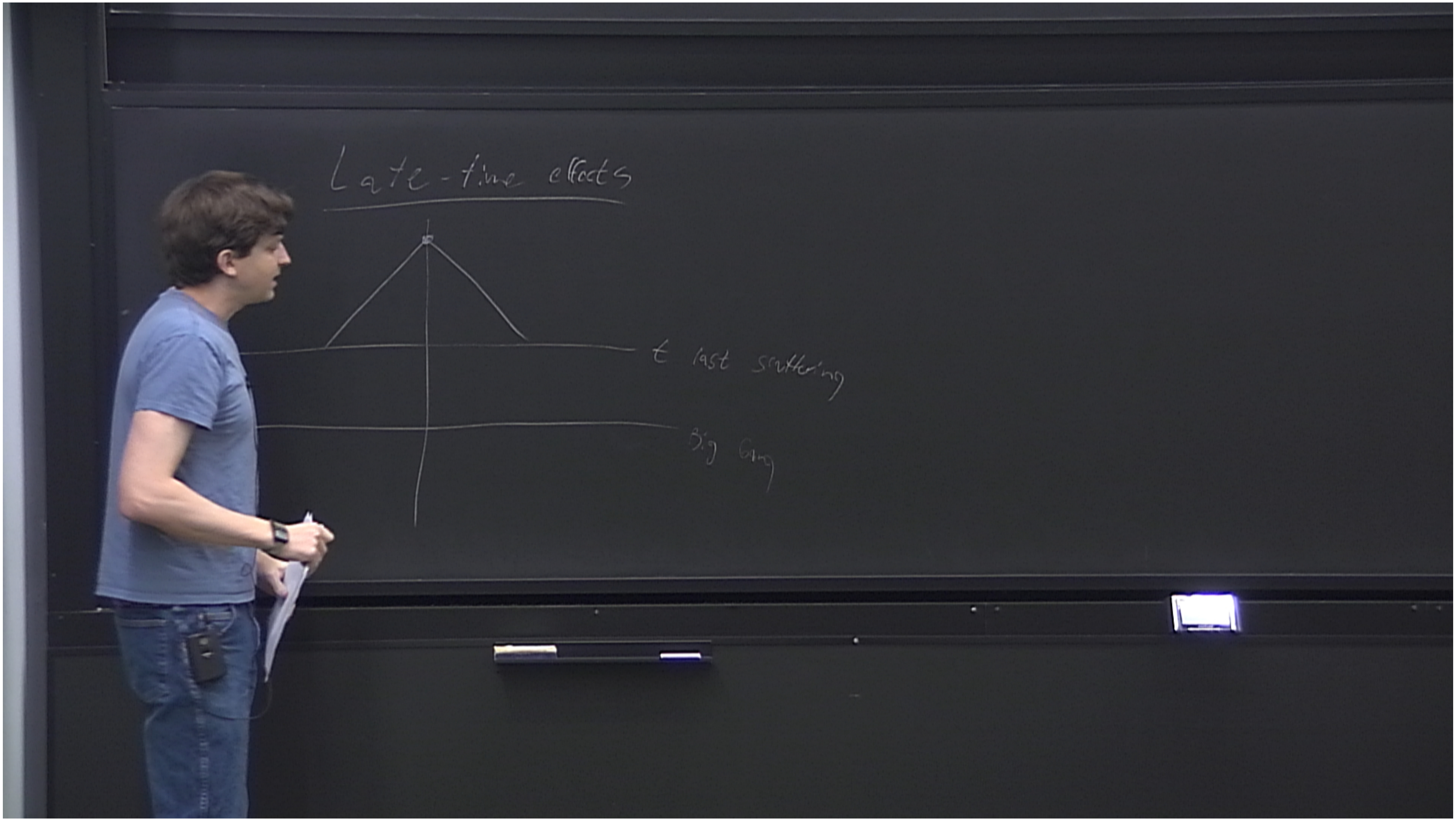
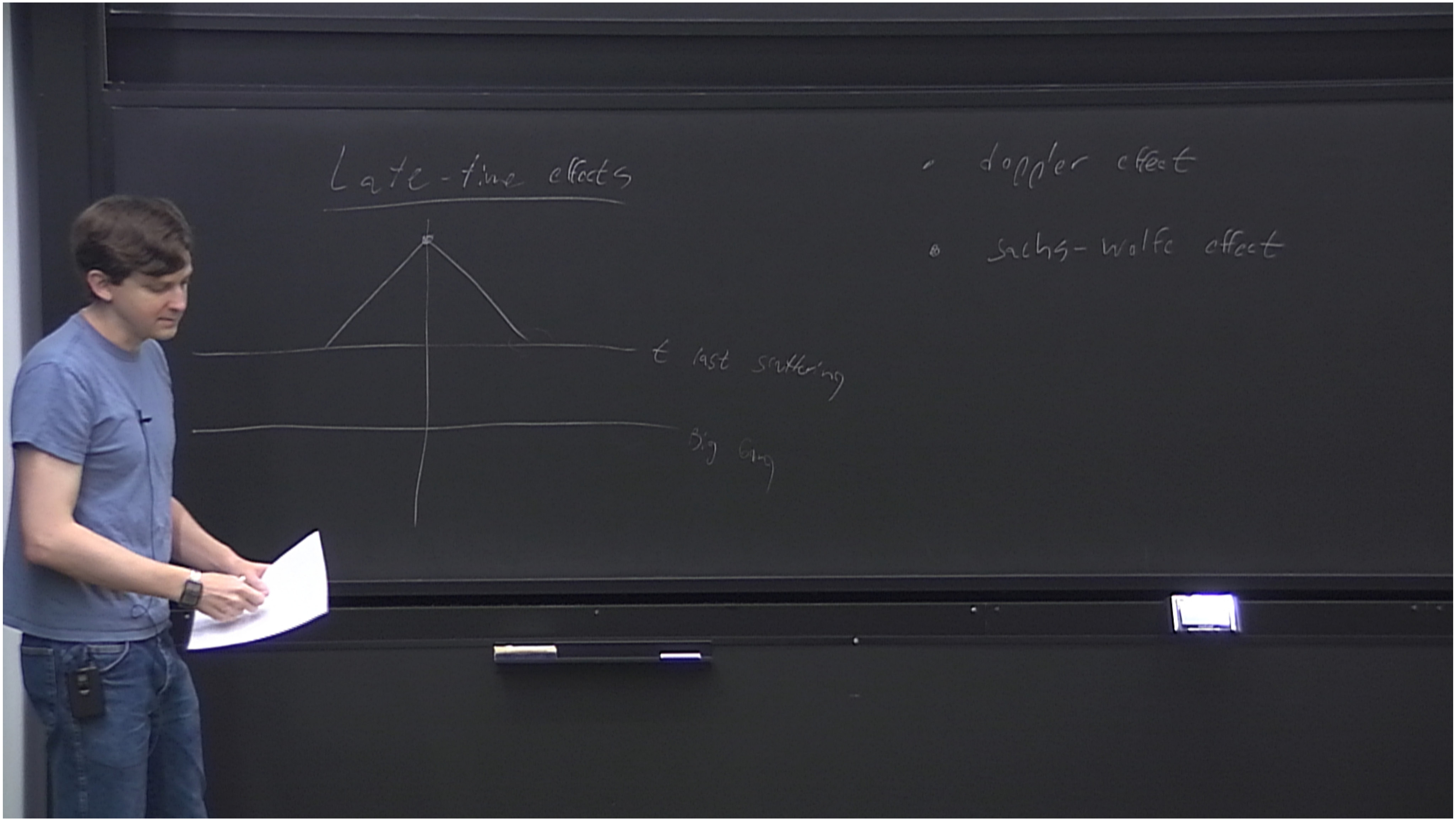
Title: Cosmology Review-15

