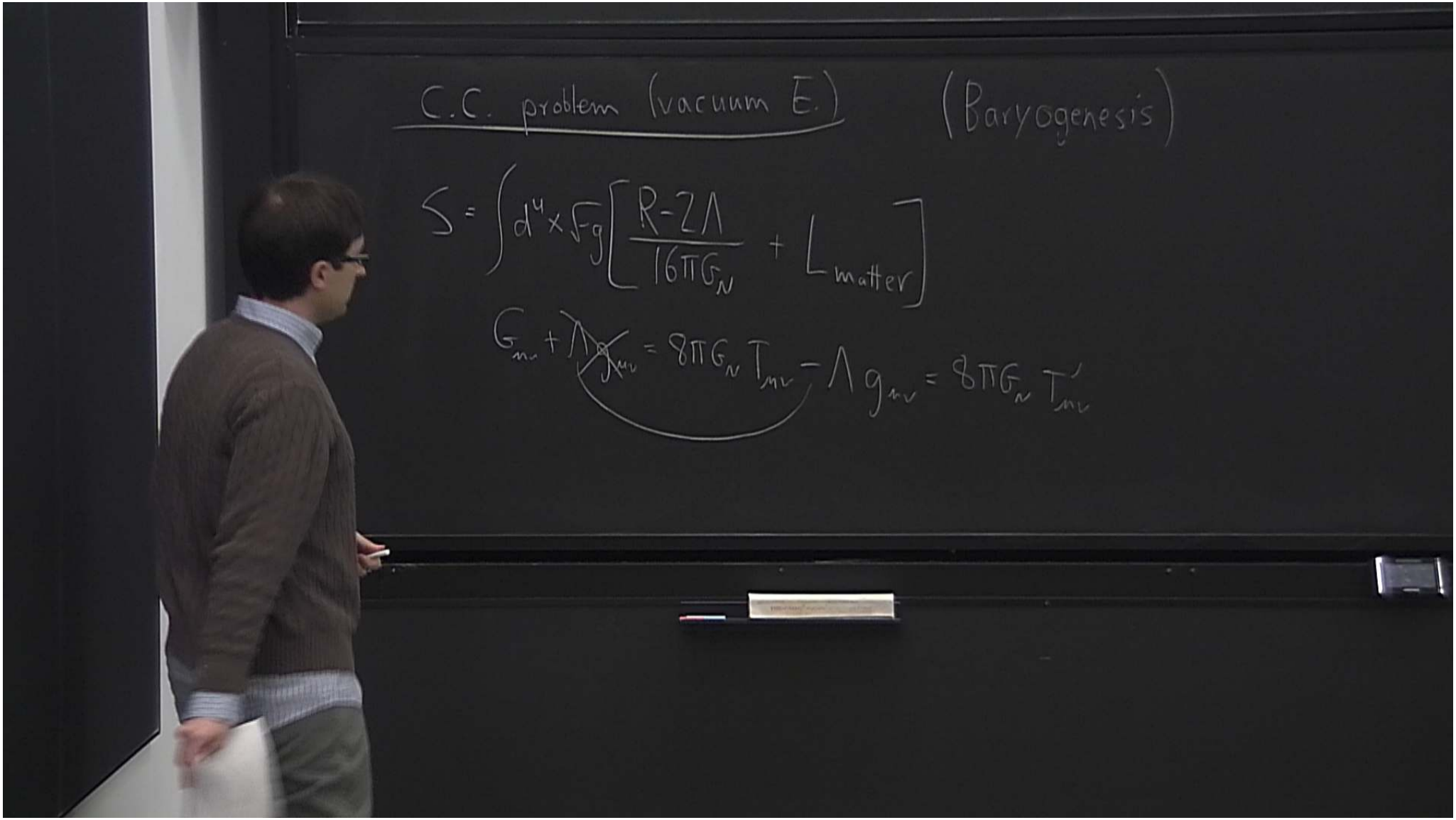


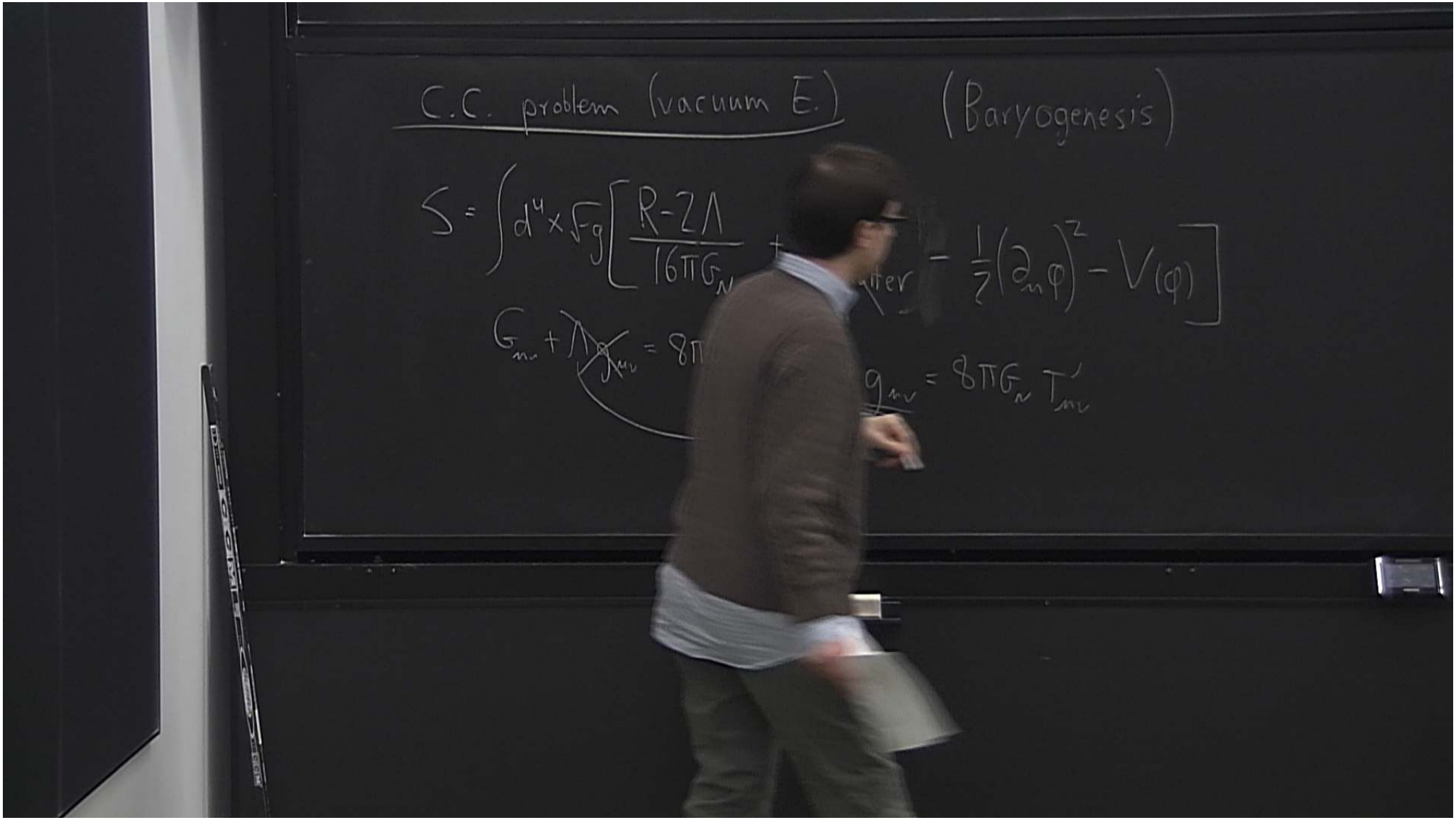

C.C. problem

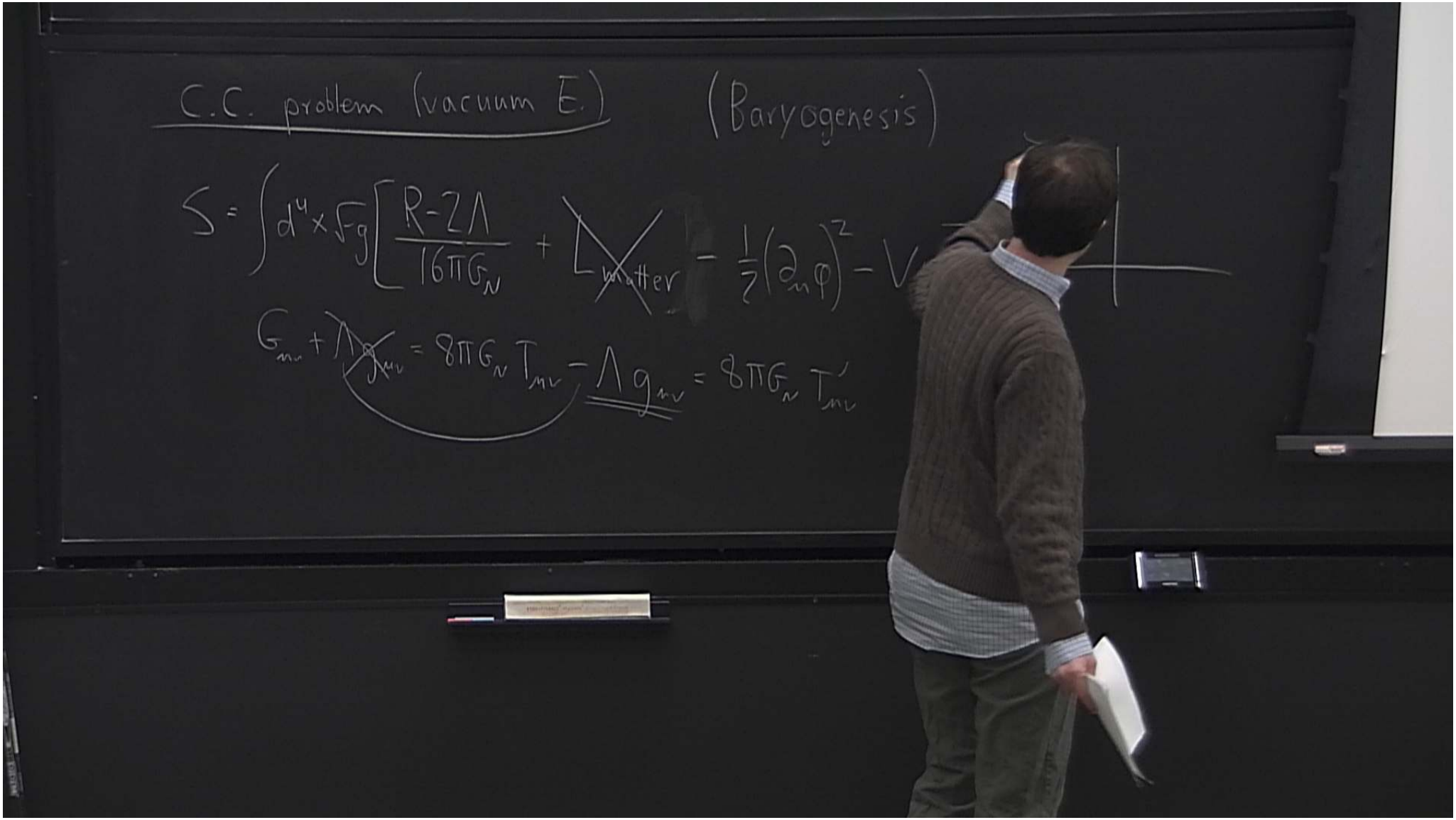

C.C. problem (vacuum E.)
(Baryogenesis)

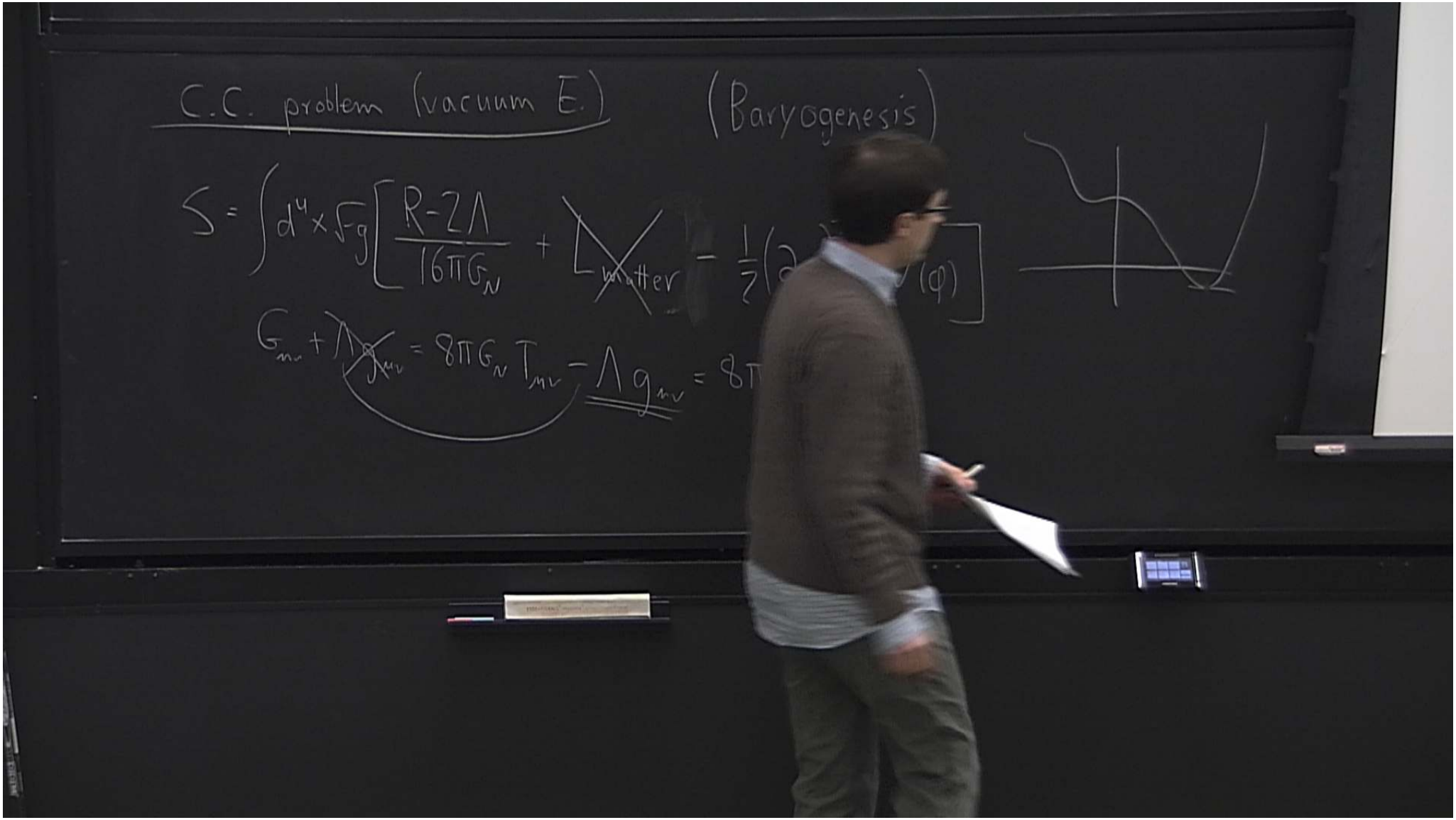

C.C. problem (vacuum E.)
(Baryogenesis)
$S = \int d^4x \sqrt{-g} \left[\frac{R - 2\Lambda}{16\pi} \right.$

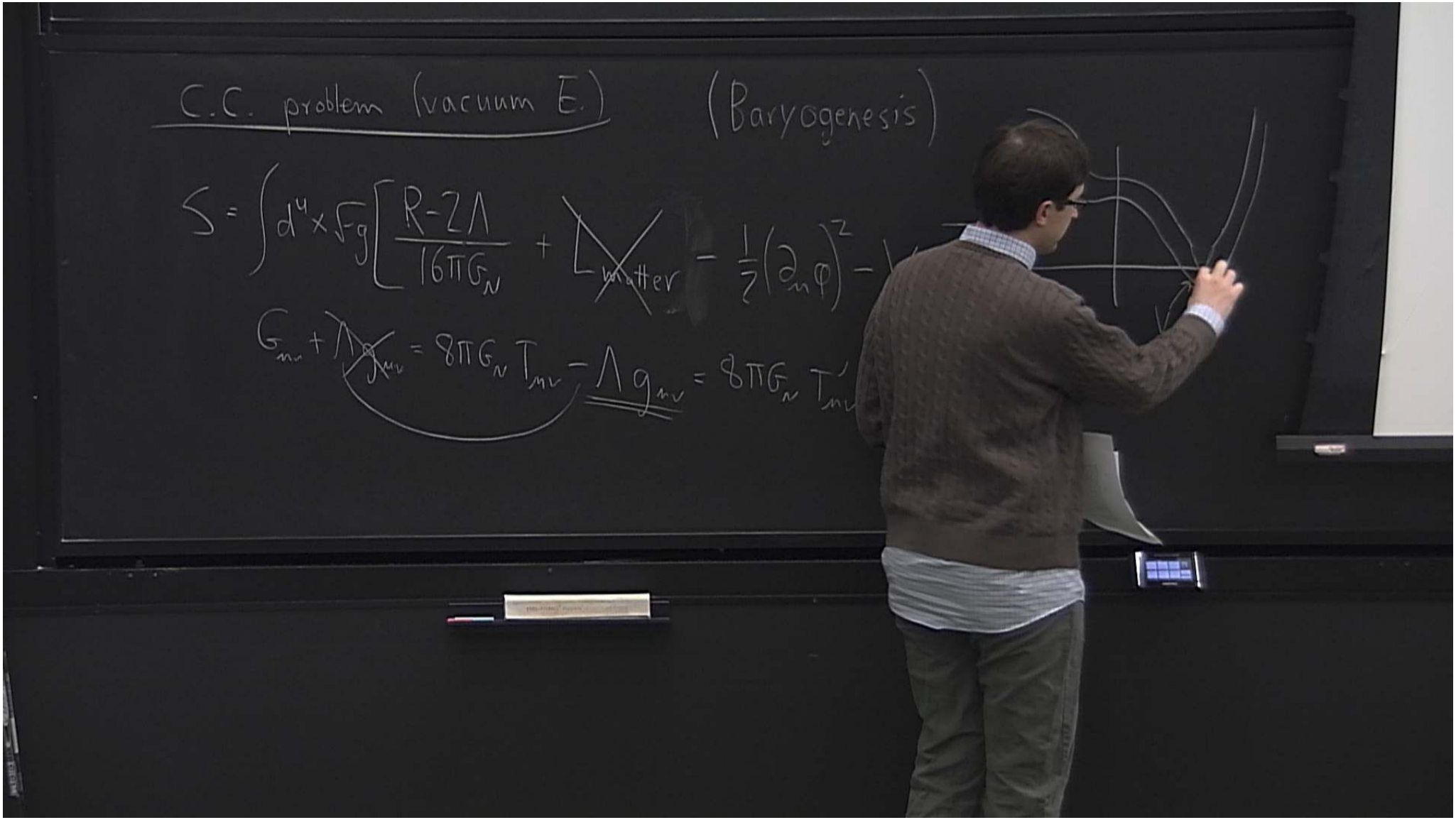

C.C. problem (vacuum E.)
(Baryogenesis)
$S = \int d^4x \sqrt{-g} \left[\frac{R - 2\Lambda}{16\pi G_N} + L_m \right]$
$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$


