Title: A Primer on Bulk Reconstruction: Part 2

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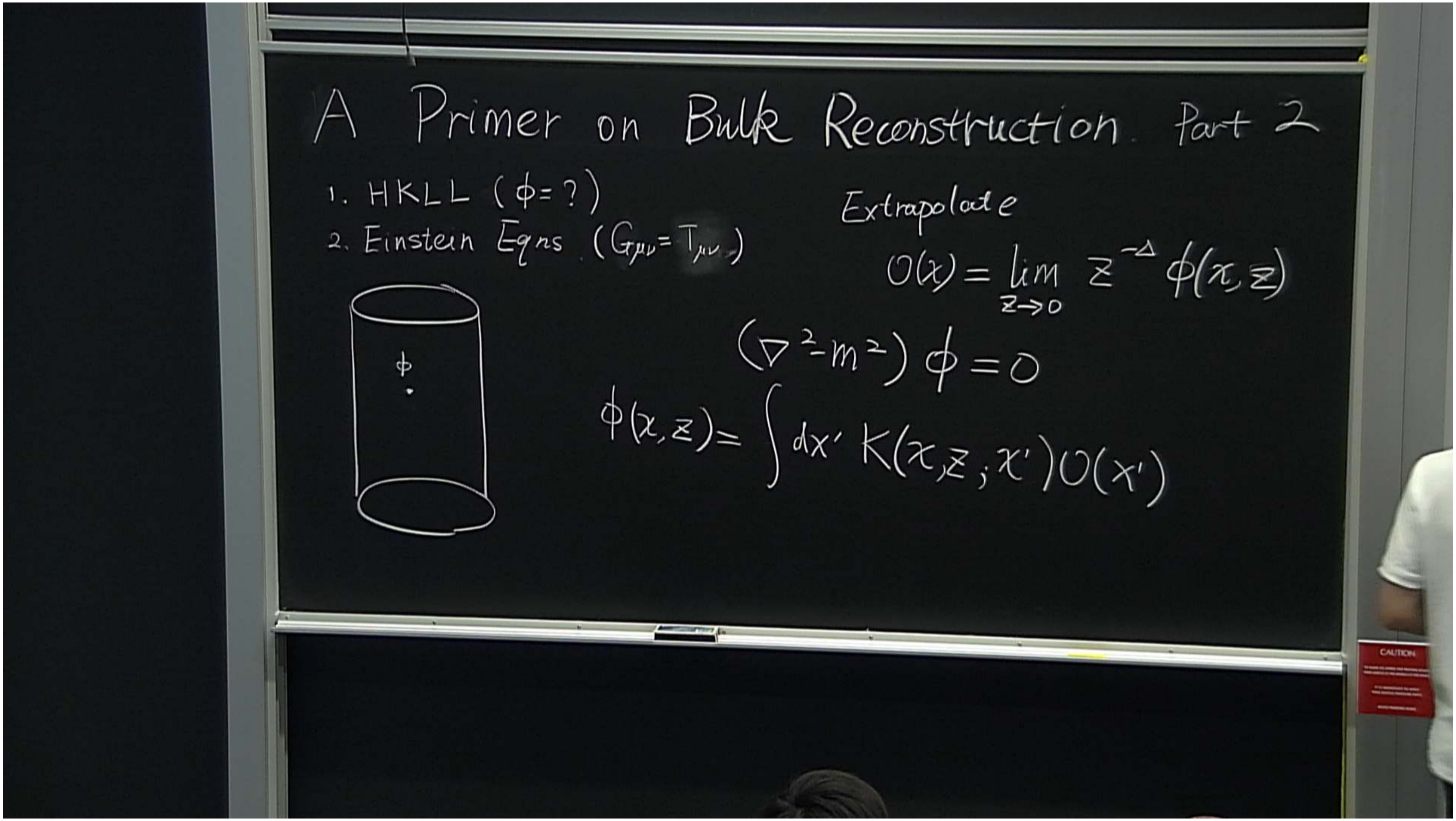