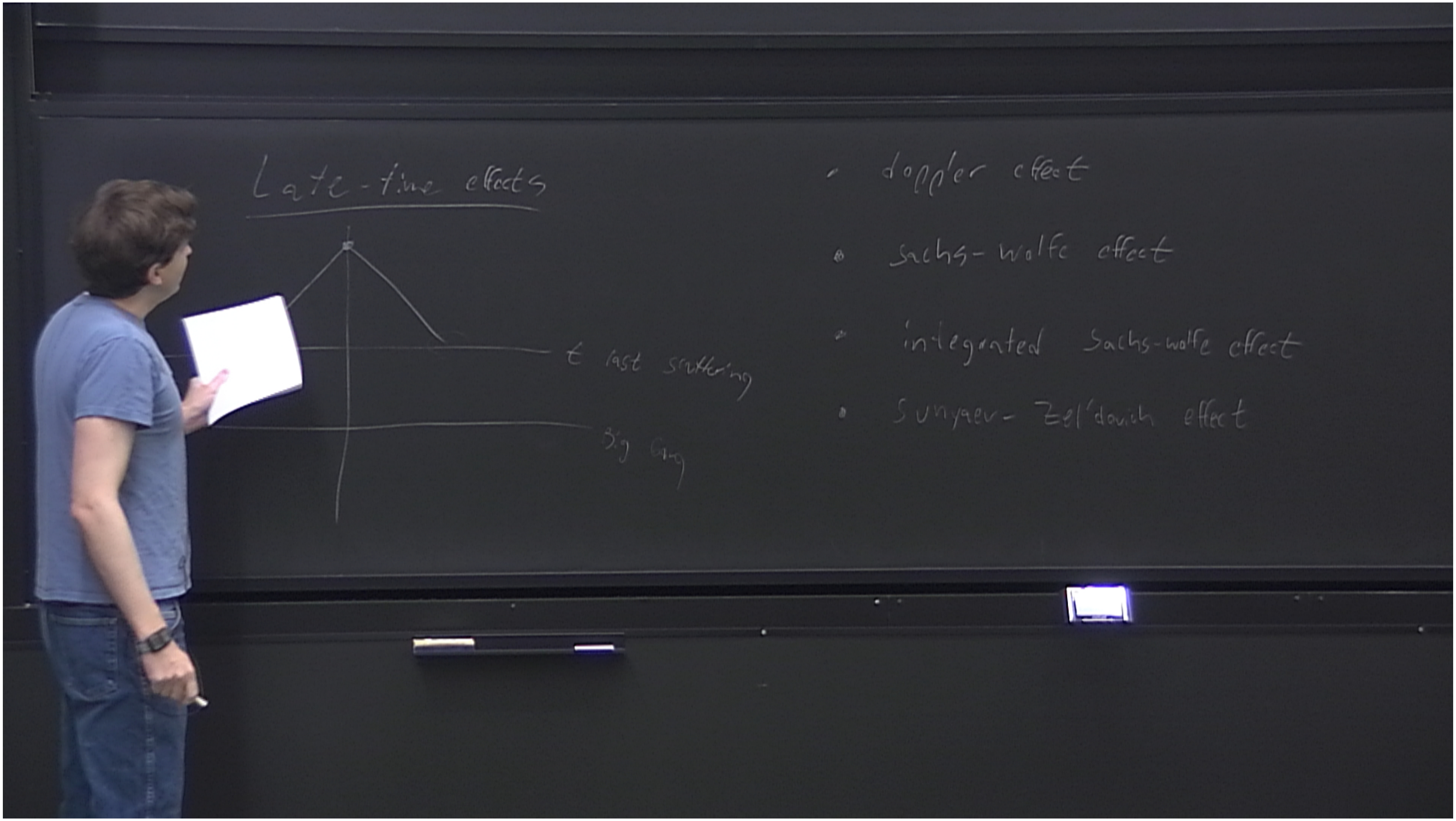
Date: Feb 13, 2015 11:30 AM

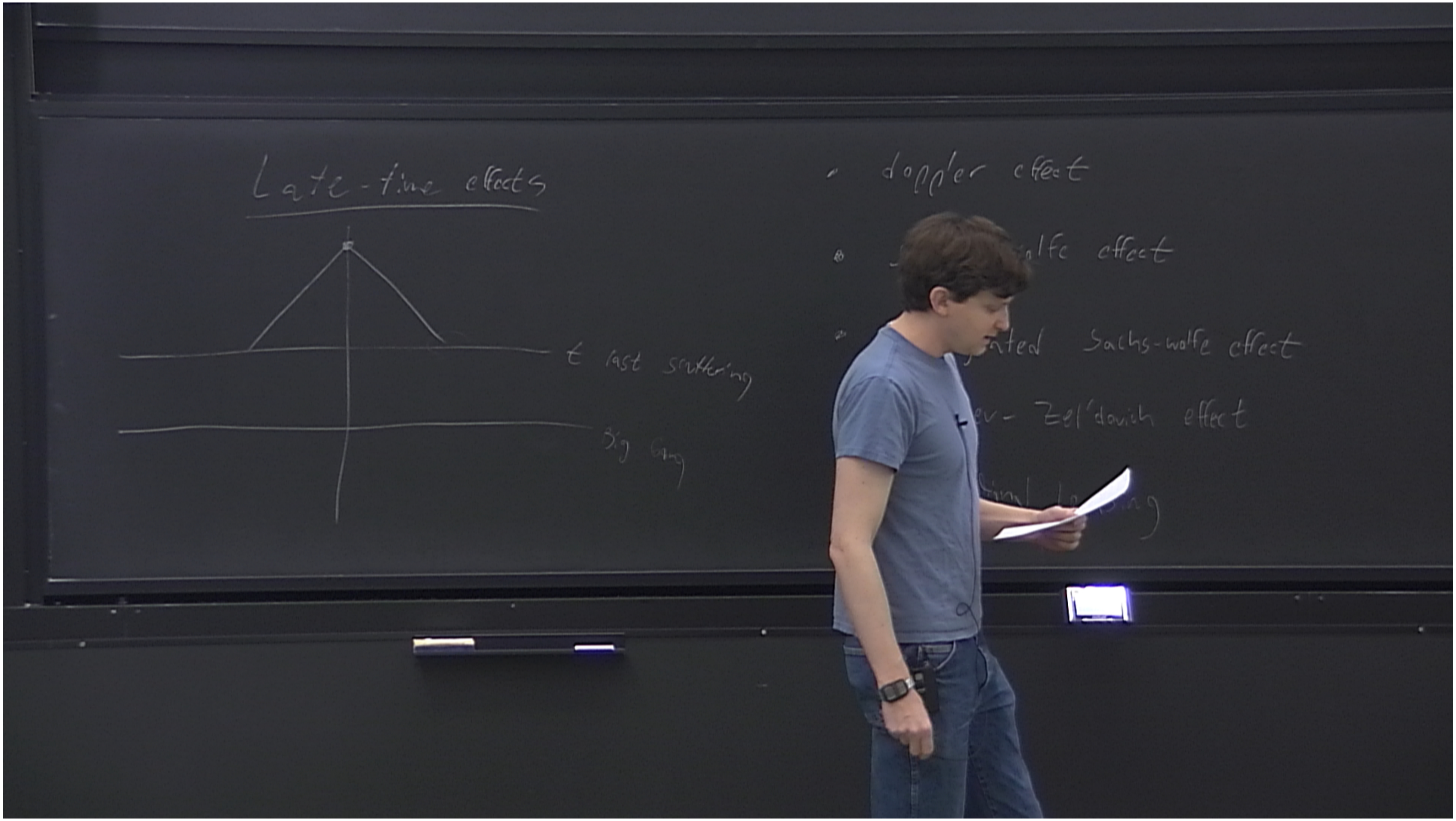
URL: http://pirsa.org/15020038

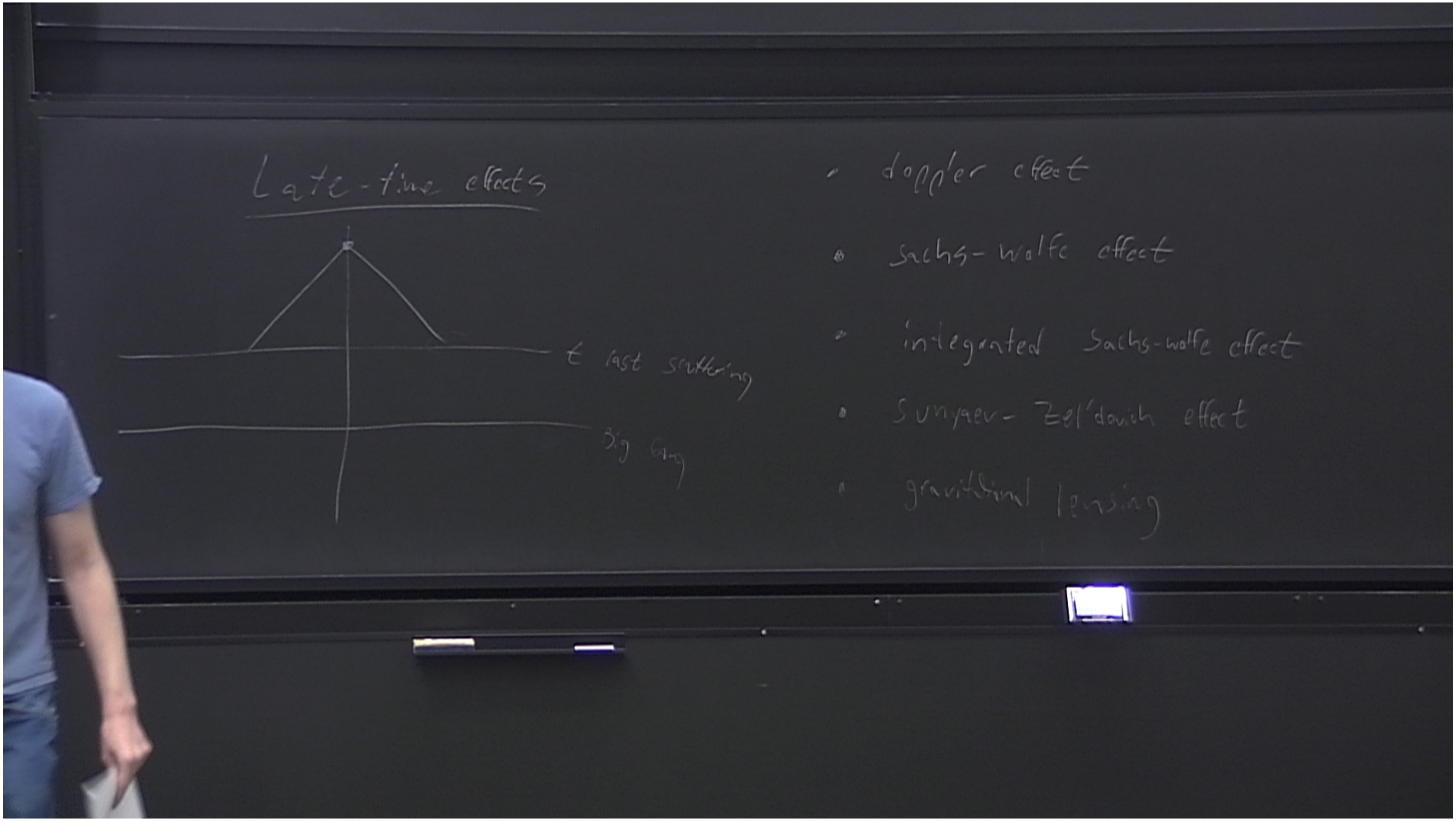
Abstract:

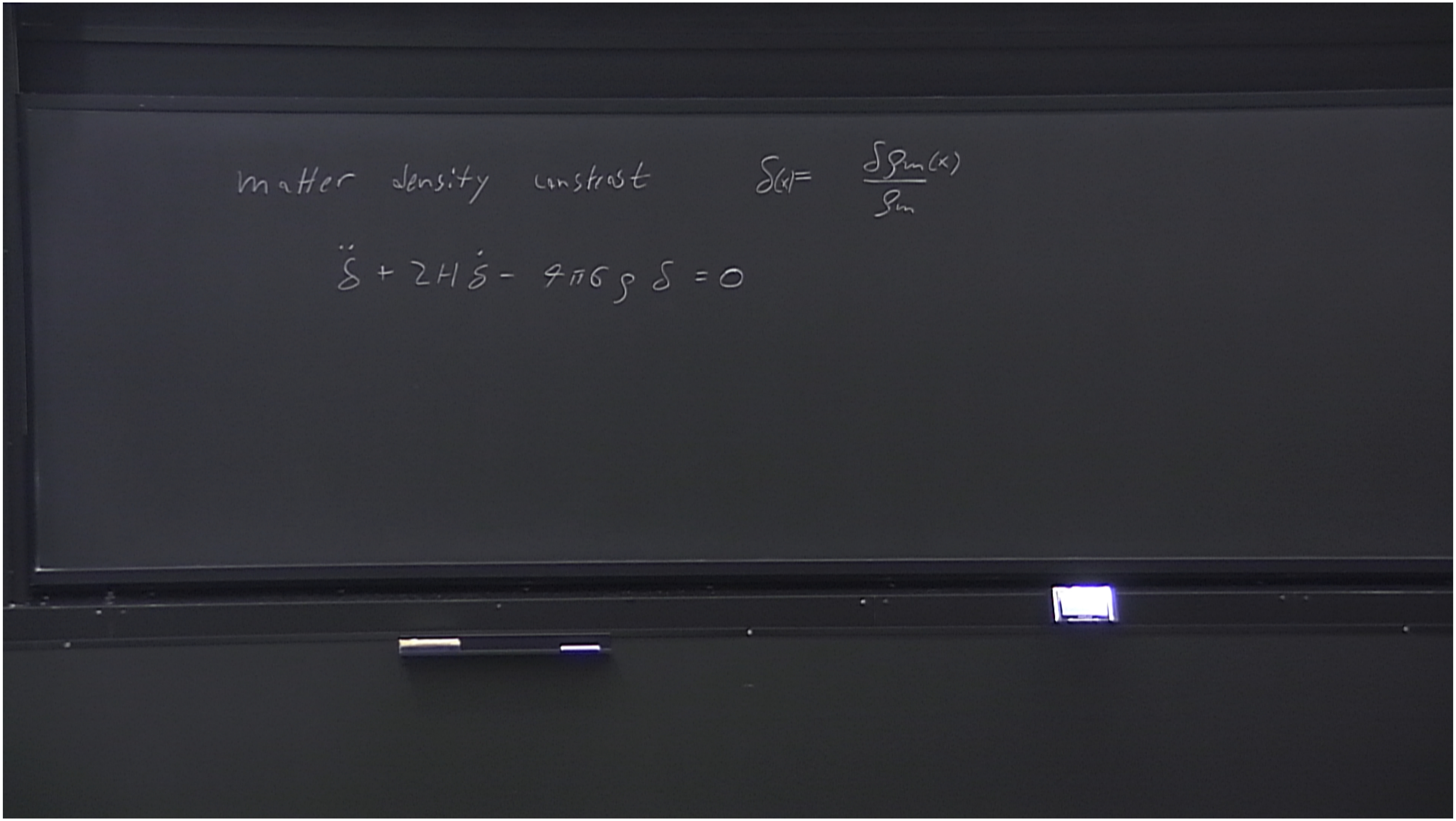

Late-time effects
t last scattering
Big Bang

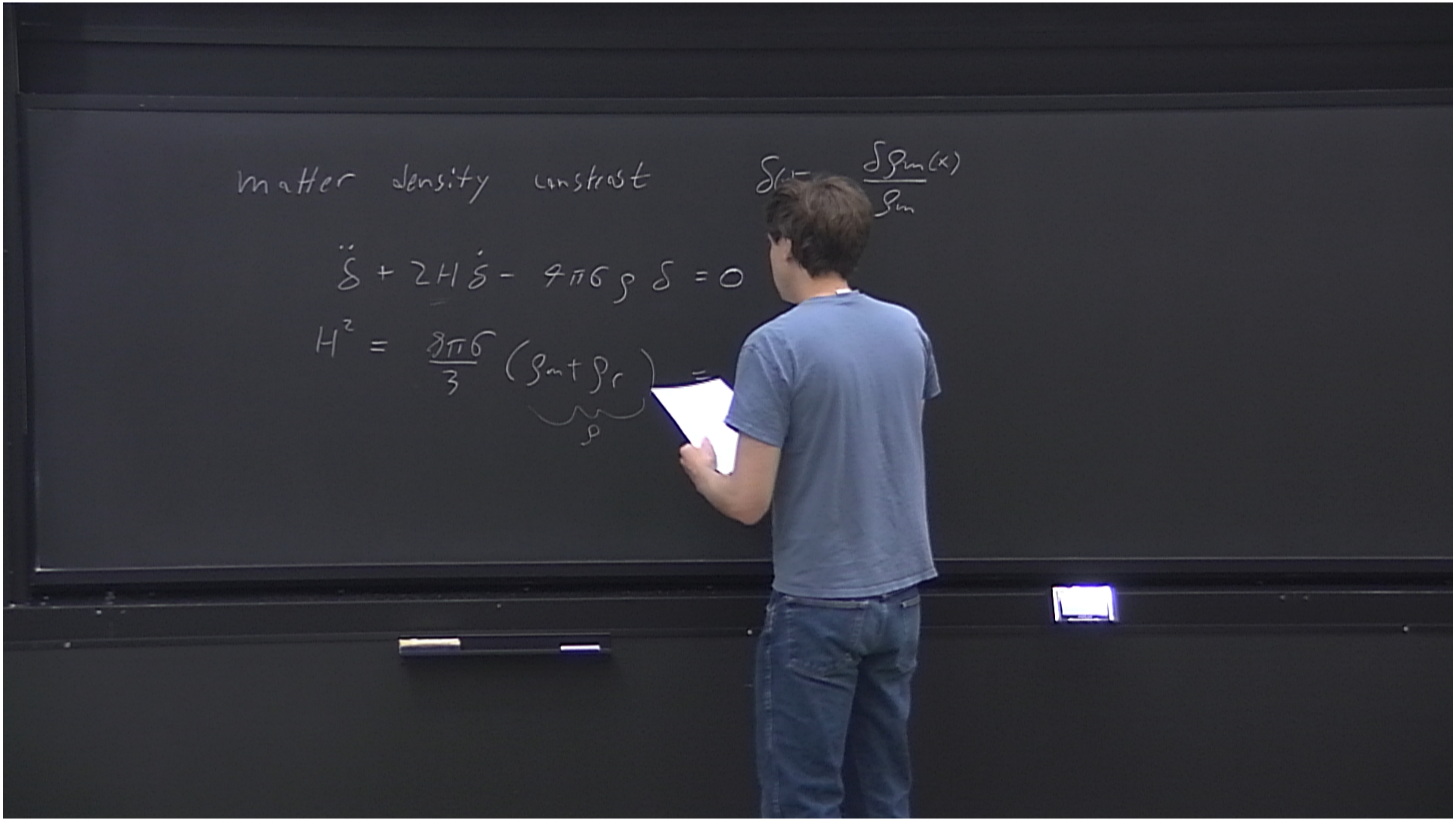

Late-time effects
t last scattering
Big Bang
• doppler effect
• sachs-wolfe effect

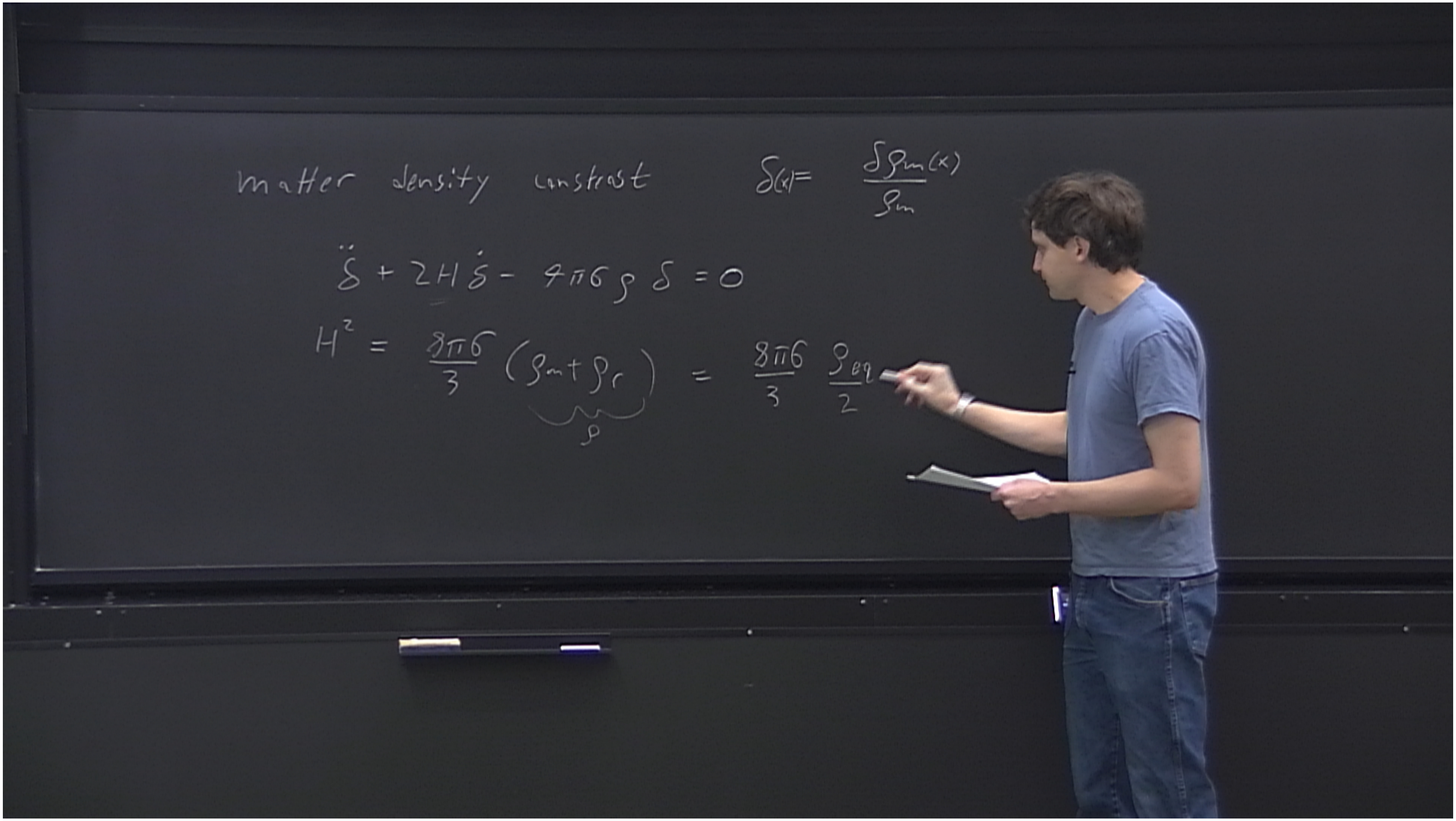

Late-time effects
t last scattering
big bang
doppler effect
sachs-wolfe effect
integrated sachs-wolfe effect
Sunyaev-Zel'dovich effect