C.C. problem (vacuum E.)
(Baryogenesis)
$S = \int d^4x \sqrt{-g} \left[\frac{R - 2\Lambda}{16\pi G_N} + L_{matter} \right]$
$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$
$-\Lambda g_{\mu\nu} = 8\pi G_N T'_{\mu\nu}$


C.C. problem (vacuum E.)
(Baryogenesis)
$S = \int d^4x \sqrt{-g} \left[\frac{R - 2\Lambda}{16\pi G_N} + \text{matter} - \frac{1}{2}(\partial_\mu \varphi)^2 - V(\varphi) \right]$
$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi$
$g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$


C.C. problem (vacuum E.)
(Baryogenesis)
$S = \int d^4x \sqrt{g} \left[\frac{R - 2\Lambda}{16\pi G_N} + \mathcal{L}_{matter} \right]$
$- \frac{1}{2}(\partial_\mu \varphi)^2 - V$
$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$
$- \Lambda g_{\mu\nu} = 8\pi G_N T'_{\mu\nu}$


C.C. problem (vacuum E.)
(Baryogenesis
$S = \int d^4x \sqrt{-g} \left[\frac{R - 2\Lambda}{16\pi G_N} + \mathcal{L}_{matter} - \frac{1}{2}(\partial \quad V(\varphi) \right]$
$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu} - \Lambda g_{\mu\nu} = 8\pi$


C.C. problem (vacuum E.)
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$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$
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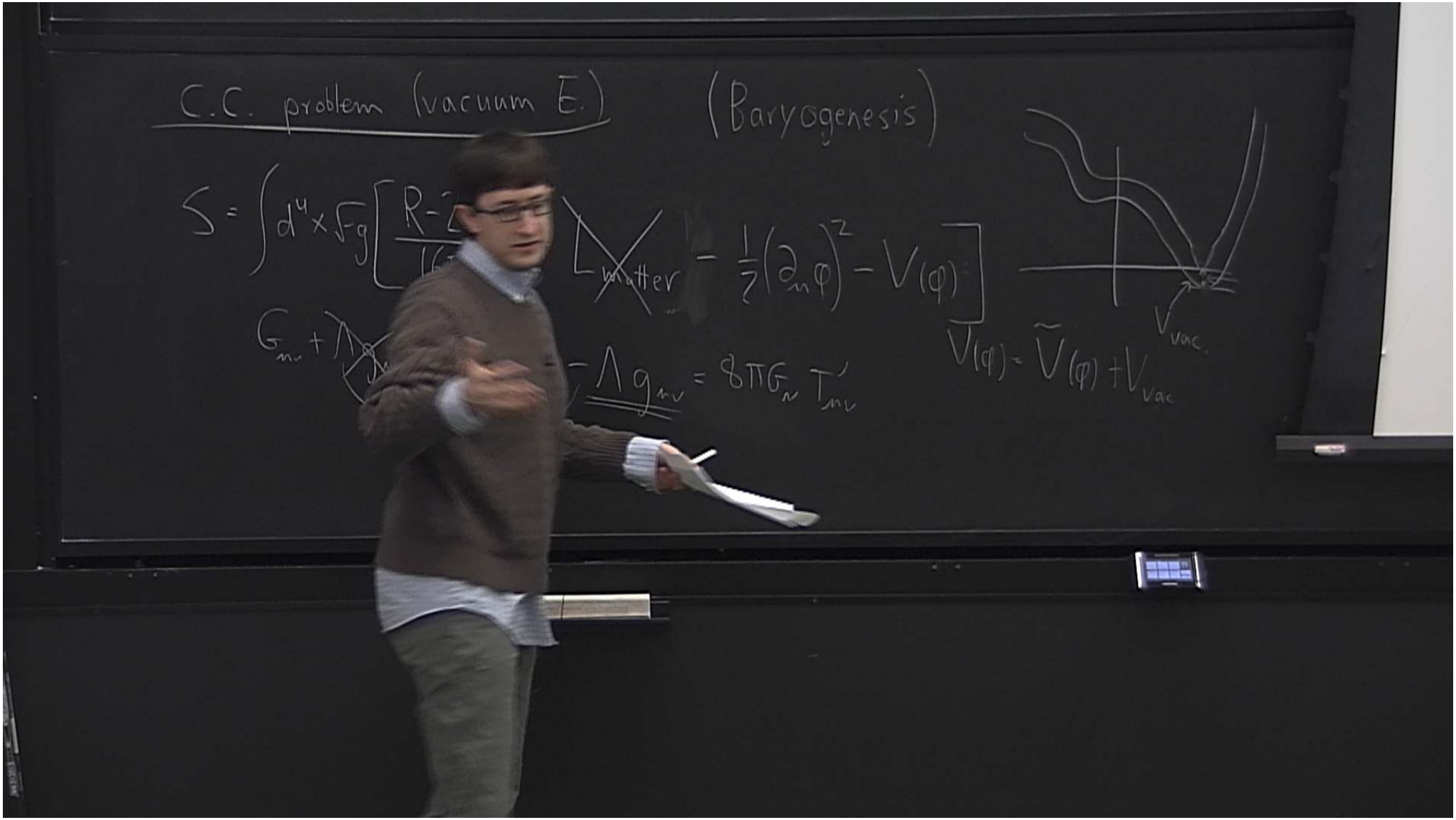
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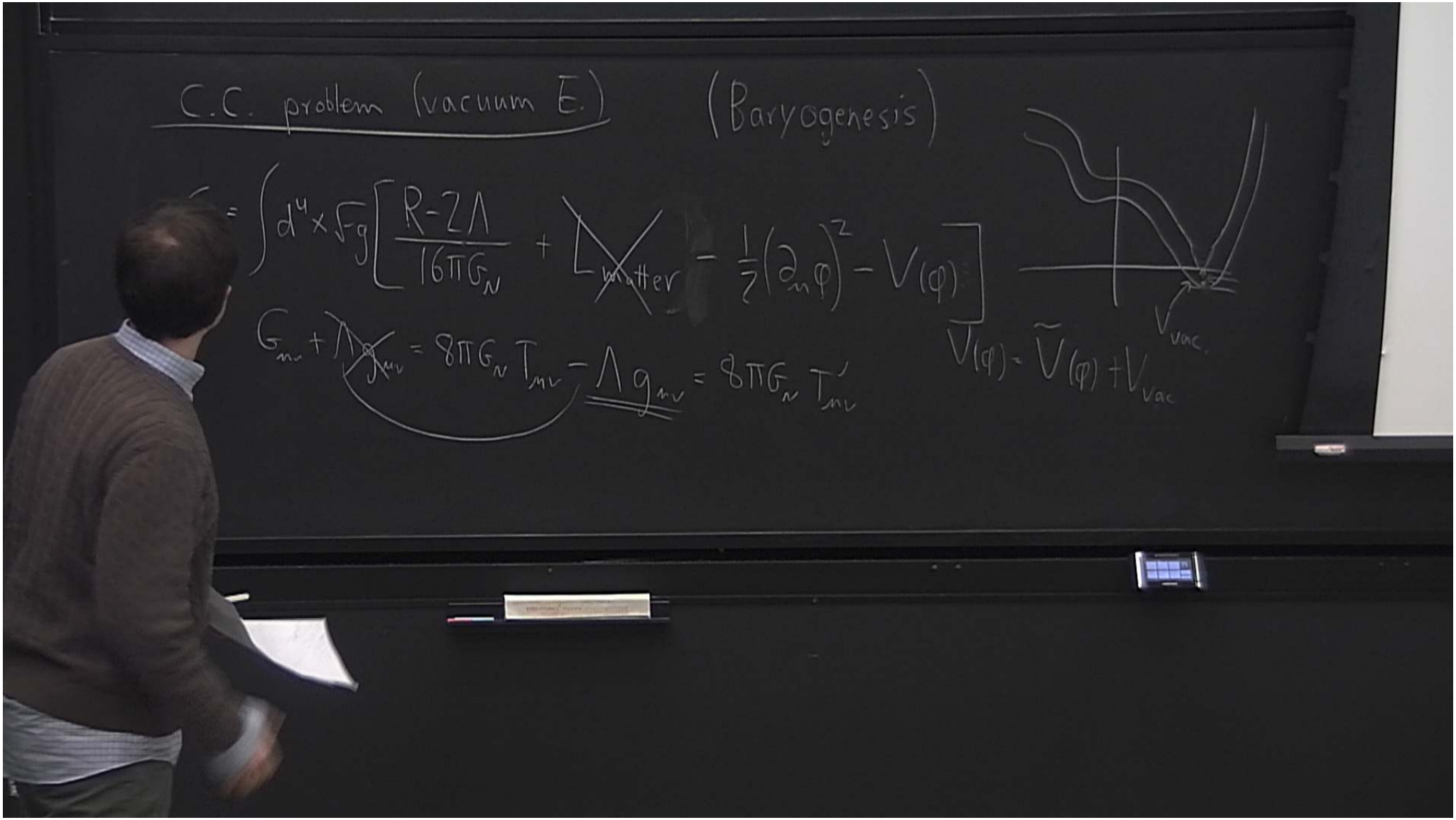
$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$
$V(\varphi) = \tilde{V}(\varphi) + V_{vac}$
V_{vac}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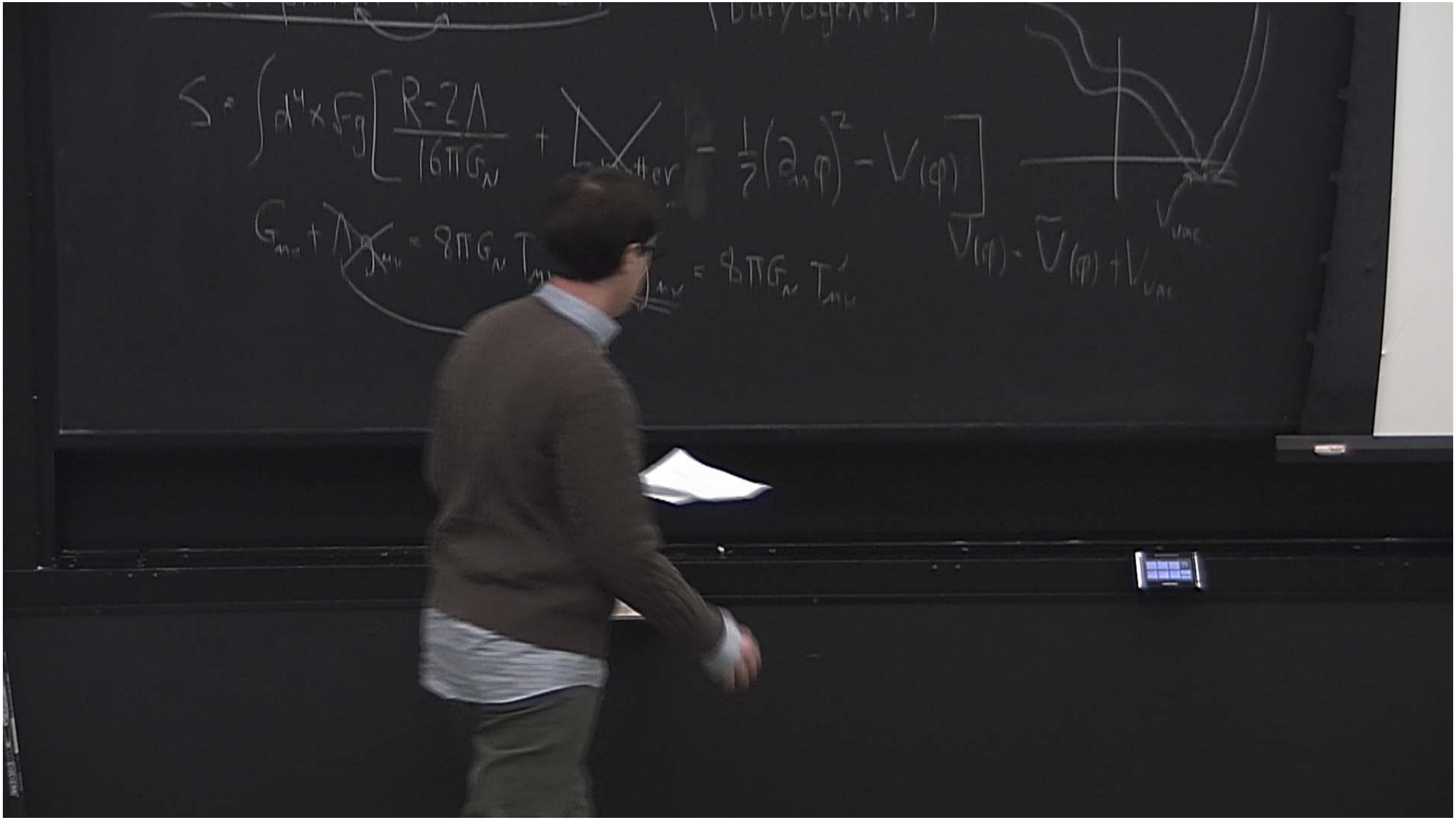
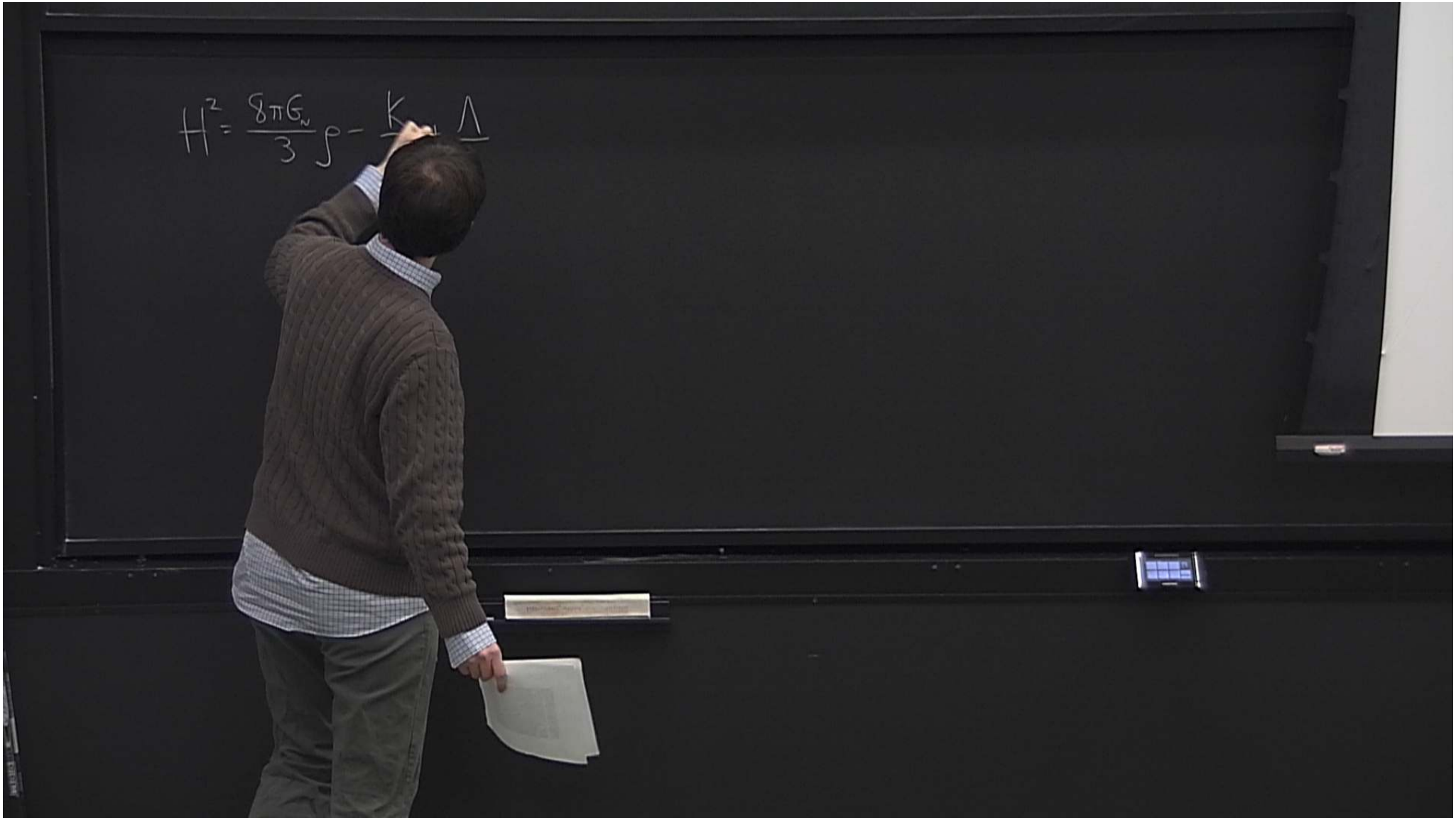
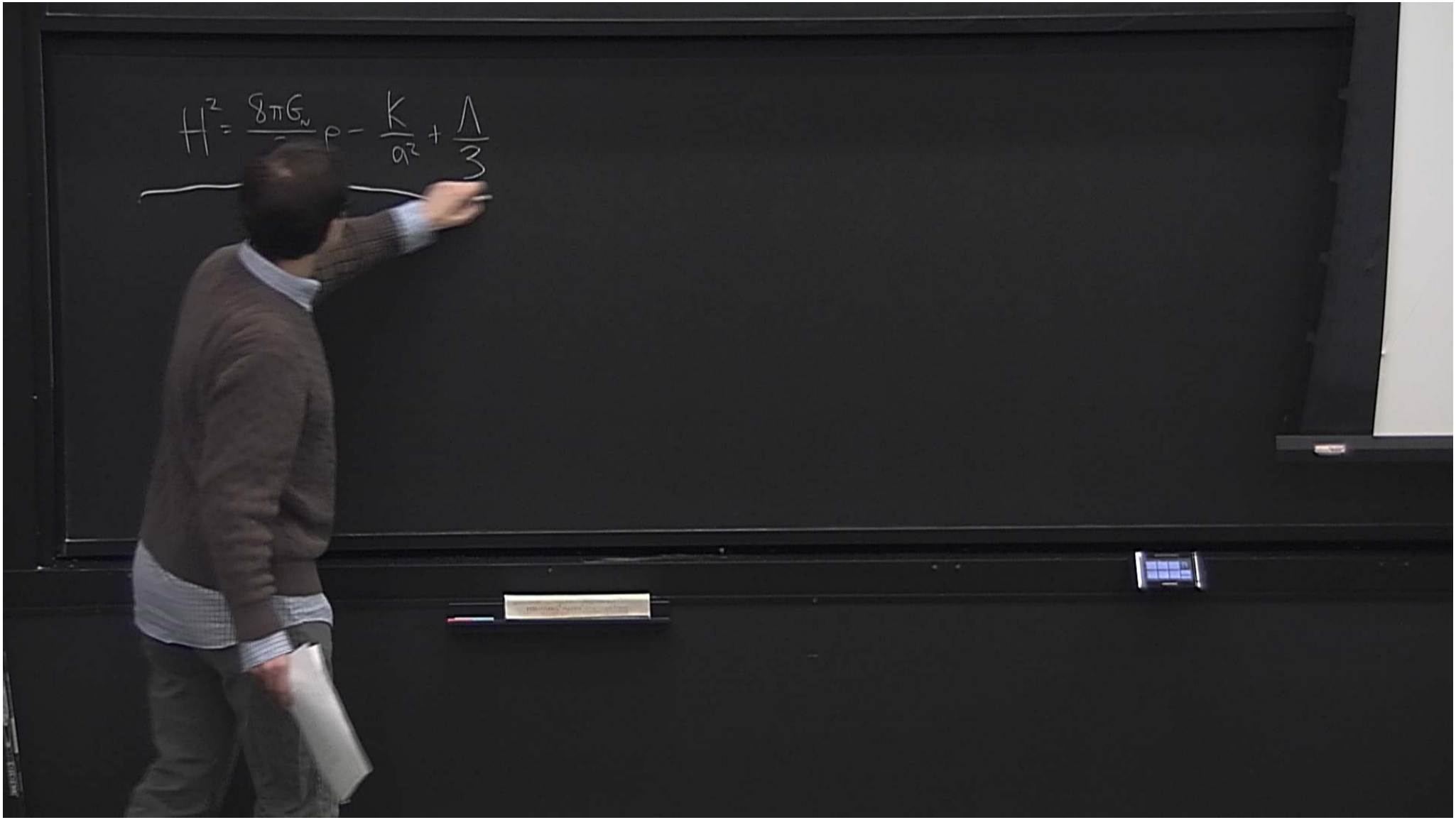
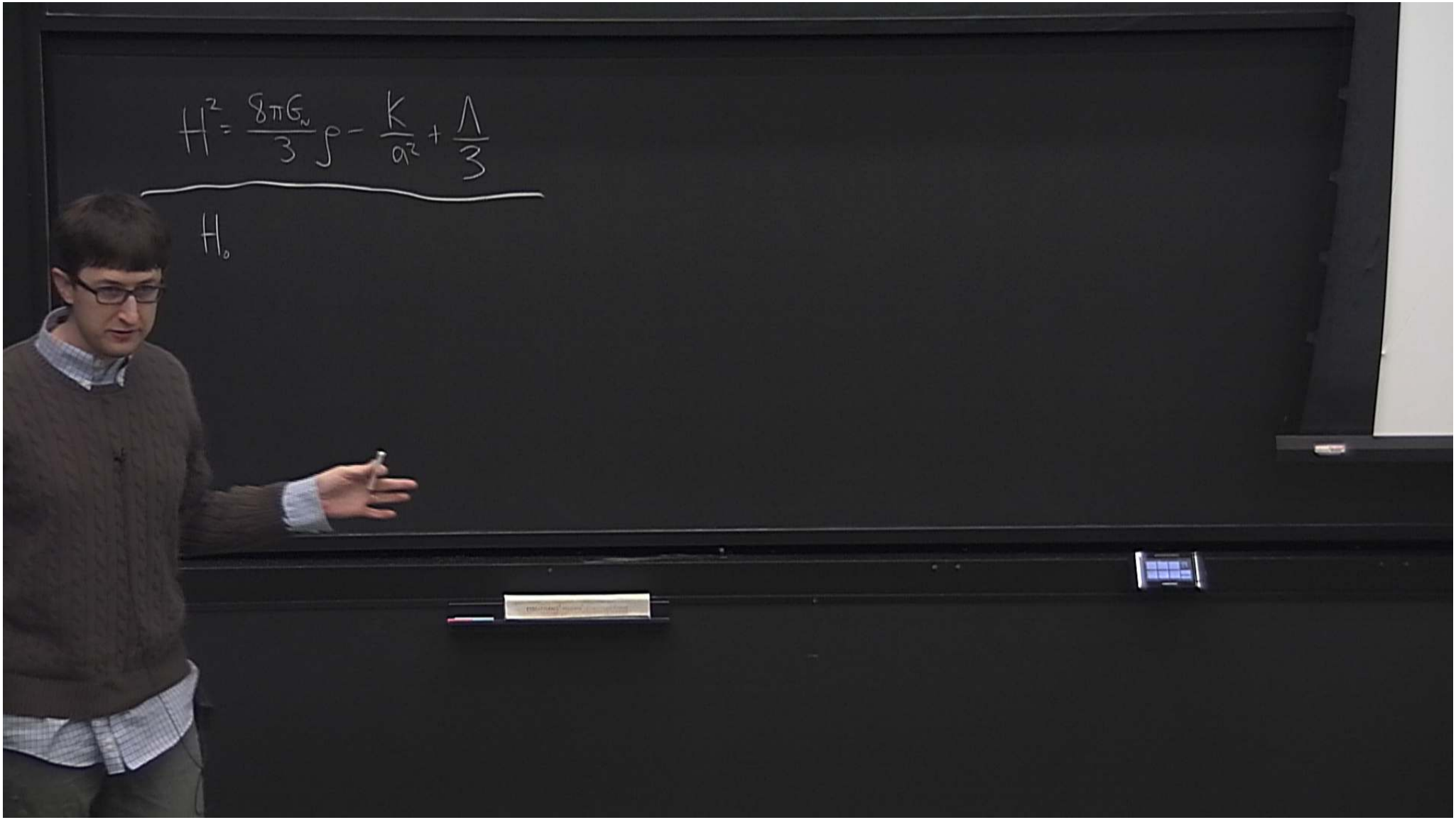
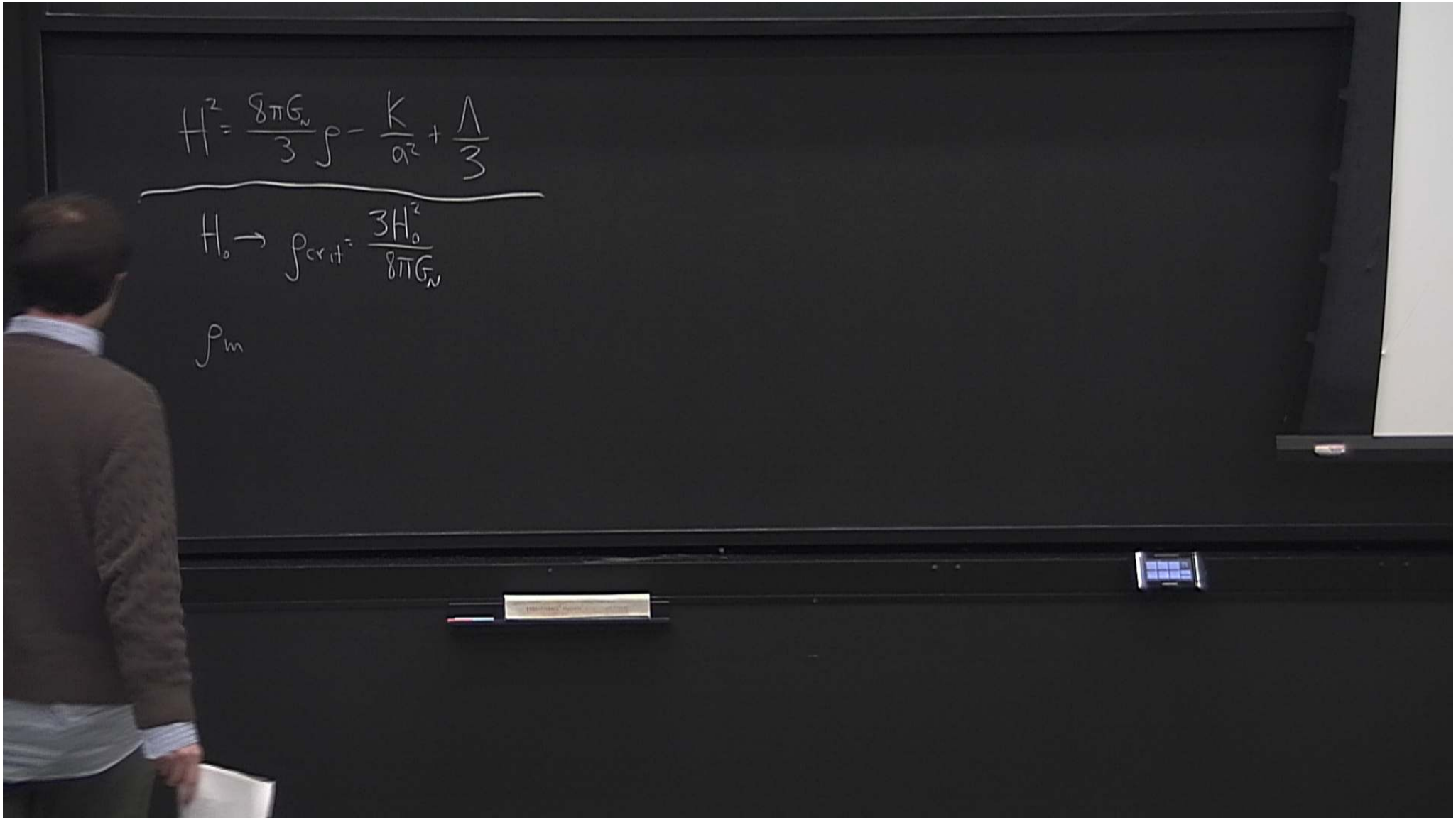
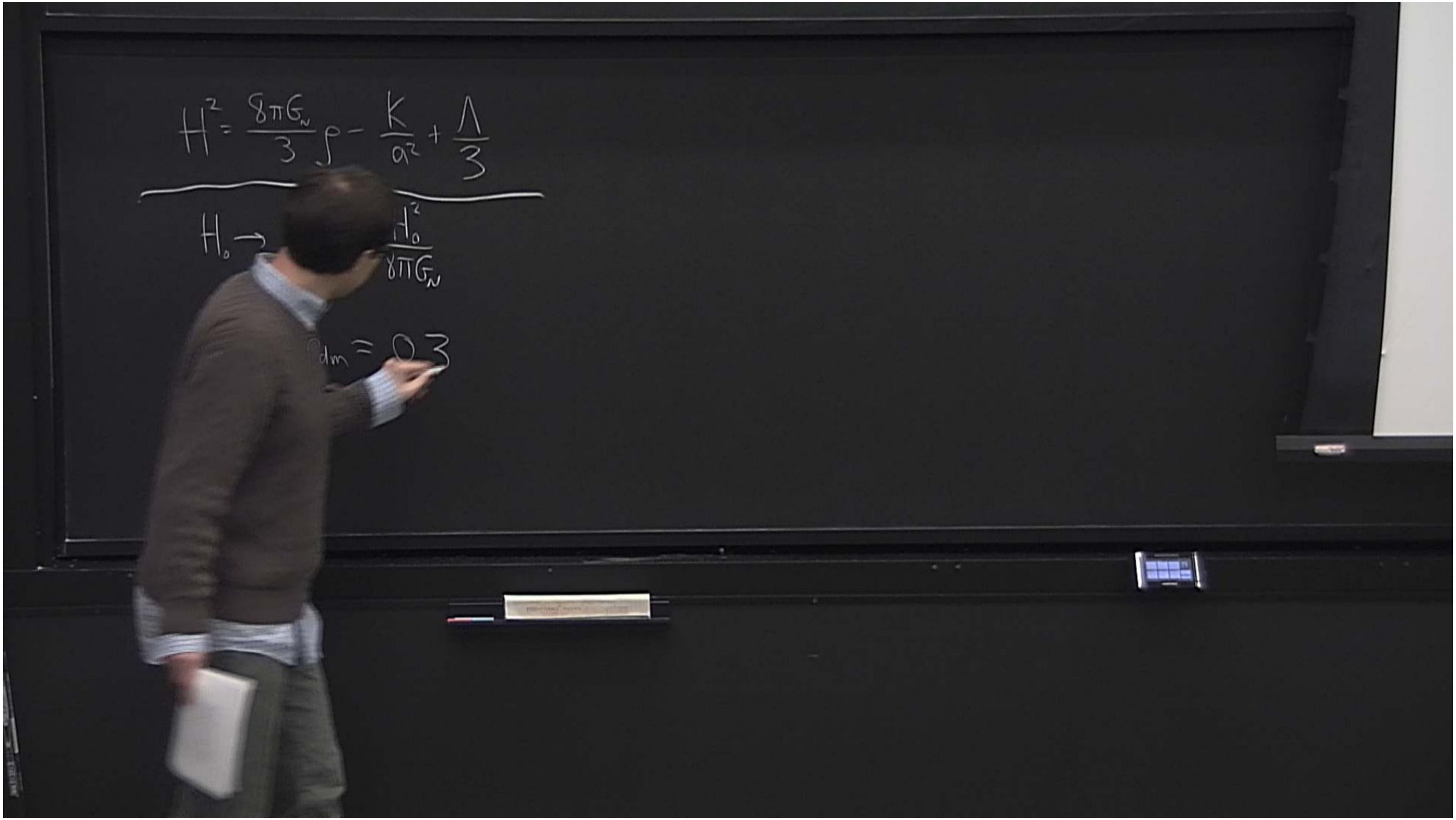

