Title: Critical Gravity from AdS Boundary

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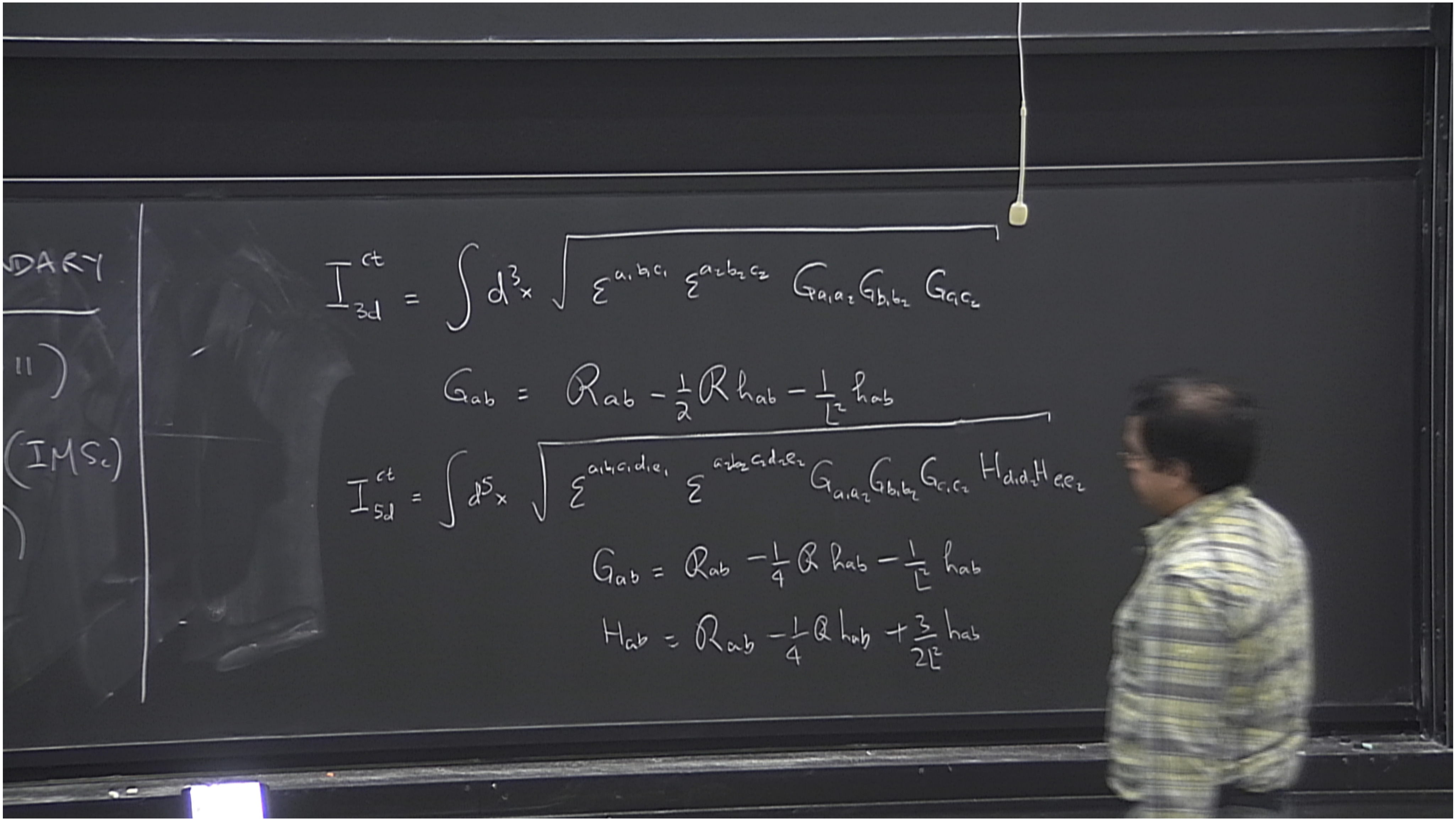
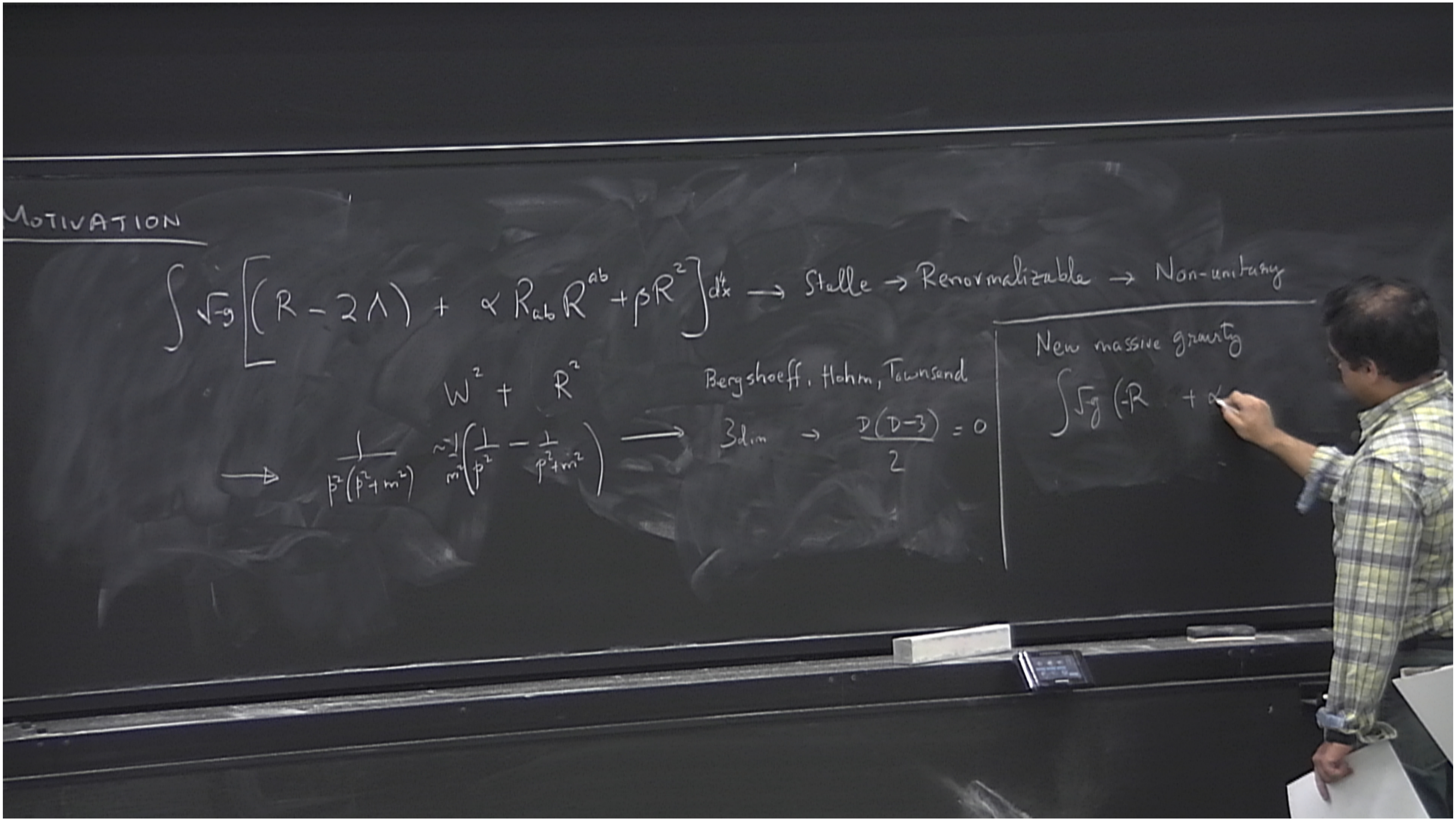
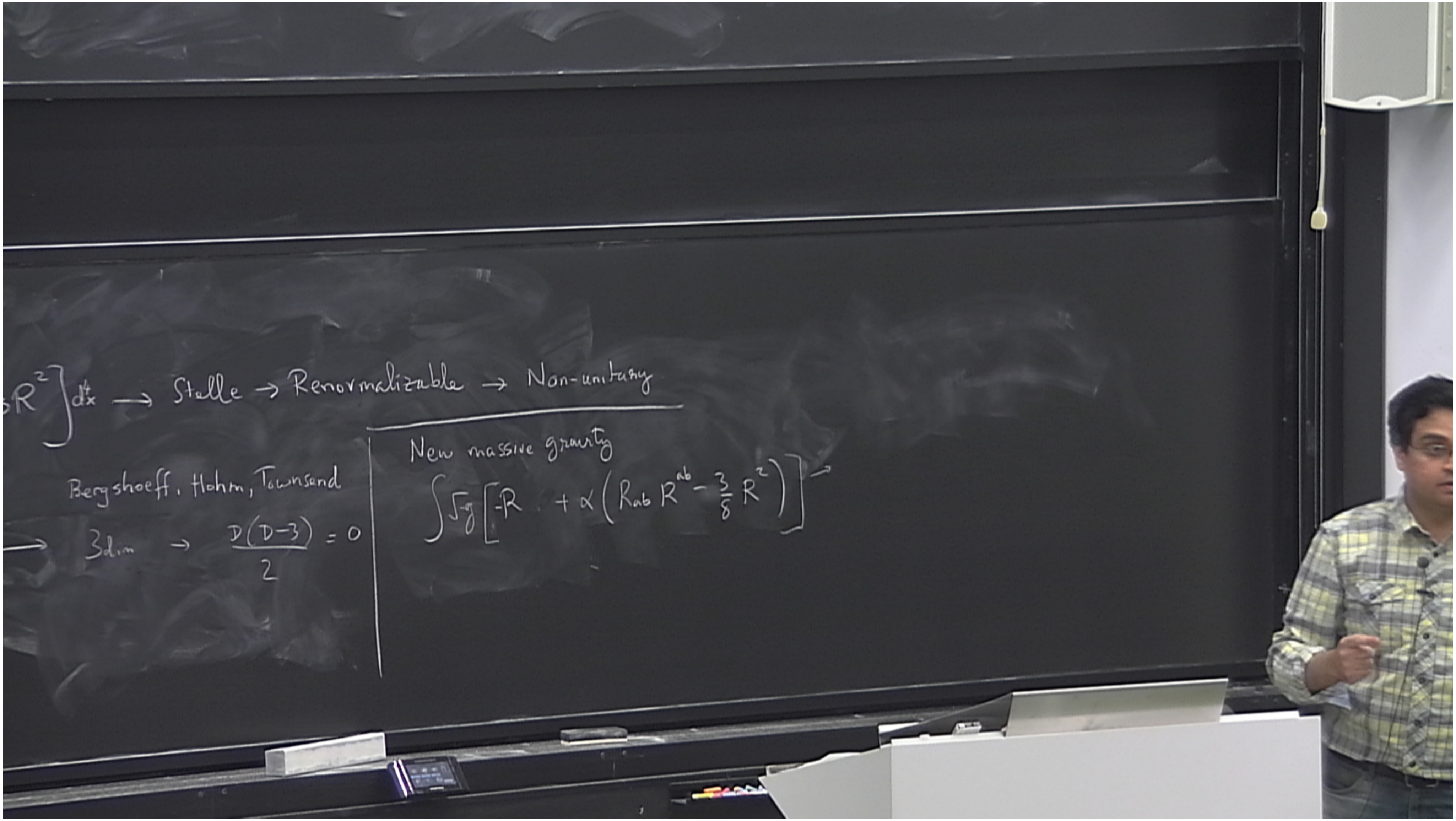
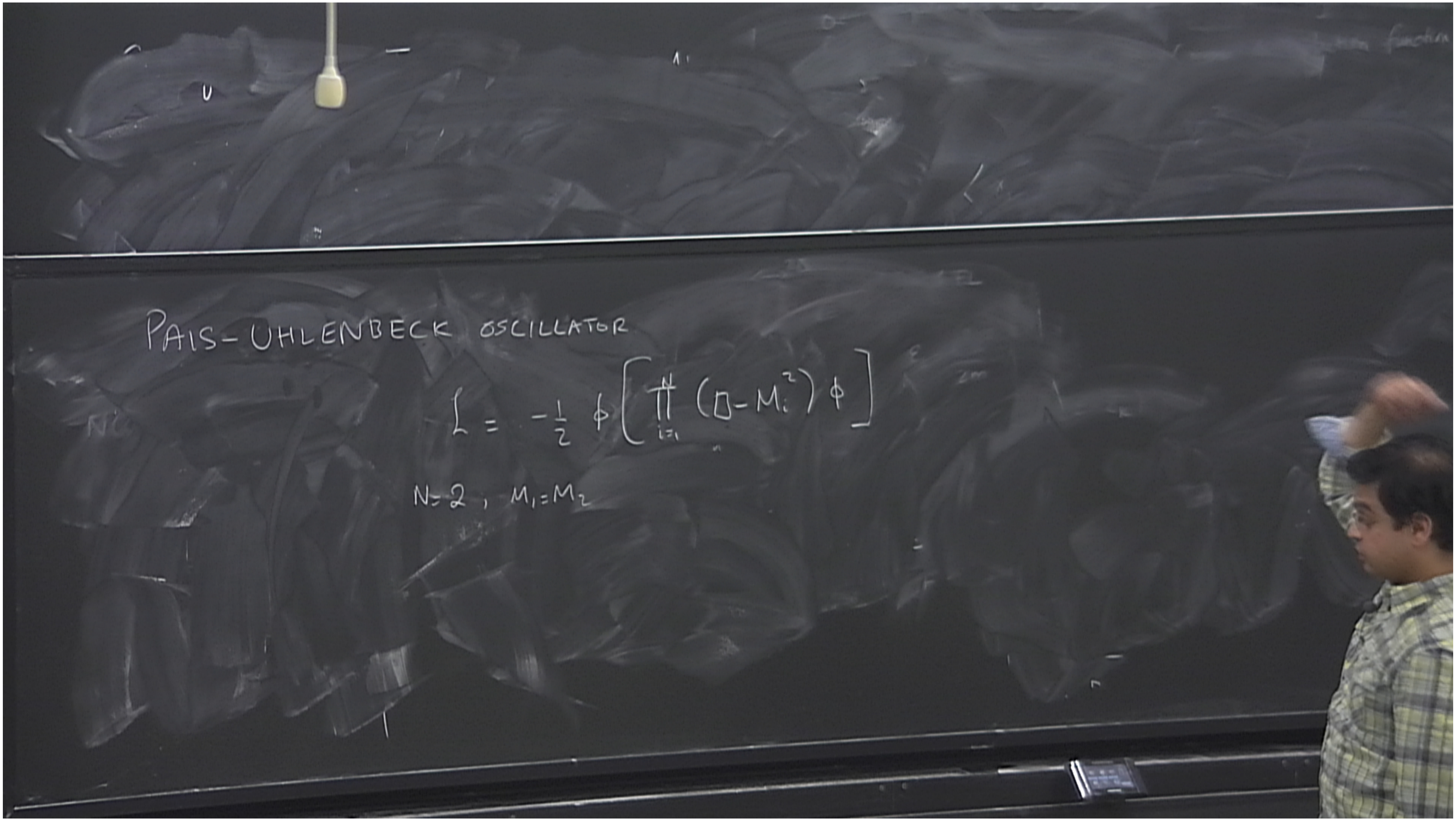
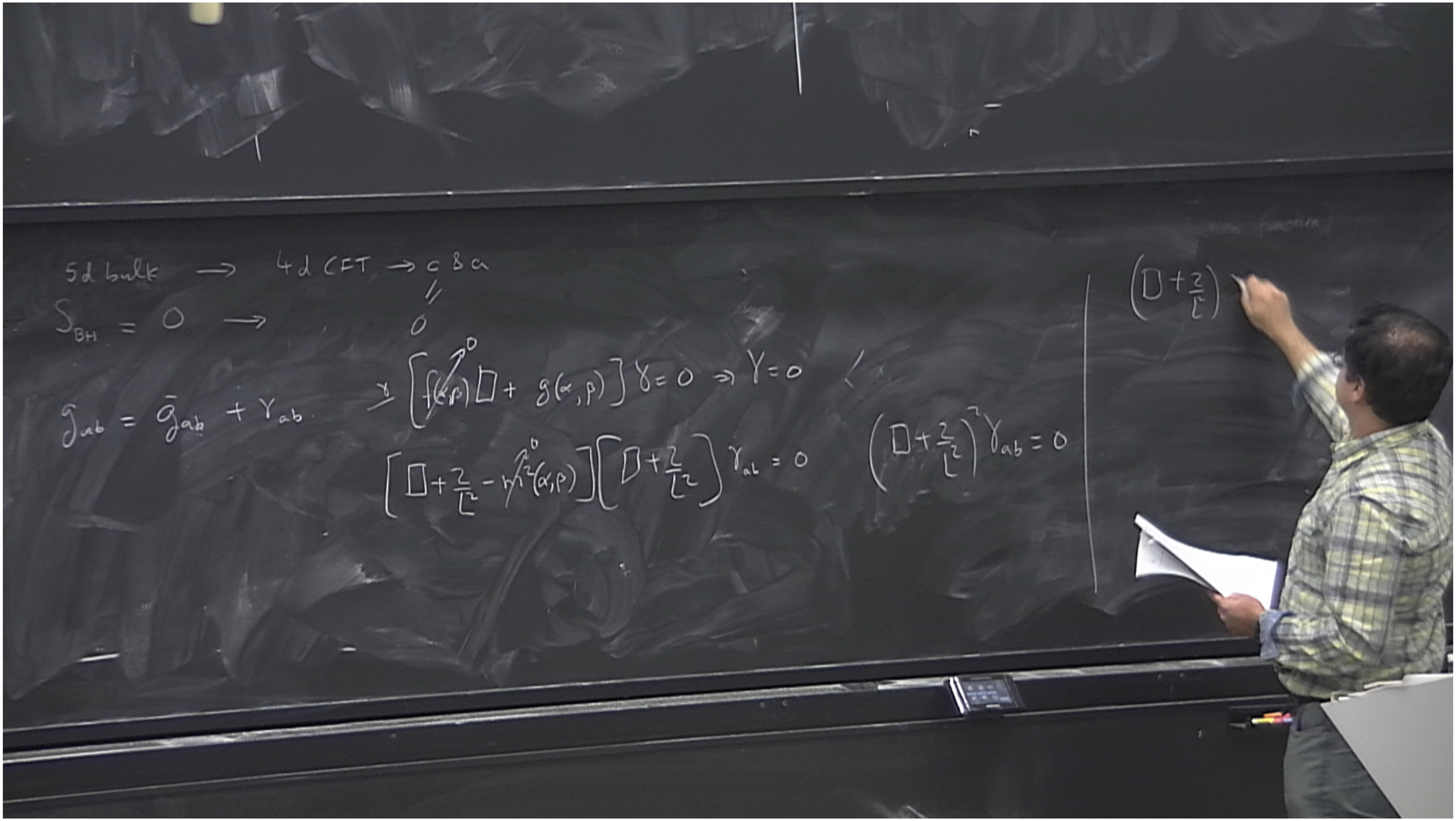
Abstract: Critical theories of gravity are certain higher derivative theories in which parameters are so tuned as to eliminate massive excitations for the spin-2 field. Asymptotically AdS black hole entropy in these theories works out to be zero. We show that such theories arise naturally on the boundary of AdS in the form of counterterms. Such counterterms are derived by demanding cutoff independence of the Euclidean onshell action and black hole entropy.
The resummed higher derivative action so obtained can be shown to be critical. Connections with log-CFTs will be discussed. For a specific choice of parameters, these theories turn out to be non-dynamical.