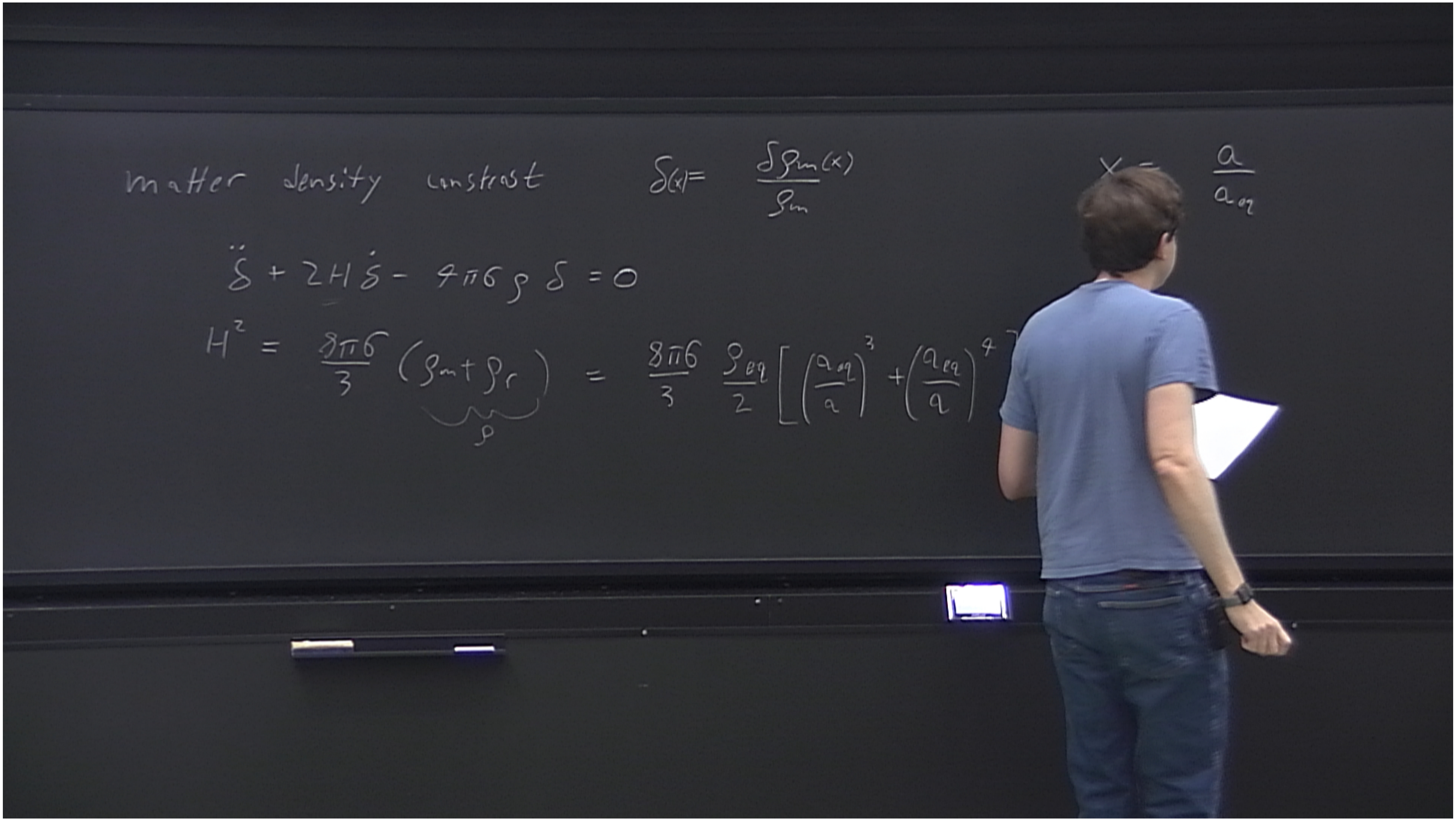

Late-time effects
t last scattering
big bang
doppler effect
effect
Sachs-wolfe effect
Zel'dovich effect

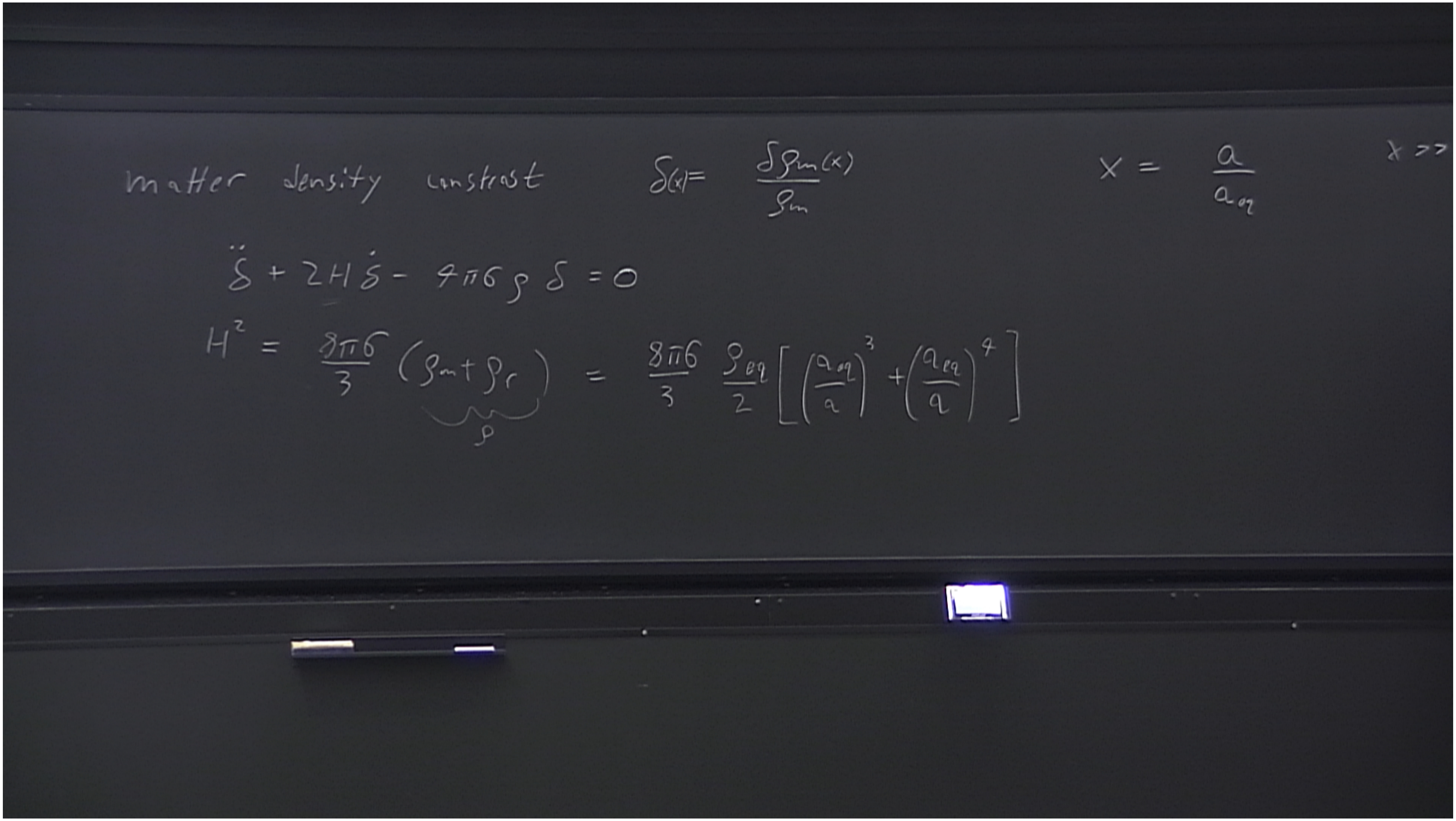

Late-time effects
t last scattering
Big Bang
• doppler effect
• Sachs-Wolfe effect
• integrated Sachs-Wolfe effect
• Sunyaev-Zel'dovich effect
• gravitational lensing

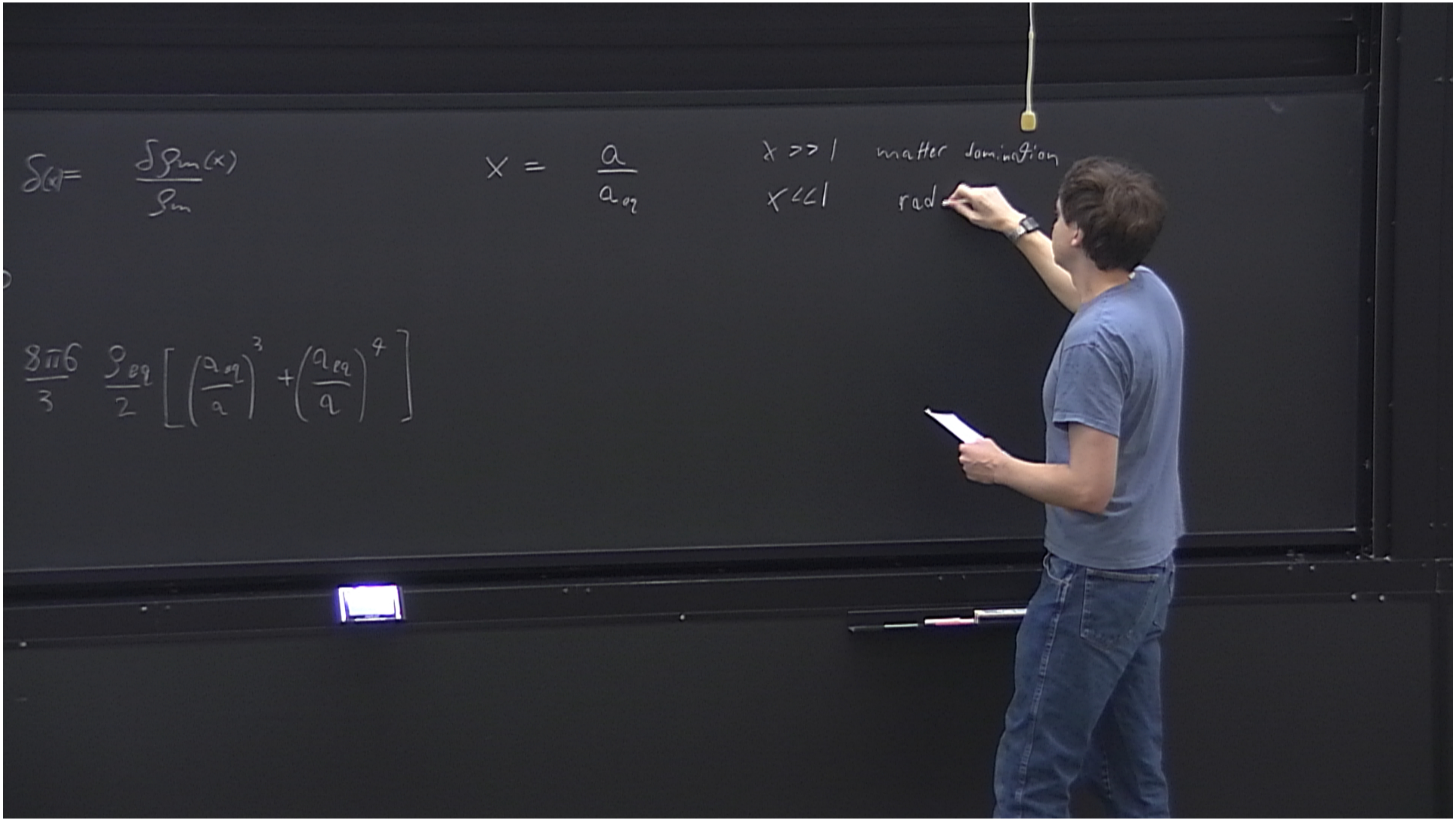

matter density constrast
$\delta(x) = \frac{\delta \rho_m(x)}{\rho_m}$
$\ddot{\delta} + 2H\dot{\delta} - 4\pi G \rho \delta = 0$

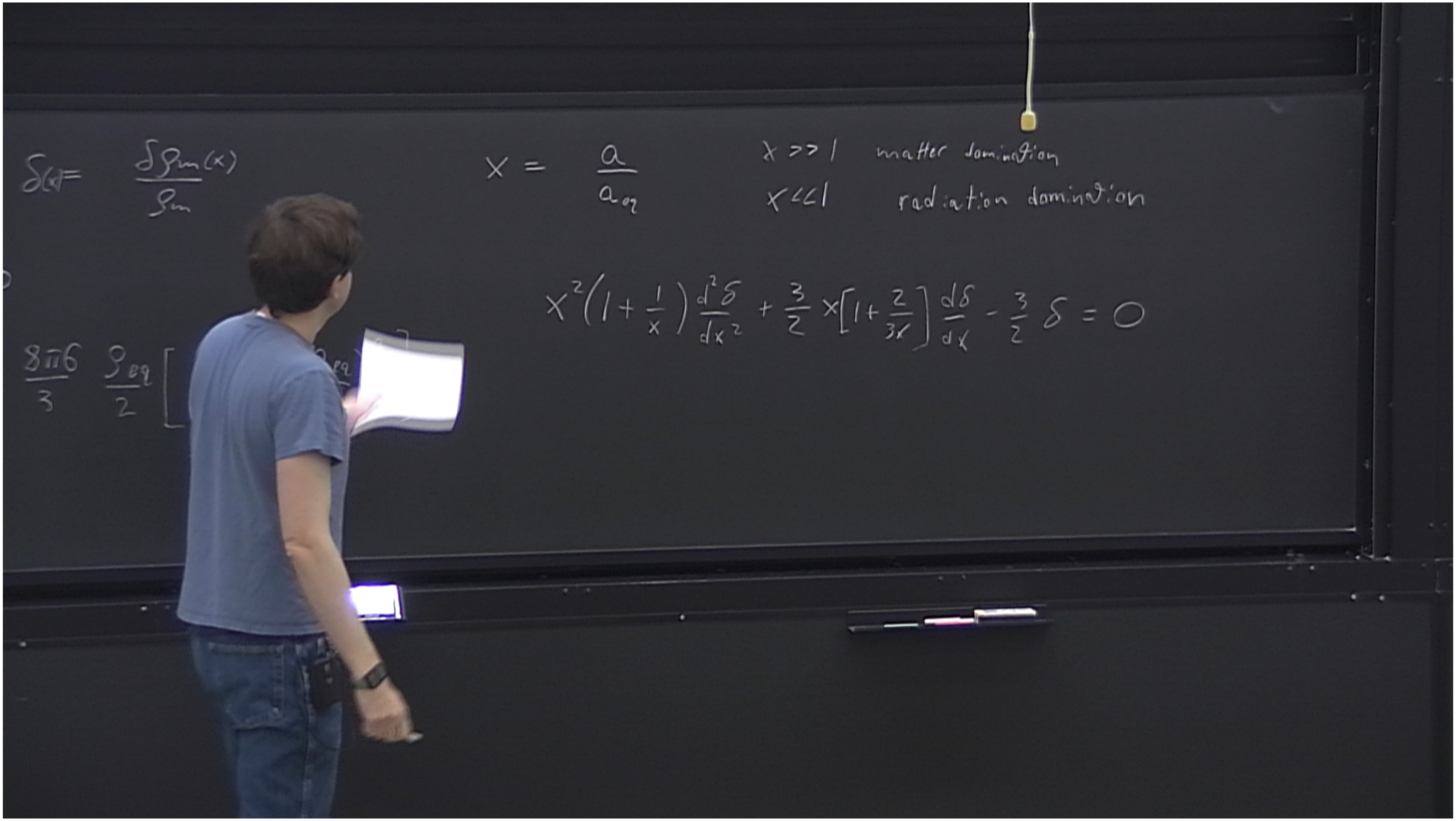

matter density constrast
$\frac{\delta\rho_m(x)}{\rho_m}$
$\ddot{\delta} + 2H\dot{\delta} - 4\pi G\rho\delta = 0$
$H^2 = \frac{8\pi G}{3}(\rho_m + \rho_r)$
ρ