$S = \int d^4x \sqrt{-g} \left[\frac{R - 2\Lambda}{16\pi G_N} + \mathcal{L}_{matter} - \frac{1}{2}(\partial_\mu \varphi)^2 - V(\varphi) \right]$
$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G_N T_{\mu\nu}$
$= 8\pi G_N T_{\mu\nu}$
$V(\varphi) = \bar{V}(\varphi) + V_{vac}$
V_{vac}

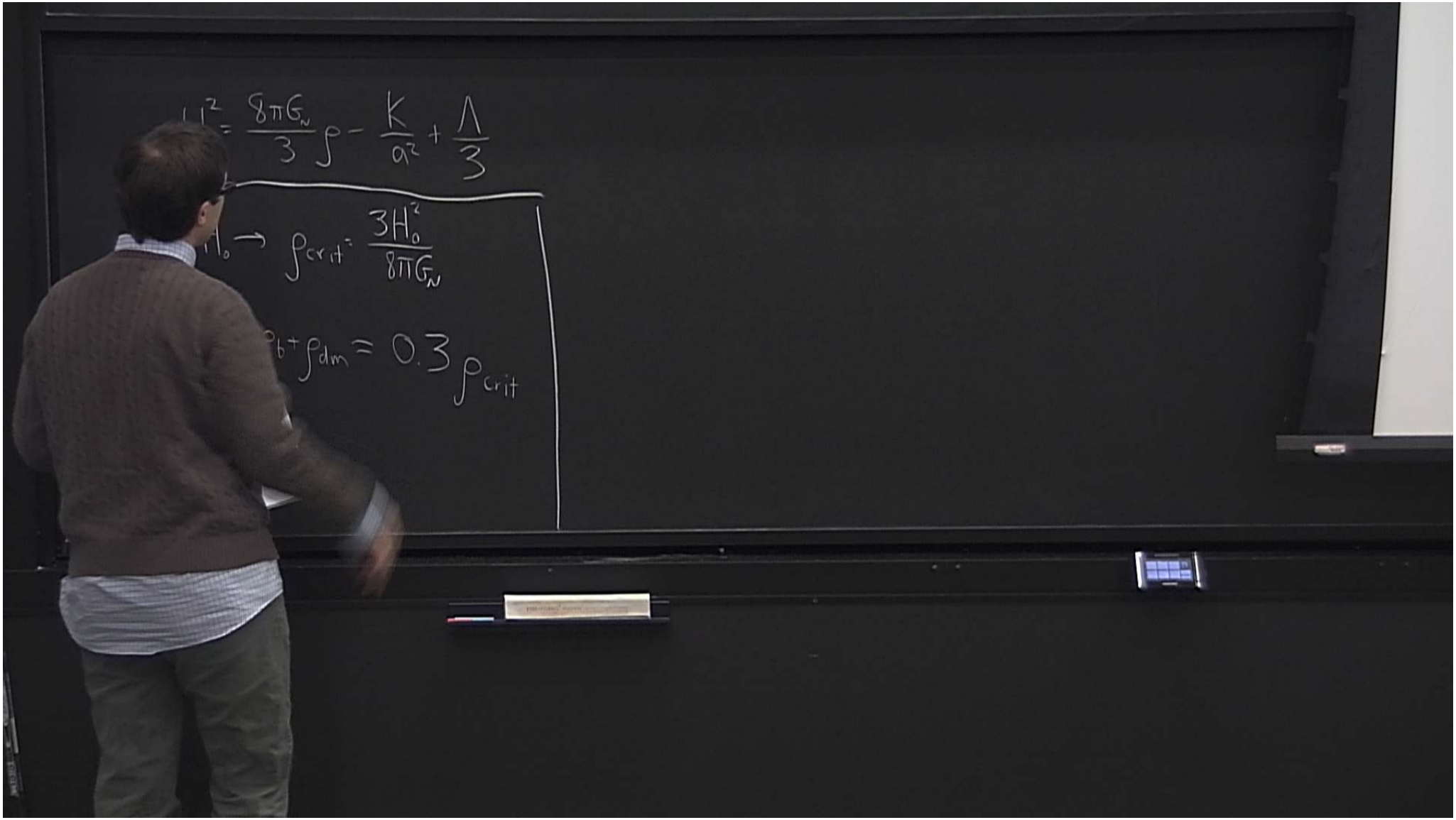

$H^2 = \frac{8\pi G_N}{3}\rho - \frac{K}{a^2} + \frac{\Lambda}{3}$

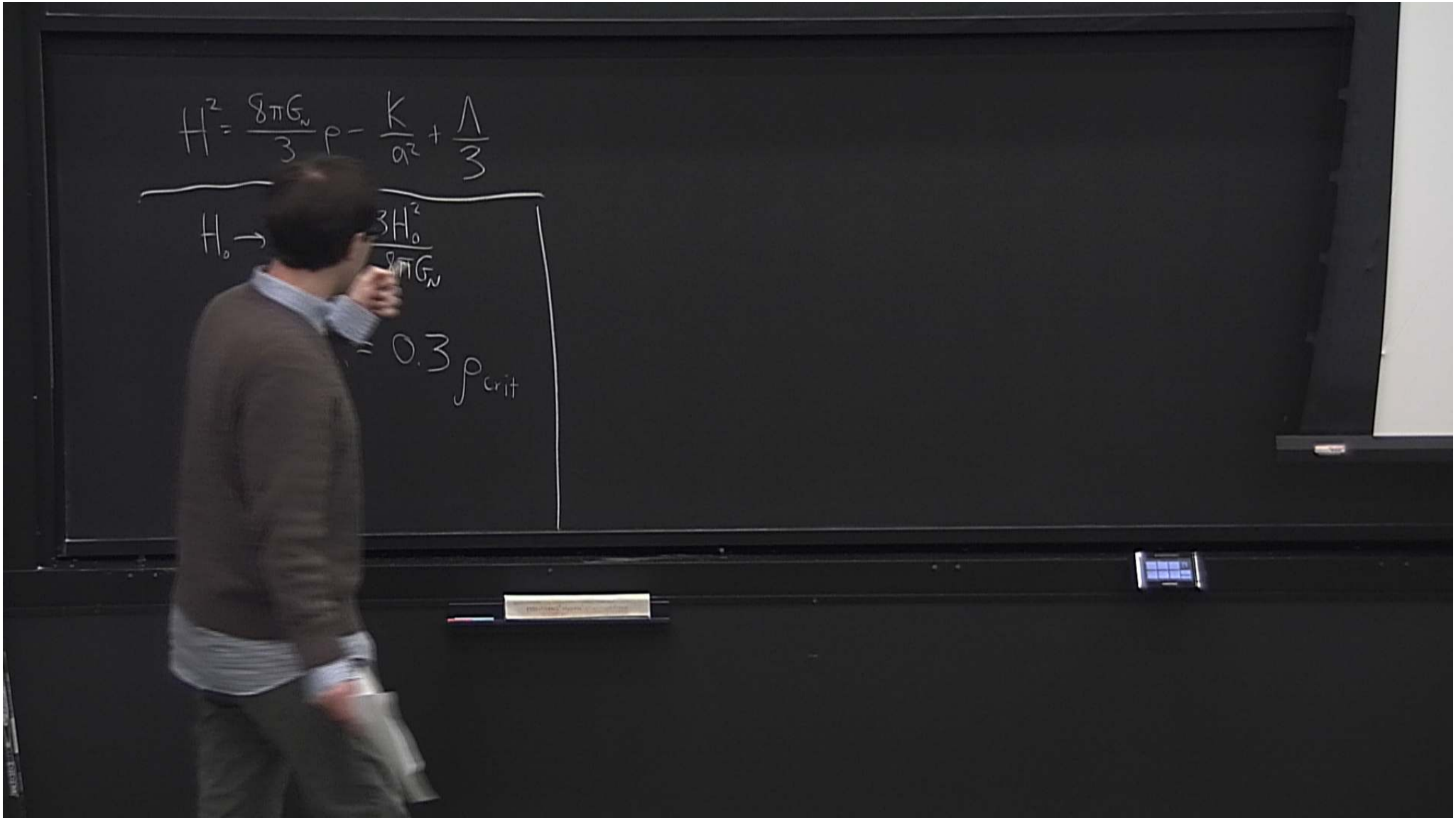

$H^2 = \frac{8\pi G_N}{3}\rho - \frac{k}{a^2} + \frac{\Lambda}{3}$

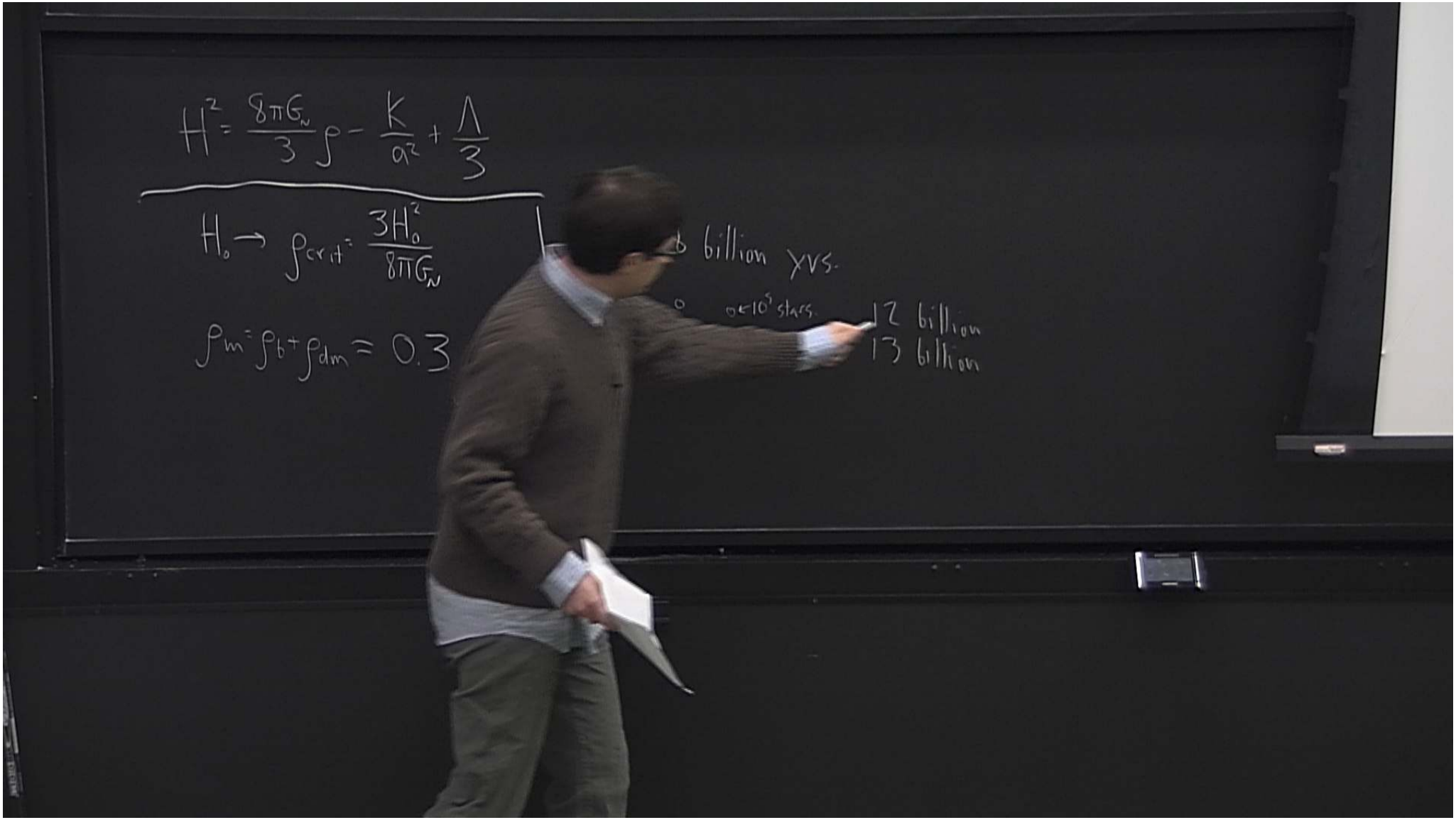

$H^2 = \frac{8\pi G_N}{3}\rho - \frac{K}{a^2} + \frac{\Lambda}{3}$
H_0

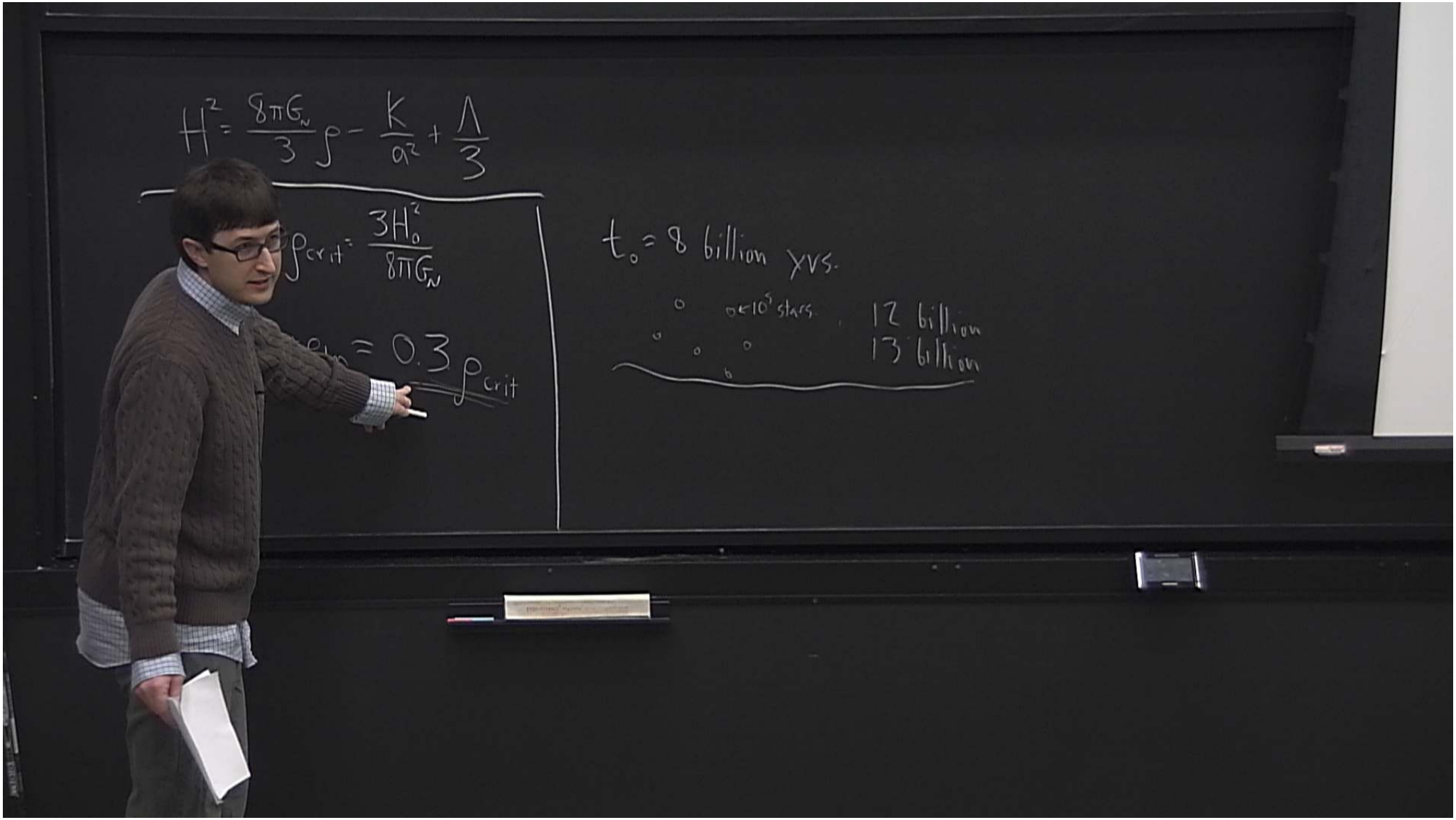

$H^2 = \frac{8\pi G_N}{3}\rho - \frac{K}{a^2} + \frac{\Lambda}{3}$
$H_0 \rightarrow \rho_{crit} = \frac{3H_0^2}{8\pi G_N}$
ρ_m

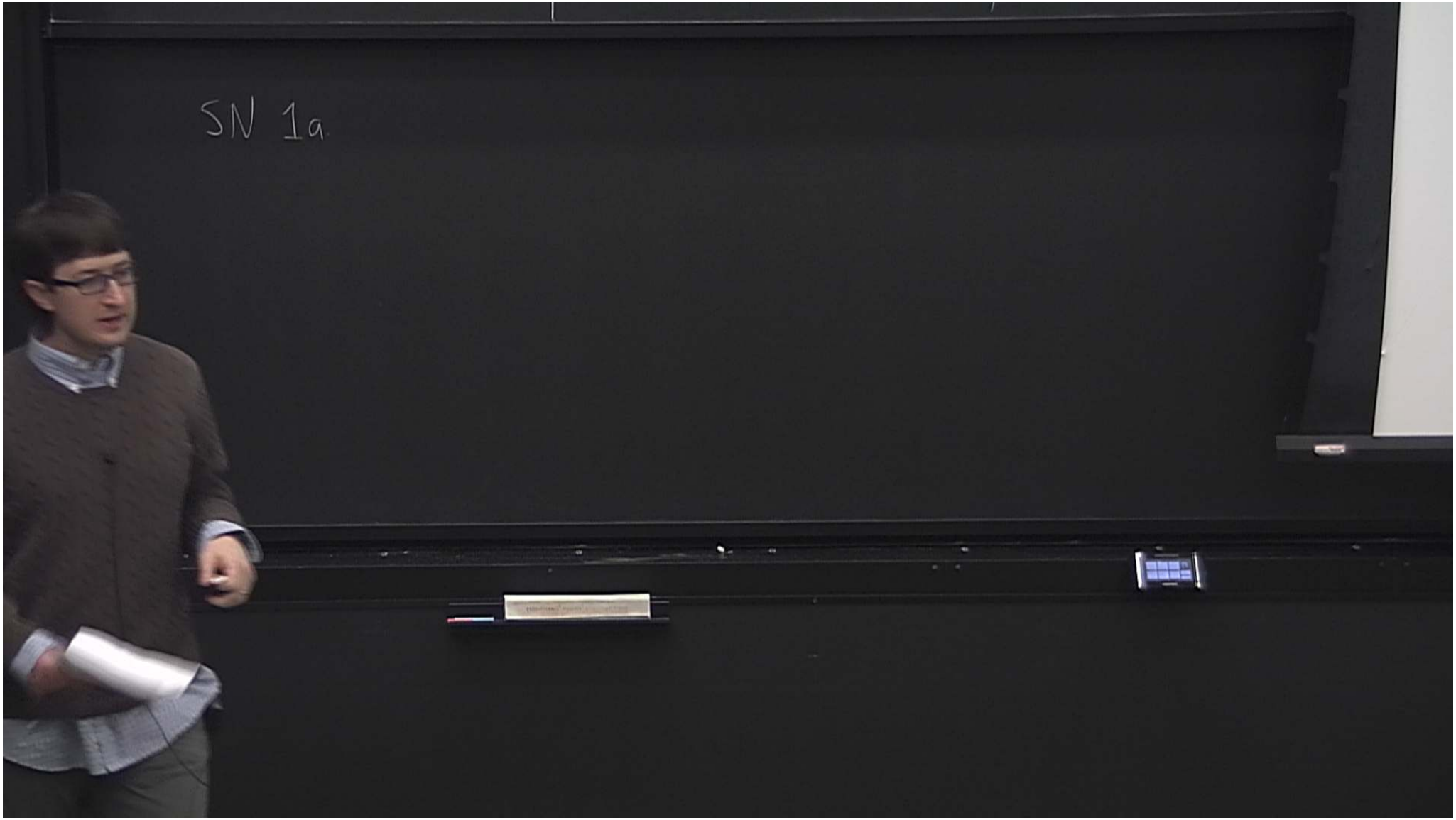

$H^2 = \frac{8\pi G_N}{3}\rho - \frac{K}{a^2} + \frac{\Lambda}{3}$
$H_0 \rightarrow$
$\frac{H_0^2}{8\pi G_N}$
$\rho_{dm} = 0.3$

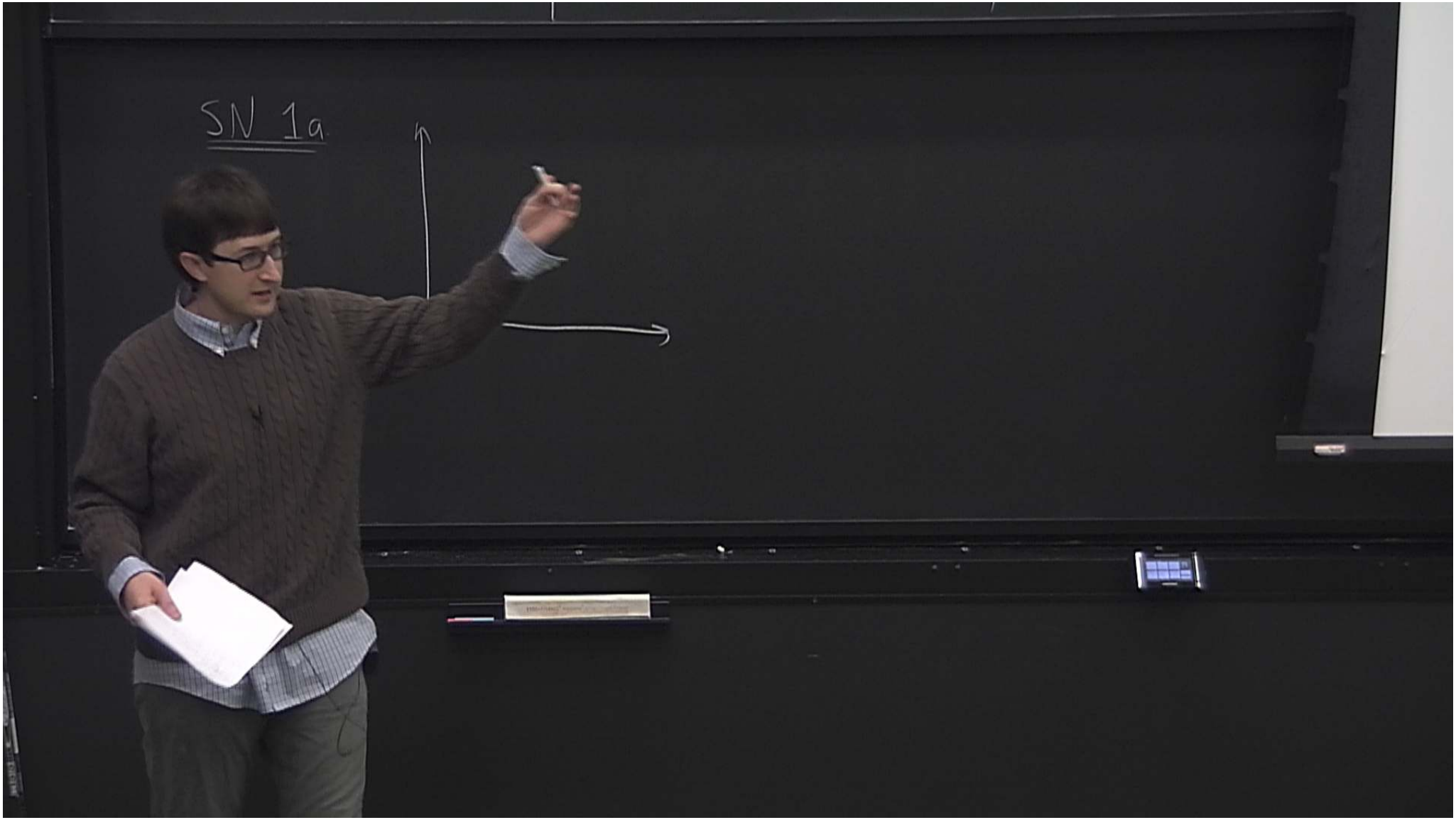

$H^2 = \frac{8\pi G_N}{3}\rho - \frac{K}{a^2} + \frac{\Lambda}{3}$
$H_0 \rightarrow \rho_{crit} = \frac{3H_0^2}{8\pi G_N}$
$\rho_b + \rho_{dm} = 0.3\,\rho_{crit}$


$H^2 = \frac{8\pi G_N}{3}\rho - \frac{K}{a^2} + \frac{\Lambda}{3}$
$H_0 \rightarrow$
$\frac{3H_0^2}{8\pi G_N}$
$= 0.3\,\rho_{crit}$