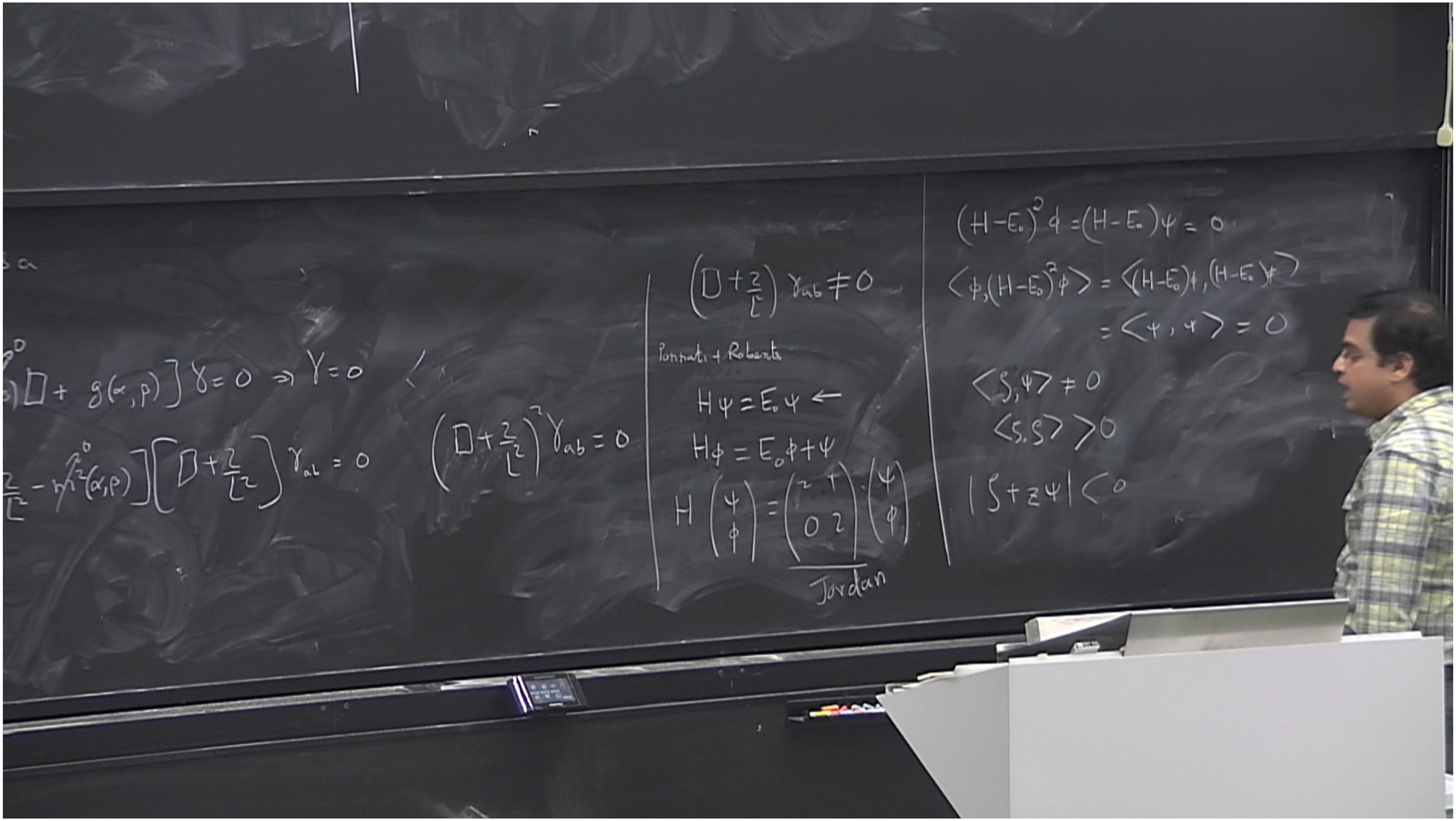

DARY
(IMS$_c$)
$I^{ct}_{3d} = \int d^3x \sqrt{\varepsilon^{a_1b_1c_1}\varepsilon^{a_2b_2c_2} G_{a_1a_2}G_{b_1b_2}G_{c_1c_2}}$
$G_{ab} = R_{ab} - \frac{1}{2} R h_{ab} - \frac{1}{L^2} h_{ab}$
$I^{ct}_{5d} = \int d^5x \sqrt{\varepsilon^{a_1b_1c_1d_1e_1}\varepsilon^{a_2b_2c_2d_2e_2} G_{a_1a_2}G_{b_1b_2}G_{c_1c_2}H_{d_1d_2}H_{e_1e_2}}$
$G_{ab} = R_{ab} - \frac{1}{4} R h_{ab} - \frac{1}{L^2} h_{ab}$
$H_{ab} = R_{ab} - \frac{1}{4} R h_{ab} + \frac{3}{2L^2} h_{ab}$