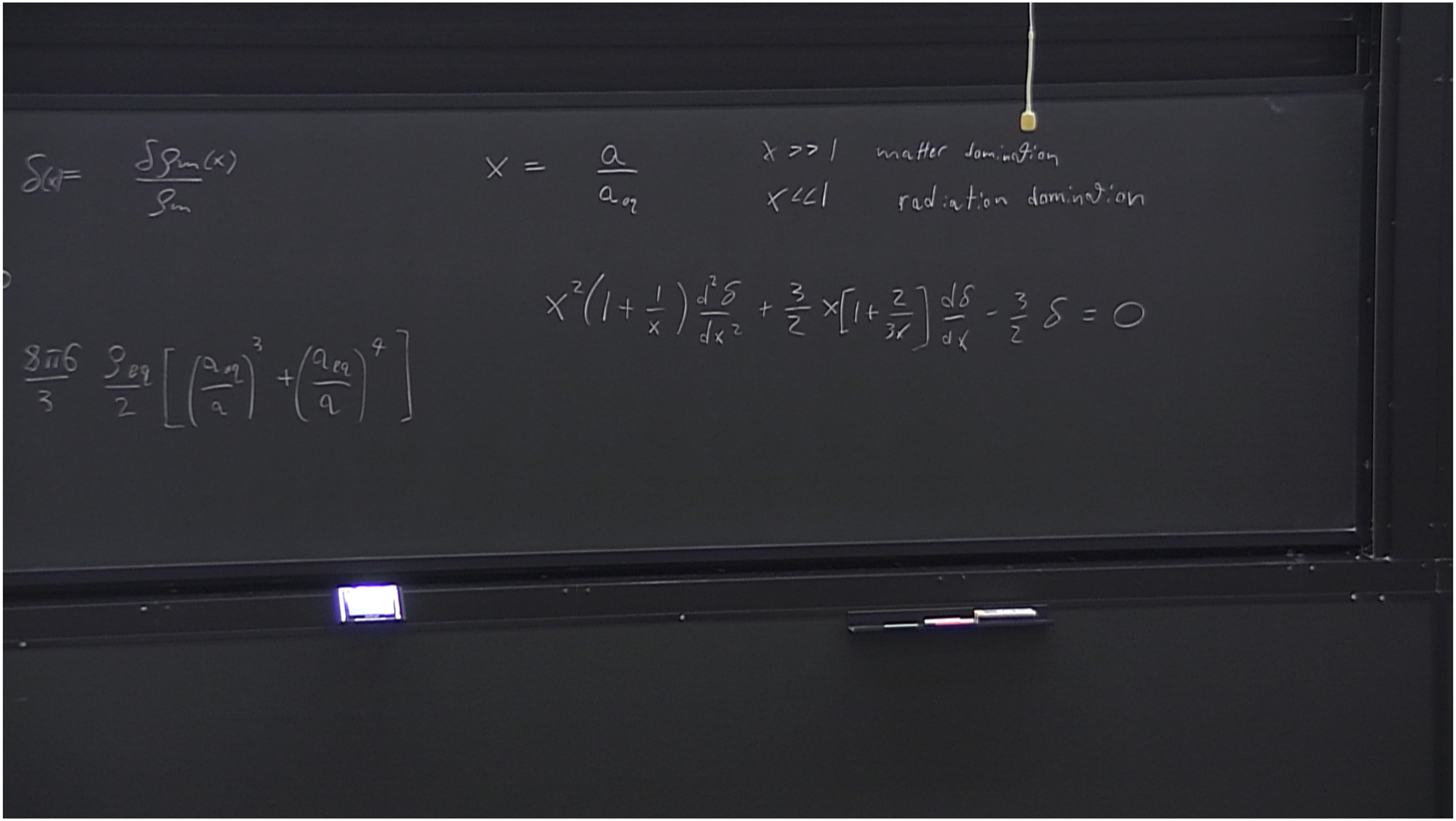

matter density constrast
$\delta(x) = \frac{\delta\rho_m(x)}{\rho_m}$
$\ddot{\delta} + 2H\dot{\delta} - 4\pi G \rho \delta = 0$
$H^2 = \frac{8\pi G}{3}\underbrace{(\rho_m + \rho_r)}_{\rho} = \frac{8\pi G}{3}\frac{\rho_{eq}}{2}$


matter density contrast
δ(x) = δρm(x) / ρm
x = a / aeq
δ̈ + 2H δ̇ − 4πG ρ δ = 0
H² = 8πG/3 (ρm + ρr) = 8πG/3 ρeq/2 [(aeq/a)³ + (aeq/a)⁴]
ρ

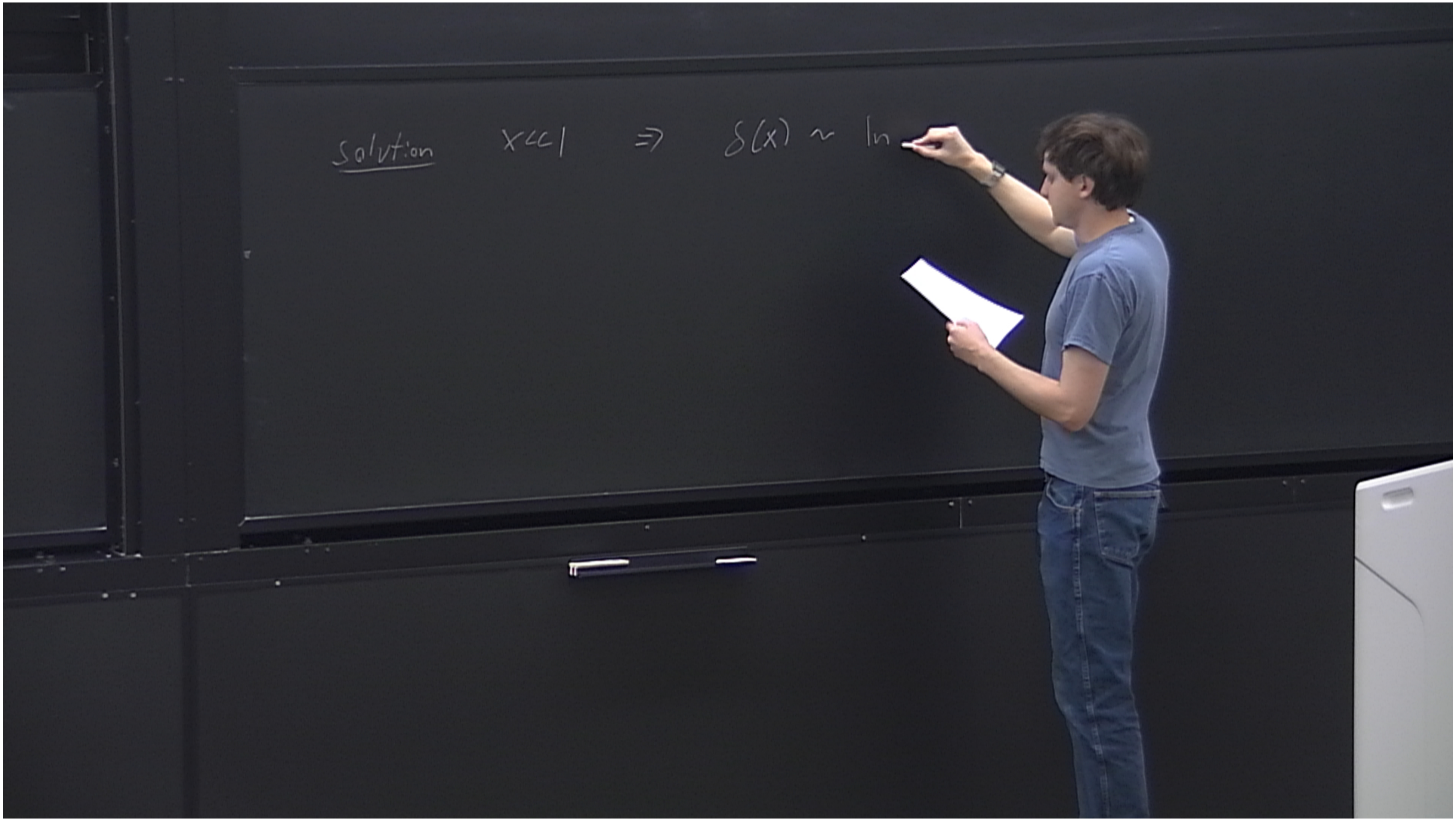

matter density constrast $\delta(x) = \frac{\delta \rho_m(x)}{\rho_m}$
$x = \frac{a}{a_{eq}}$
$x >>$
$\ddot{\delta} + 2H\dot{\delta} - 4\pi G \rho \delta = 0$
$H^2 = \frac{8\pi G}{3}(\underbrace{\rho_m + \rho_r}_{\rho}) = \frac{8\pi G}{3} \frac{\rho_{eq}}{2}\left[\left(\frac{a_{eq}}{a}\right)^3 + \left(\frac{a_{eq}}{a}\right)^4\right]$

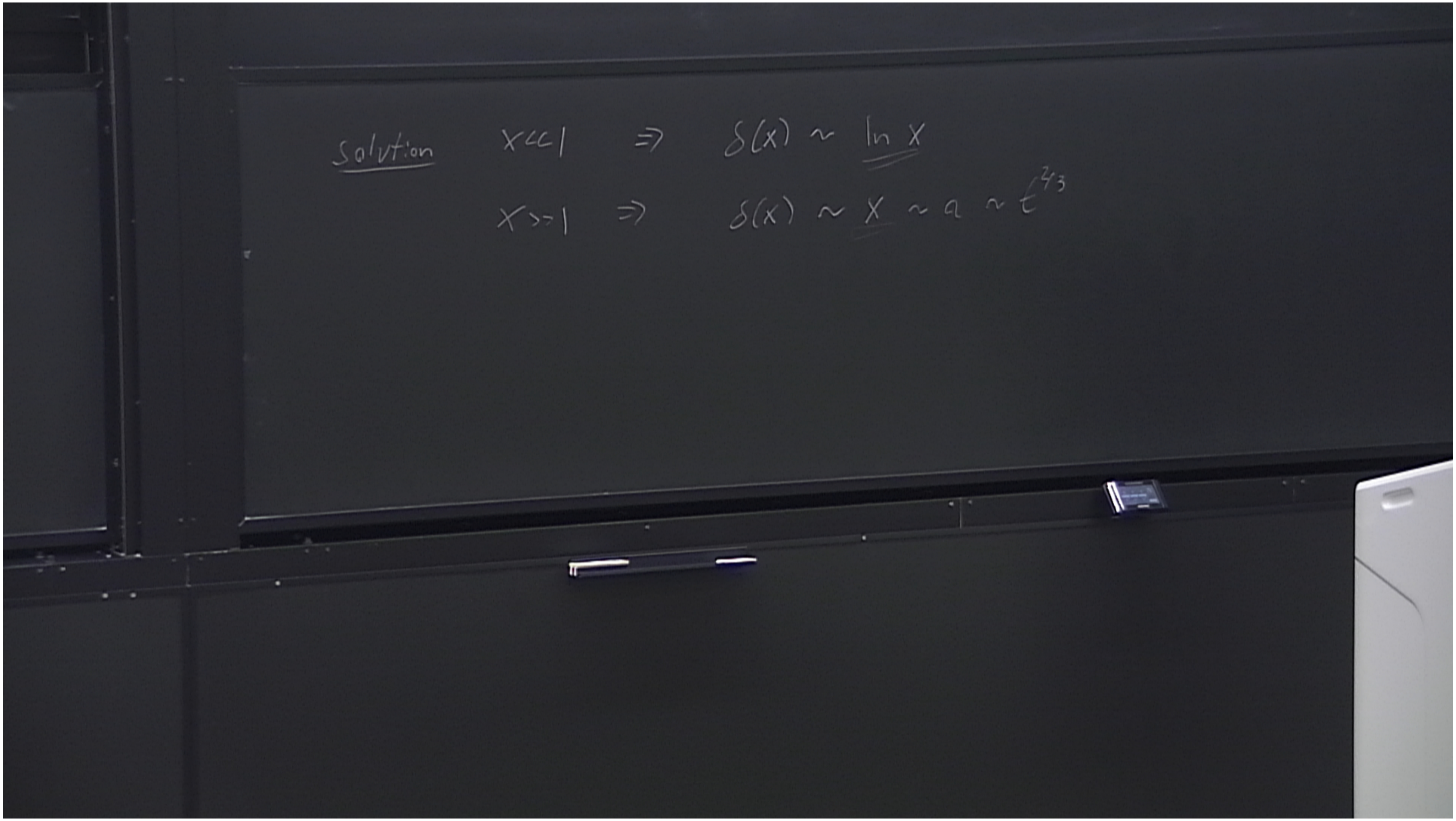

δ(x) = δρm(x) / ρm
X = a / aeq
x >> 1 matter domination
x << 1 rad
8πG/3 ρeq/2 [(aeq/a)^3 + (aeq/a)^4]