$H^2 = \frac{8\pi G_N}{3}\rho - \frac{K}{a^2} + \frac{\Lambda}{3}$
$H_0 \rightarrow \rho_{crit} = \frac{3H_0^2}{8\pi G_N}$
$\rho_m = \rho_b + \rho_{dm} = 0.3$
billion yrs.
$\sim 10^{11}$ stars.
2 billion
13 billion


$H^2 = \frac{8\pi G_N}{3}\rho - \frac{K}{a^2} + \frac{\Lambda}{3}$
$\rho_{crit} = \frac{3H_0^2}{8\pi G_N}$
$= 0.3\,\rho_{crit}$
$t_0 = 8$ billion yrs.
$\sim 10^5$ stars
12 billion
13 billion


SN 1a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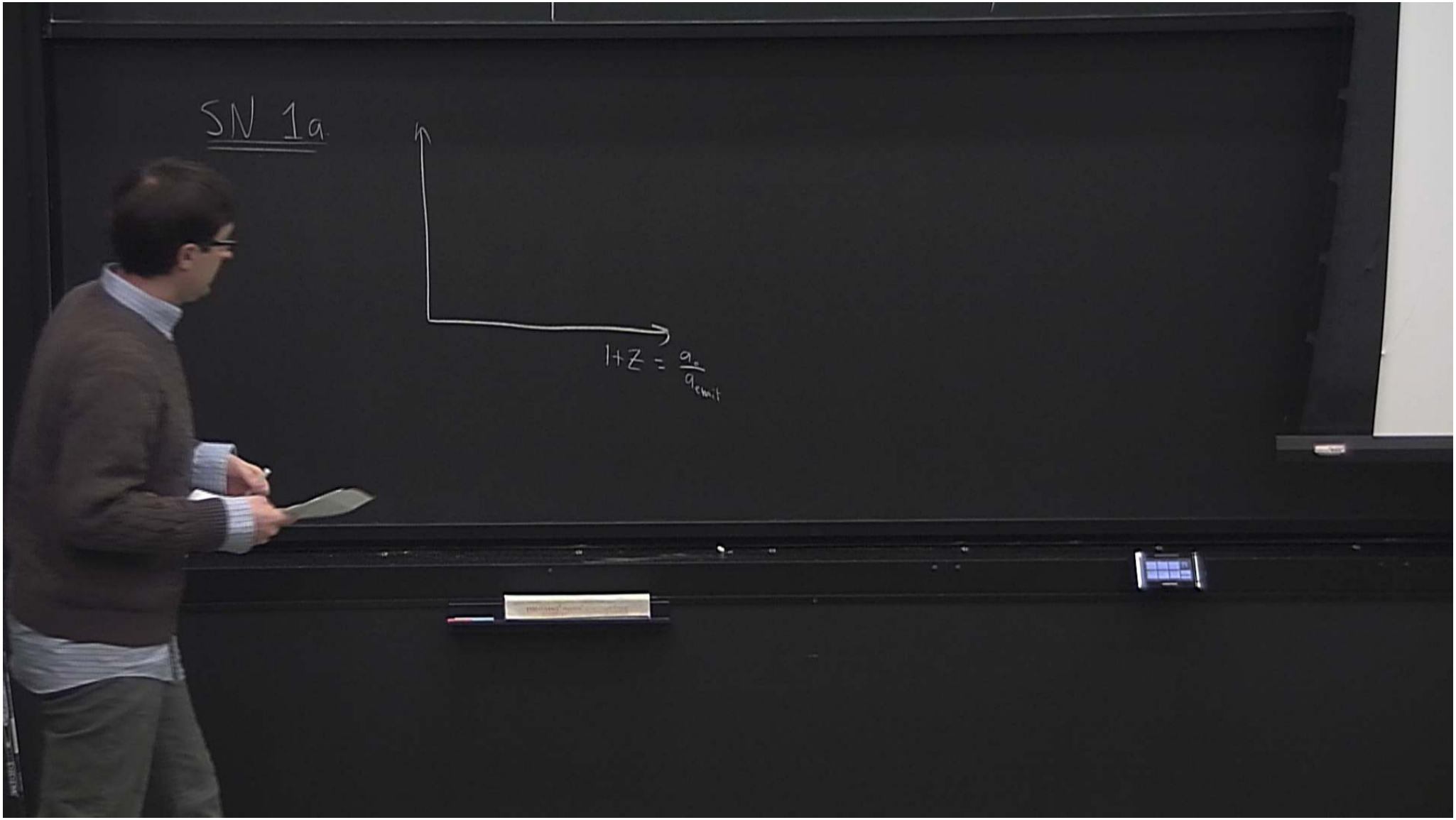
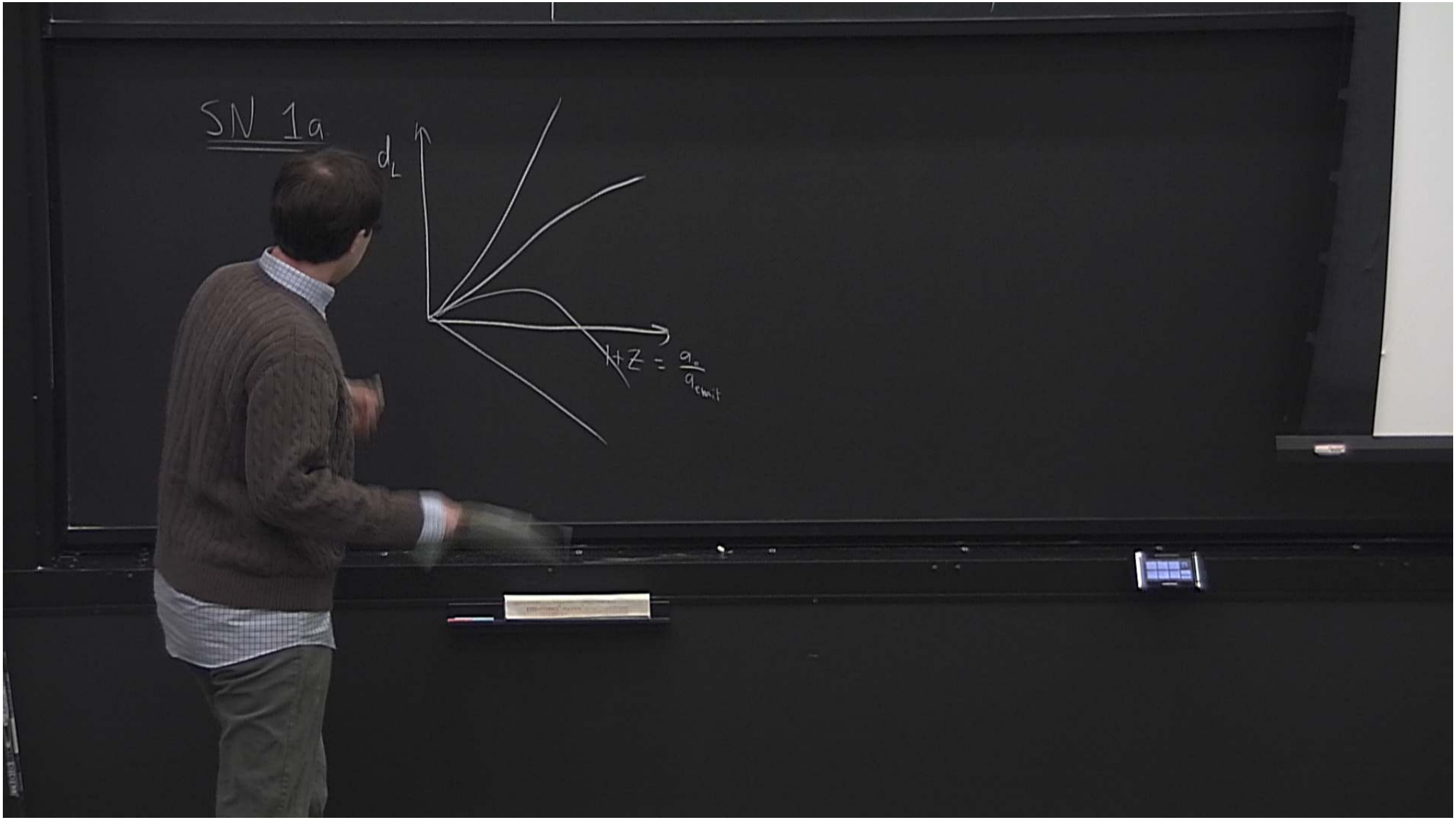
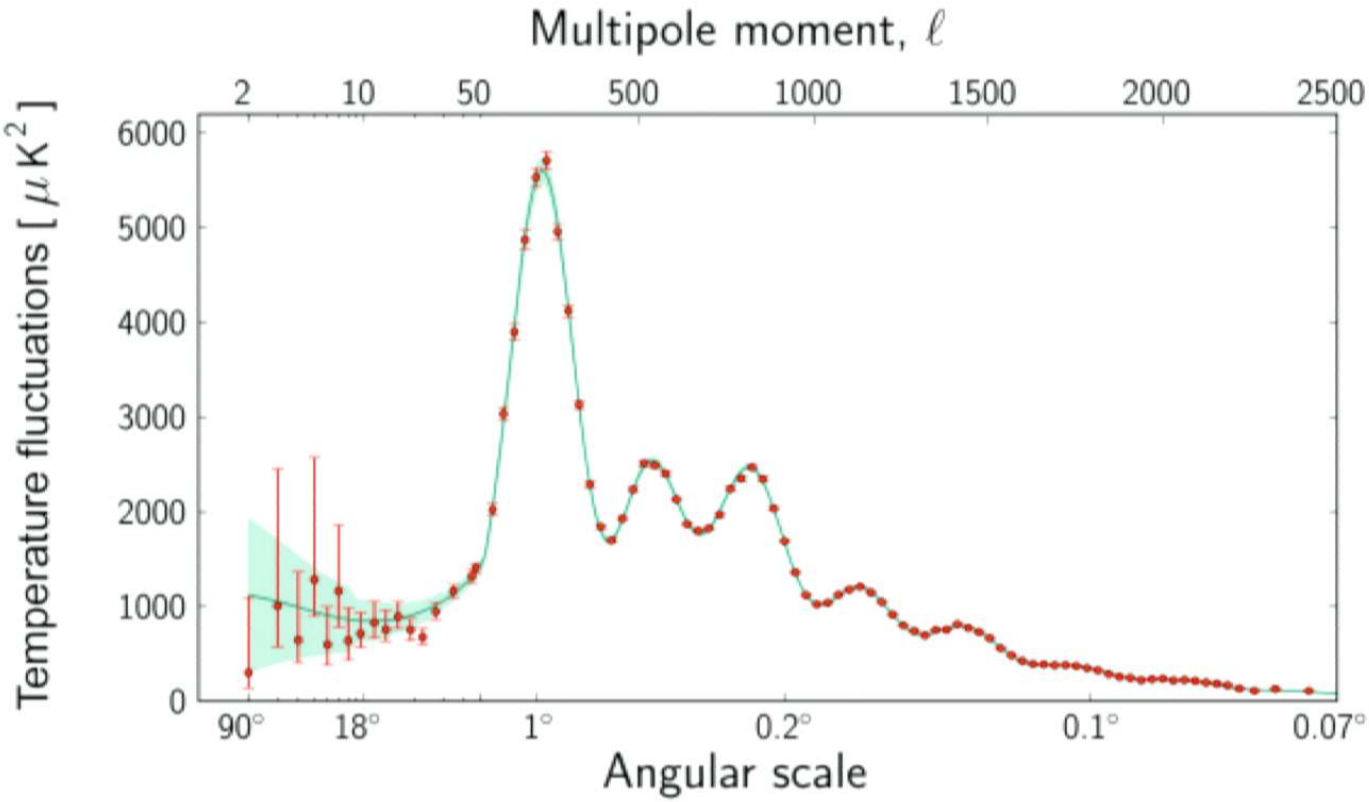
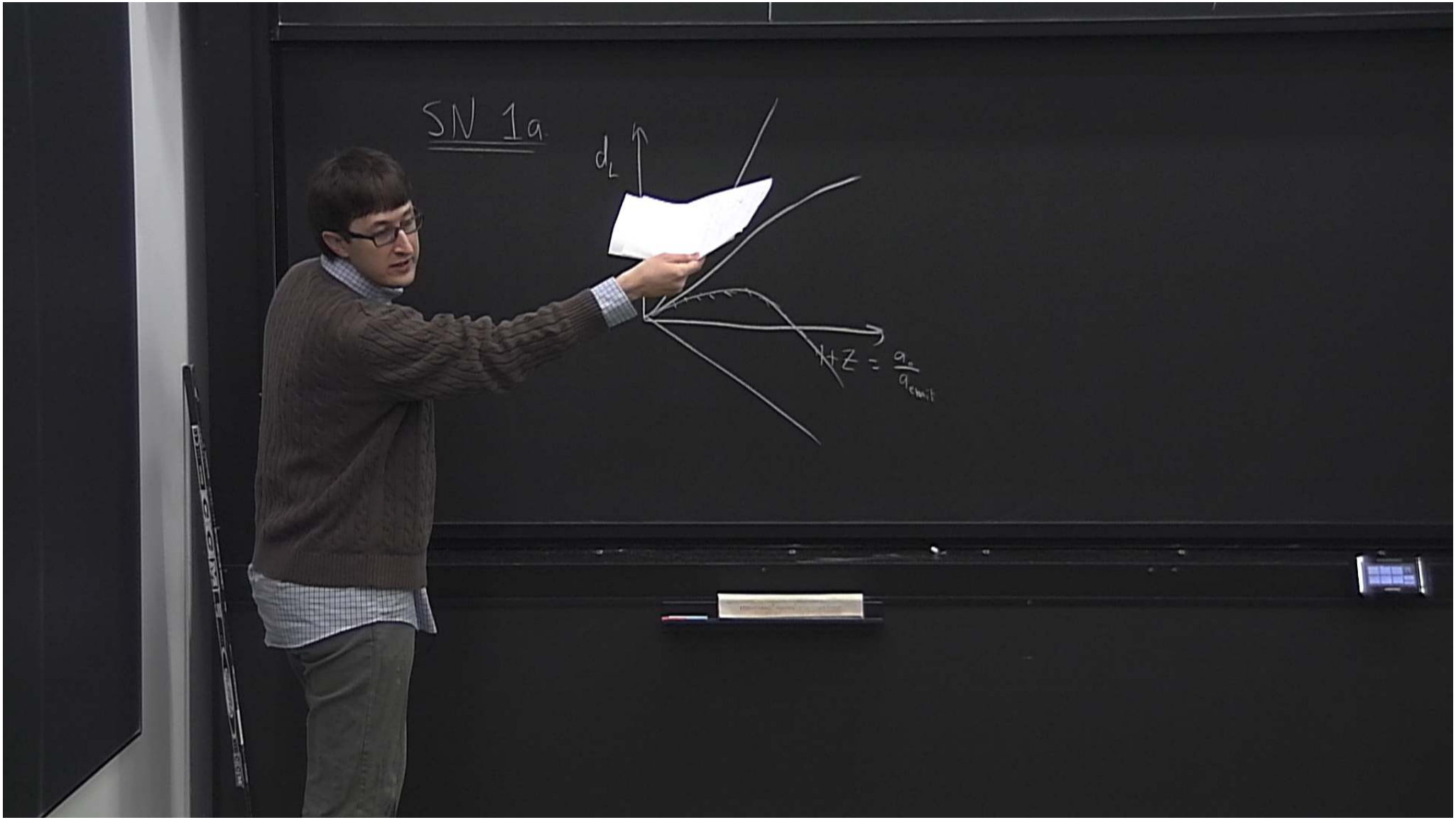
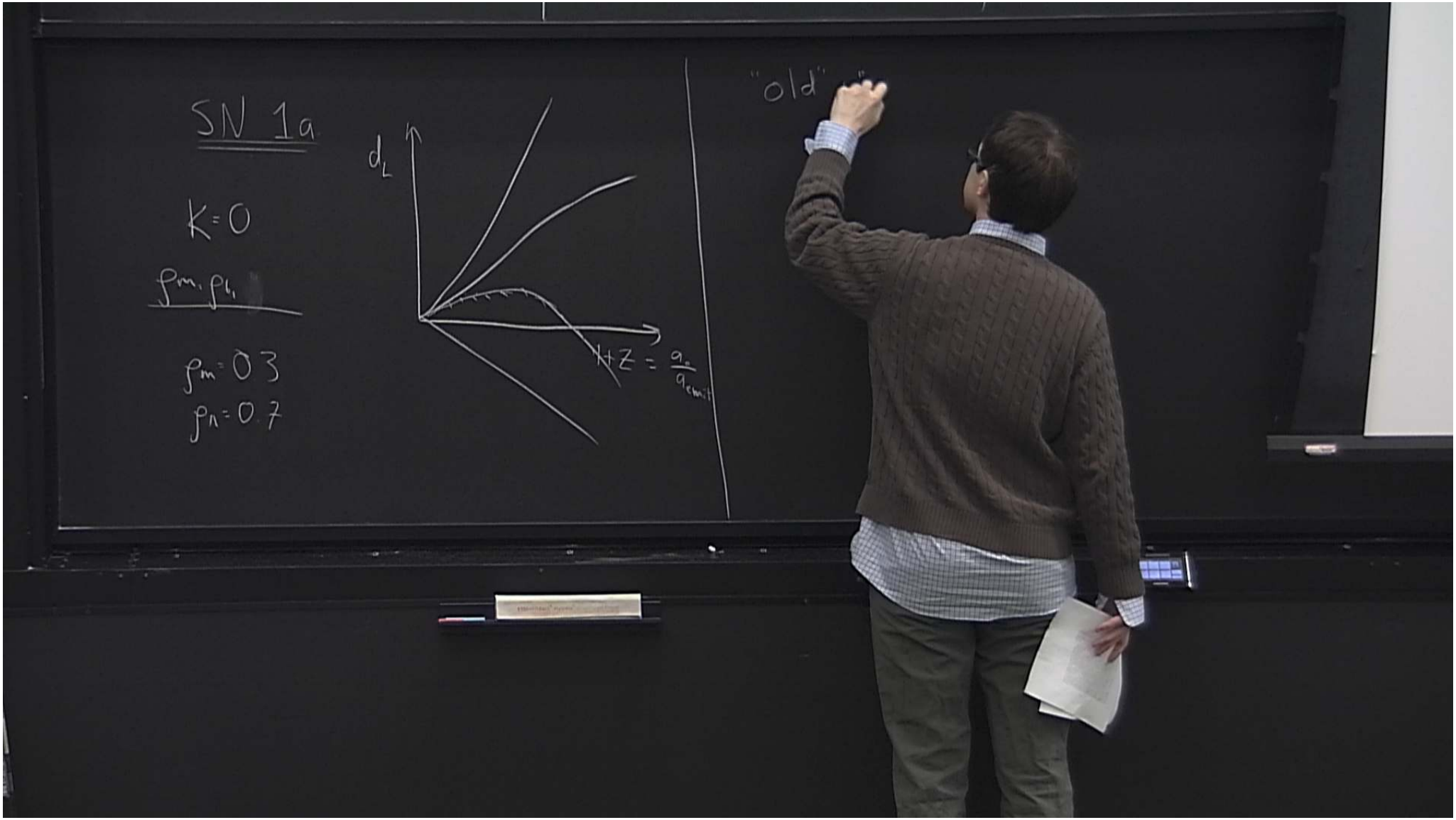