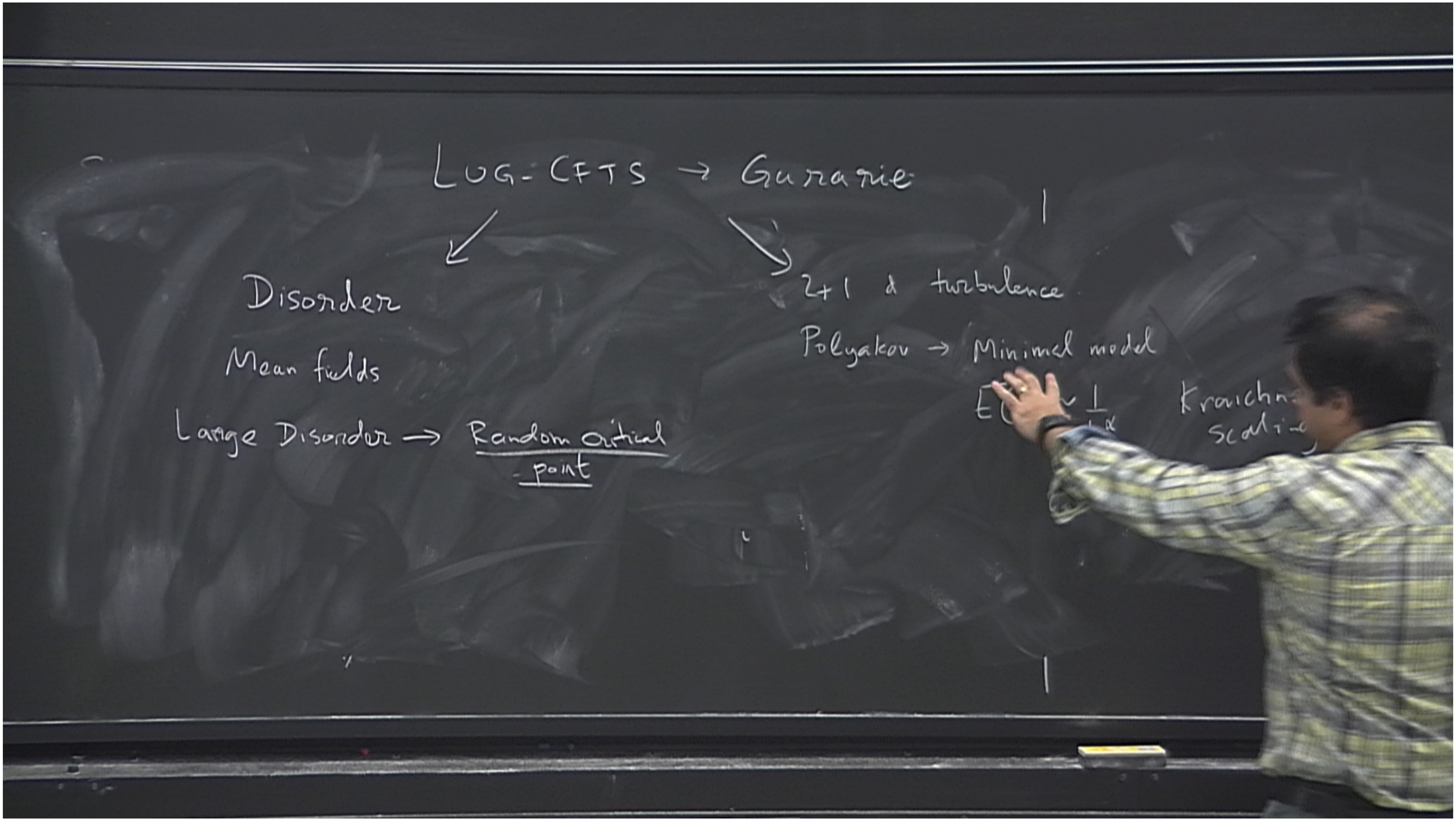

MOTIVATION
$\int \sqrt{-g}\left[(R-2\Lambda) + \alpha R_{ab}R^{ab} + \beta R^2\right] d^4x \longrightarrow$ Stelle $\to$ Renormalizable $\to$ Non-unitary
$W^2 + R^2$
$\longrightarrow \frac{1}{p^2(p^2+m^2)} \sim \frac{1}{m^2}\left(\frac{1}{p^2} - \frac{1}{p^2+m^2}\right) \longrightarrow$
Bergshoeff, Hohm, Townsend
3dim $\to \frac{D(D-3)}{2} = 0$
New massive gravity
$\int \sqrt{-g}\,(-R + \alpha$

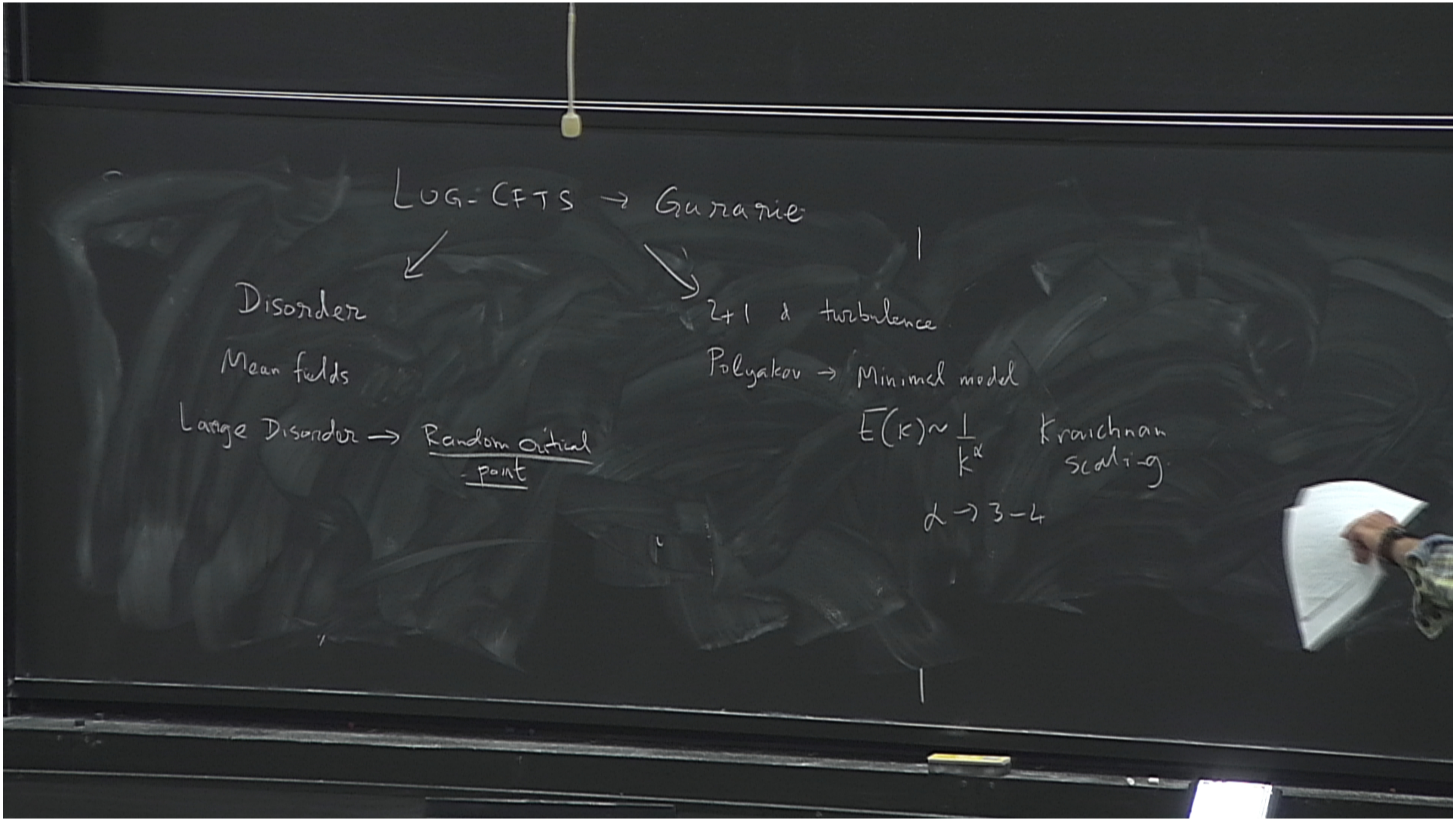

R²] d⁴x → Stelle → Renormalizable → Non-unitary
Bergshoeff, Hohm, Townsend
→ 3dim → D(D−3)/2 = 0
New massive gravity
∫√-g [-R + α (R_ab R^ab − 3/8 R²)] →


PAIS-UHLENBECK OSCILLATOR
$\mathcal{L} = -\frac{1}{2} \phi \left[\prod_{i=1}^{N} (\Box - M_i^2) \phi \right]$
$N=2, \; M_1 = M_2$


5d bulk → 4d CFT → c & a
S_BH = 0 → 0
[f(α,β) □ + g(α,β)] γ = 0 ⇒ γ = 0
g_ab = ḡ_ab + γ_ab
[□ + 2/l² − m²(α,β)] [□ + 2/l²] γ_ab = 0
(□ + 2/l²)² γ_ab = 0
(□ + 2/l²)