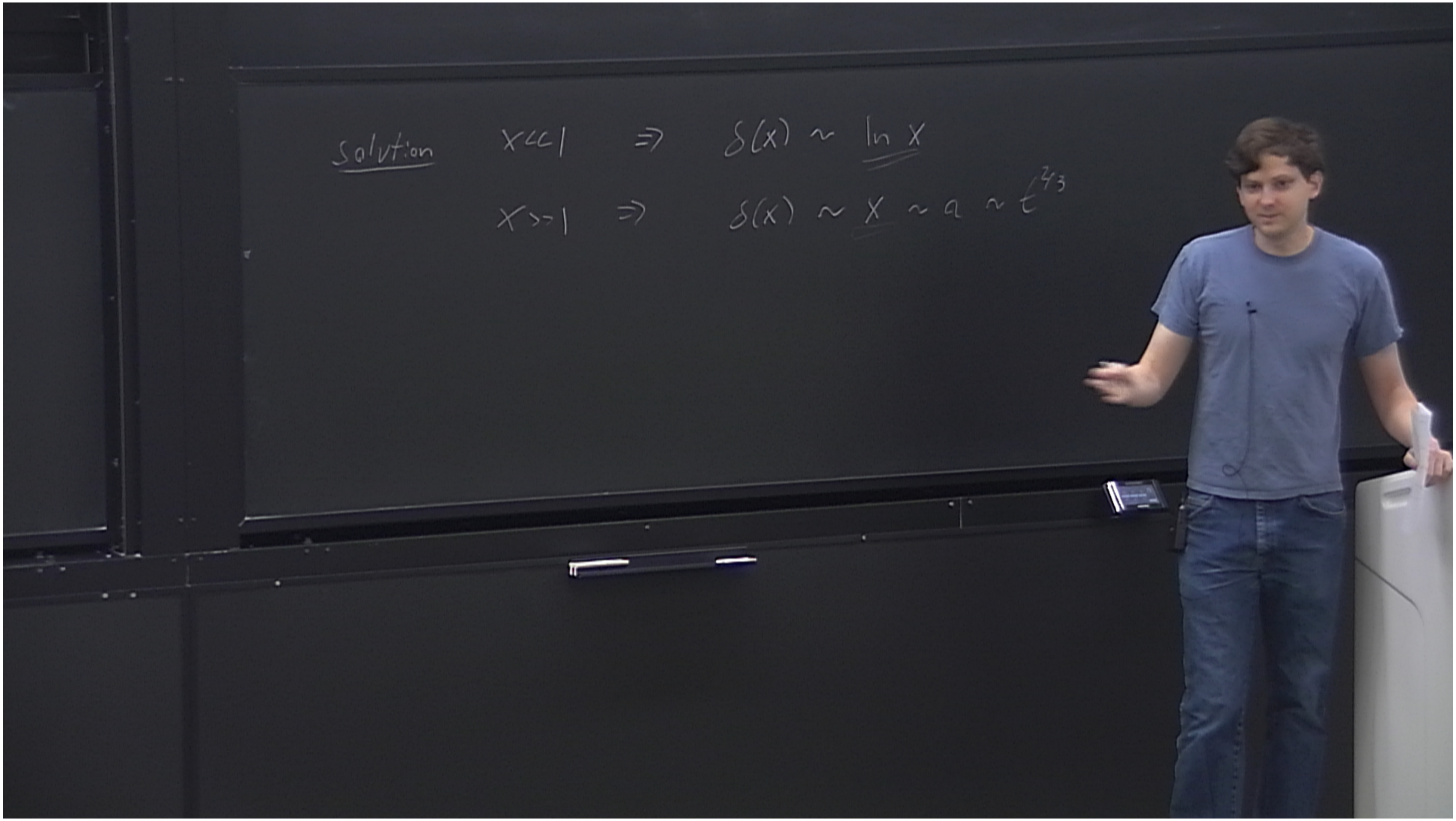

δ(x) = δρ_m(x) / ρ_m
x = a / a_eq
x >> 1 matter domination
x << 1 radiation domination
x^2 (1 + 1/x) d^2δ/dx^2 + 3/2 x [1 + 2/(3x)] dδ/dx - 3/2 δ = 0
8πG/3 ρ_eq/2 [

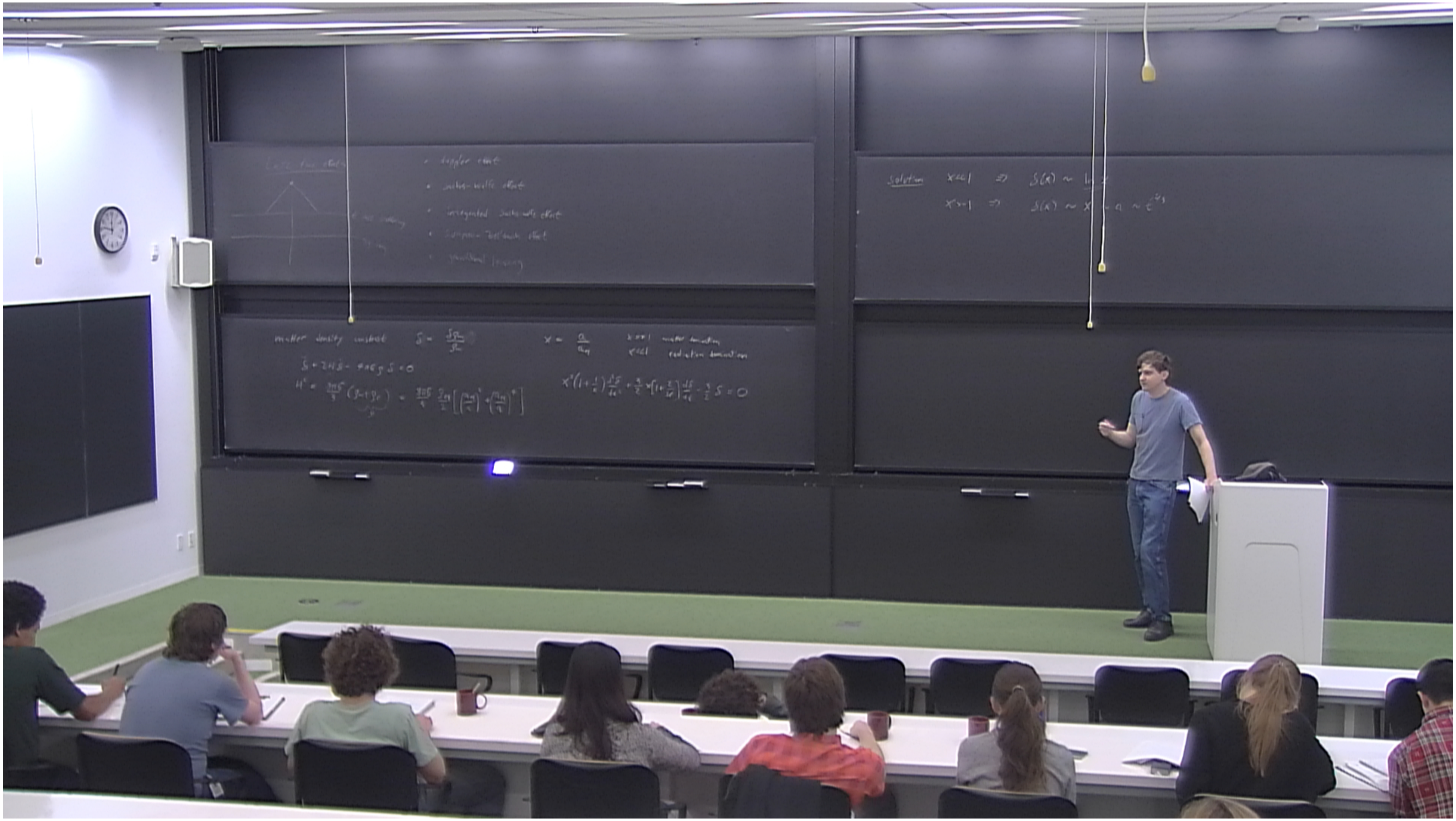


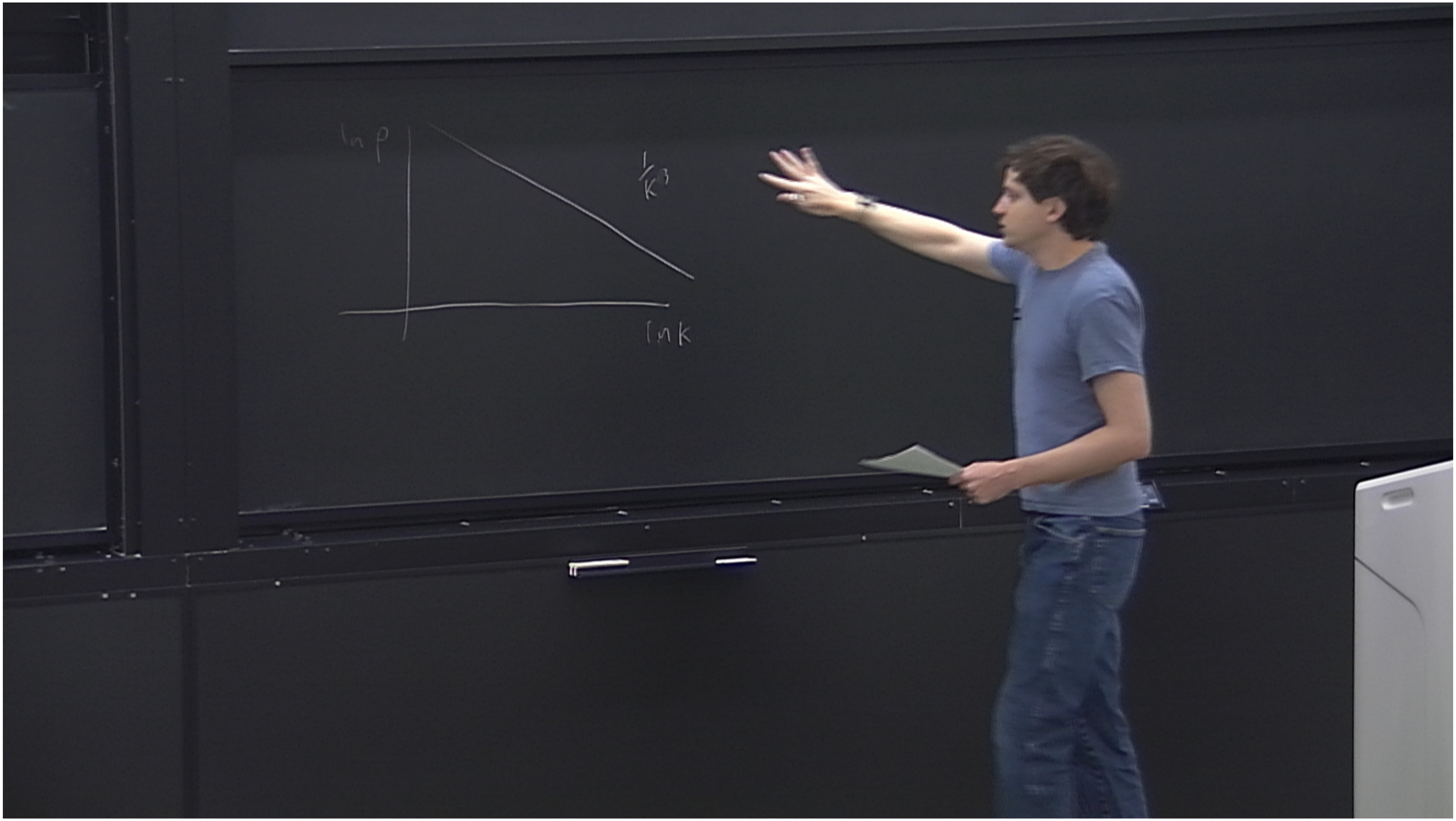
δ(x) = δρ_m(x) / ρ_m
x = a / a_eq
x >> 1 matter domination
x << 1 radiation domination
x^2 (1 + 1/x) d^2δ/dx^2 + 3/2 x [1 + 2/(3x)] dδ/dx - 3/2 δ = 0
8πG/3 ρ_eq/2 [(a_eq/a)^3 + (a_eq/a)^4]


Solution x<<1 ⇒ δ(x) ~ ln

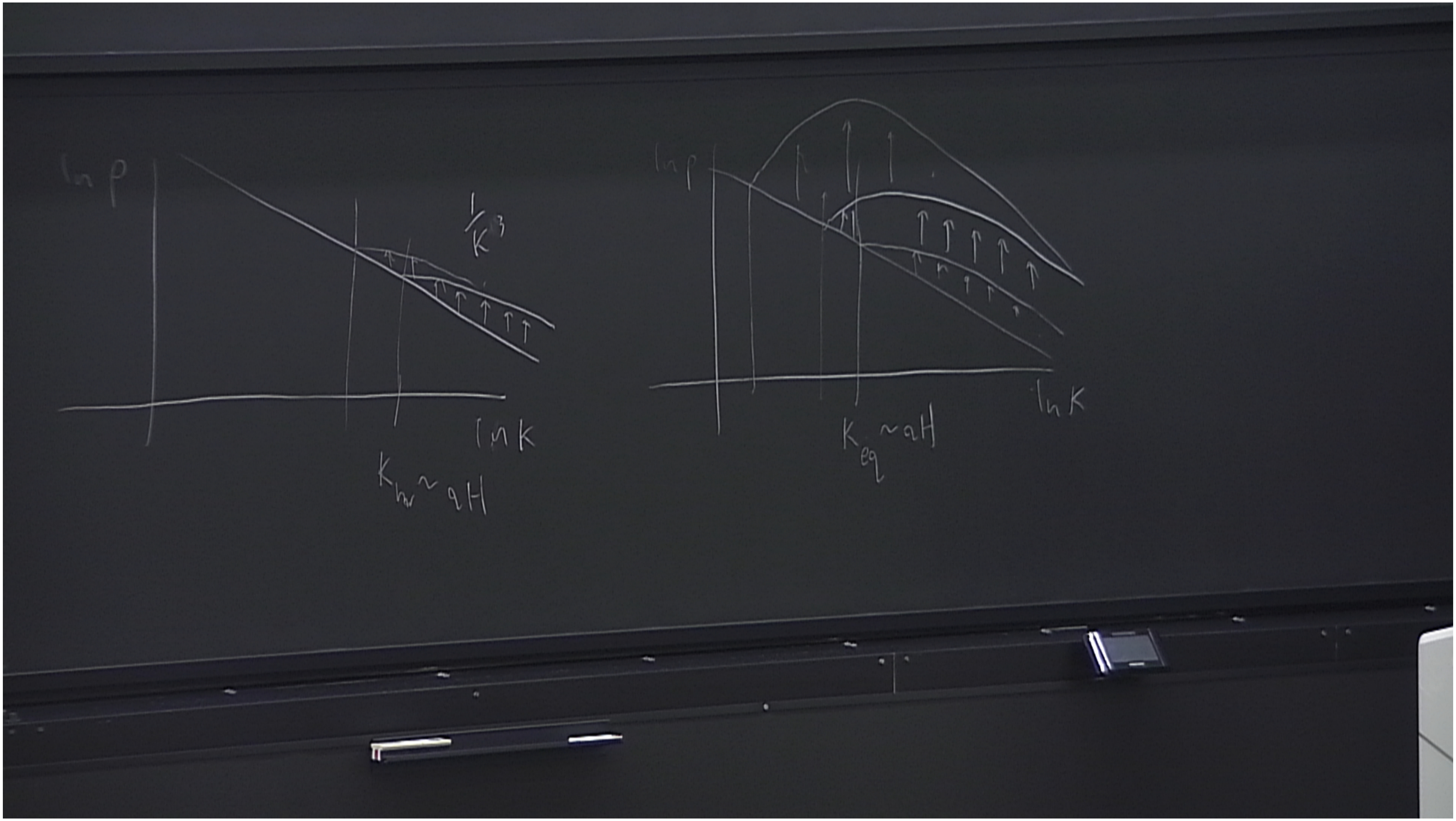

Solution $x \ll 1 \Rightarrow \delta(x) \sim \ln x$
$x \gg 1 \Rightarrow \delta(x) \sim x \sim a \sim t^{2/3}$