SN 1a
1+z = a0/aemit

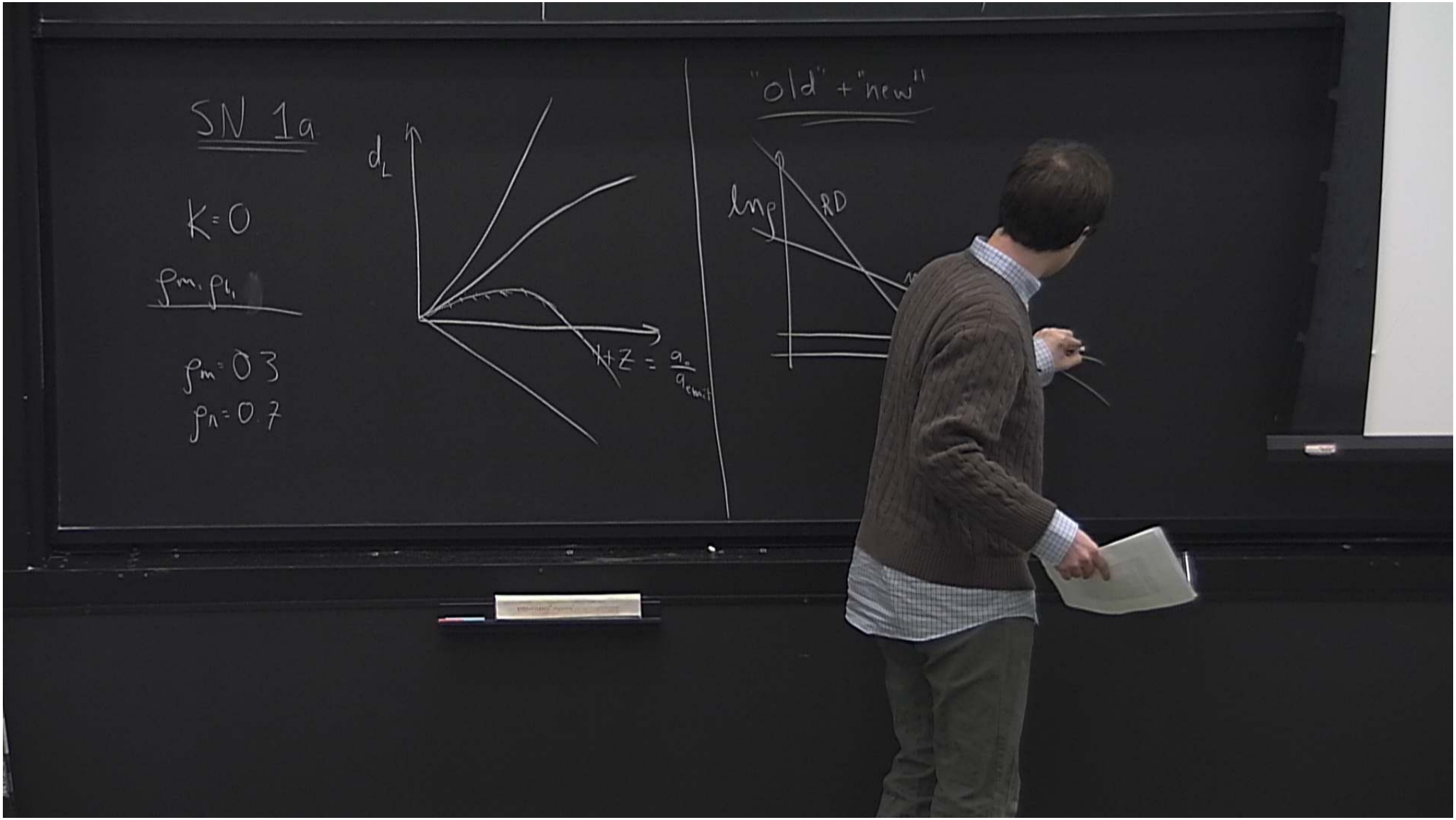

SN 1a
d_L
$1+z = \frac{a_0}{a_{emit}}$

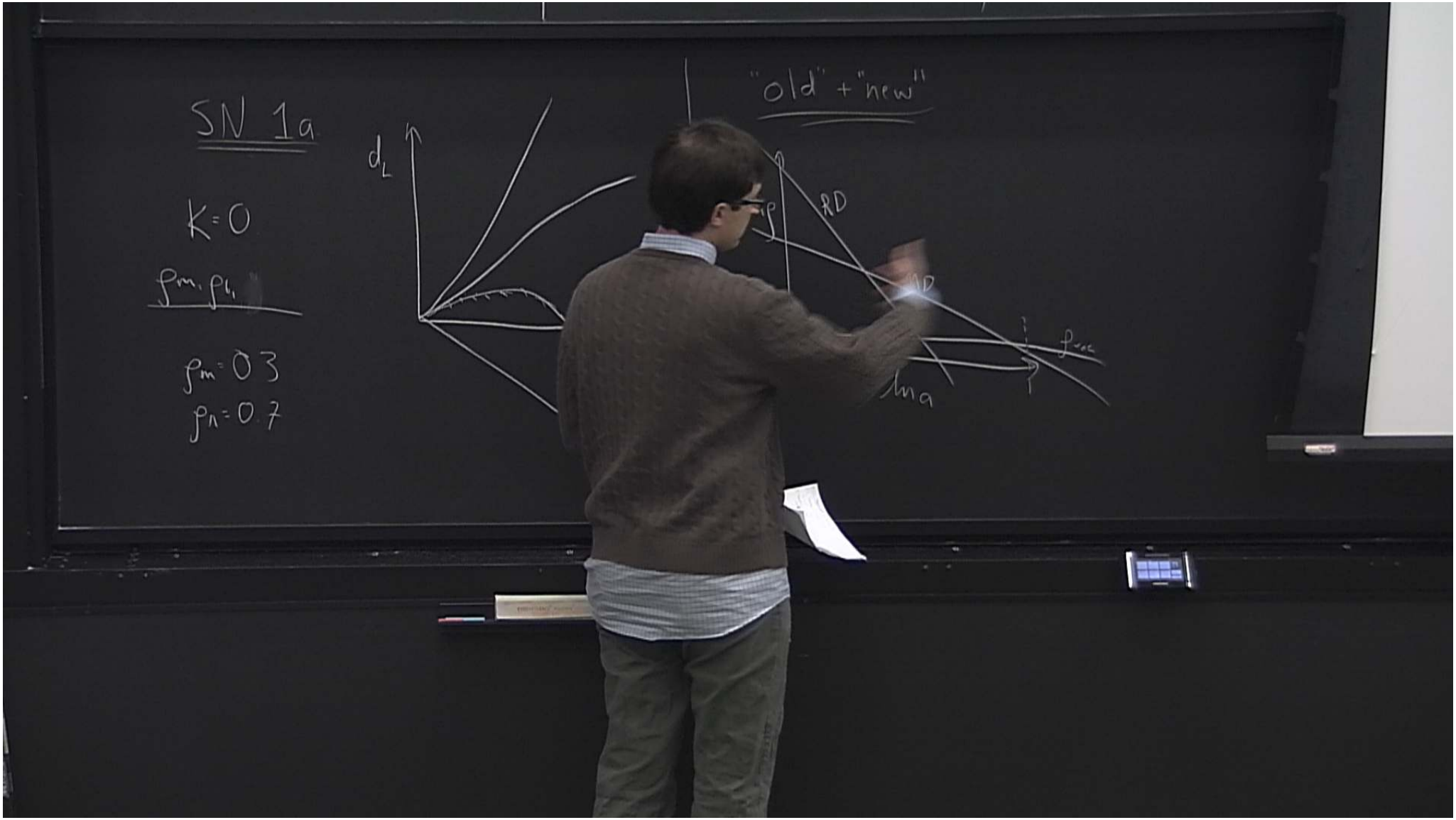

Multipole moment, ℓ
2
10
50
500
1000
1500
2000
2500
Temperature fluctuations [μ K^2]
6000
5000
4000
3000
2000
1000
0
90°
18°
1°
0.2°
0.1°
0.07°
Angular scale

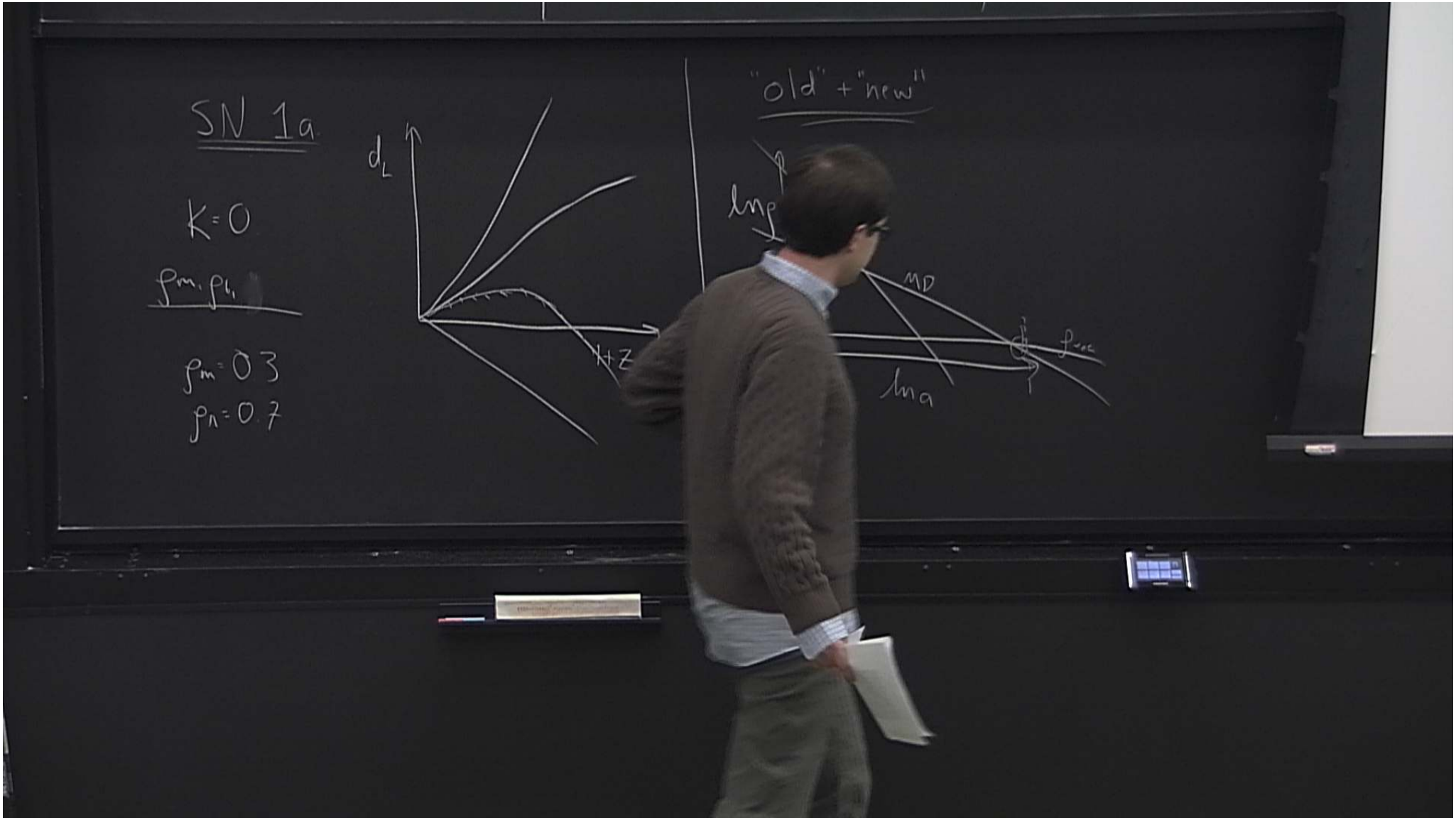

SN 1a
d_L
$1+z = \frac{a_0}{a_{emit}}$

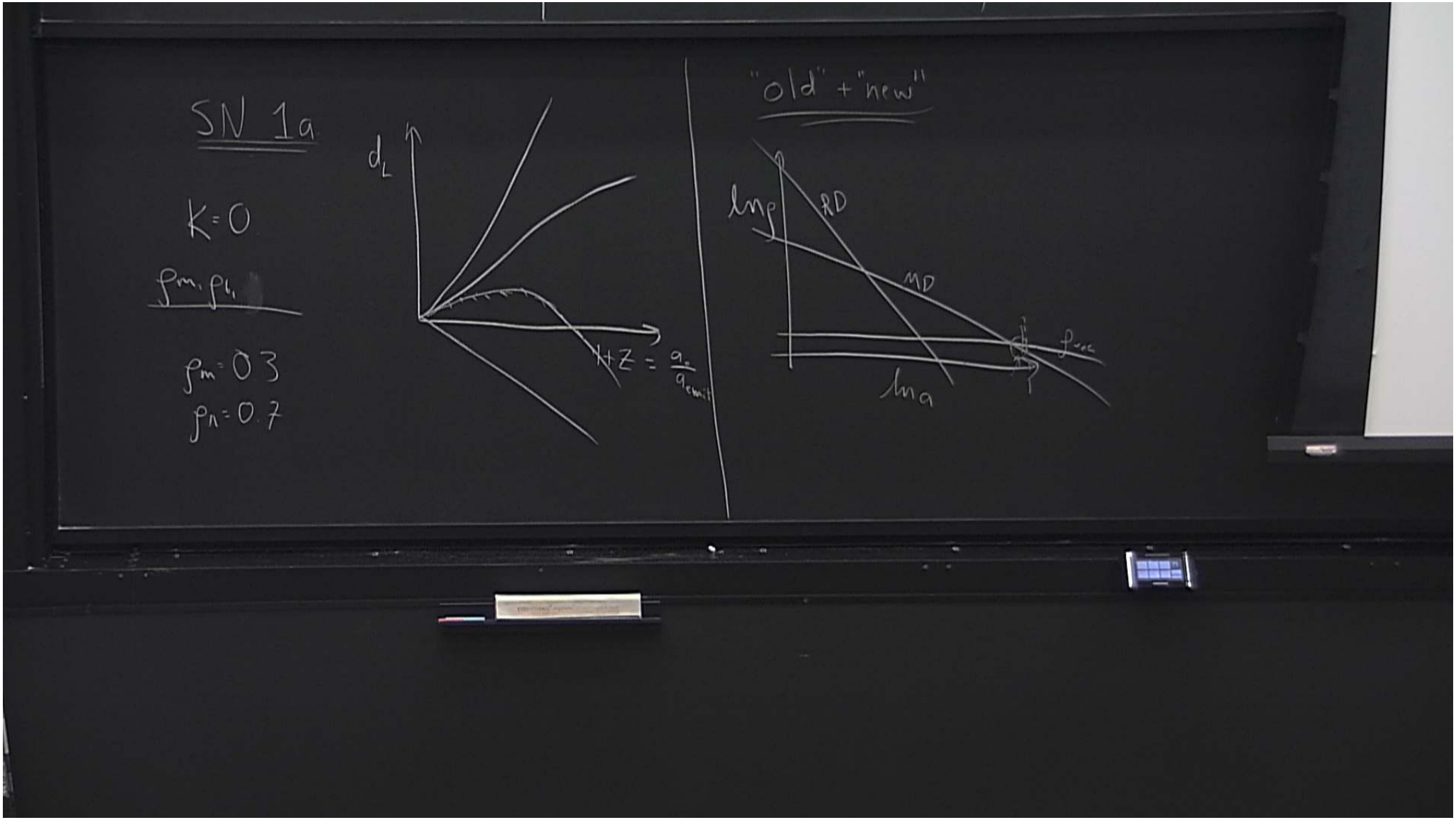

SN 1a
K=0
ρ_m, ρ_Λ
$\rho_m = 0.3$
$\rho_\Lambda = 0.7$
d_L
$1+z = \frac{a_0}{a_{emit}}$
"old"

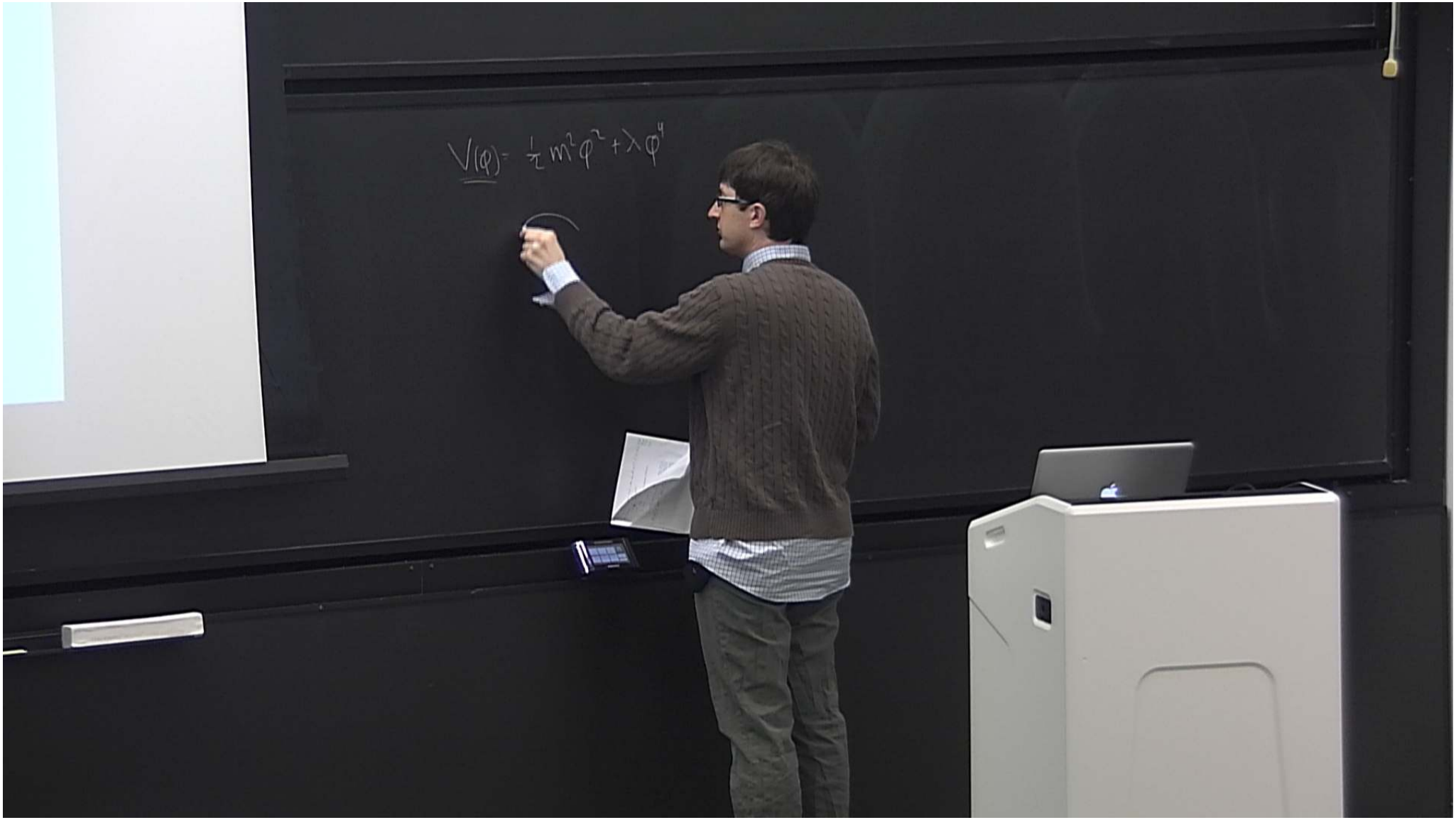
SN 1a
K=0
ρ_m, ρ_Λ
$\rho_m = 0.3$
$\rho_\Lambda = 0.7$
d_L
$1+z = \frac{a_0}{a_{emit}}$
"old" + "new"