$\left(\Box + \frac{2}{L^2}\right) \gamma_{ab} \neq 0$
Porrati + Roberts
$H\psi = E_0 \psi$
$H\phi = E_0\phi + \psi$
Jordan
$\left(\Box + \frac{2}{L^2}\right)^2 \gamma_{ab} = 0$
$(H-E_0)^2 \phi = (H-E_0)\psi = 0$
$\langle \phi, (H-E_0)^2\phi \rangle = \langle (H-E_0)\phi, (H-E_0)\phi \rangle$
$= \langle \psi, \psi \rangle = 0$
$\langle \zeta, \psi \rangle \neq 0$
$\langle \zeta, \zeta \rangle > 0$
$|\zeta + z\psi| < 0$


LOG-CFTS → Gurarie
Disorder
Mean fields
Large Disorder → Random critical point
2+1 d turbulence
Polyakov → Minimal model

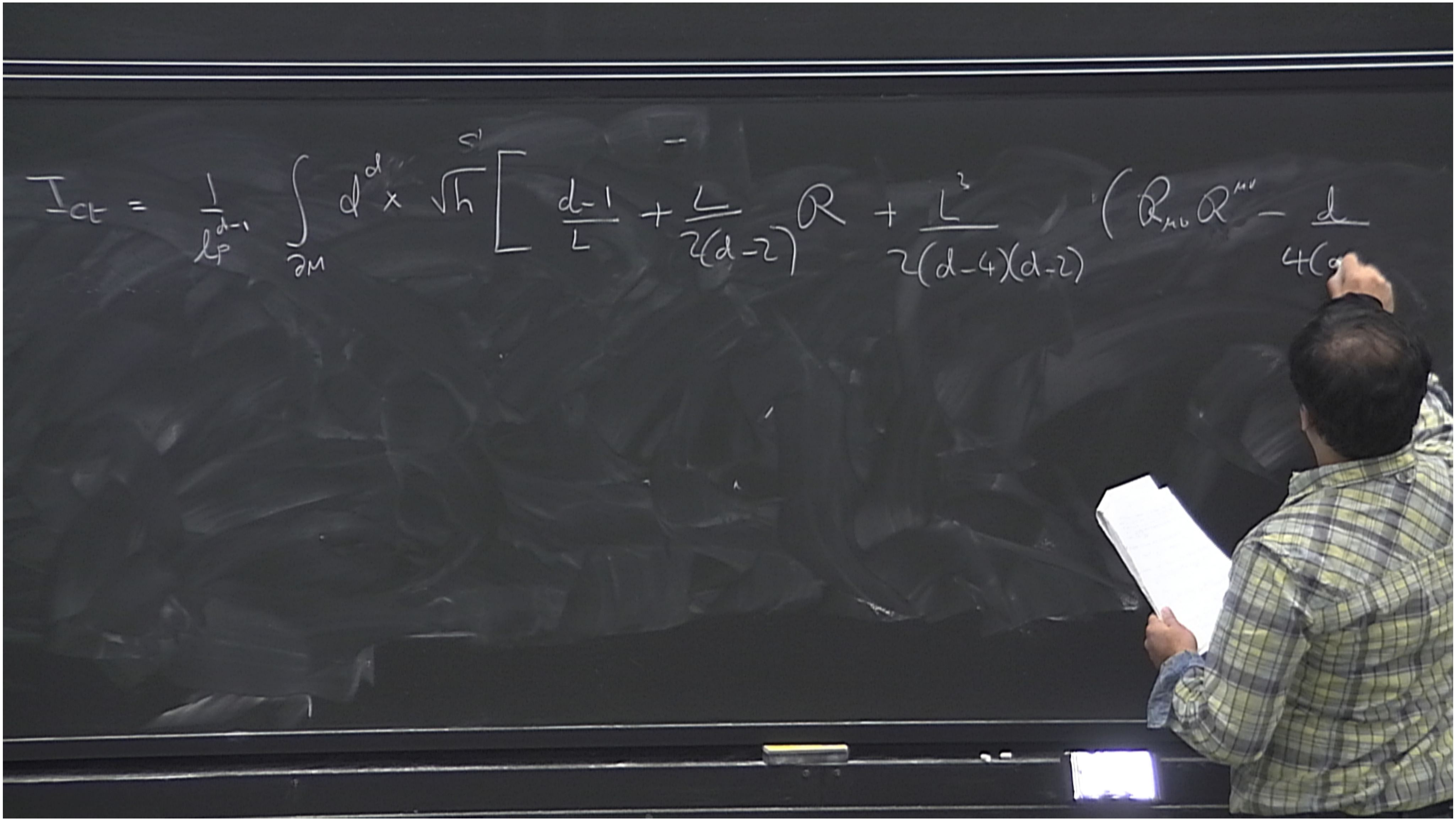

LOG-CFTS → Gurarie
Disorder
Mean fields
Large Disorder → Random critical point
2+1 d turbulence
Polyakov → Minimal model
$E(k) \sim \frac{1}{k^{\alpha}}$
Kraichnan scaling
$\alpha \to 3-4$

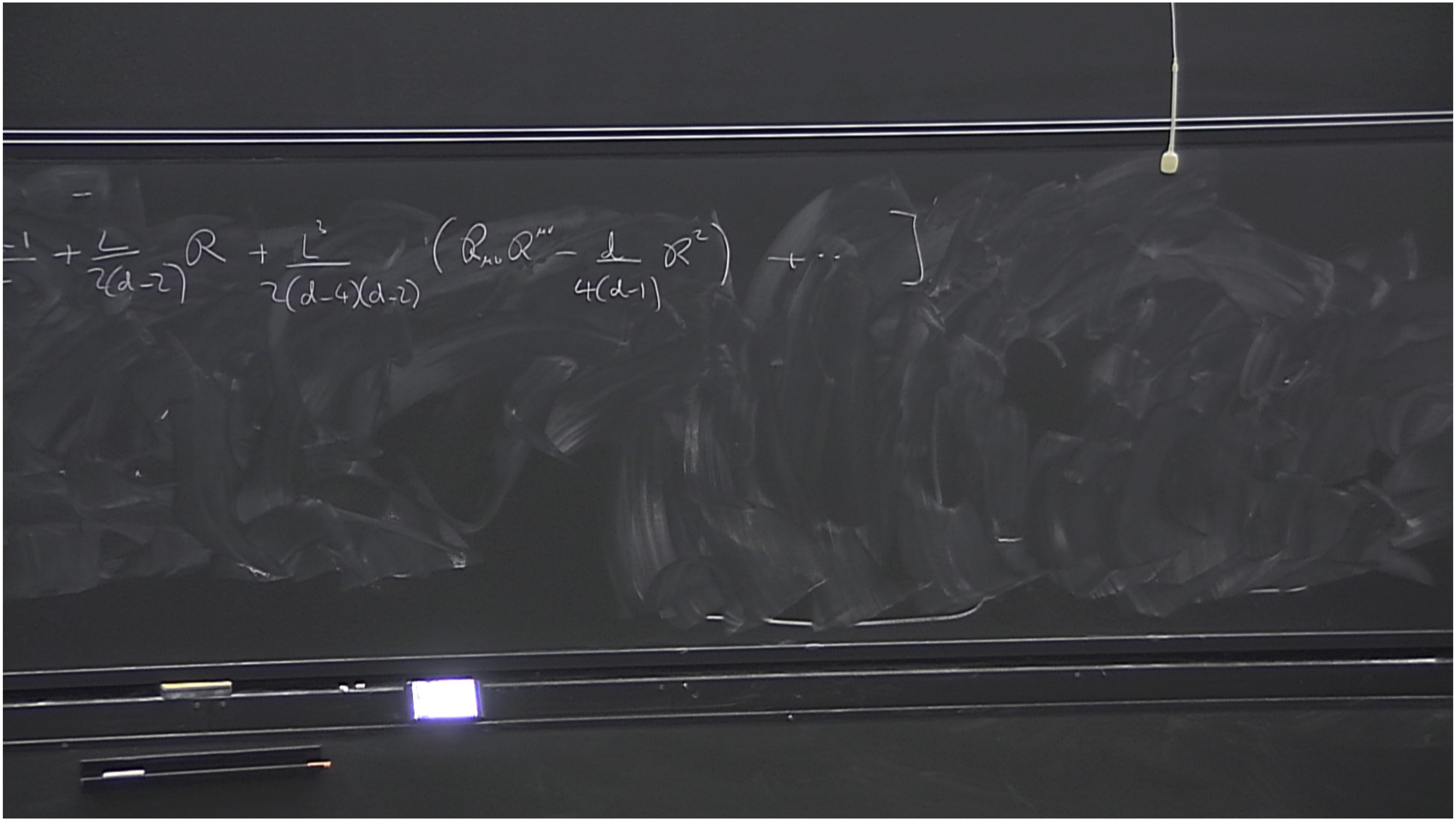
$$\left(R_{ab}R^{ab} - \frac{n}{4(n-1)}R^2\right)$$

