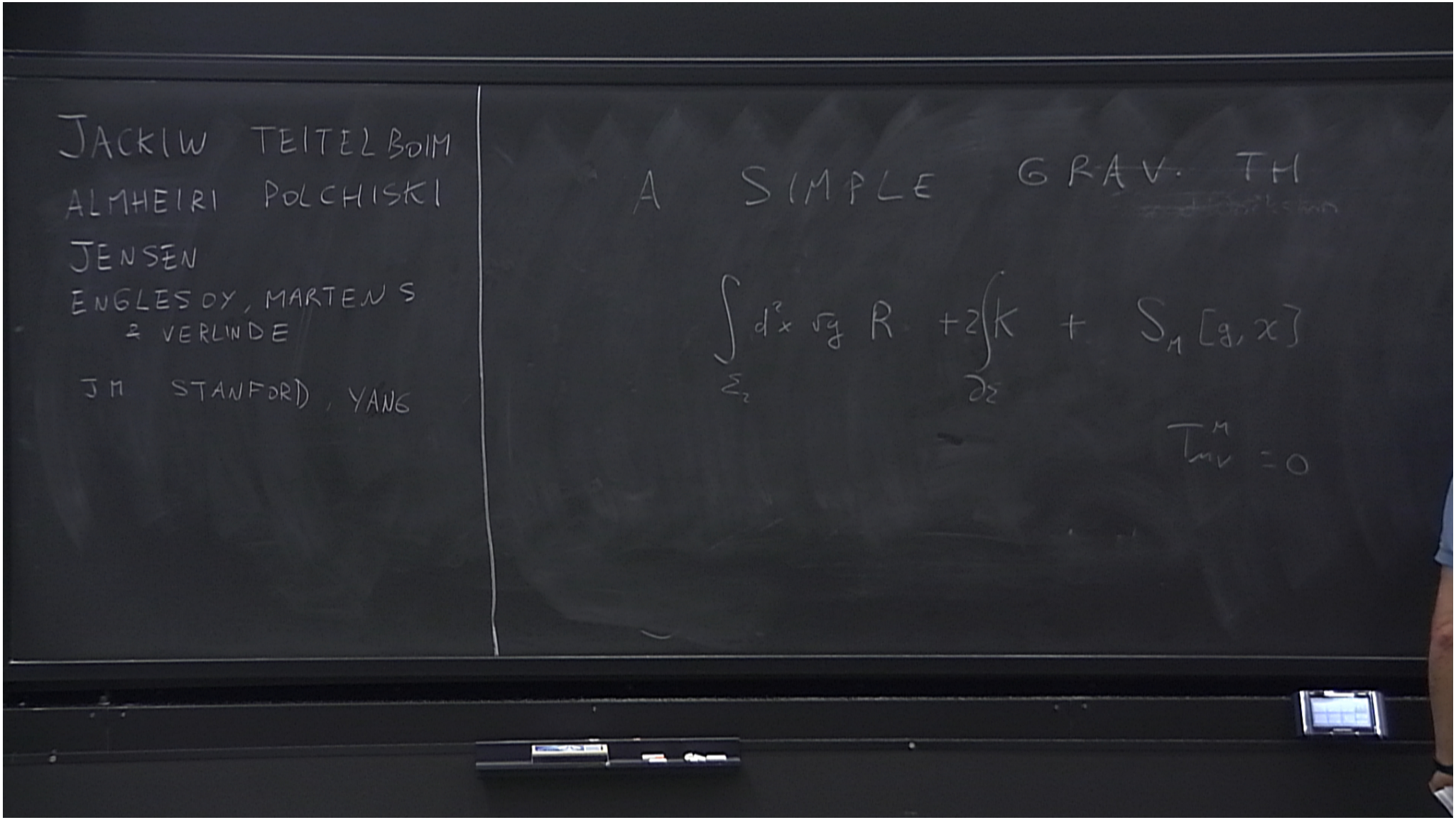