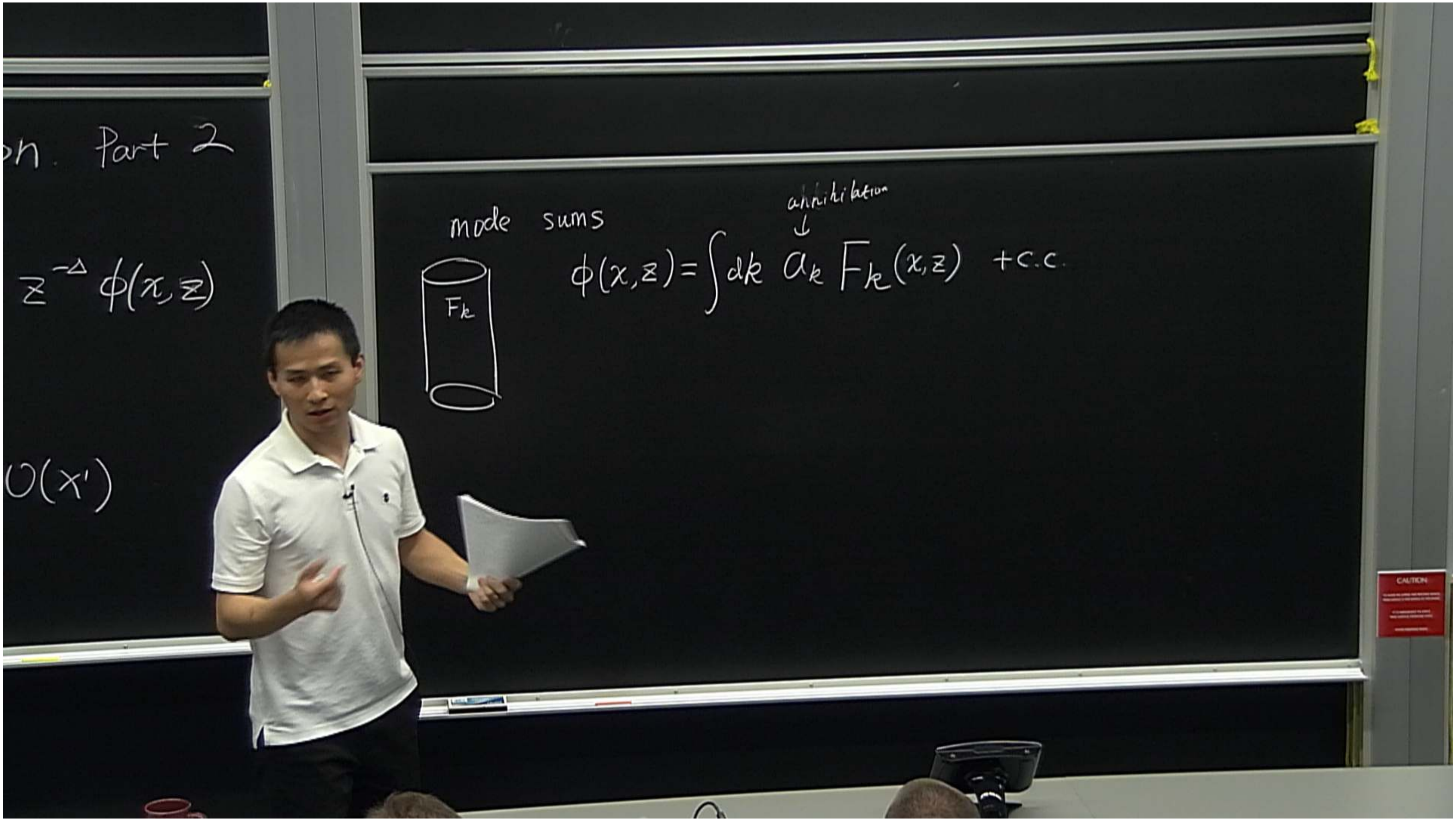
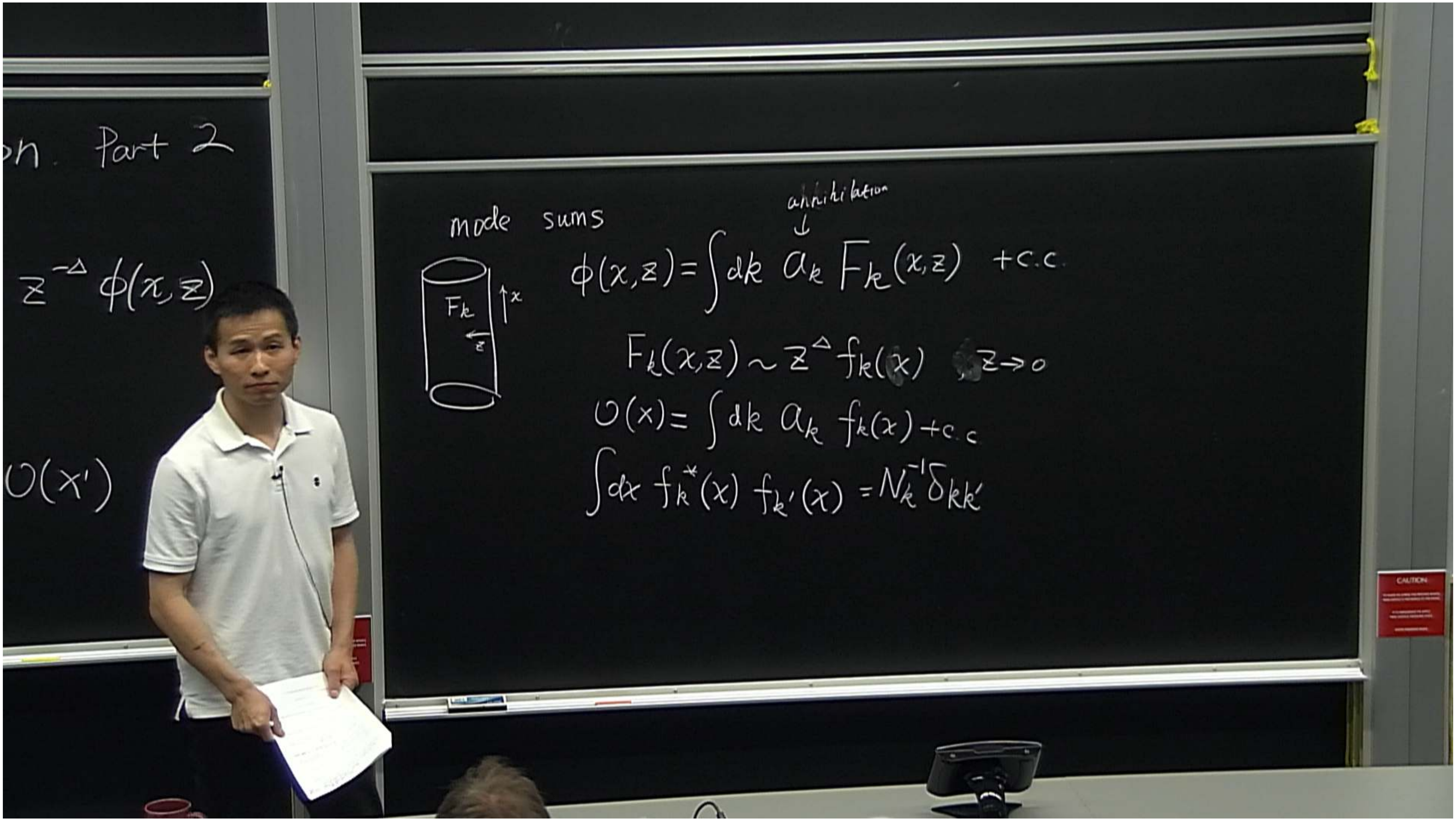
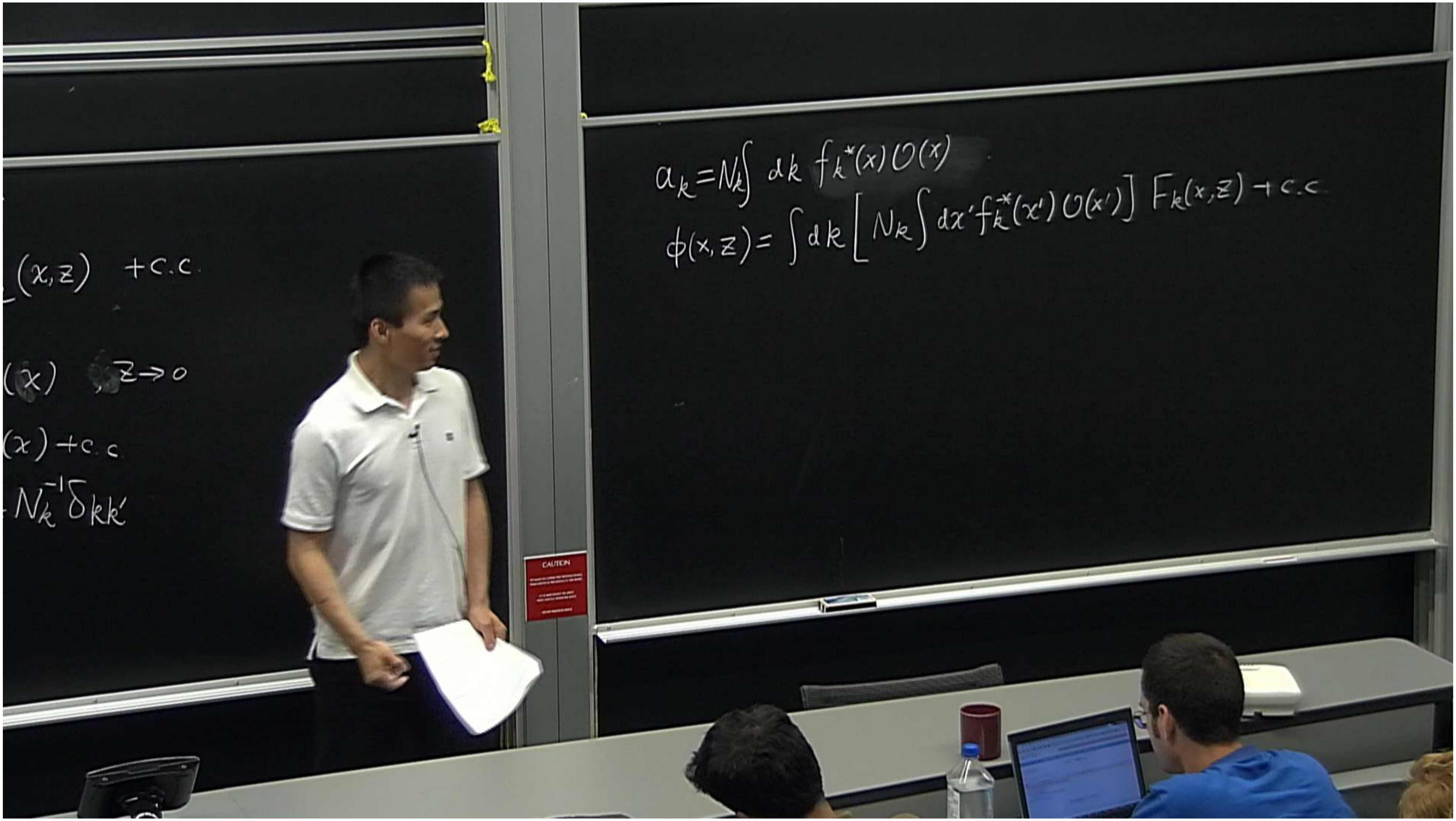
Abstract:

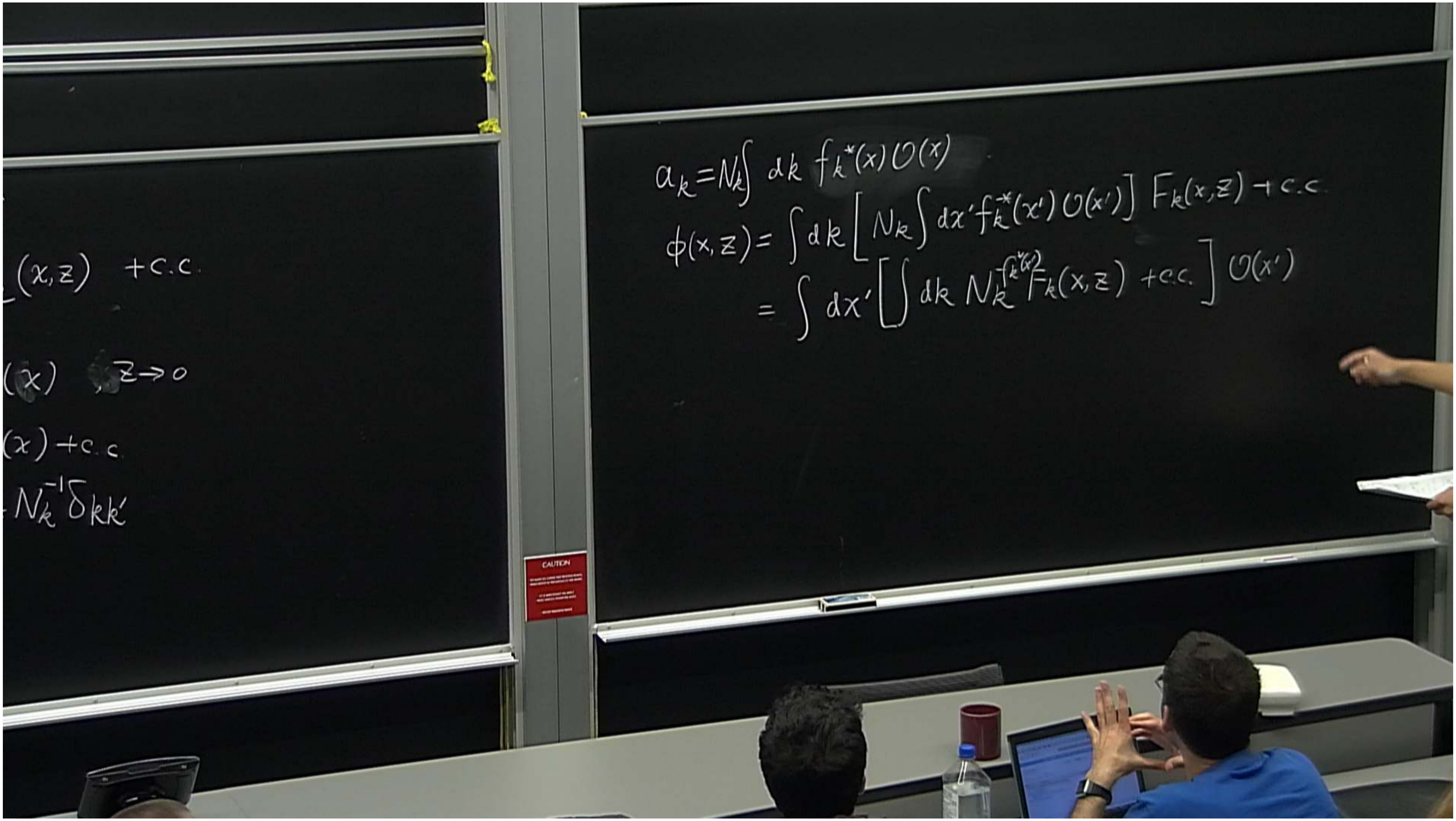

A Primer on Bulk Reconstruction Part 2
1. HKLL (ϕ = ?)
2. Einstein Eqns ($G_{\mu\nu} = T_{\mu\nu}$)
Extrapolate
$O(x) = \lim_{z \to 0} z^{-\Delta} \phi(x, z)$
$(\nabla^2 - m^2)\phi = 0$
$\phi(x, z) = \int dx' \, K(x, z; x') \, O(x')$
ϕ
CAUTION



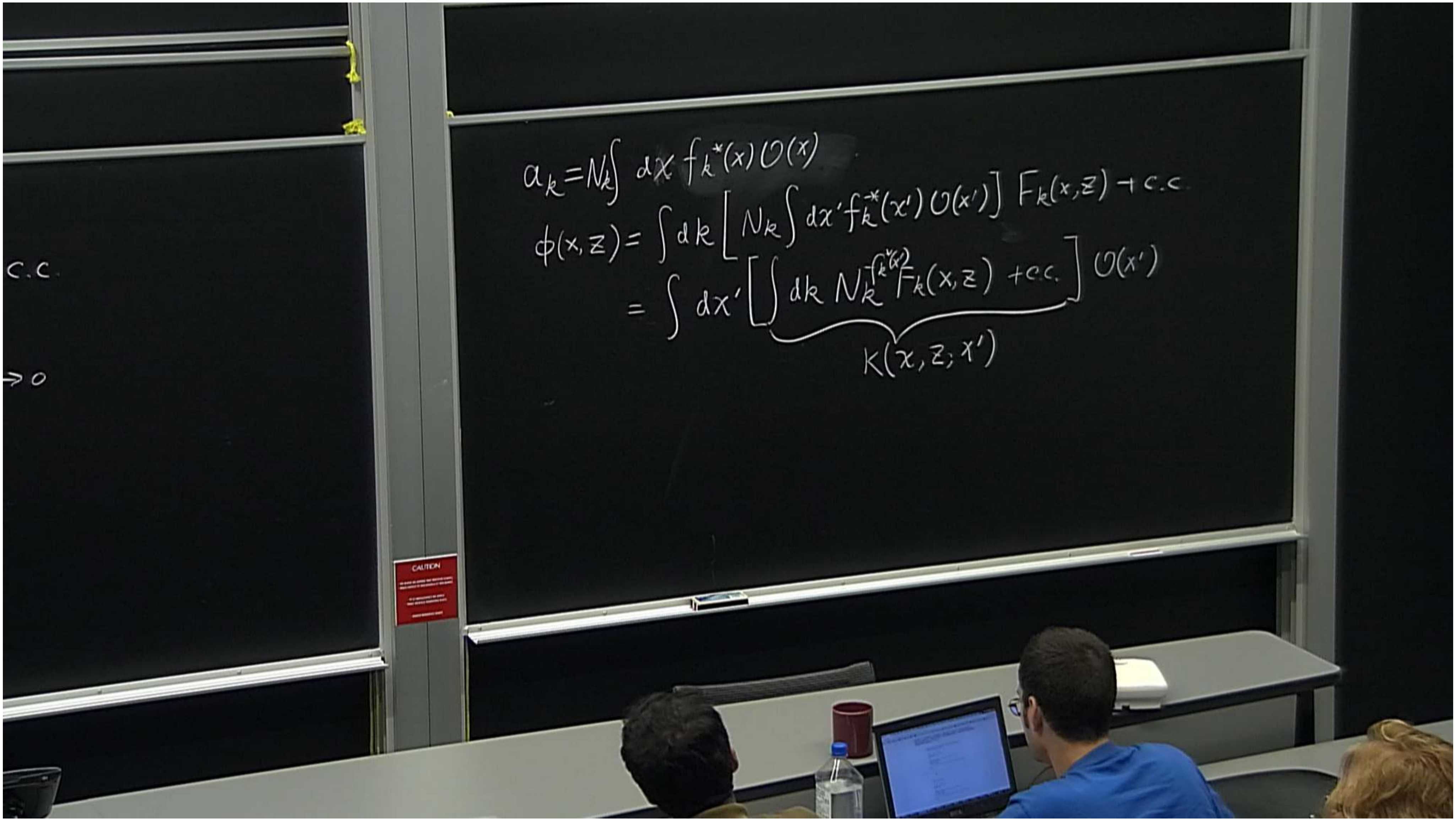
Part 2
mode sums
annihilation
$\phi(x,z) = \int dk\, a_k F_k(x,z) + c.c.$
F_k
$z^{-\Delta} \phi(x,z)$
$O(x')$