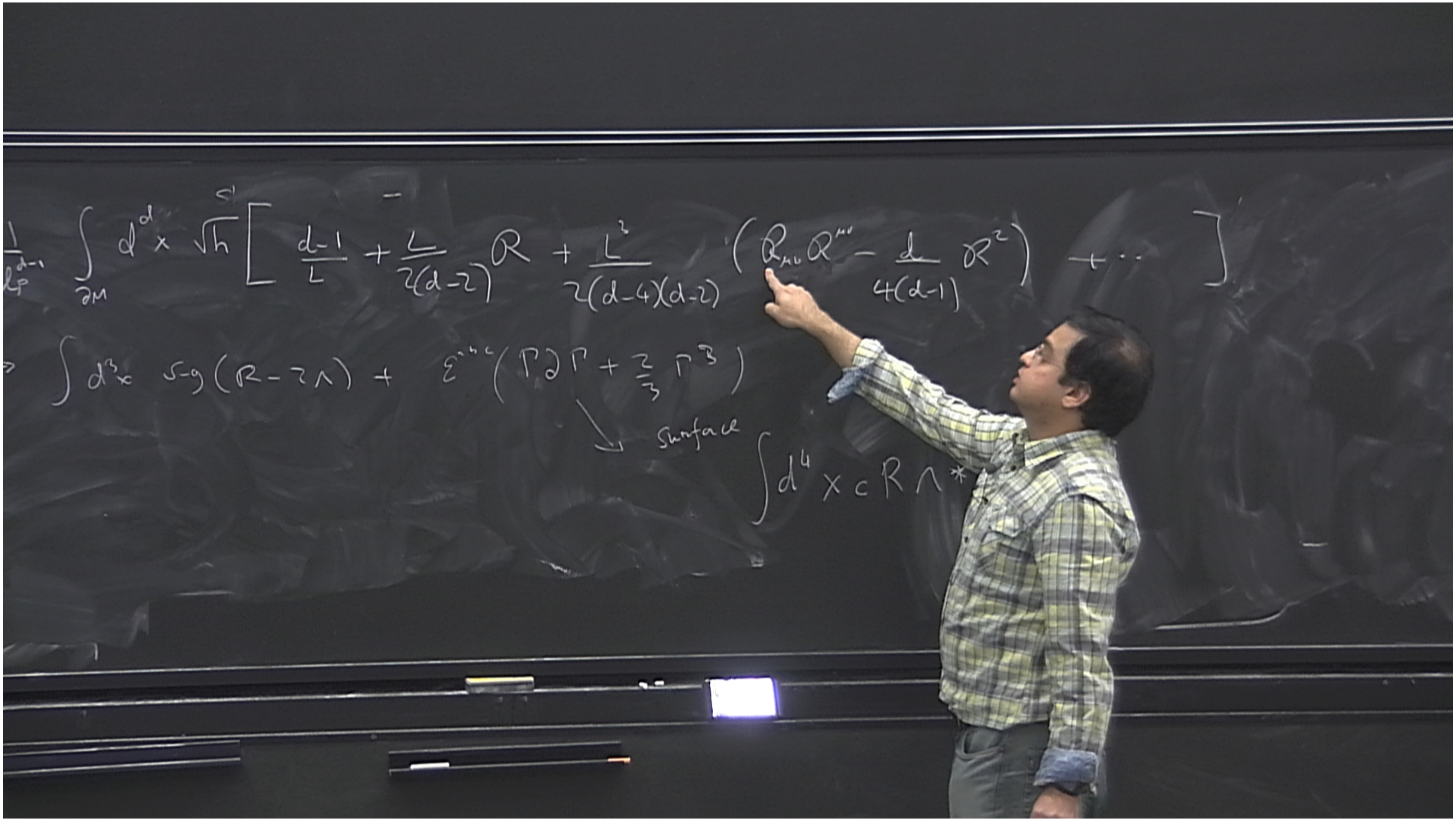
mparan + Johnson + Myers 9903238

$$I = -\frac{1}{2\ell_p^{d-1}}\int d^{d+1}x\,\sqrt{-g}\left(R + \frac{d(d-1)}{L^2}\right) - \frac{1}{\ell_p^{d-1}}\int_{\partial M} d^d x\,\sqrt{h}\,K$$

$$+\ I_{ct}$$


S'
$I_{ct} = \frac{1}{l_p^{d-1}} \int_{\partial M} d^d x \sqrt{h} \Big[\frac{d-1}{L} + \frac{L}{2(d-2)} R + \frac{L^3}{2(d-4)(d-2)} \Big(R_{\mu\nu} R^{\mu\nu} - \frac{d}{4(d}$


$-1 + \frac{L}{2(d-2)} R + \frac{L^3}{2(d-4)(d-2)} \left(R_{\mu\nu} R^{\mu\nu} - \frac{d}{4(d-1)} R^2 \right) + \cdots \Big]$


$\frac{1}{l_p^{d-1}} \int_{\partial M} d^d x \sqrt{h} \left[\frac{d-1}{L} + \frac{L}{2(d-2)} R + \frac{L^3}{2(d-4)(d-2)} \left(R_{\mu\nu} R^{\mu\nu} - \frac{d}{4(d-1)} R^2 \right) + \cdots \right]$
$\int d^3x \sqrt{-g} (R - 2\Lambda) + \varepsilon^{abc} \left(\Gamma \partial \Gamma + \frac{2}{3} \Gamma^3 \right)$
surface
$\int d^4 x \, c \, R \wedge *$

NDARY

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(IMS$_c$)

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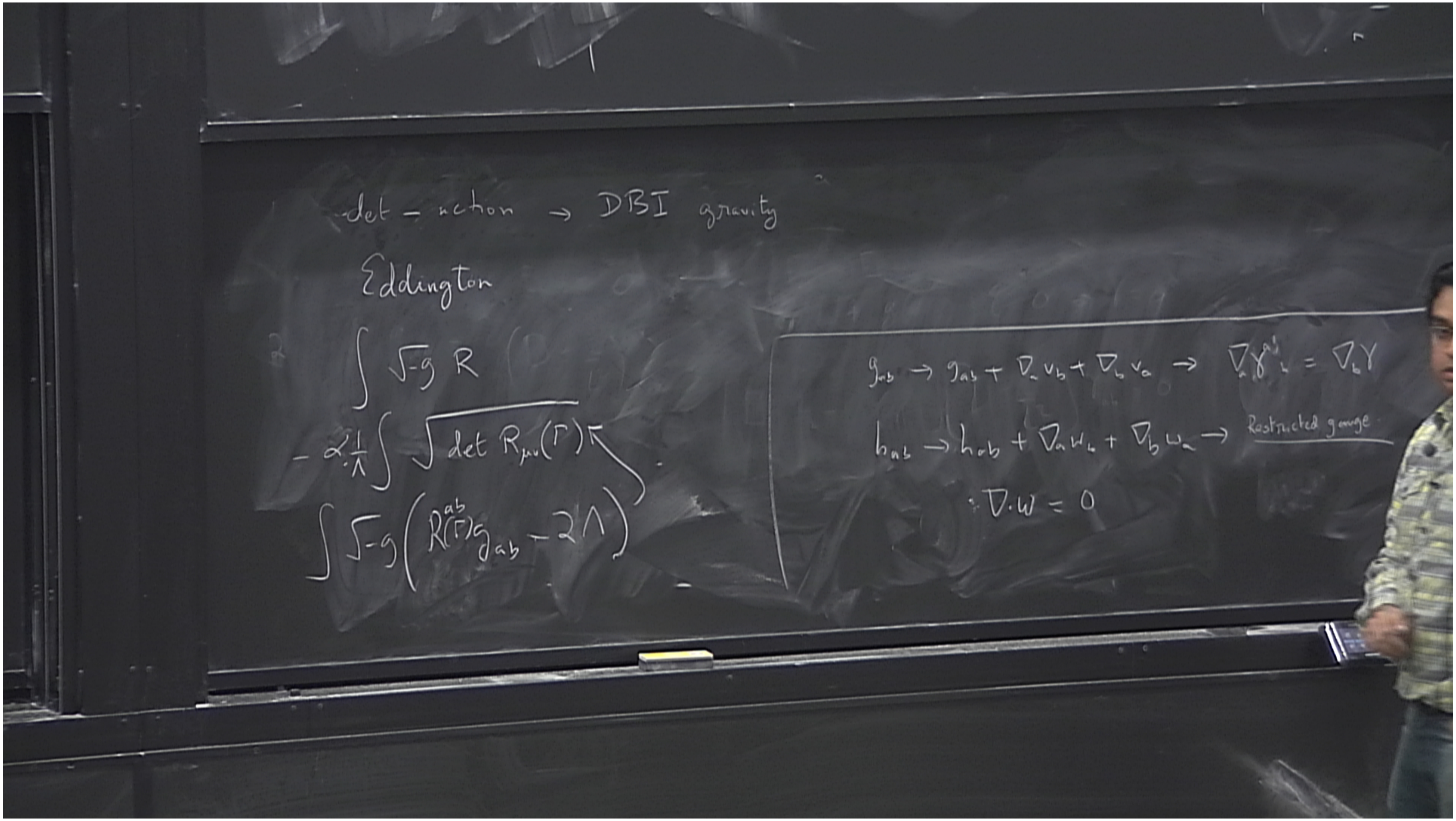
$$I^{ct}_{3d} = \int d^3x \sqrt{\varepsilon^{a_1b_1c_1}\,\varepsilon^{a_2b_2c_2}\, G_{a_1a_2}G_{b_1b_2}G_{c_1c_2}}$$