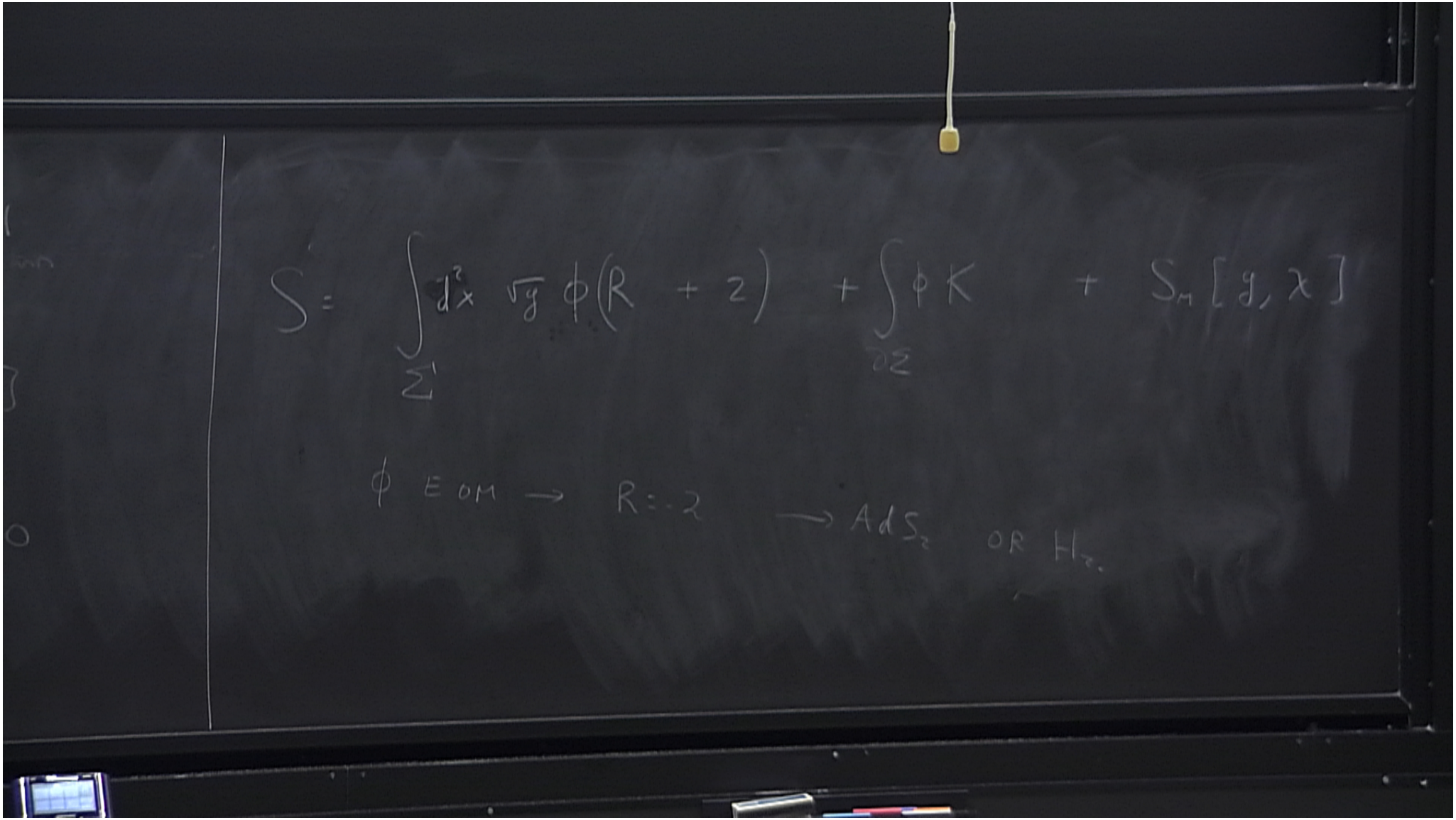
Title: Chaos