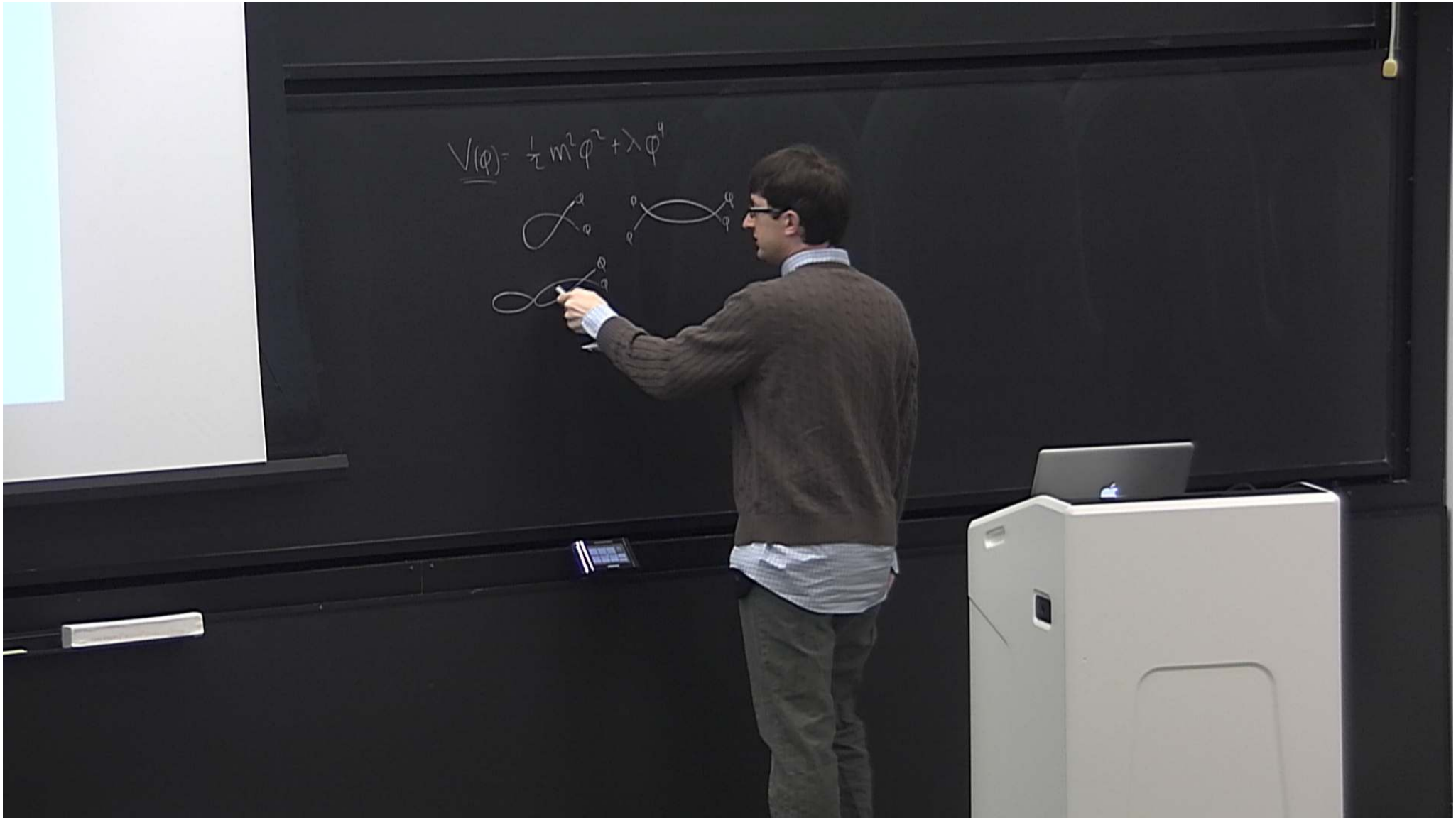

SN 1a
K=0
ρ_m, ρ_Λ
$\rho_m = 0.3$
$\rho_\Lambda = 0.7$
d_L
$1+z = \frac{a_0}{a_{emit}}$
"old" + "new"
$\ln \rho$
RD


SN 1a
K=0
ρm=0.3
ρΛ=0.7
"old" + "new"
RD


SN 1a
K=0
ρ_m, ρ_Λ
$\rho_m = 0.3$
$\rho_\Lambda = 0.7$
d_L
1+z
"old" + "new"
ln ρ
MD
ln a


SN 1a
K=0
ρ_m, ρ_Λ
$\rho_m = 0.3$
$\rho_\Lambda = 0.7$
d_L
$1+z = \frac{a_0}{a_{emit}}$
"old" + "new"
$\ln\rho$
RD
MD
ρ_{acc}
$\ln a$


V(φ) = ½ m²φ² + λφ⁴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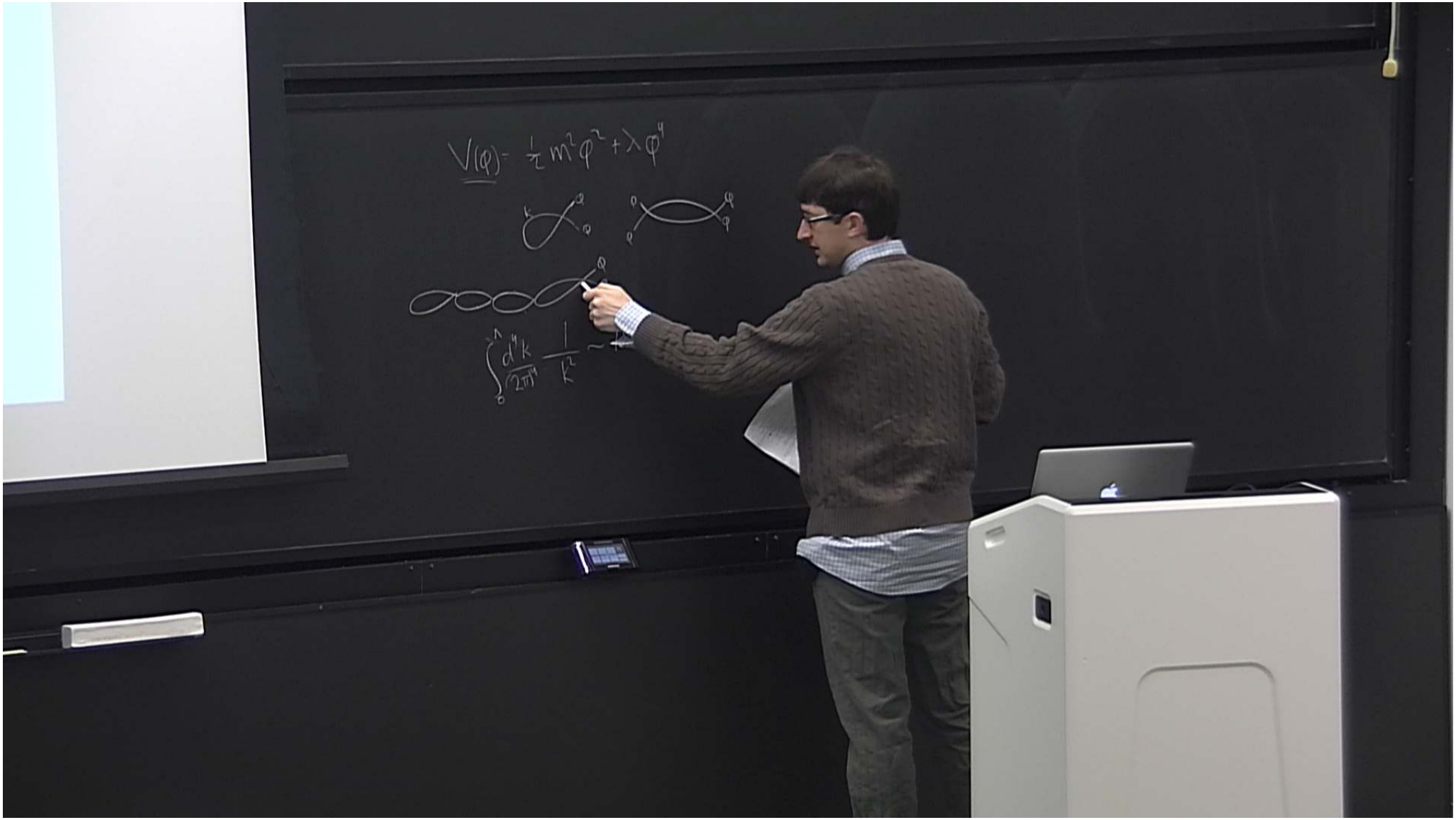
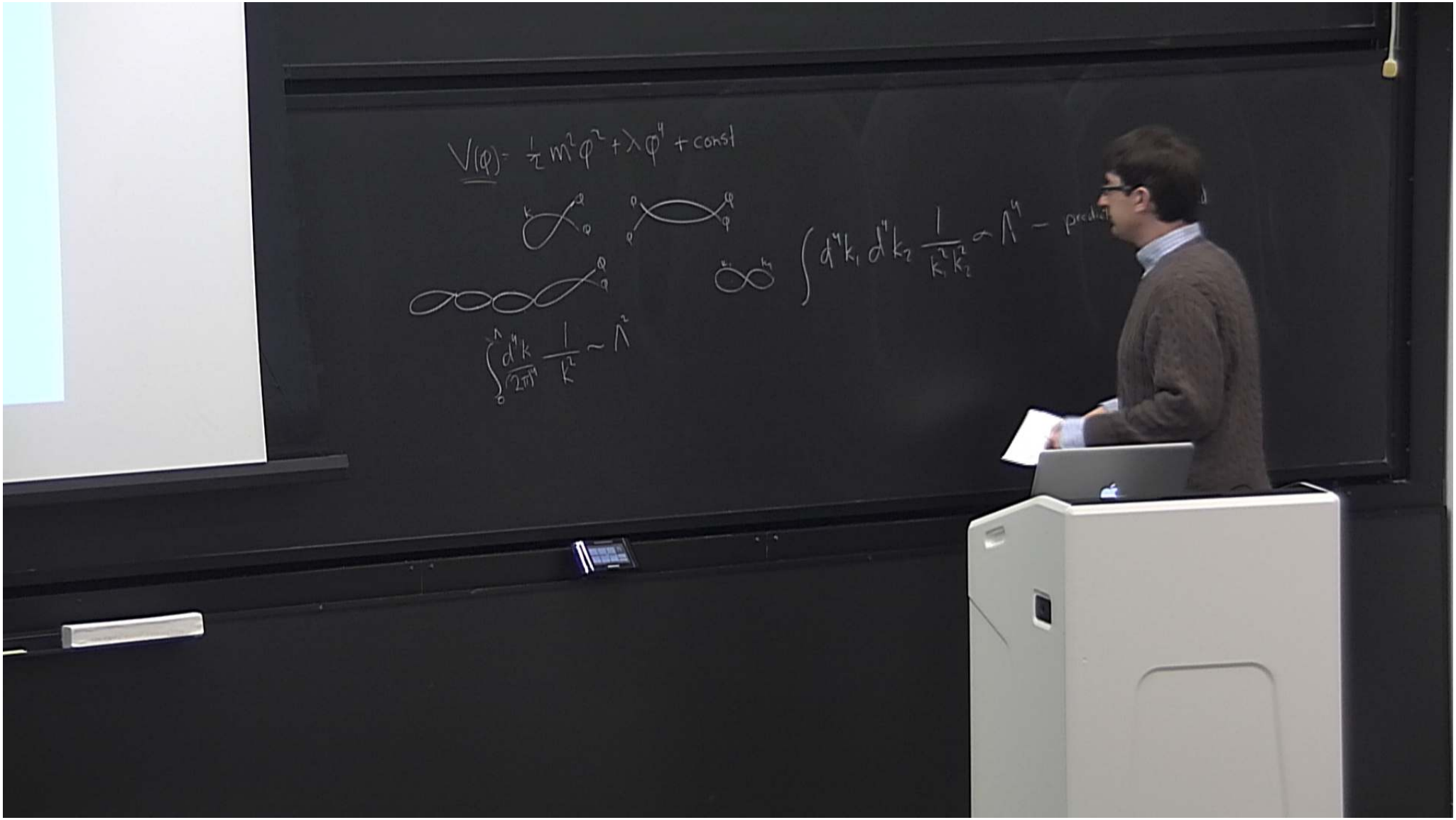
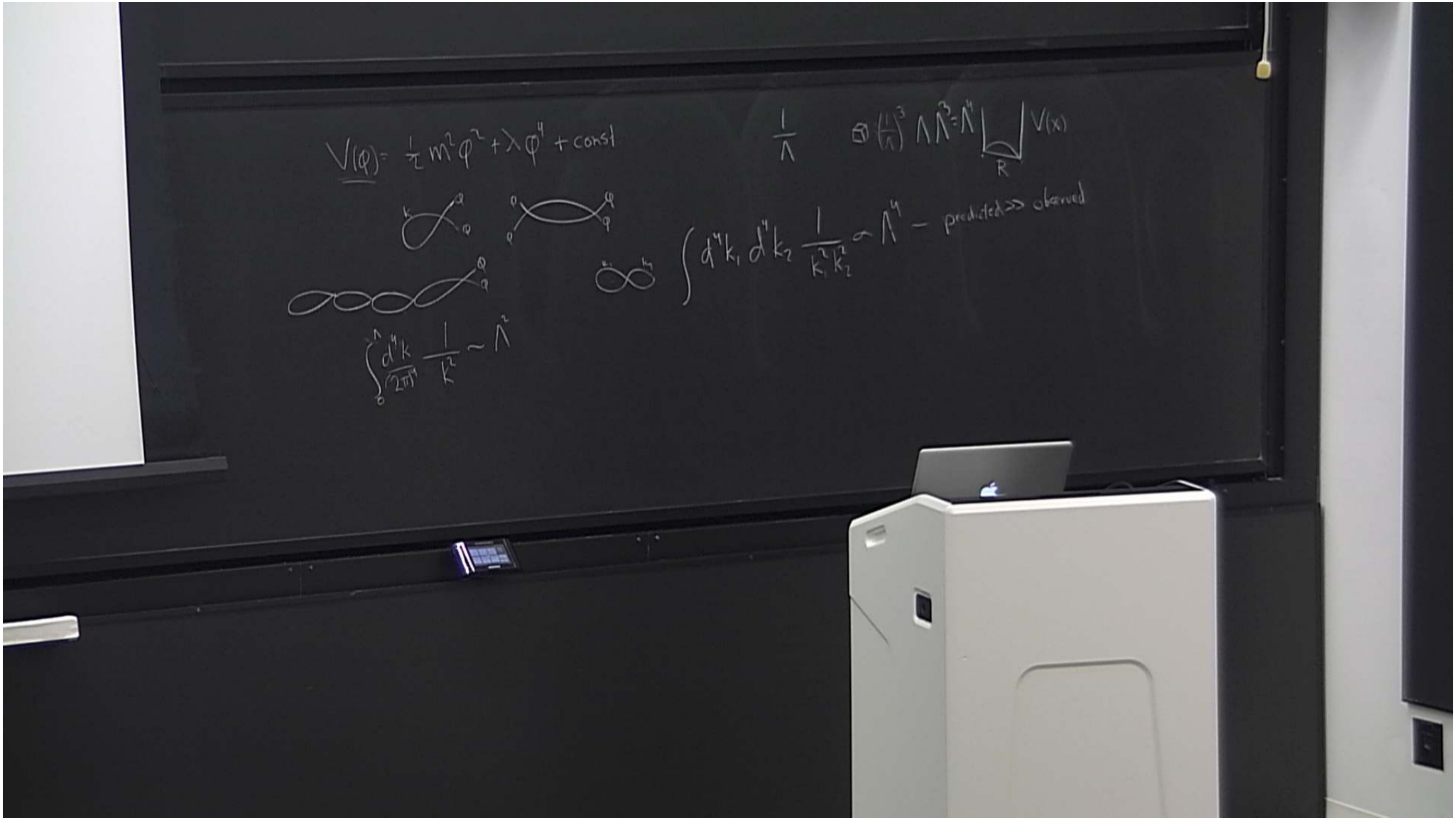
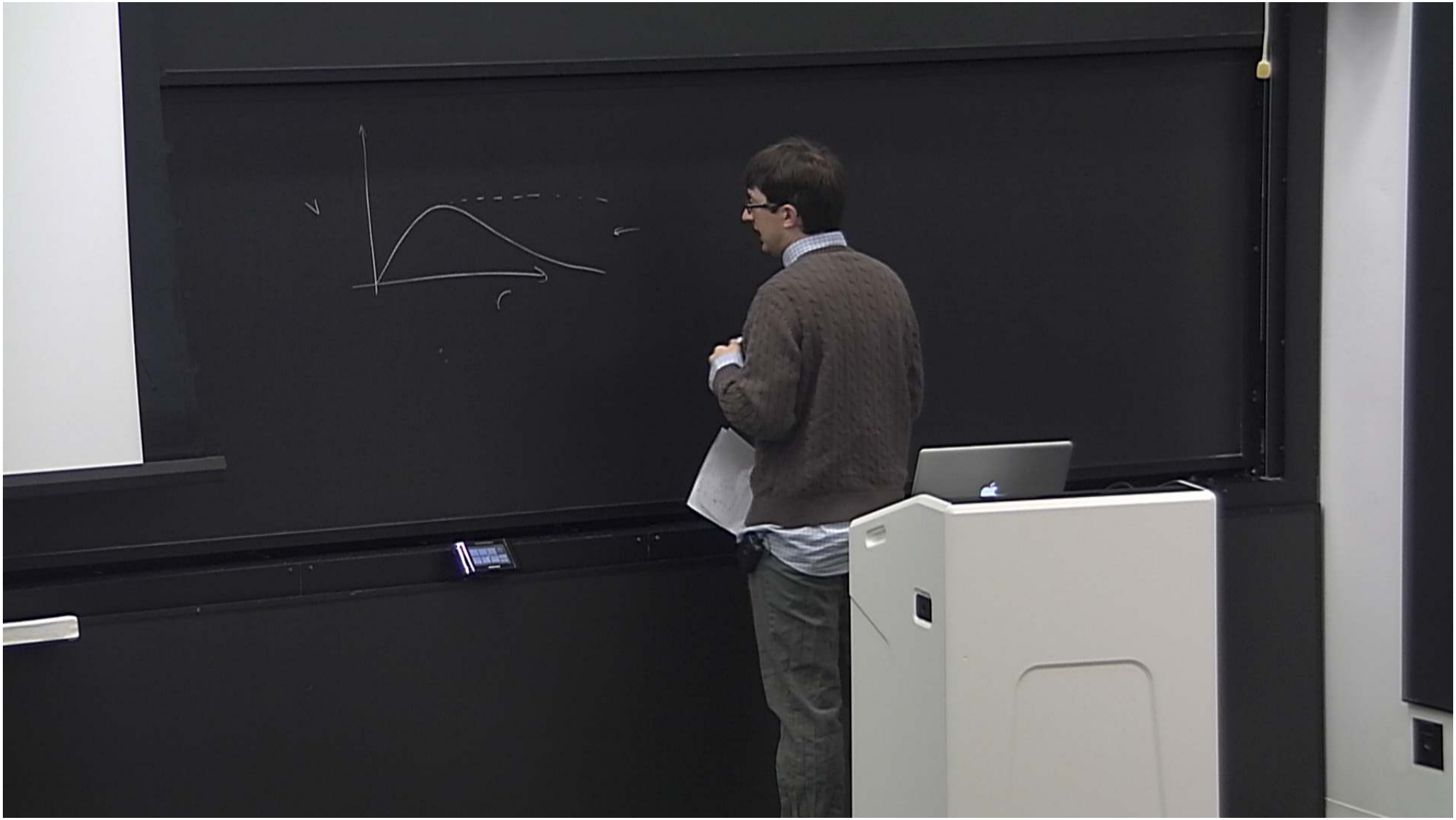
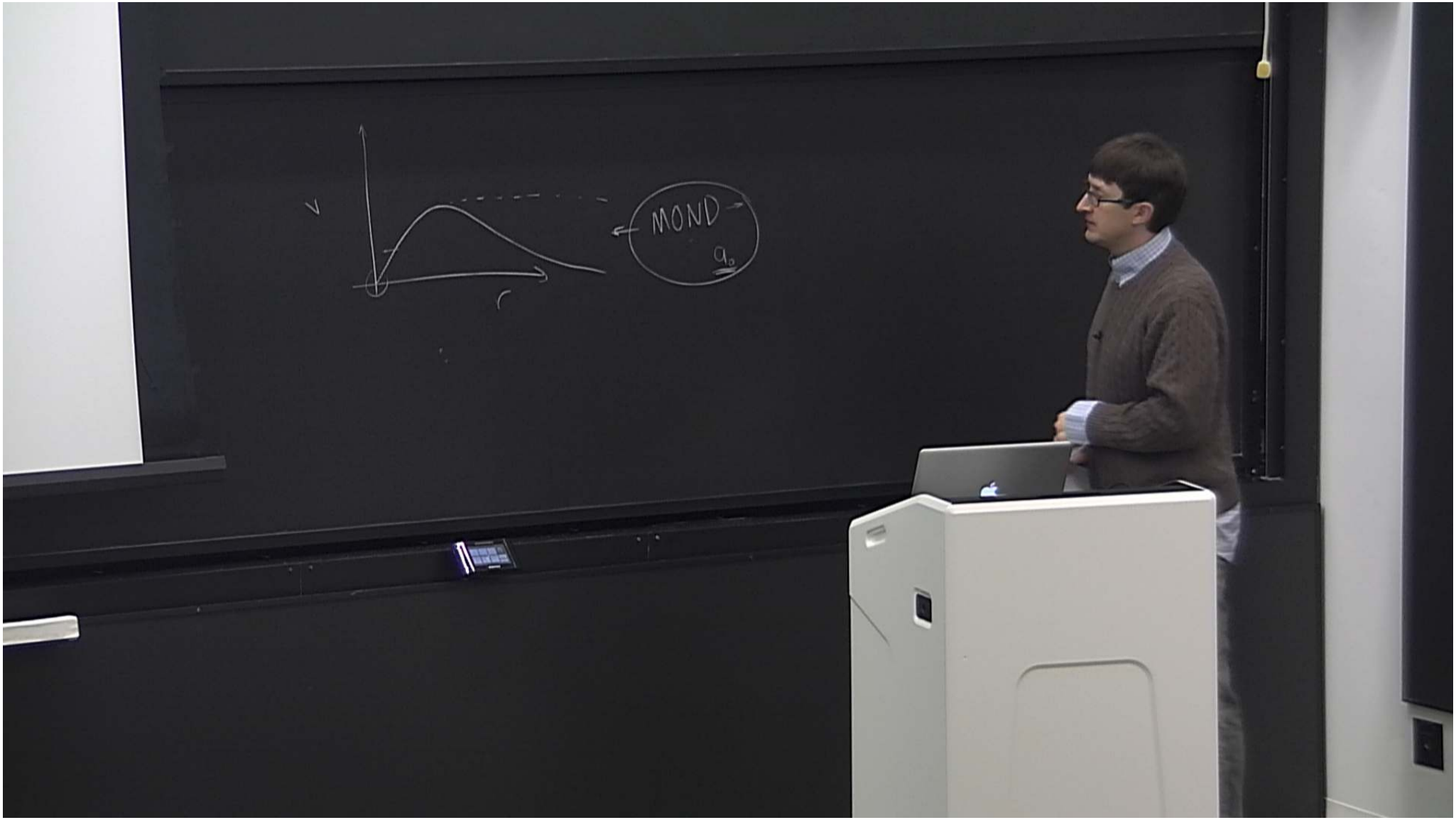
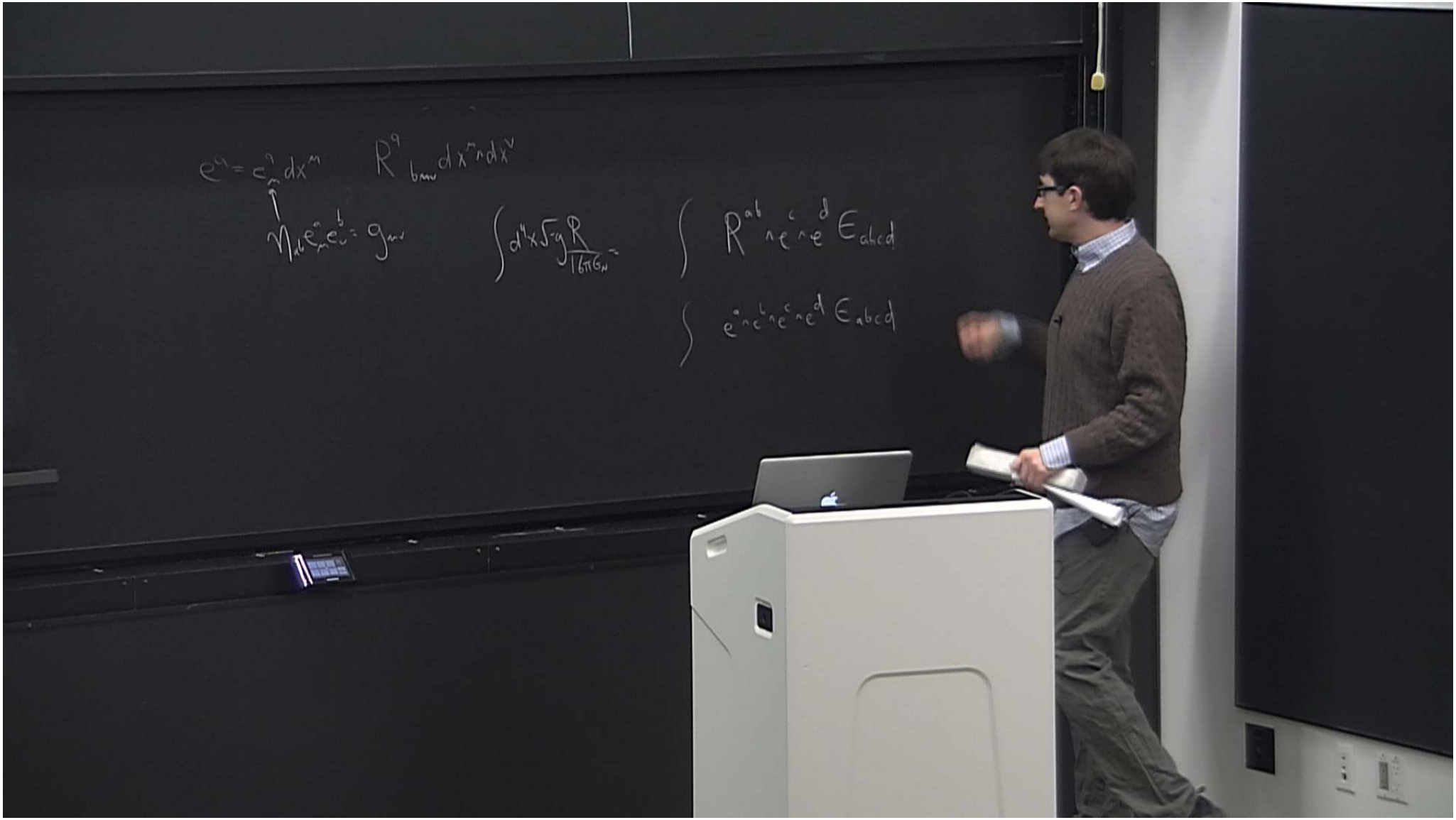