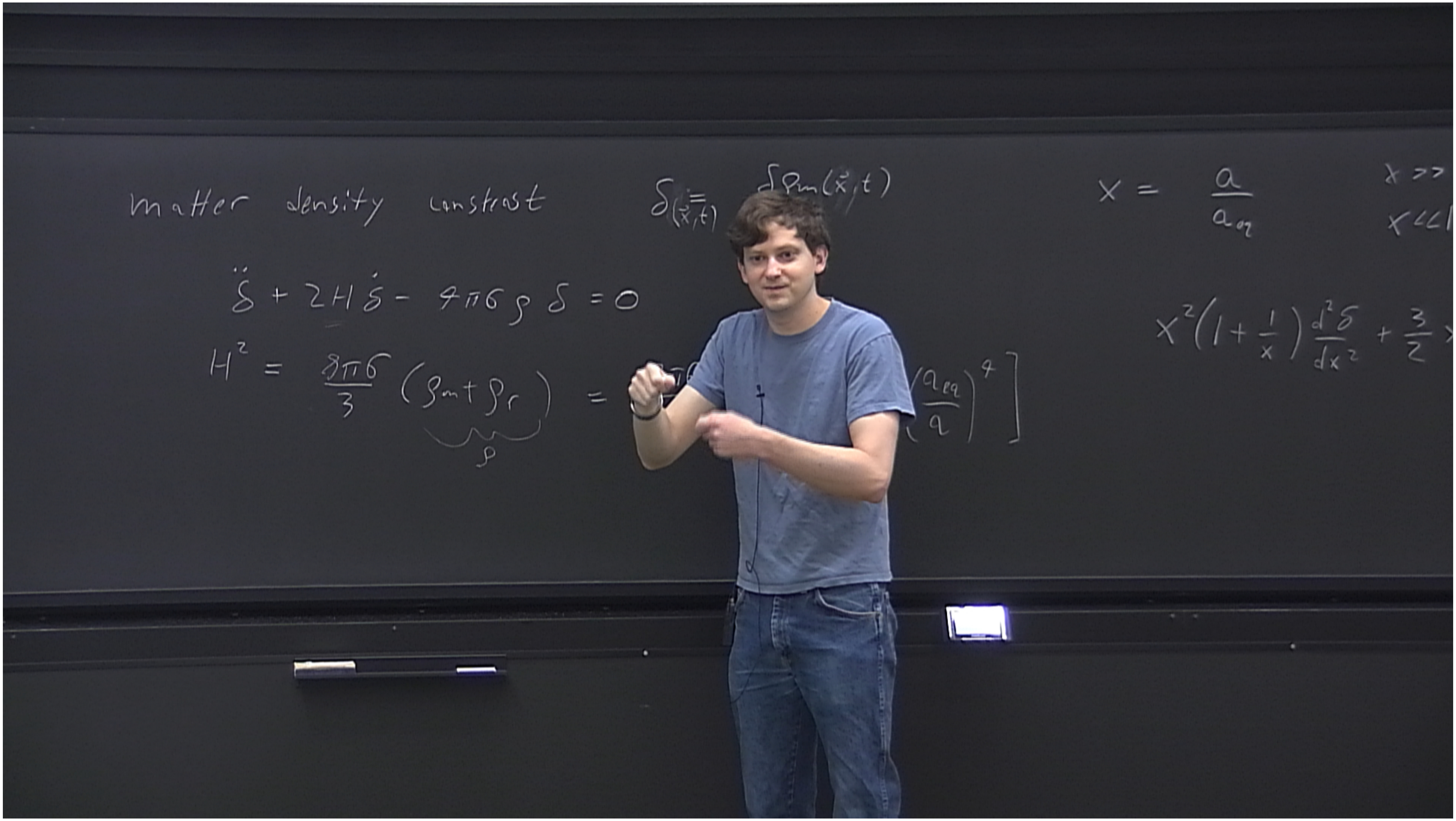

Solution x<<1 ⇒ δ(x) ~ ln x
x>>1 ⇒ δ(x) ~ x ~ a ~ t^2/3

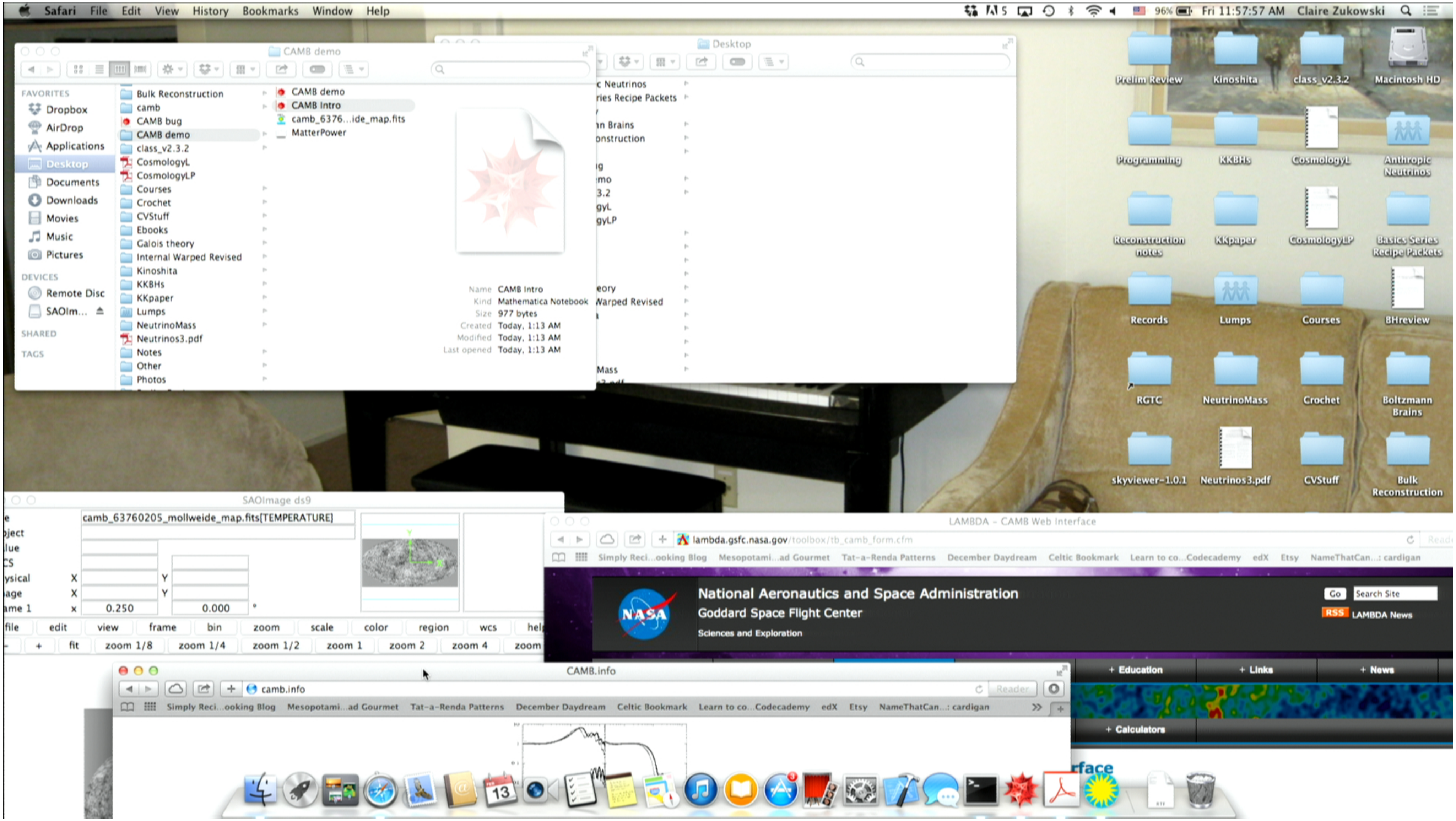



ln ρ
1/k³
ln k

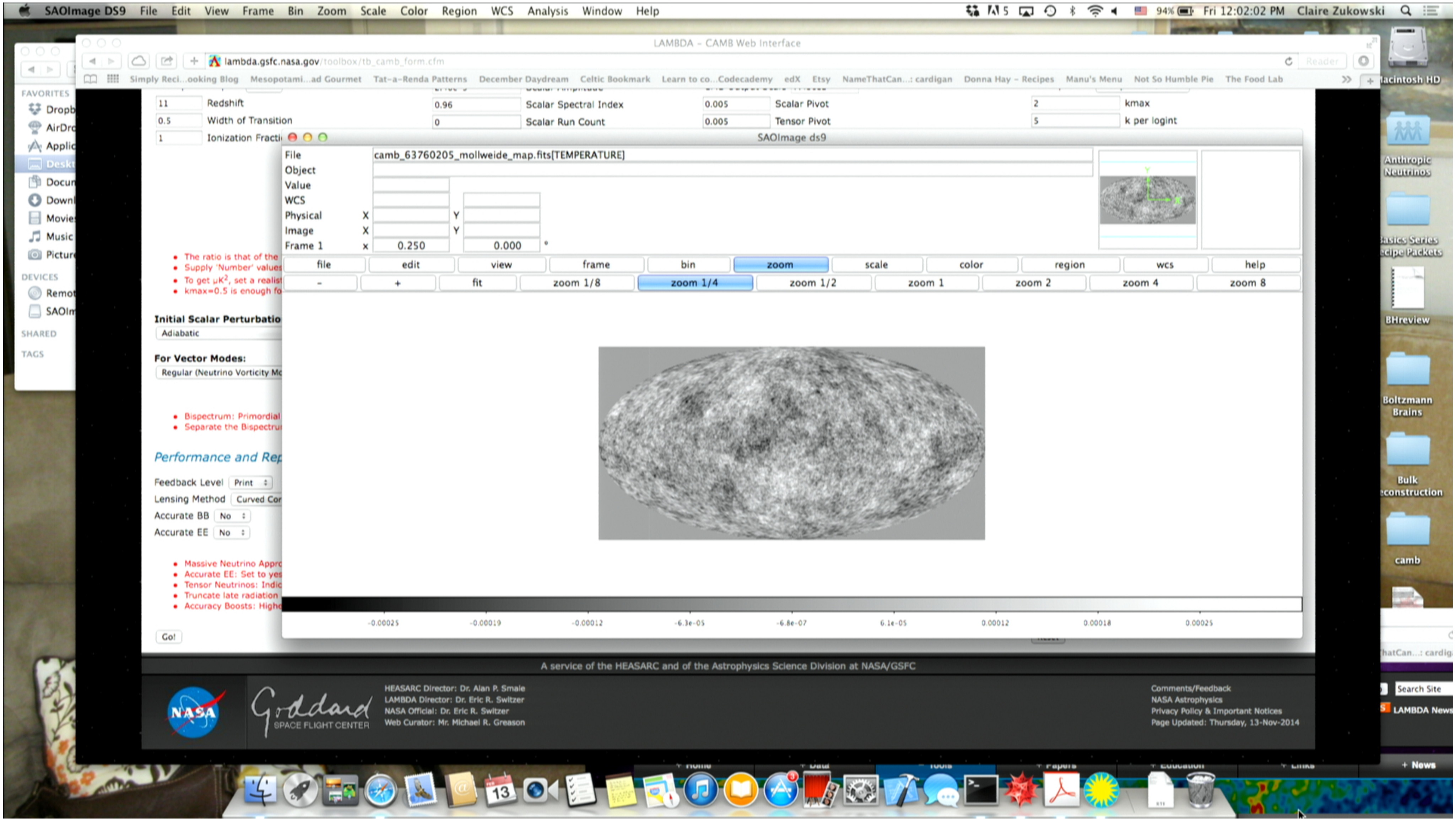

ln ρ
1/k³
ln k
k_hr ~ aH
ln ρ
ln k
k_eq ~ aH


ln ρ
1/k^3
ln k
k_hr ~ aH
ln ρ
ln k
k_eq ~ aH


matter density constrast
δ̈ + 2H δ̇ − 4πG ρ δ = 0
H² = 8πG/3 (ρm + ρr)
x = a / aeq


Safari File Edit View History Bookmarks Window Help
Fri 11:57:57 AM Claire Zukowski
CAMB demo
Desktop
CAMB Intro
Mathematica Notebook
977 bytes
SAOImage ds9
camb_63760205_mollweide_map.fits[TEMPERATURE]
LAMBDA - CAMB Web Interface
lambda.gsfc.nasa.gov/toolbox/tb_camb_form.cfm
National Aeronautics and Space Administration
Goddard Space Flight Center
Sciences and Exploration
CAMB.info
camb.info