Date: Jul 26, 2016 02:30 PM

URL: http://pirsa.org/16070074

Abstract:


JACKIW TEITELBOIM
ALMHEIRI POLCHISKI
JENSEN
ENGLESOY, MARTENS & VERLINDE
JM STANFORD, YANG
A SIMPLE GRAV. TH
$\int_{\Sigma_2} d^2x \sqrt{g} R + 2\int_{\partial\Sigma_2} k + S_M[g, x]$
$T^M_{MV} = 0$


$S = \int_{\Sigma} d^2x \sqrt{g}\,\phi(R + 2) + \int_{\partial\Sigma} \phi K + S_M[g, \chi]$
ϕ EOM $\rightarrow$ $R = -2$ $\rightarrow$ AdS_2 OR H_2.

EOM g

$$\left(\nabla_\mu \nabla_\nu - g_{\mu\nu}\nabla^2 + 2 g_{\mu\nu}\right)\phi + T^M_{\mu\nu} = 0$$

- FIX MET
- SOLV. MAT
- SOLV. ϕ

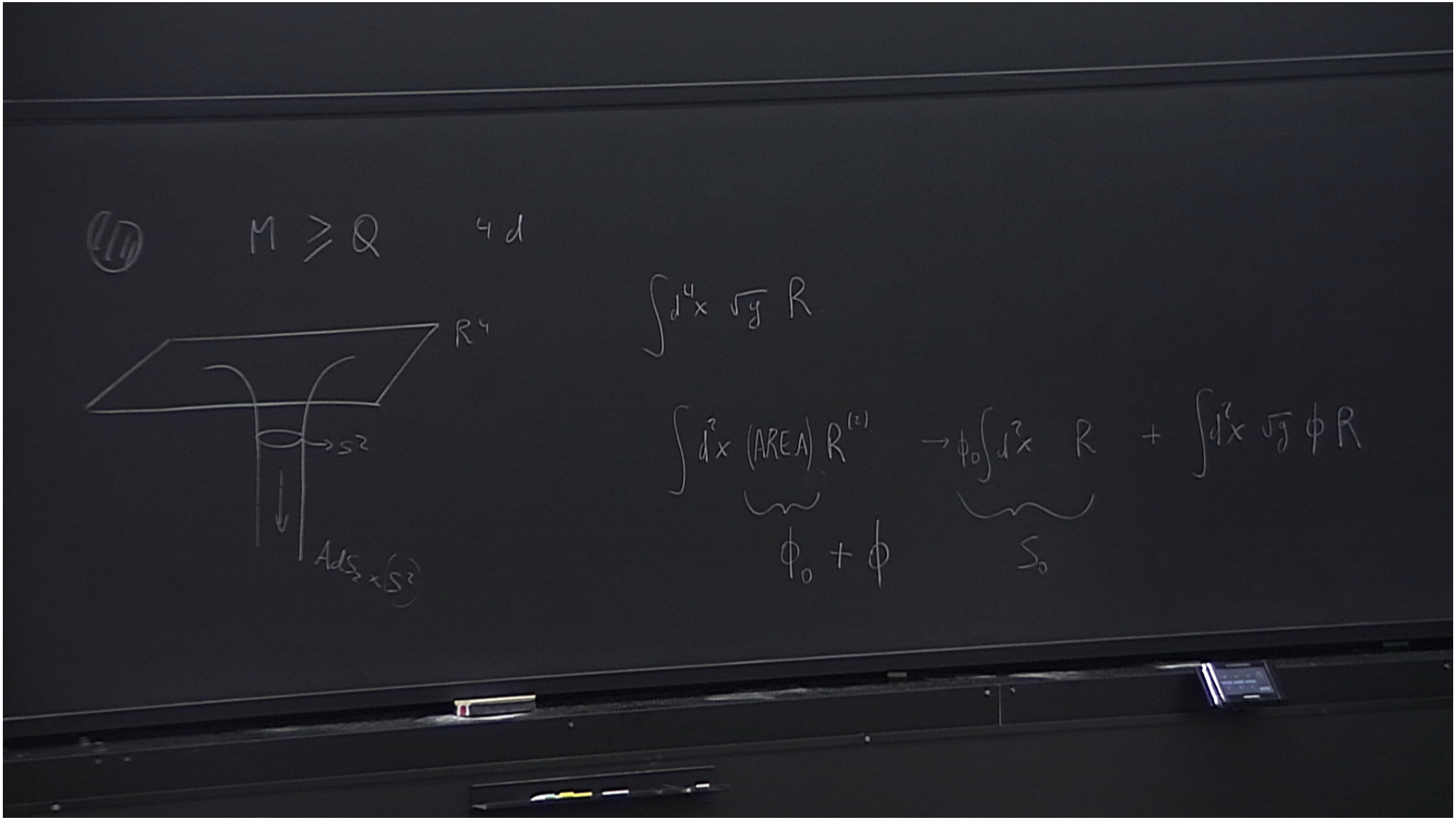
$$ds^2 = \frac{-dt^2 + dz^2}{z^2}$$

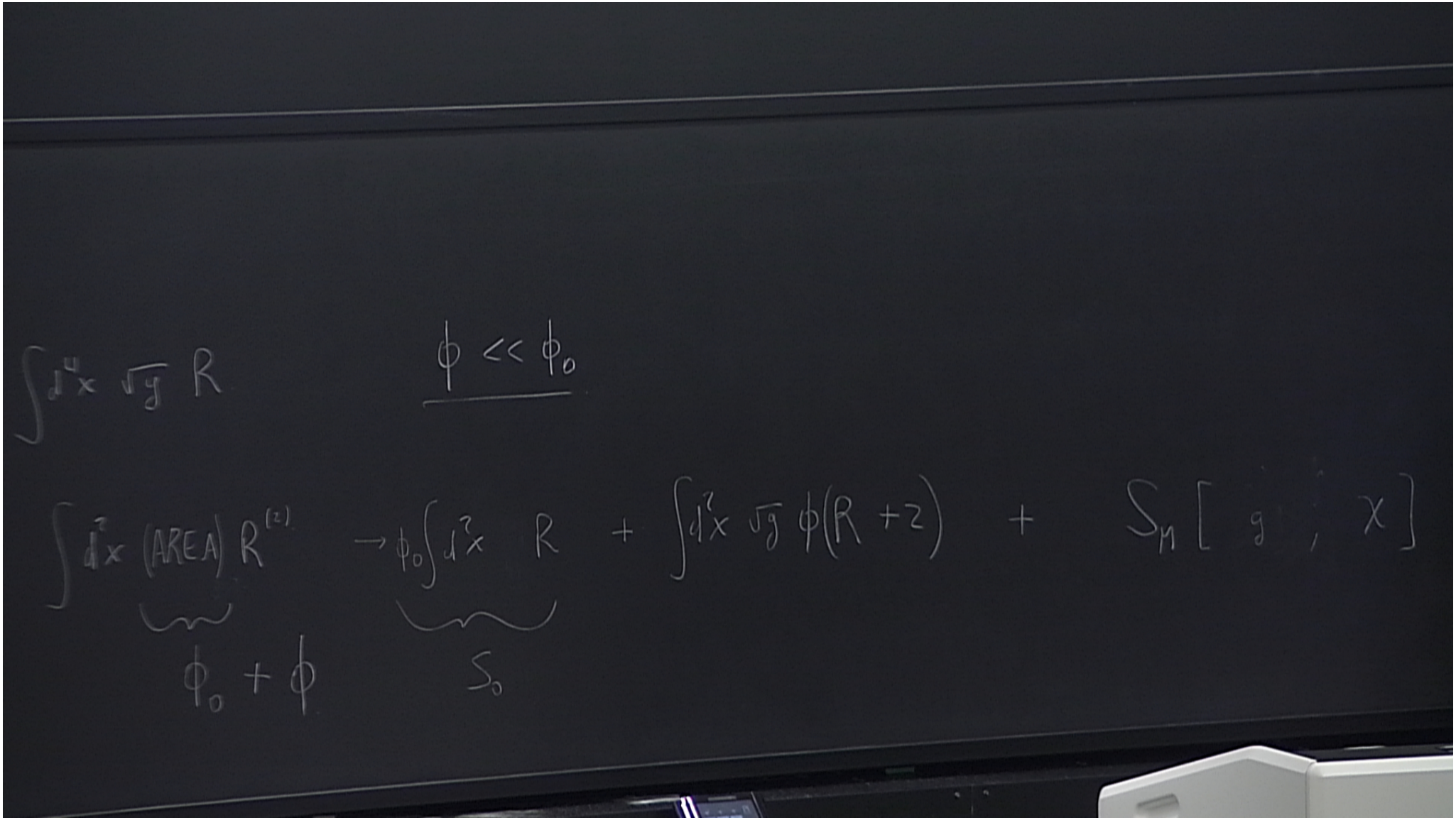
$$\phi \sim \frac{\text{CONST}}{z}$$

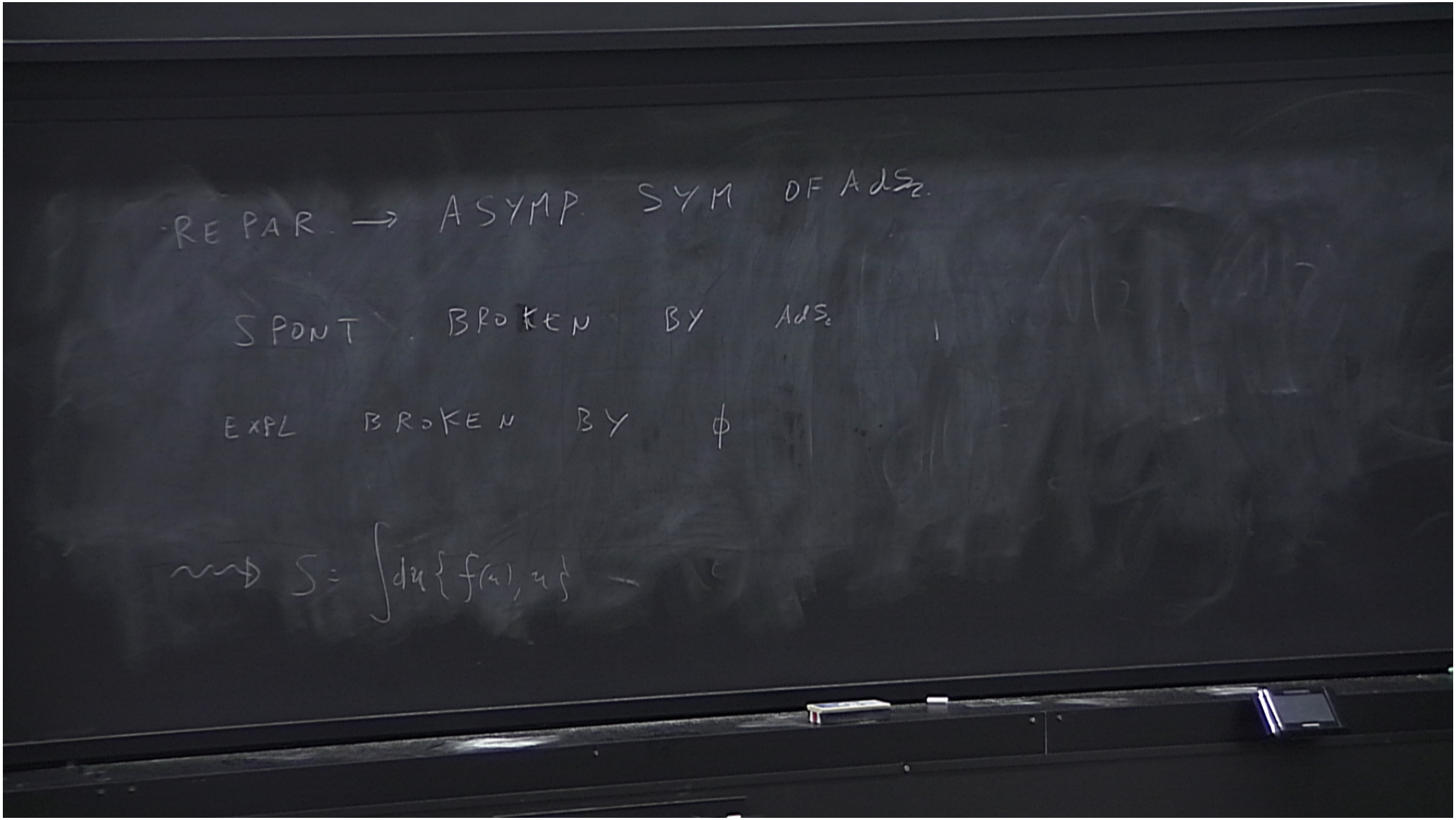
$$ds^2 = \frac{-dt^2 + dz^2}{z^2}$$

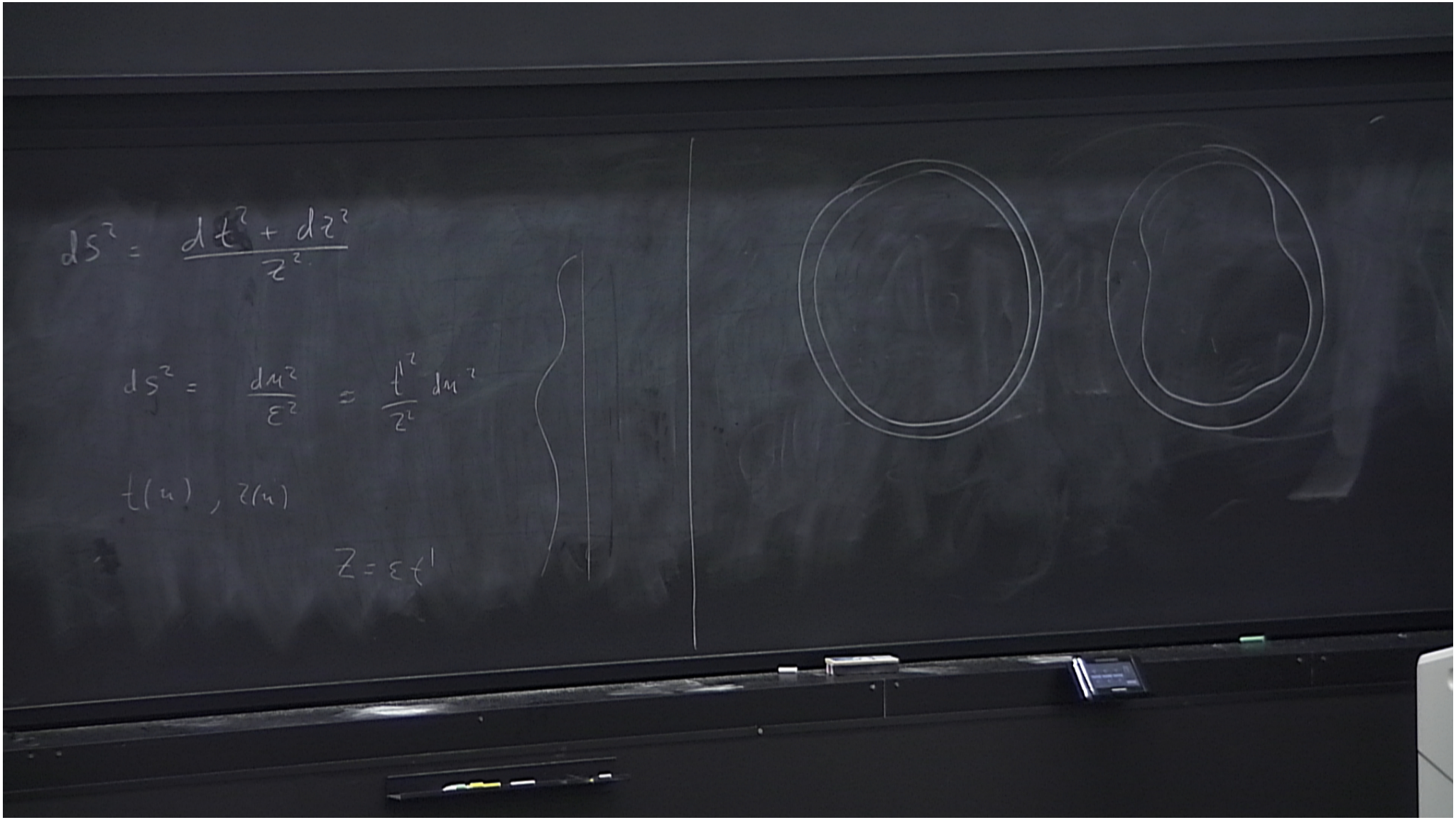