V(φ) = ½ m²φ² + λφ⁴
∫ d⁴k / (2π)⁴ 1/k² ~

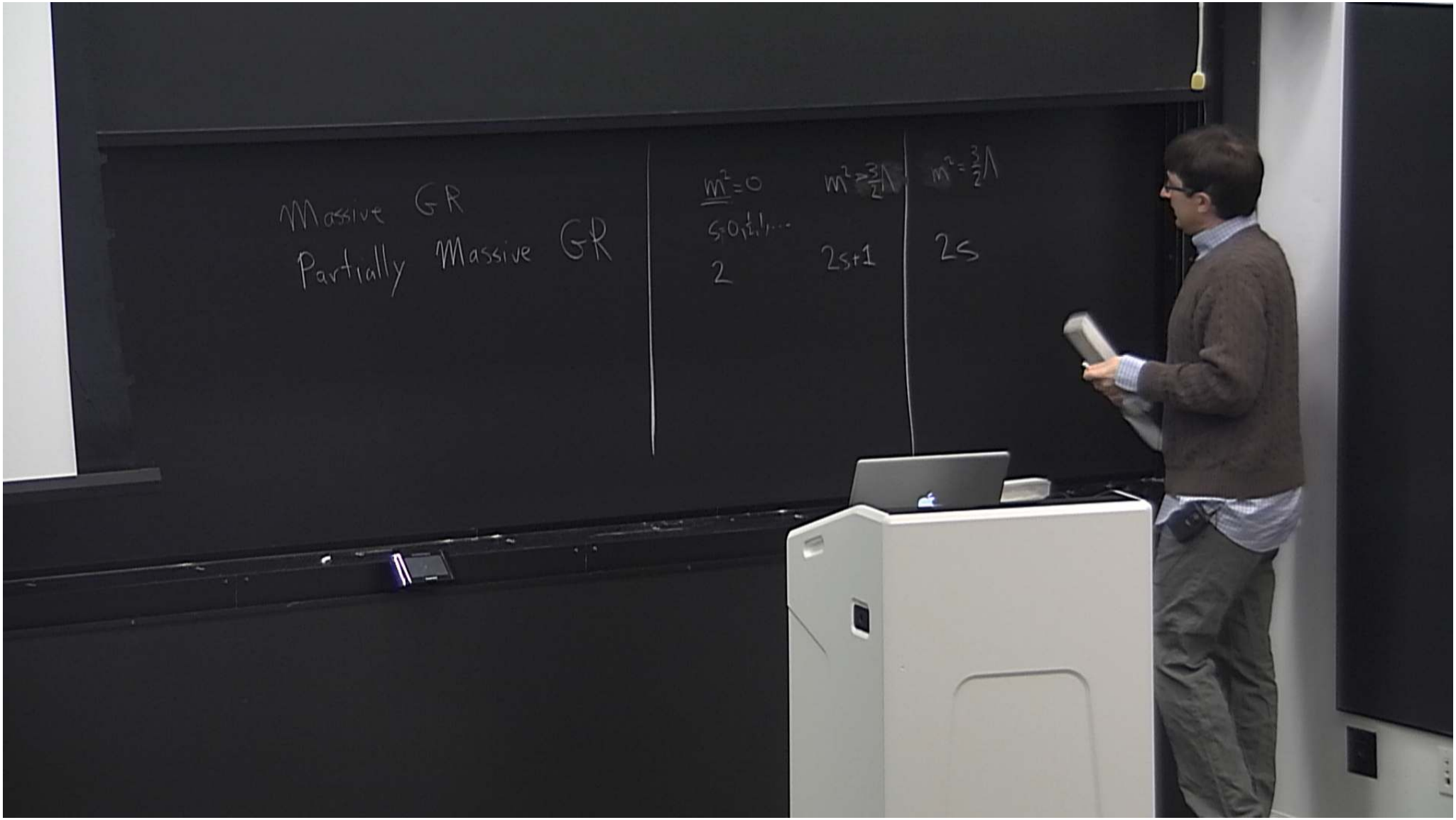

V(φ) = ½ m²φ² + λφ⁴ + const
∫ d⁴k₁ d⁴k₂ 1/(k₁²k₂²) ~ Λ⁴ –
∫₀^Λ d⁴k/(2π)⁴ 1/k² ~ Λ²

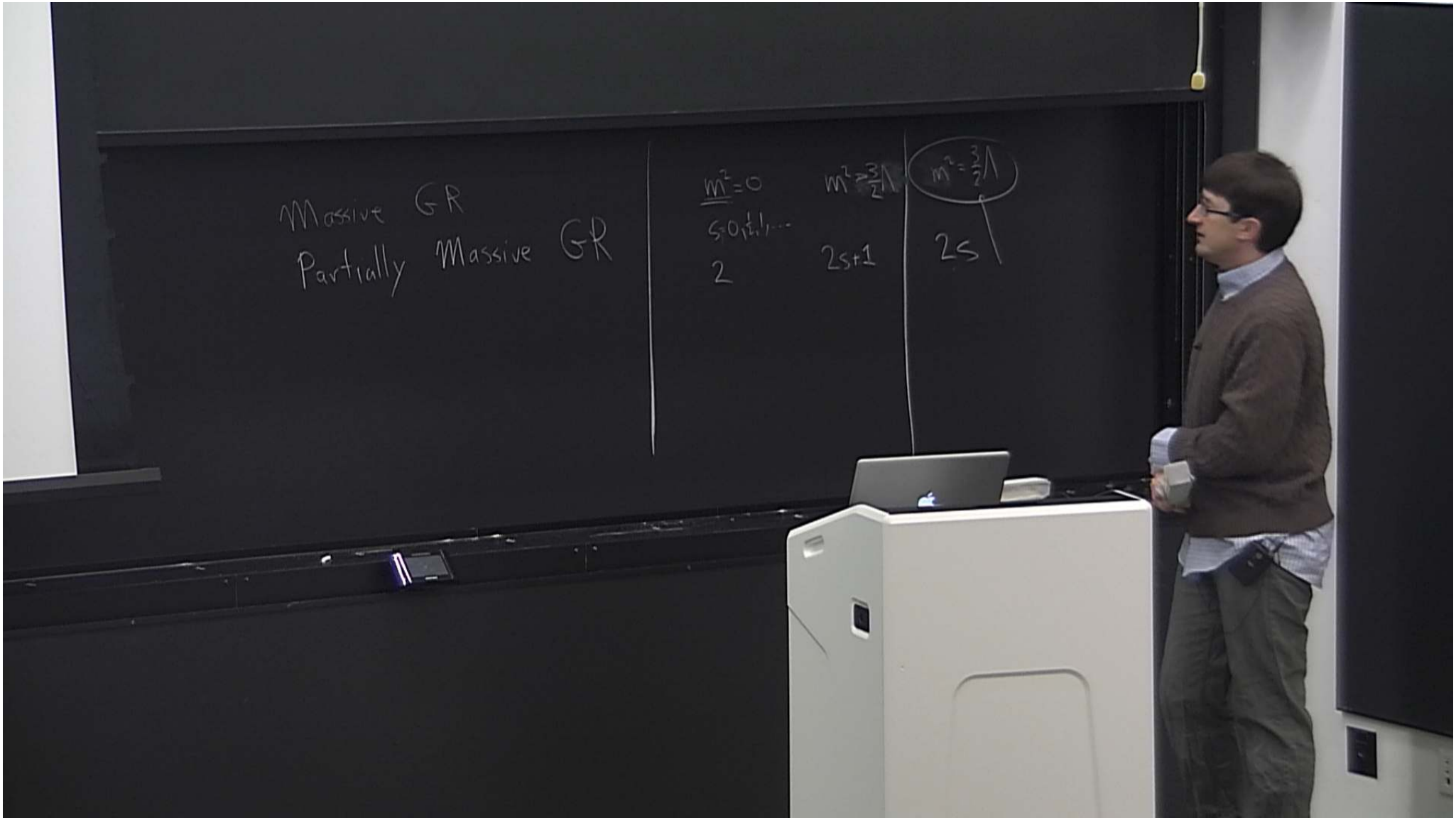

V(φ) = ½ m²φ² + λφ⁴ + const
1/Λ
(1/Λ)³ Λ Λ² = Λ⁴
R
V(x)
∫ d⁴k₁ d⁴k₂ 1/(k₁²k₂²) ~ Λ⁴ – predicted >> observed
∫₀^Λ d⁴k/(2π)⁴ 1/k² ~ Λ²




v
r
MOND
a_0


$e^a = e^a_\mu dx^\mu$
$R^{ab}{}_{\mu\nu} dx^\mu \wedge dx^\nu$
$\eta_{ab} e^a_\mu e^b_\nu = g_{\mu\nu}$
$\int d^4x \sqrt{-g} \frac{R}{16\pi G_N} =$
$\int R^{ab} \wedge e^c \wedge e^d \epsilon_{abcd}$
$\int e^a \wedge e^b \wedge e^c \wedge e^d \epsilon_{abcd}$


Massive GR
Partially Massive GR
$m^2=0$
$m^2>\frac{3}{2}\Lambda$
$m^2=\frac{3}{2}\Lambda$
$s=0,\frac{1}{2},1,\ldots$
2
$2s+1$
$2s$


Massive GR
Partially Massive GR
$m^2=0$
$s=0,\frac{1}{2},1,\ldots$
2
$m^2=\frac{3}{2}1$
$2s+1$
$m^2=\frac{3}{2}1$
$2s$