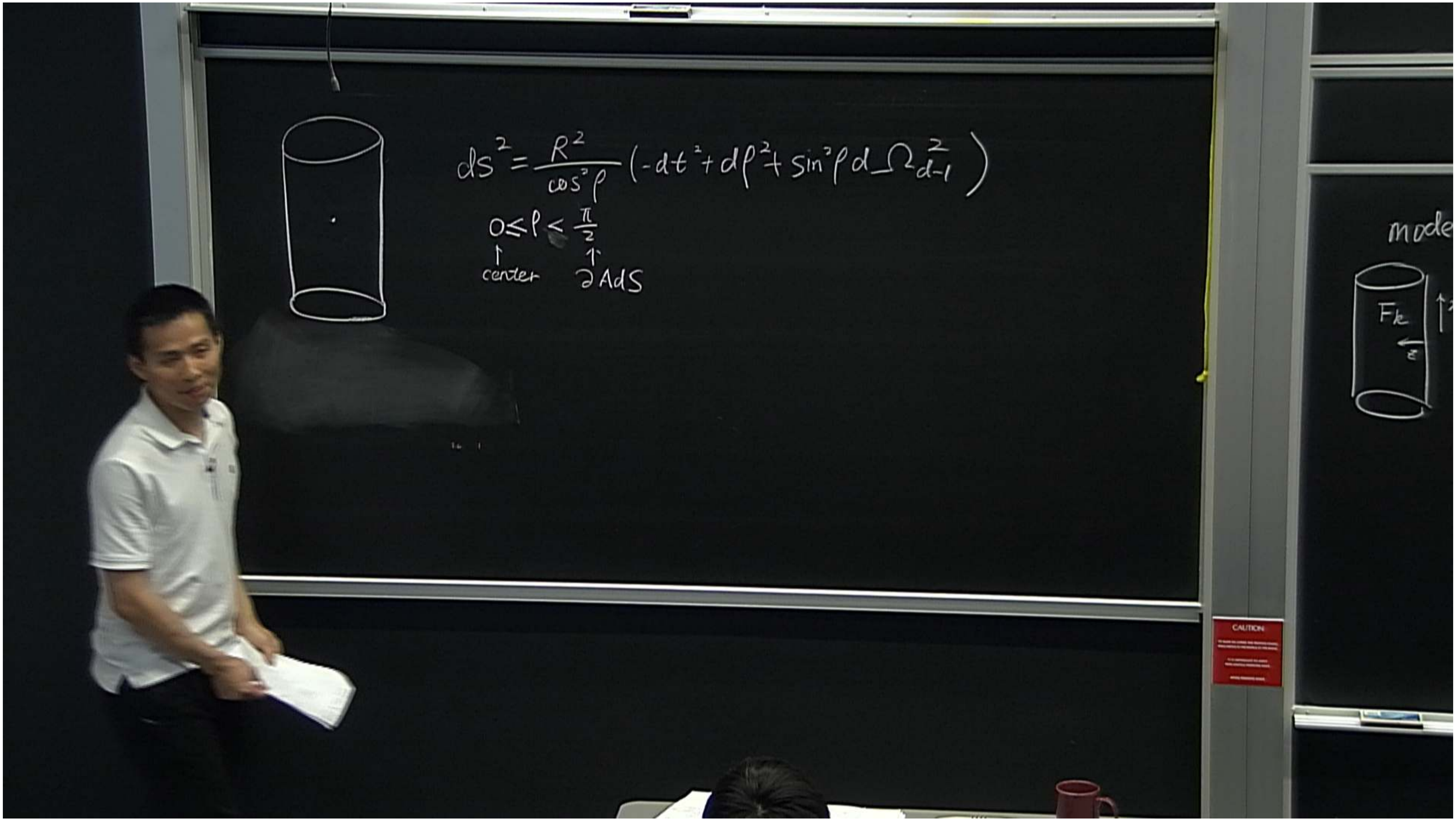

on Part 2
$z^{-\Delta}\phi(x,z)$
$O(x')$
mode sums
F_k
x
z
annihilation
$\phi(x,z) = \int dk\, a_k F_k(x,z) + c.c.$
$F_k(x,z) \sim z^{\Delta} f_k(x) \quad z \to 0$
$O(x) = \int dk\, a_k f_k(x) + c.c$
$\int dx\, f_k^*(x) f_{k'}(x) = N_k^{-1} \delta_{kk'}$


$a_k = N_k \int dk \, f_k^*(x) \mathcal{O}(x)$
$\phi(x,z) = \int dk \left[N_k \int dx' f_k^*(x') \mathcal{O}(x') \right] F_k(x,z) + c.c$
$(x,z) \quad + c.c$
$(x) \quad , z \to 0$
$(x) + c.c$
$N_k^{-1} \delta_{kk'}$
CAUTION



$(x, z) \quad + c.c$
$(x) \quad , z \to 0$
$(x) + c.c$
$N_k^{-1} \delta_{kk'}$
$a_k = N_k \int dk \, f_k^*(x) \mathcal{O}(x)$
$\phi(x, z) = \int dk \left[N_k \int dx' f_k^*(x') \mathcal{O}(x') \right] F_k(x, z) + c.c$
$= \int dx' \left[\int dk \, N_k f_k^*(x') F_k(x, z) + c.c. \right] \mathcal{O}(x')$


c.c
→ 0
$a_k = N_k \int dx\, f_k^*(x)\, \mathcal{O}(x)$
$\phi(x,z) = \int dk \left[N_k \int dx' f_k^*(x')\, \mathcal{O}(x') \right] F_k(x,z) + c.c.$
$= \int dx' \left[\underbrace{\int dk\, N_k f_k^*(x') F_k(x,z) + c.c.}_{K(x,z;x')} \right] \mathcal{O}(x')$


$ds^2 = \frac{R^2}{\cos^2\rho}\left(-dt^2 + d\rho^2 + \sin^2\rho\, d\Omega^2_{d-1}\right)$
$0 \leq \rho < \frac{\pi}{2}$
center
∂AdS
mode
F_k

$$ds^2 = \frac{R^2}{\cos^2\rho}\left(-dt^2 + d\rho^2 + \sin^2\rho\, d\Omega_{d-1}^2\right)$$

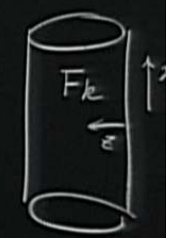
$$\underset{\text{center}}{\overset{\uparrow}{0}} \le \rho < \underset{\partial\text{AdS}}{\overset{\uparrow}{\tfrac{\pi}{2}}}$$