$$\phi \sim \frac{\text{CONST}}{z}$$

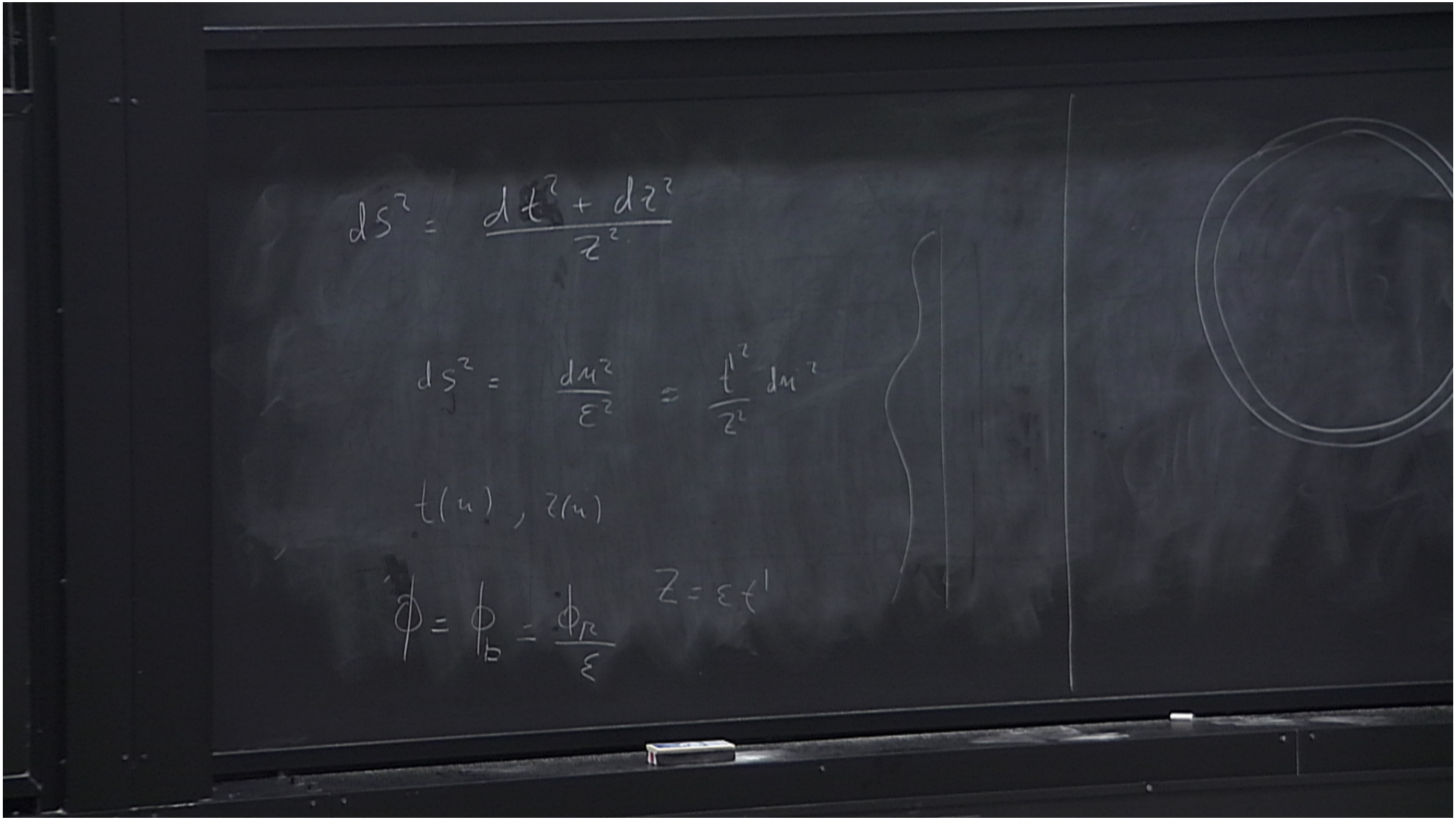


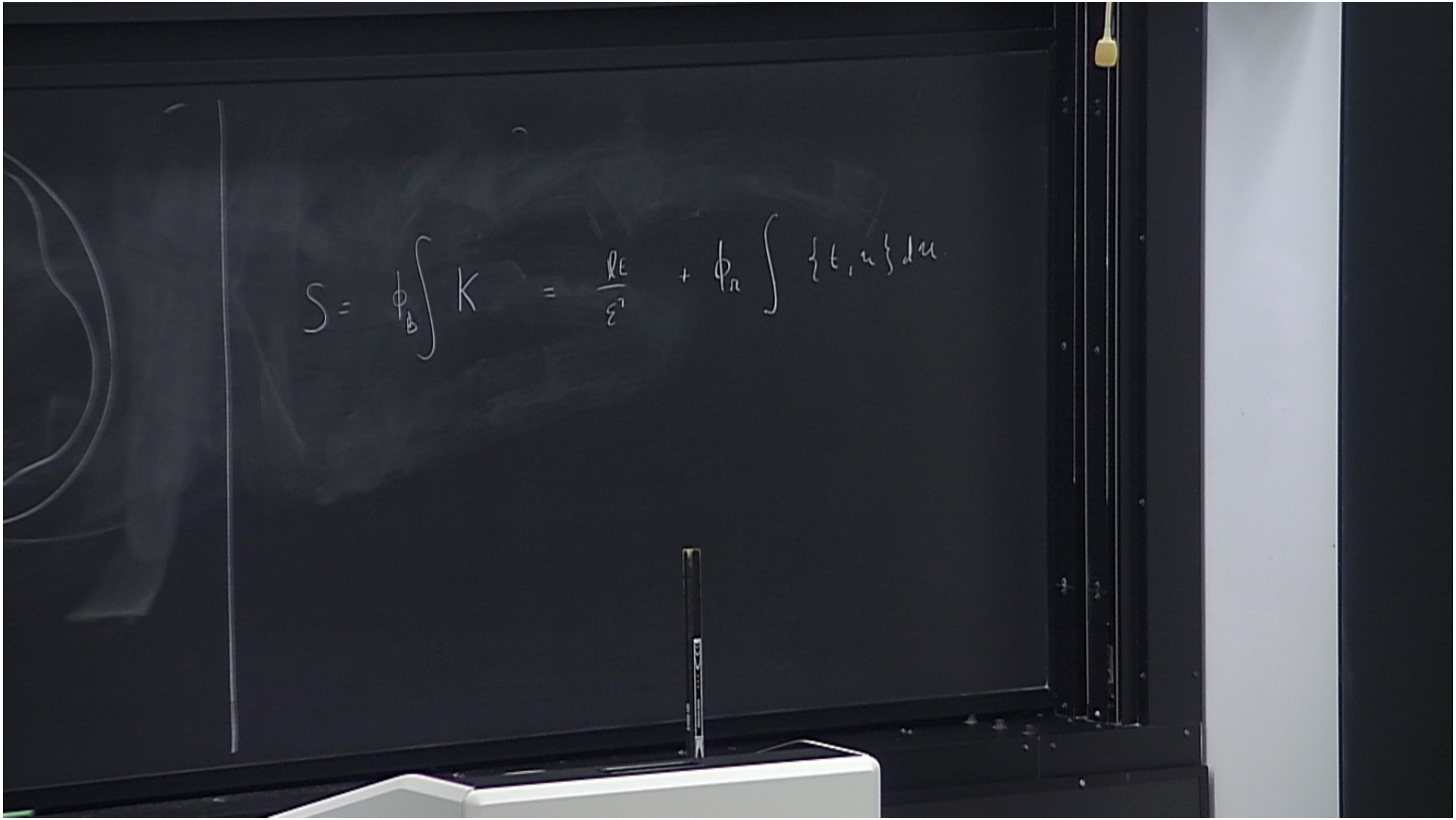

M ≥ Q
4d
R^4
S^2
$AdS_2 \times S^2$
$\int d^4x \sqrt{g} R$
$\int d^2x$ (AREA) $R^{(2)} \to \phi_0 \int d^2x R + \int d^2x \sqrt{g} \phi R$
$\phi_0 + \phi$
S_0


$\int d^4x \sqrt{g} R$
$\phi \ll \phi_0$
$\int d^2x$ (AREA) $R^{(2)} \to \phi_0 \int d^2x \; R + \int d^2x \sqrt{g} \, \phi (R + 2) + S_M [g, X]$
$\phi_0 + \phi$
S_0


REPAR ⟶ ASYMP SYM OF AdS$_2$.
SPONT BROKEN BY AdS$_2$
EXPL BROKEN BY ϕ
$\rightsquigarrow S = \int du \{ f(u), u \}$