CMBFast


SAOImage DS9 File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Window Help
Fri 12:02:02 PM Claire Zukowski
LAMBDA - CAMB Web Interface
lambda.gsfc.nasa.gov
Redshift
Width of Transition
Scalar Spectral Index
Scalar Run Count
Scalar Pivot
Tensor Pivot
kmax
k per logint
SAOImage ds9
File camb_63760205_mollweide_map.fits[TEMPERATURE]
Object
Value
WCS
Physical
Image
Frame 1 x 0.250 0.000
file edit view frame bin zoom scale color region wcs help
- + fit zoom 1/8 zoom 1/4 zoom 1/2 zoom 1 zoom 2 zoom 4 zoom 8
-0.00025 -0.00019 -0.00012 -6.3e-05 -6.8e-07 6.1e-05 0.00012 0.00018 0.00025
Initial Scalar Perturbatio
Adiabatic
For Vector Modes:
Performance and Rep
Feedback Level
Lensing Method
Accurate BB
Accurate EE
Go!
A service of the HEASARC and of the Astrophysics Science Division at NASA/GSFC
HEASARC Director: Dr. Alan P. Smale
LAMBDA Director: Dr. Eric R. Switzer
NASA Official: Dr. Eric R. Switzer
Web Curator: Mr. Michael R. Greason
Comments/Feedback
NASA Astrophysics
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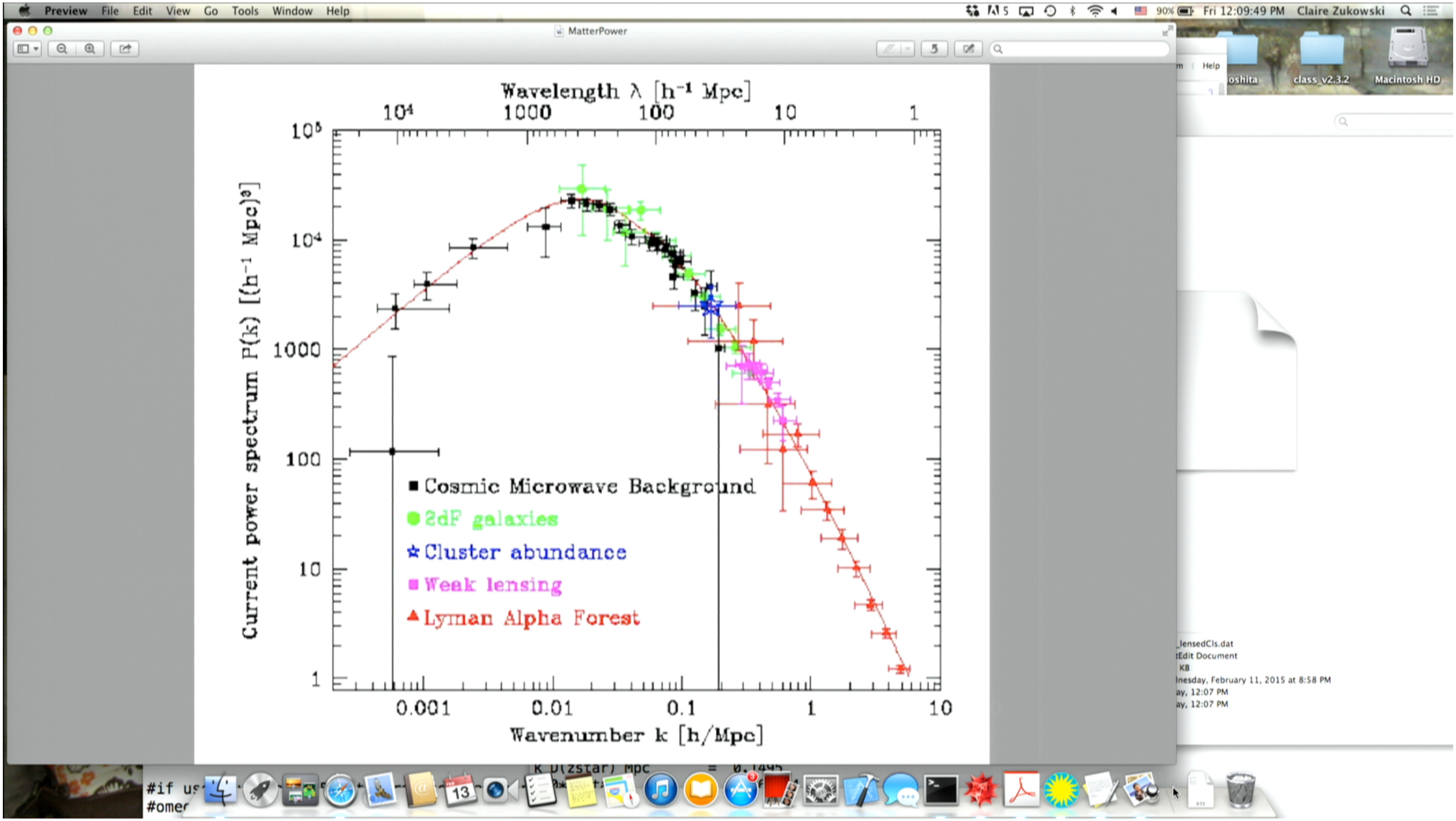
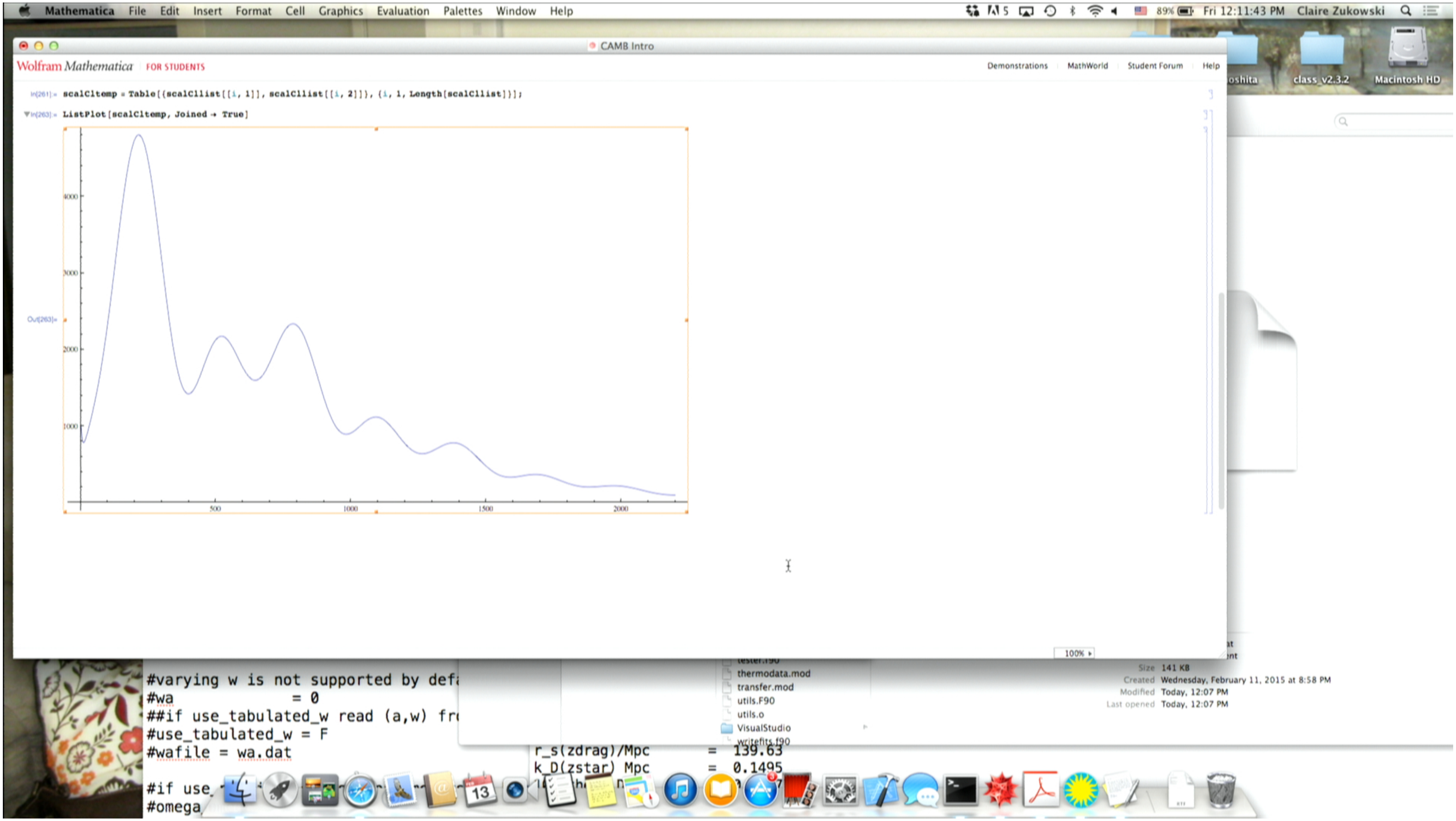
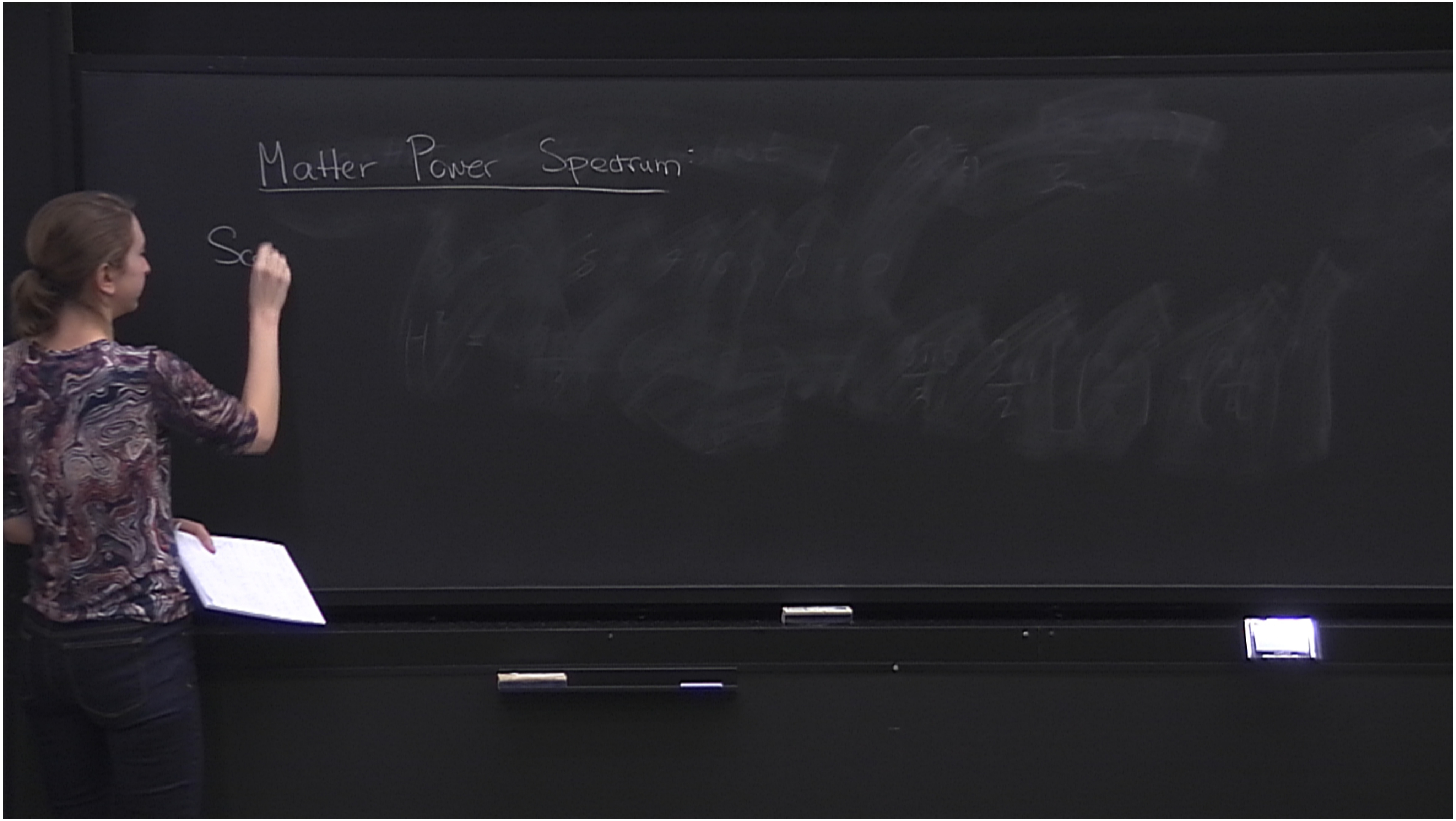
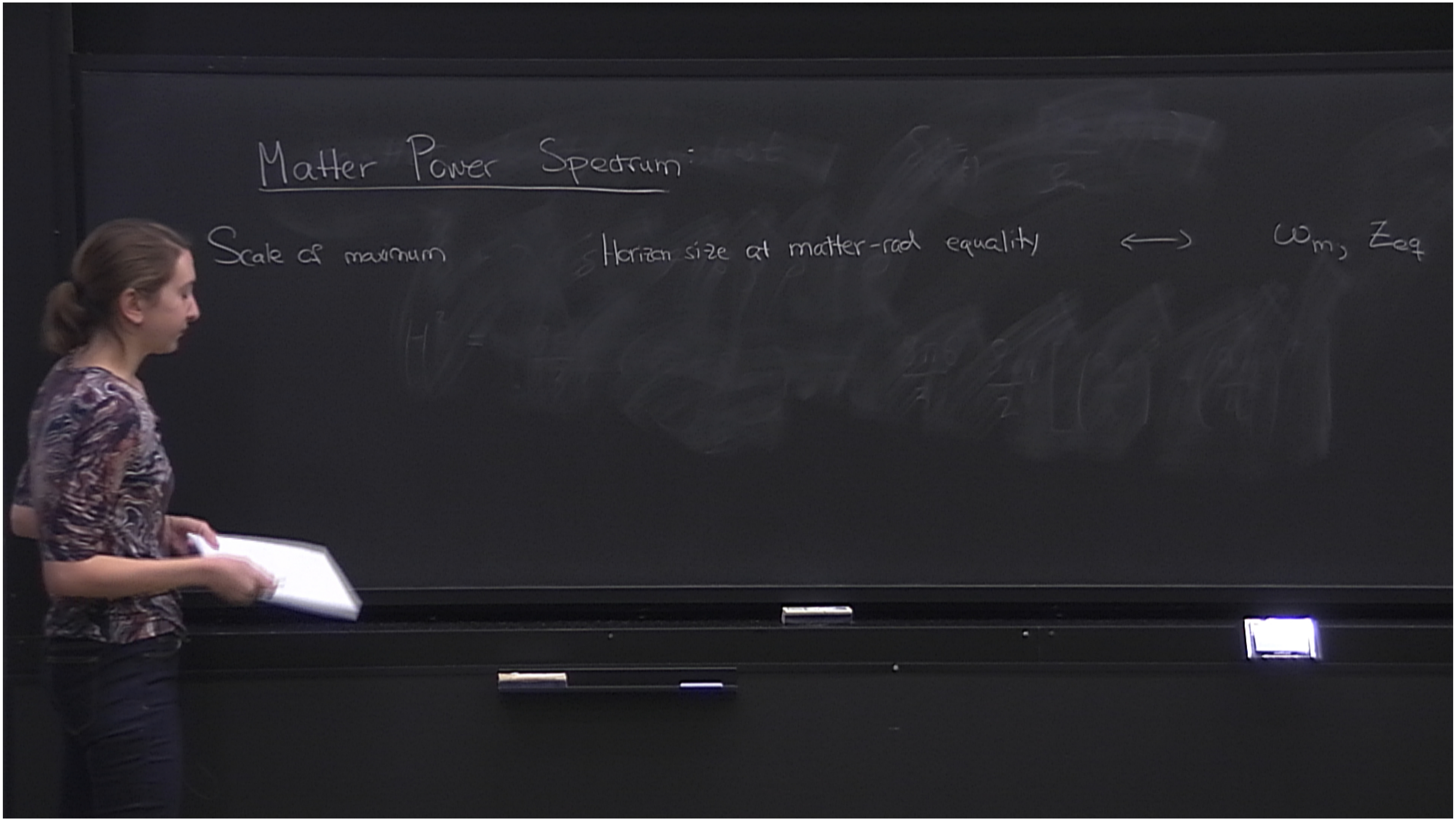
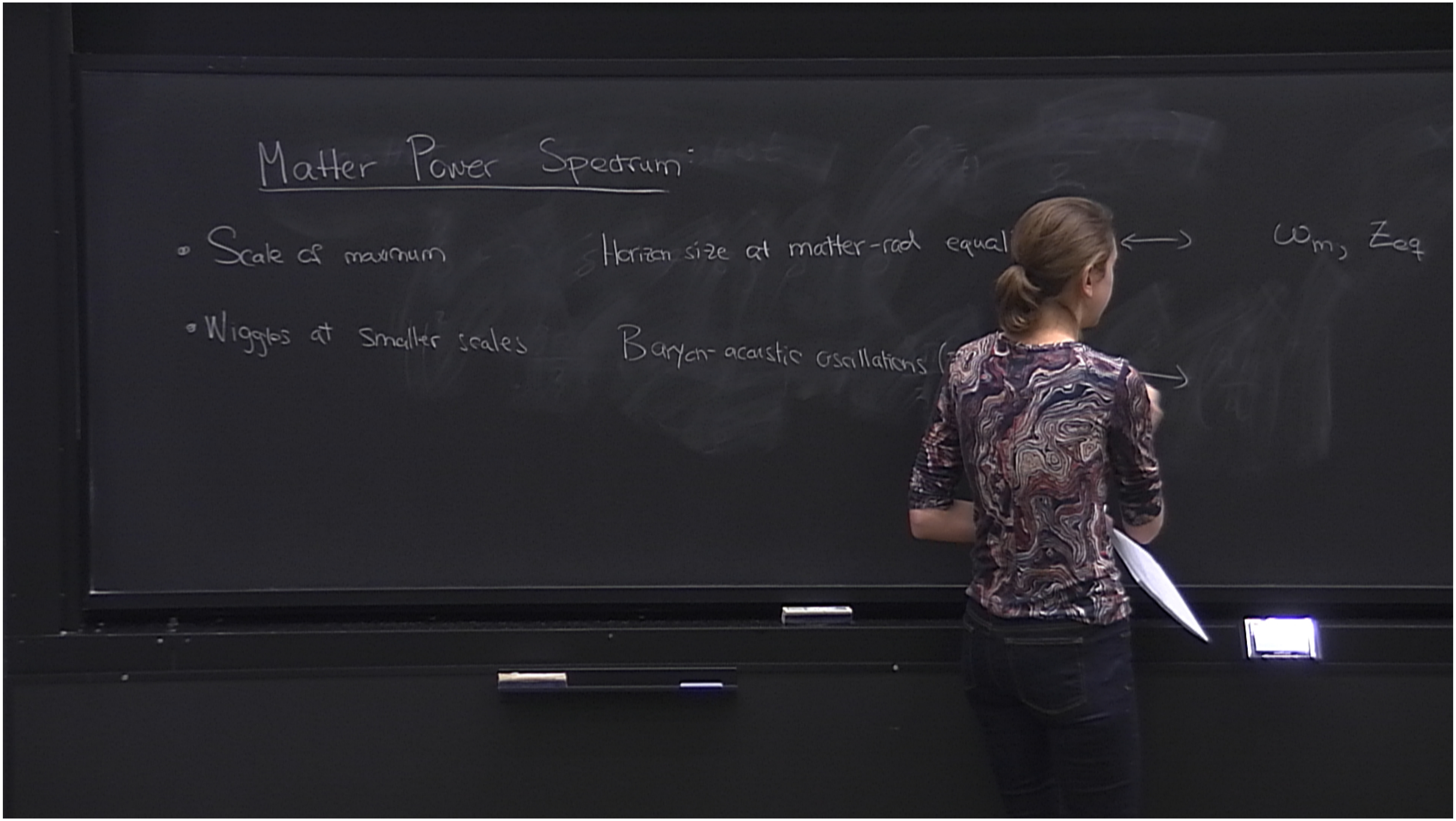
Page Updated: Thursday, 13-Nov-2014
Anthropic Neutrinos
BHreview
Boltzmann Brains
camb