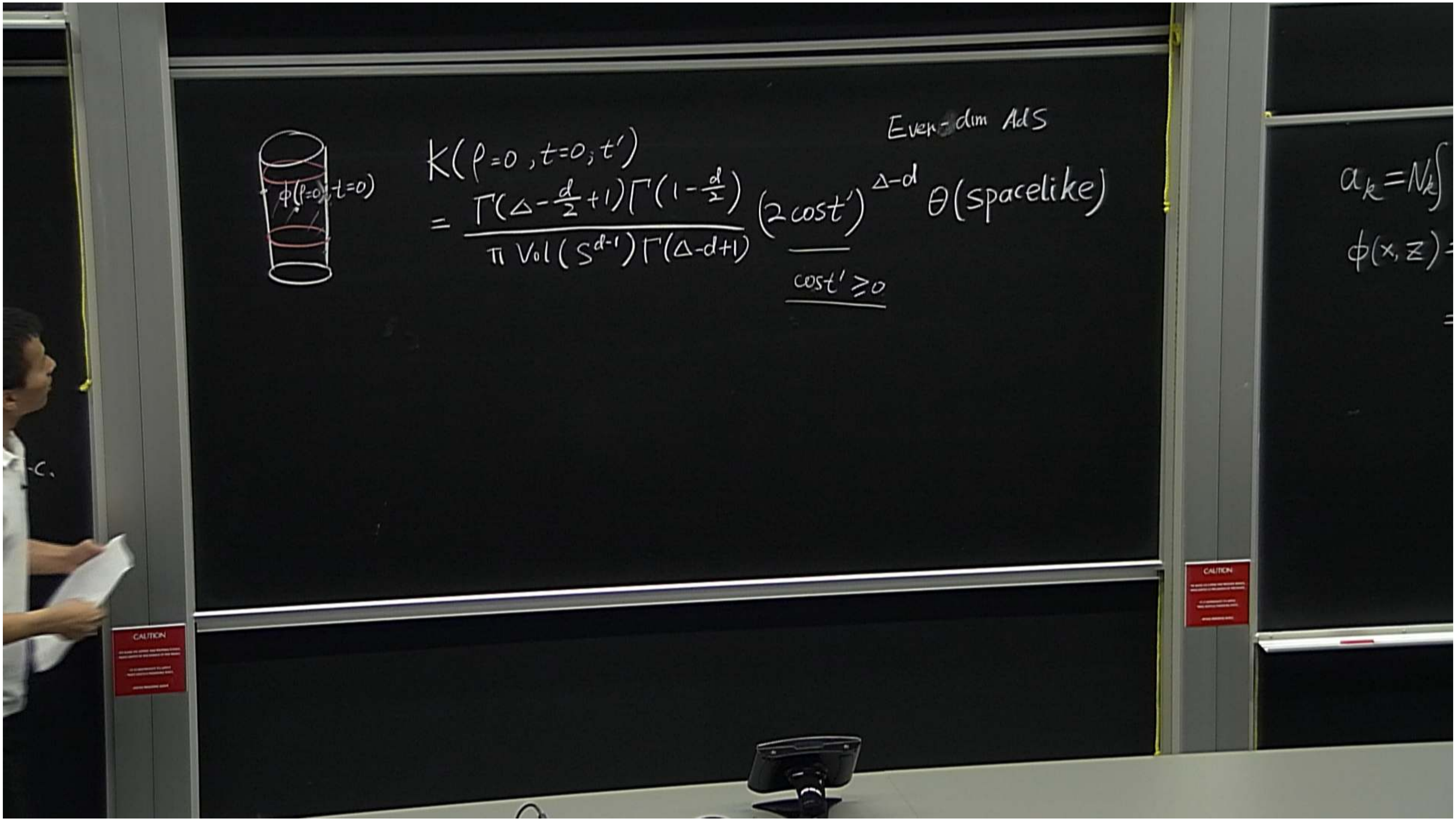
$$\phi(x,z) = \sum_{n=0}^{\infty} \sum_{lm} a_{nlm}\, e^{-i(2n+l+\Delta)t} \times$$

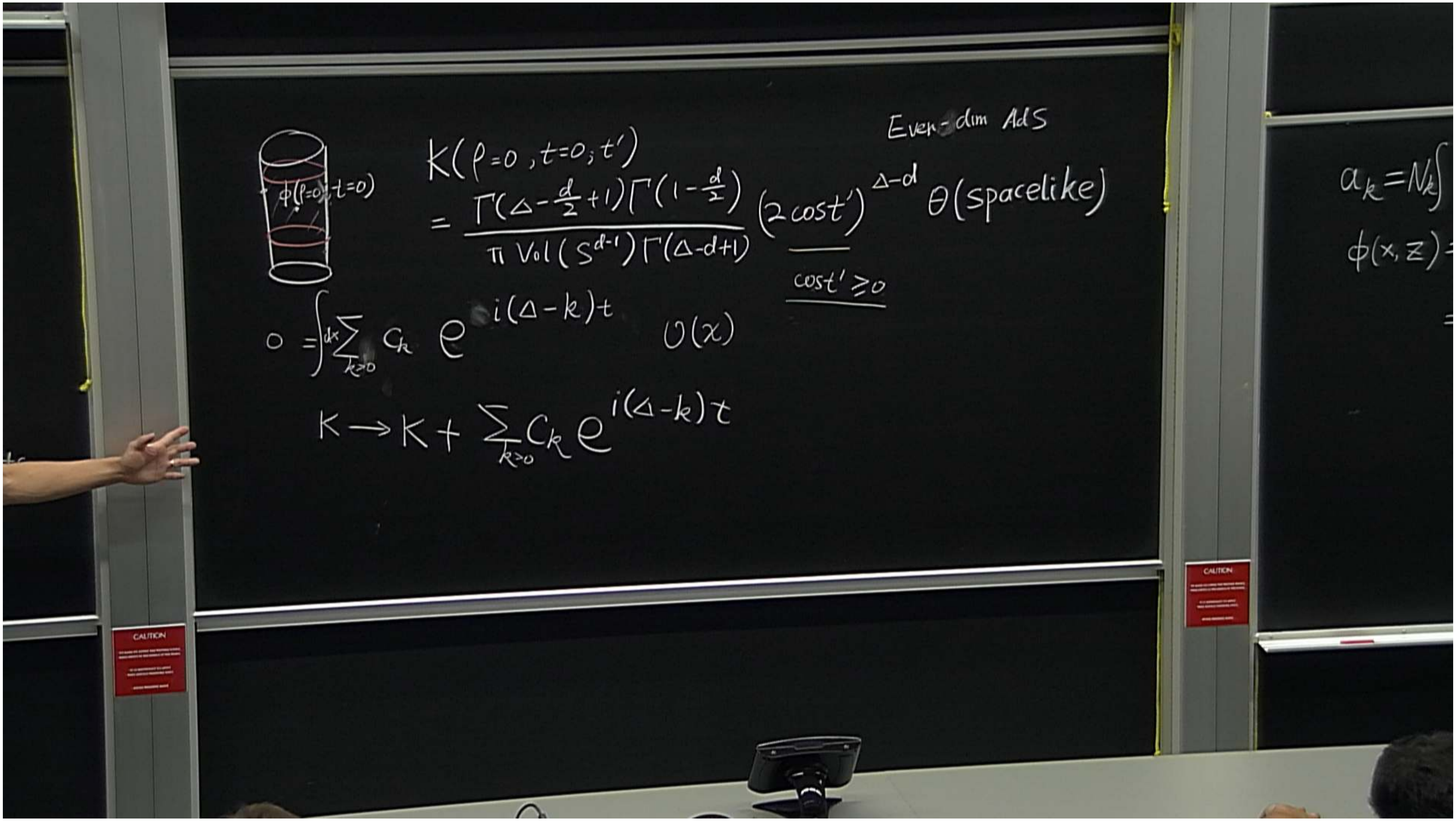
$$\times (\sin\rho)^l (\cos\rho)^\Delta P_n^{(\Delta-\frac{d}{2},\, l+\frac{d}{2}-1)}(-\cos 2\rho)\, Y_{lm}(\Omega) + c.c.$$