$$G_{ab} = R_{ab} - \frac{1}{2} R\, h_{ab} - \frac{1}{L^2} h_{ab}$$

$$I^{ct}_{5d} = \int d^5x \sqrt{\varepsilon^{a_1b_1c_1d_1e_1}\,\varepsilon^{a_2b_2c_2d_2e_2}\, G_{a_1a_2}G_{b_1b_2}G_{c_1c_2} H_{d_1d_2}H_{e_1e_2}}$$

$$G_{ab} = R_{ab} - \frac{1}{4} R\, h_{ab} - \frac{1}{L^2} h_{ab}$$

$$H_{ab} = R_{ab} - \frac{1}{4} R\, h_{ab} + \frac{3}{2L^2} h_{ab}$$


det - action → DBI gravity
Eddington
$\int \sqrt{-g}\, R$
$- \alpha \cdot \frac{1}{\Lambda} \int \sqrt{\det R_{\mu\nu}(\Gamma)}$
$\int \sqrt{-g} \left(R^{ab}(\Gamma) g_{ab} - 2\Lambda \right)$
$g_{ab} \to g_{ab} + \nabla_a v_b + \nabla_b v_a \to \nabla_a \gamma^{ab} = \nabla_b \gamma$
$h_{ab} \to h_{ab} + \nabla_a w_b + \nabla_b w_a \to$ Restricted gauge
$\nabla \cdot w = 0$

$$\varepsilon^{a_2 b_2 c_2} G_{a_1 a_2} G_{b_1 b_2} G_{c_1 c_2}$$

$$S = C_s T^{\alpha}$$

$$\frac{1}{2} R h_{ab} - \frac{1}{L^2} h_{ab}$$

$$\varepsilon^{a_2 b_2 c_2 d_2 e_2} G_{a_1 a_2} G_{b_1 b_2} G_{c_1 c_2} H_{d_1 d_2} H_{e_1 e_2}$$