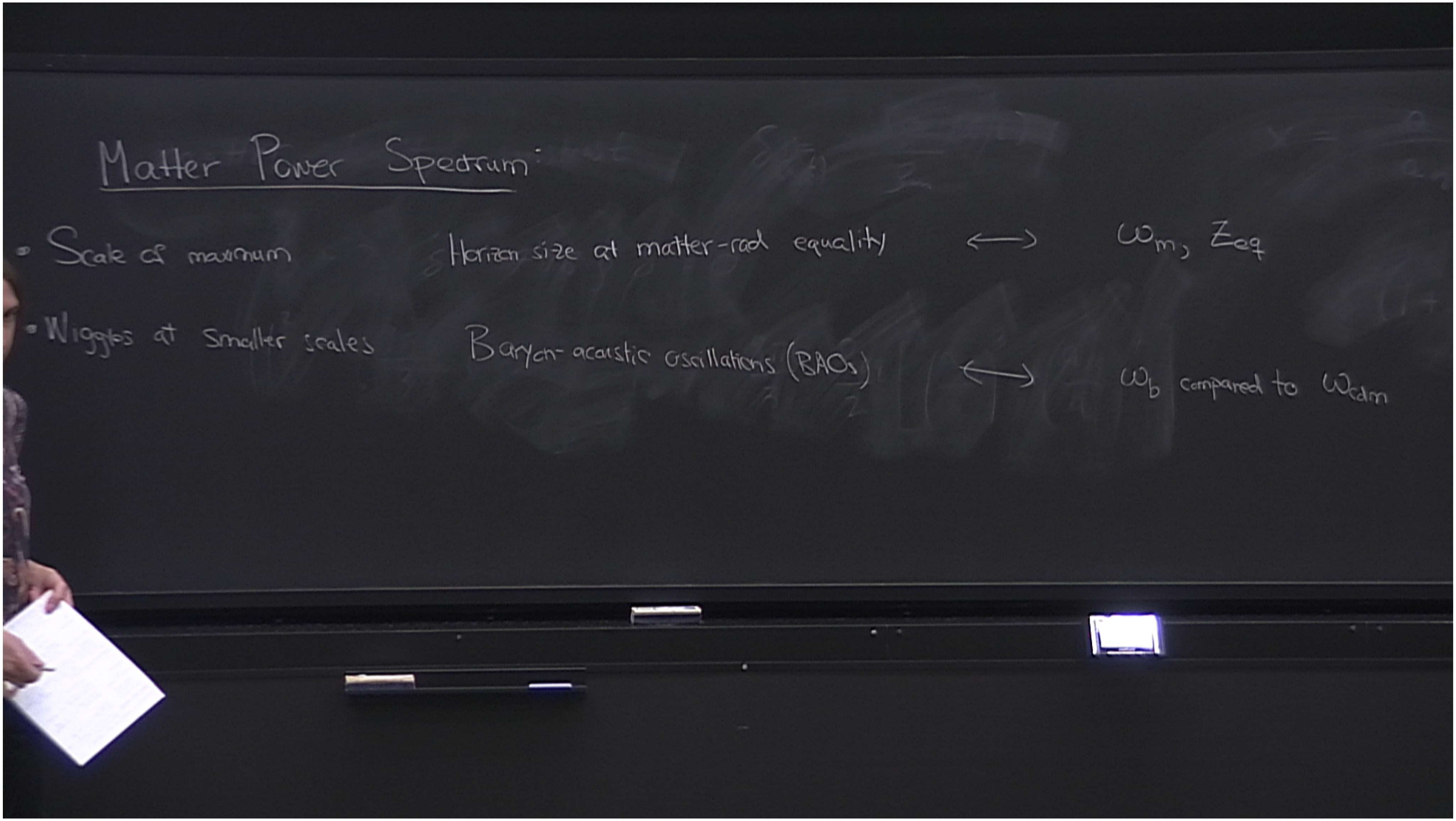

MatterPower
Wavelength λ [h⁻¹ Mpc]
Current power spectrum P(k) [(h⁻¹ Mpc)³]
Wavenumber k [h/Mpc]
Cosmic Microwave Background
2dF galaxies
Cluster abundance
Weak lensing
Lyman Alpha Forest

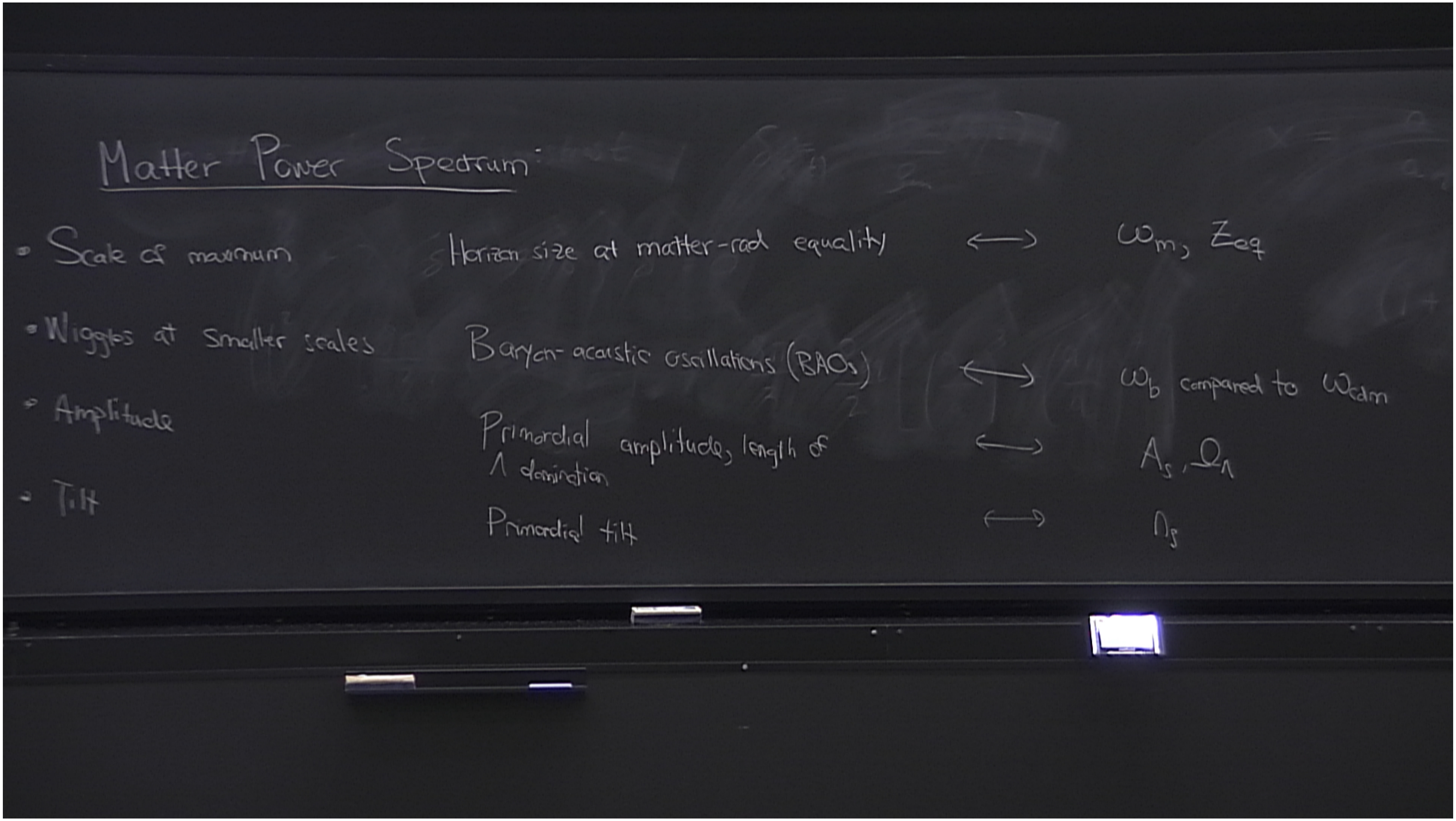

Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Fri 12:11:43 PM Claire Zukowski
CAMB Intro
Wolfram Mathematica FOR STUDENTS
Demonstrations MathWorld Student Forum Help
scalCltemp = Table[{scalCllist[[i, 1]], scalCllist[[i, 2]]}, {i, 1, Length[scalCllist]}];
ListPlot[scalCltemp, Joined → True]
4000
3000
2000
1000
500
1000
1500
2000
class_v2.3.2
Macintosh HD
#varying w is not supported by def
#wa = 0
##if use_tabulated_w read (a,w) fr
#use_tabulated_w = F
#wafile = wa.dat
#if use
#omega
thermodata.mod
transfer.mod
utils.F90
utils.o
VisualStudio
r_s(zdrag)/Mpc = 139.63
k_D(zstar) Mpc = 0.1495
Size 141 KB
Created Wednesday, February 11, 2015 at 8:58 PM
Modified Today, 12:07 PM
Last opened Today, 12:07 PM

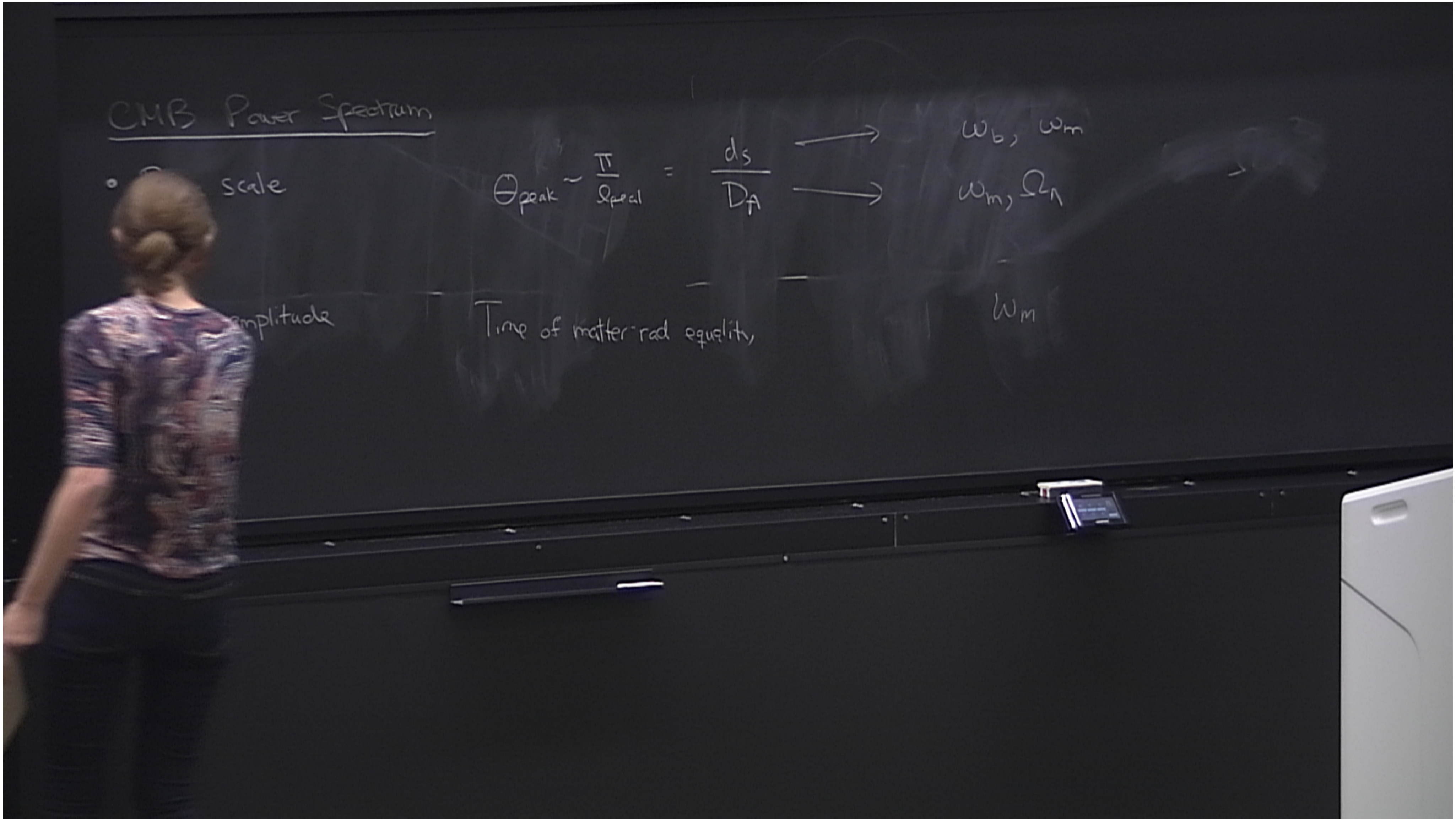

Matter Power Spectrum:


Matter Power Spectrum:
Scale of maximum
Horizon size at matter-rad equality
⟷
ωm, zeq


Matter Power Spectrum:
• Scale of maximum
Horizon size at matter-rad equal
ωm, zeq
• Wiggles at smaller scales
Baryon-acoustic oscillations (


Matter Power Spectrum:
• Scale of maximum
Horizon size at matter-rad equality
⟷
ω_m, z_{eq}
• Wiggles at smaller scales
Baryon-acoustic oscillations (BAOs)
⟷
ω_b compared to ω_{cdm}


Matter Power Spectrum:
• Scale of maximum
Horizon size at matter-rad equality ⟷ ω_m, z_{eq}
• Wiggles at smaller scales
Baryon-acoustic oscillations (BAOs) ⟷ ω_b compared to ω_{cdm}
• Amplitude
Primordial amplitude, length of Λ domination ⟷ A_s, Ω_Λ
• Tilt
Primordial tilt ⟷ n_s


CMB Power Spectrum
scale
mplitude
θpeak ~ π / ℓpeak = ds / DA
ωb, ωm
ωm, ΩΛ
Time of matter-rad equality
ωm