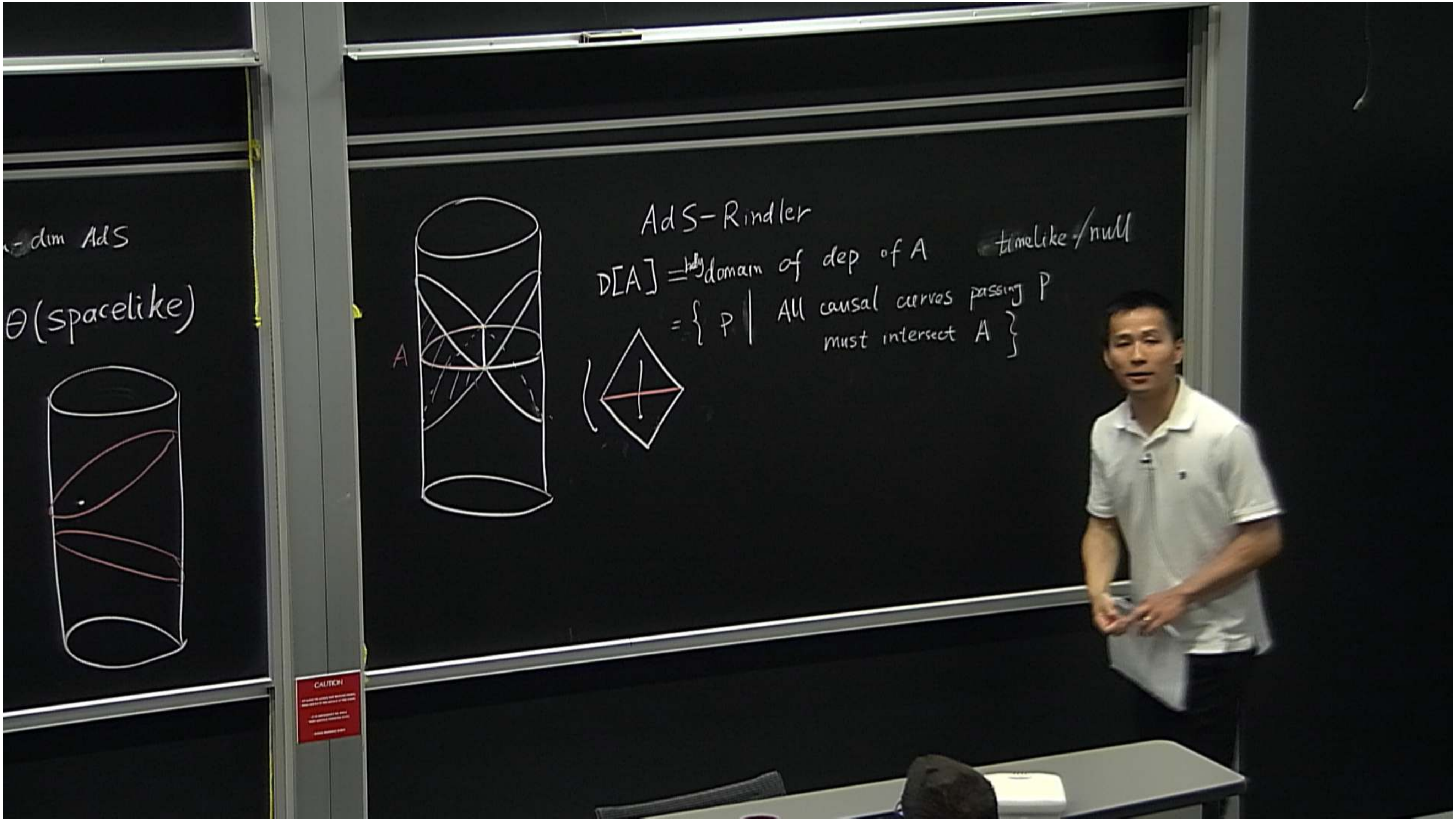
$z \sim \cos\rho$

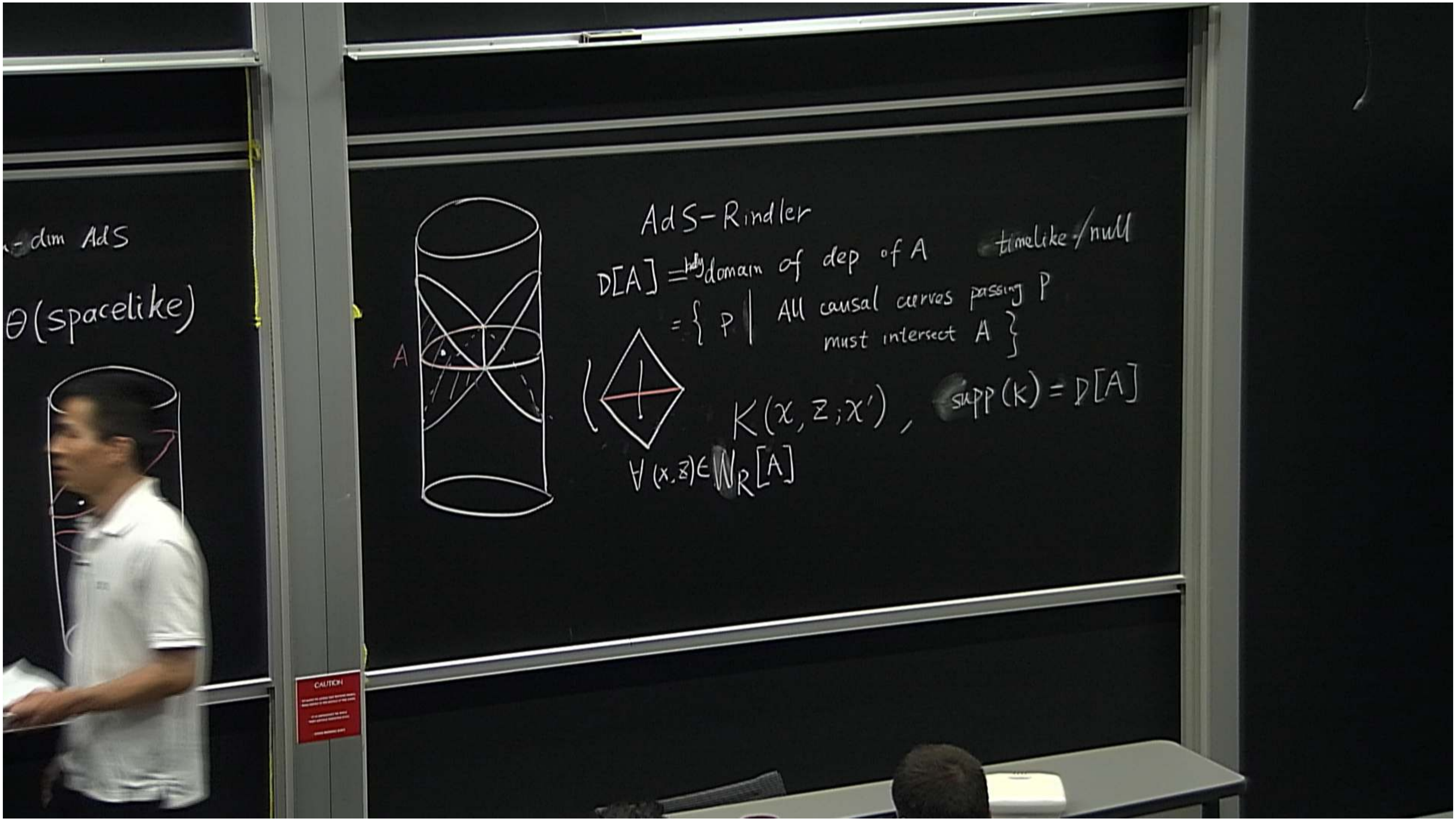
mode



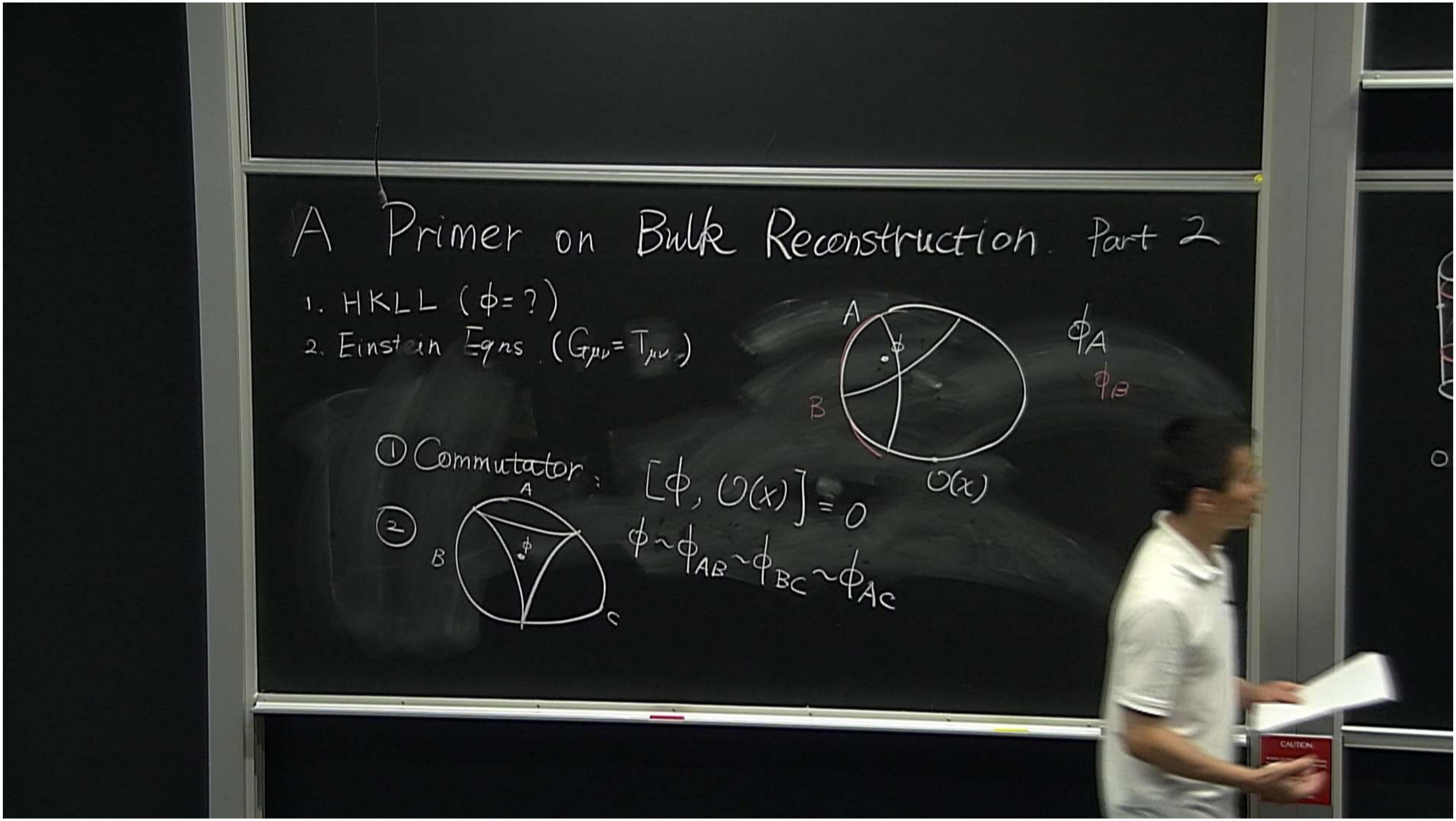

Even-dim AdS
$\phi(\rho=0, t=0)$
$K(\rho=0, t=0; t')$
$= \frac{\Gamma(\Delta-\frac{d}{2}+1)\Gamma(1-\frac{d}{2})}{\pi \, \mathrm{Vol}(S^{d-1})\Gamma(\Delta-d+1)} (2\cos t')^{\Delta-d} \, \theta(\text{spacelike})$