$$R_{ab} - \frac{1}{4} R h_{ab} - \frac{1}{L^2} h_{ab}$$

$$= R_{ab} - \frac{1}{4} R h_{ab} + \frac{3}{2L^2} h_{ab}$$

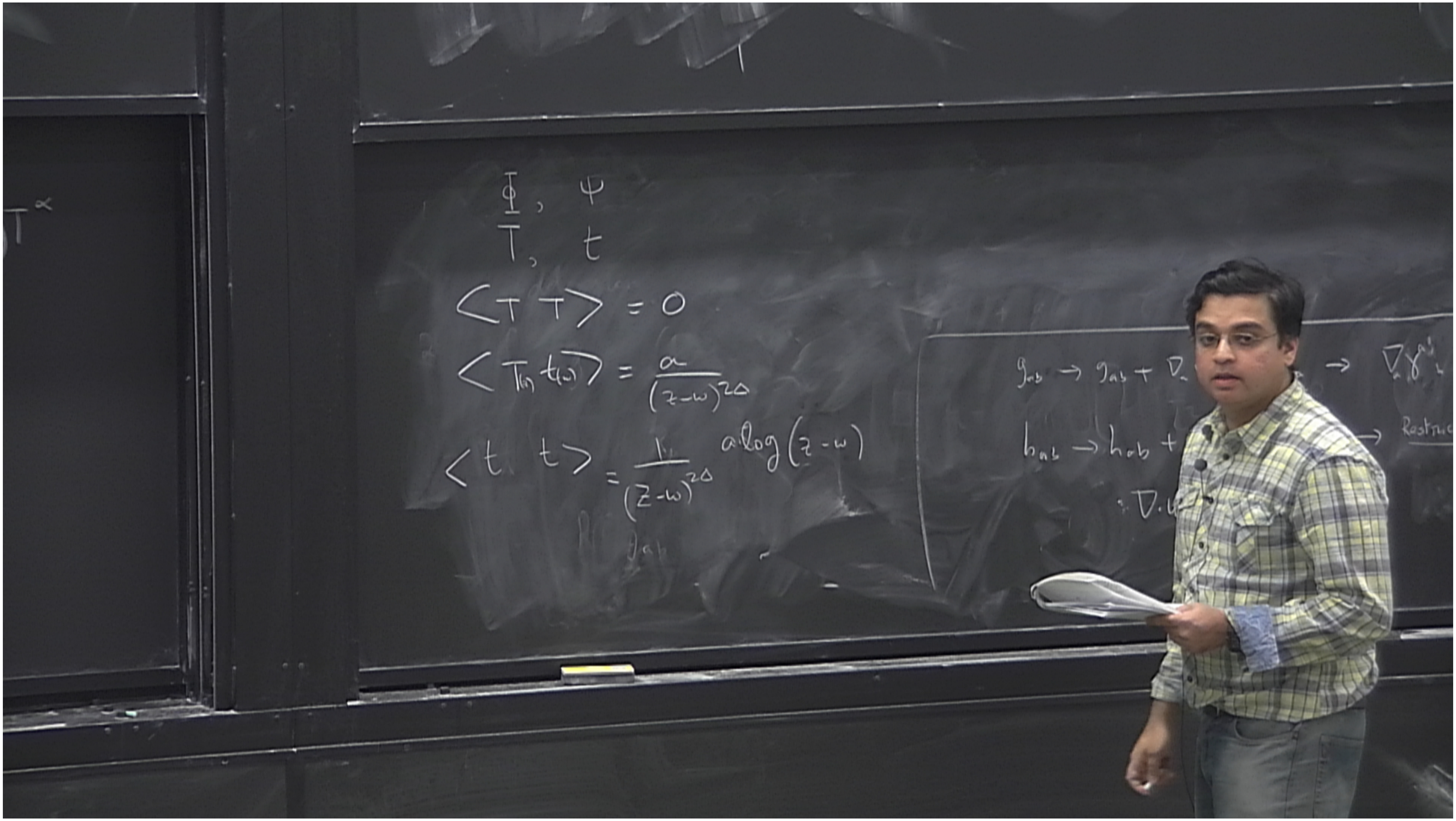
det - action → DBI

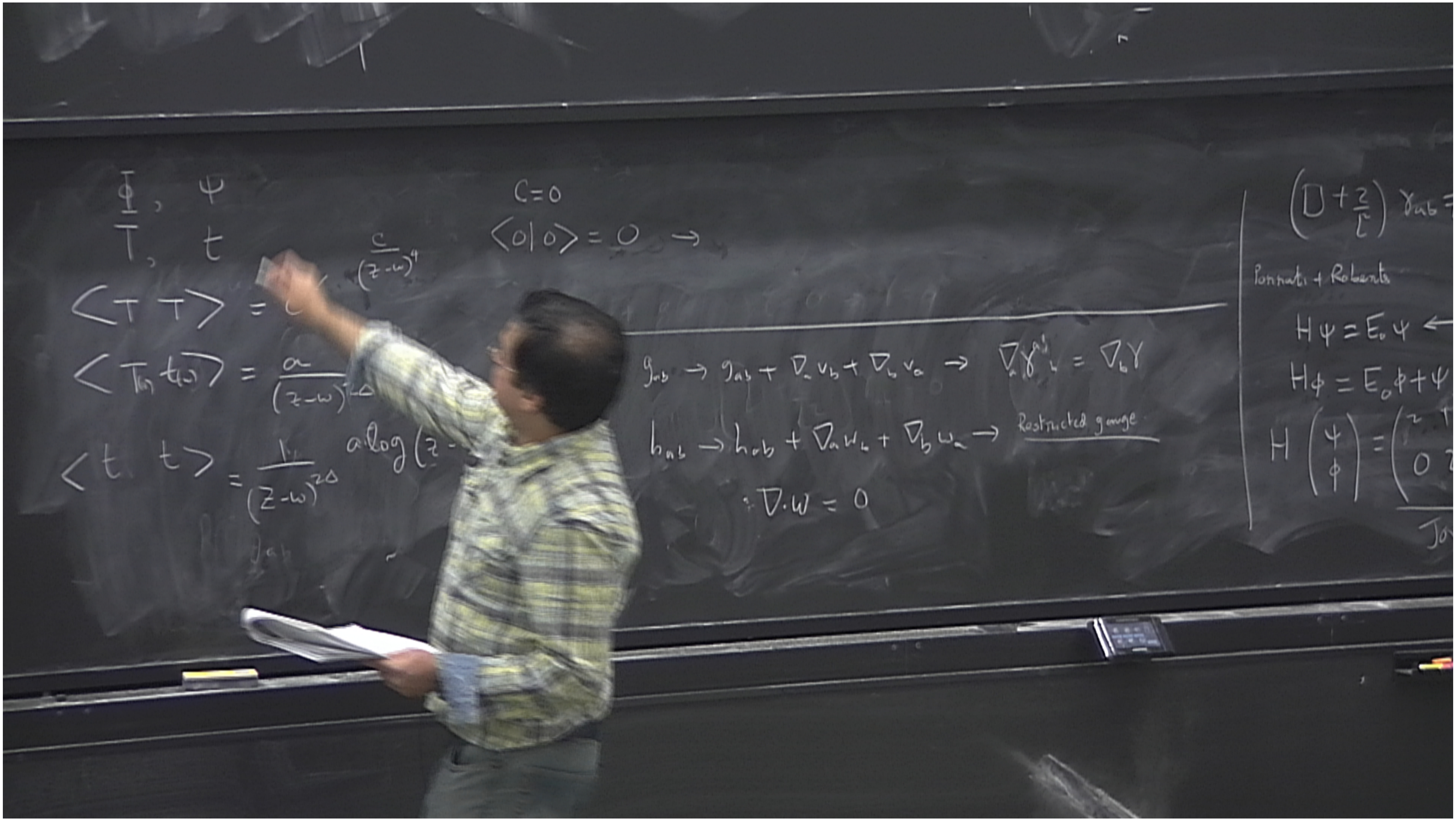
Eddington

$$\int \sqrt{-g}\, R$$

$$-\alpha \frac{1}{\Lambda} \int \sqrt{\det R_{\mu\nu}(\Gamma)}$$

$$\int \sqrt{-g} \left(R^{ab}(\Gamma) g_{ab} - 2\Lambda \right)$$


Φ, Ψ
T, t
⟨T T⟩ = 0
⟨T(z) t(w)⟩ = a / (z-w)^{2Δ}
⟨t t⟩ = 1 / (z-w)^{2Δ} a log(z-w)


Restricted gauge

$\Phi, \ \psi$ ← Rank-n Jordan cell

$T, \ t$

$c=0$

$\langle 0|0\rangle = 0 \rightarrow$

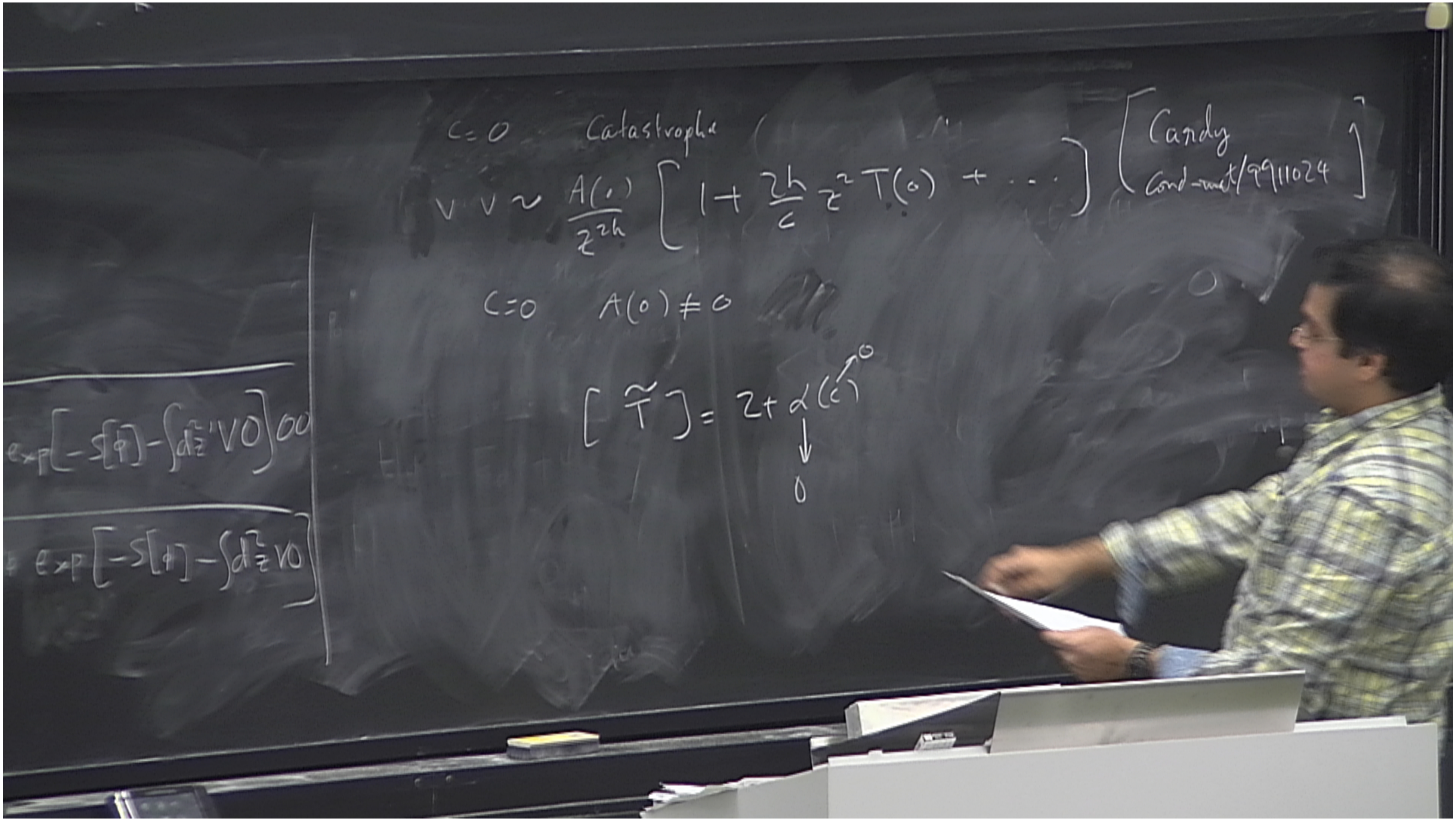
$\langle T \, T\rangle = 0$ ← $\frac{c}{(z-w)^4}$

$\langle T(z)\, t(w)\rangle = \frac{a}{(z-w)^{2\Delta}}$

$\langle t \ t\rangle = \frac{b}{(z-w)^{2\Delta}} \ a \log(z-w))^{n-1}$

Quenched disorder

$$\langle O \ O\rangle = \int \mathcal{D}V \, P[V] \, \frac{\int \mathcal{D}\phi \, \exp\left[-S[\phi] - \int d^2z \, VO\right] OO}{\int \mathcal{D}\phi \, \exp\left[-S[\phi] - \int d^2z \, VO\right]}$$


c = 0 Catastrophe
V V ~ A(0)/z^2h [1 + 2h/c z^2 T(0) + . . .]
[Candy cond-mat/9911024]
c = 0 A(0) ≠ 0
[T̃] = 2 + α(c)
0
exp[- S[φ] - ∫d²z' VO] OO
exp[- S[φ] - ∫d²z VO]