$\cos t' \geq 0$
$a_k = N_k \int$
$\phi(x, z) =$

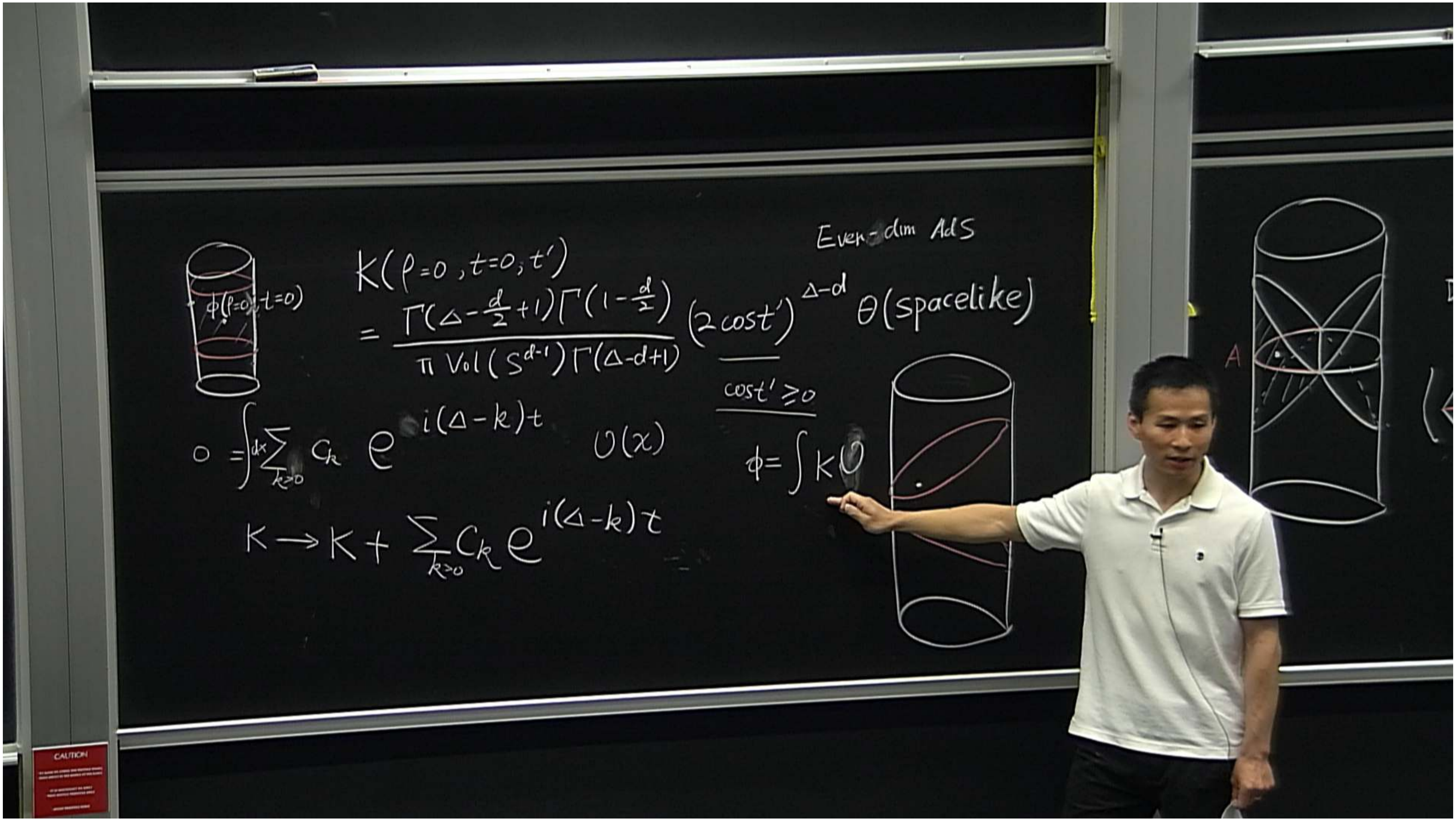

Even-dim AdS
K(ρ=0, t=0; t′)
ϕ(ρ=0, t=0)
= Γ(Δ − d/2 + 1) Γ(1 − d/2) / π Vol(S^{d−1}) Γ(Δ−d+1) (2 cos t′)^{Δ−d} θ(spacelike)
cos t′ ≥ 0
0 = ∫dx Σ_{k≥0} c_k e^{i(Δ−k)t} O(x)
K → K + Σ_{k≥0} c_k e^{i(Δ−k)t}
a_k = N_k ∫
ϕ(x, z) =

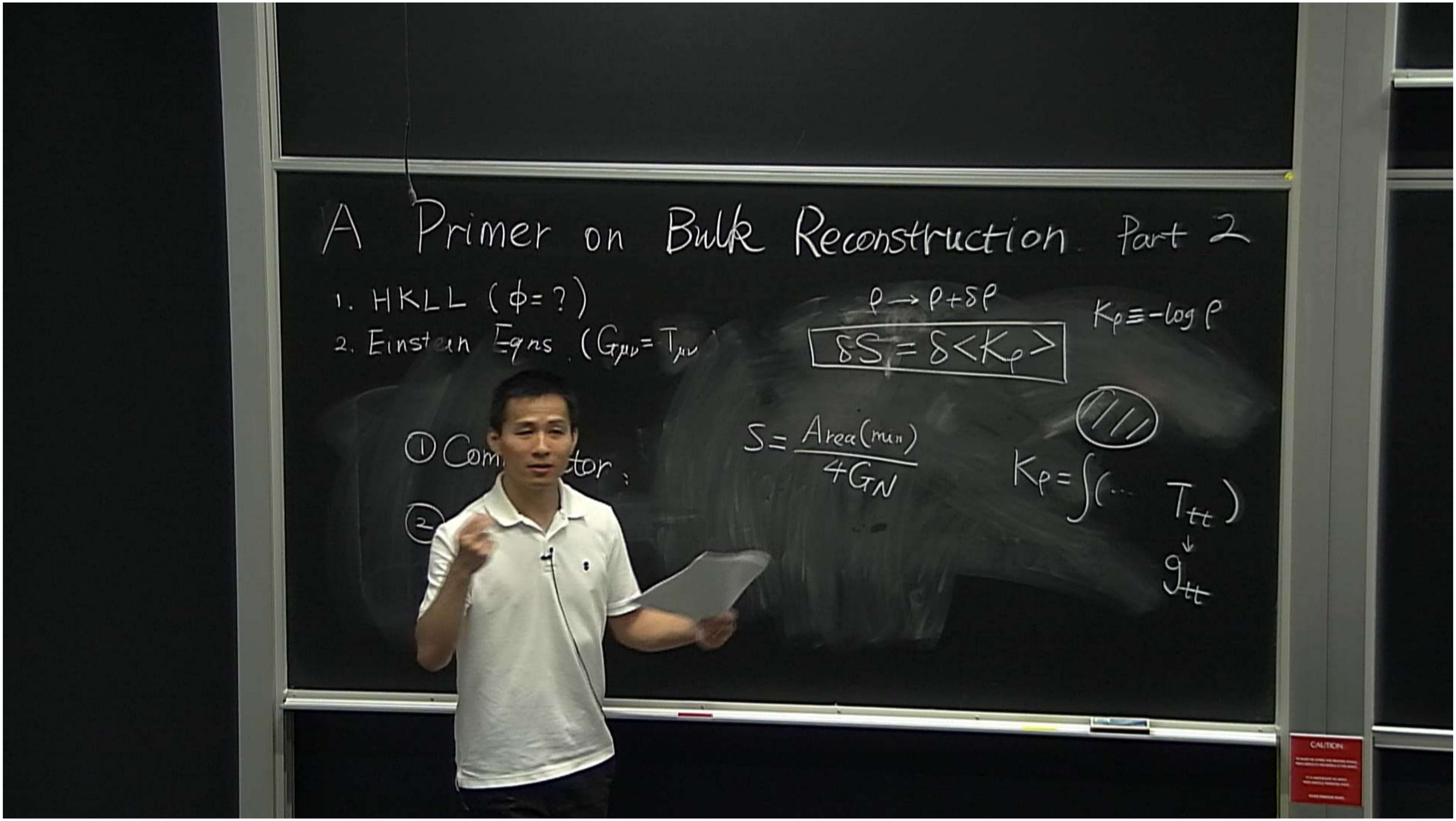

-dim AdS
Θ(spacelike)
A
AdS-Rindler
D[A] = bulk domain of dep of A
timelike / null
= { p | All causal curves passing p
must intersect A }



-dim AdS
Θ(spacelike)
AdS-Rindler
timelike/null
D[A] = bdy domain of dep of A
= { P | All causal curves passing P must intersect A }
A
K(x, z; x'), supp(K) = D[A]
∀ (x,z) ∈ W_R[A]


A Primer on Bulk Reconstruction. Part 2
1. HKLL (φ=?)
2. Einstein Eqns (G_μν = T_μν)
① Commutator: [φ, O(x)] = 0
②
φ ~ φ_AB ~ φ_BC ~ φ_AC
A
B
C
O(x)
φ_A
φ_B


Even-dim AdS
K(ρ=0, t=0; t′)
= Γ(Δ − d/2 + 1) Γ(1 − d/2) / (π Vol(S^{d-1}) Γ(Δ-d+1)) (2 cos t′)^{Δ-d} θ(spacelike)
cos t′ ≥ 0
φ(ρ=0, t=0)
0 = ∫dx Σ_{k>0} c_k e^{i(Δ-k)t} O(x)
φ = ∫ K O
K → K + Σ_{k>0} c_k e^{i(Δ-k)t}
A
CAUTION



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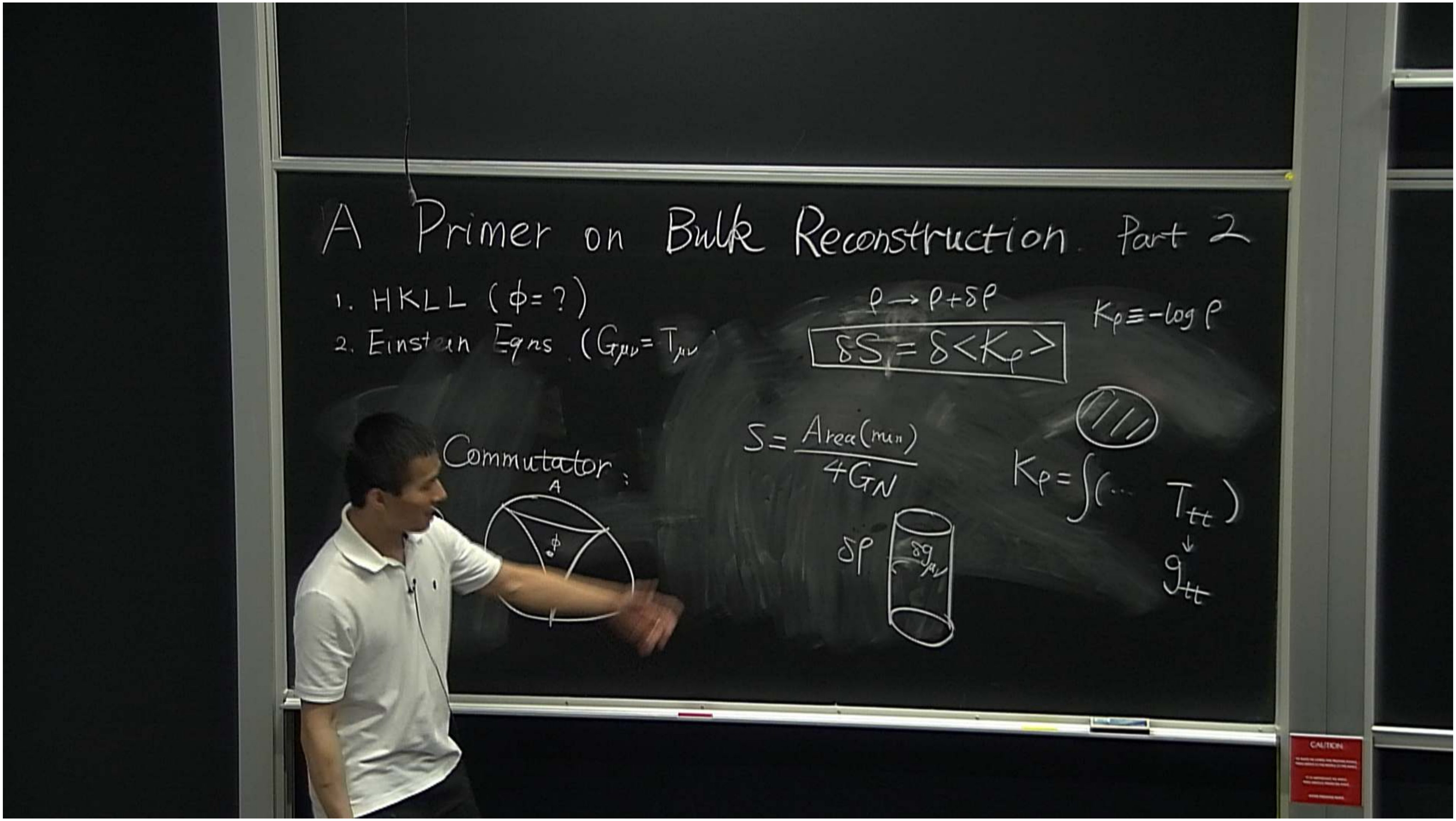
1. HKLL (ϕ = ?)
2. Einstein Eqns (Gμν = Tμν
ρ → ρ + δρ
δS = δ⟨Kρ⟩
Kρ ≡ −log ρ
① Com... ...tor :
②
S = Area(min) / 4GN
Kρ = ∫(... Ttt)
gtt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ρ → ρ + δρ
δS = δ<Kρ>
Kρ ≡ −log ρ
S = Area(min) / 4GN
Commutator:
A
ϕ
δρ
δgμν
Kρ = ∫(... Ttt)
gtt
CAUTION