$ds^2 = \frac{dt^2 + dz^2}{z^2}$
$ds^2 = \frac{du^2}{\varepsilon^2} = \frac{t'^2}{z^2} du^2$
$t(u), z(u)$
$z = \varepsilon t'$


$ds^2 = \frac{dt^2 + dz^2}{z^2}$
$ds^2 = \frac{dw^2}{\varepsilon^2} = \frac{t'^2}{z^2} dw^2$
$t(w), z(w)$
$\phi = \phi_b = \frac{\phi_r}{\varepsilon}$
$z = \varepsilon t'$


$S = \frac{\phi_B}{}\int K = \frac{RE}{\varepsilon^2} + \phi_n \int \{t, u\}\, du$

TEITELBOIM
POLCHINSKI

, MARTENS
DE

FORD, YANG

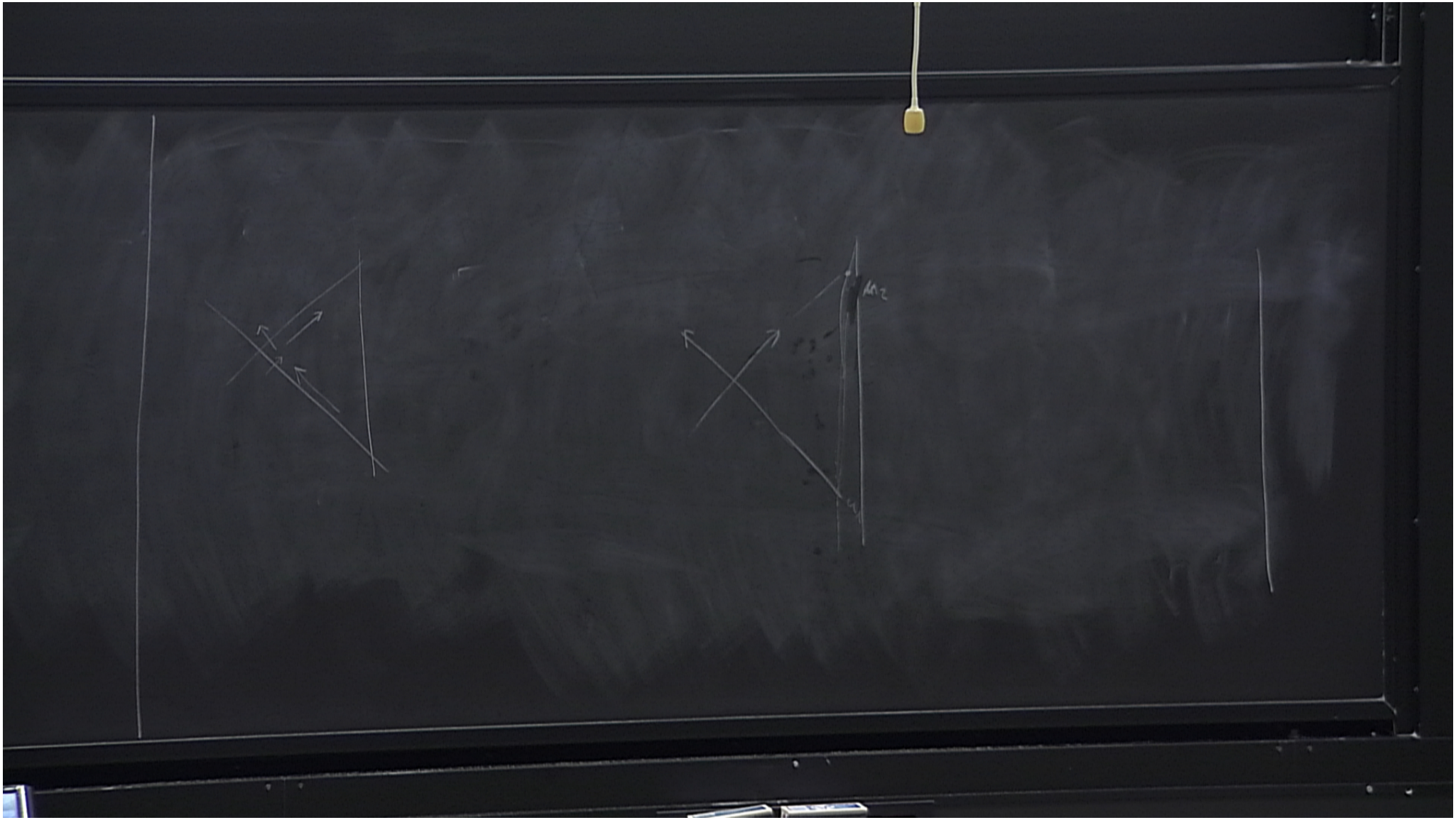
COSEQ

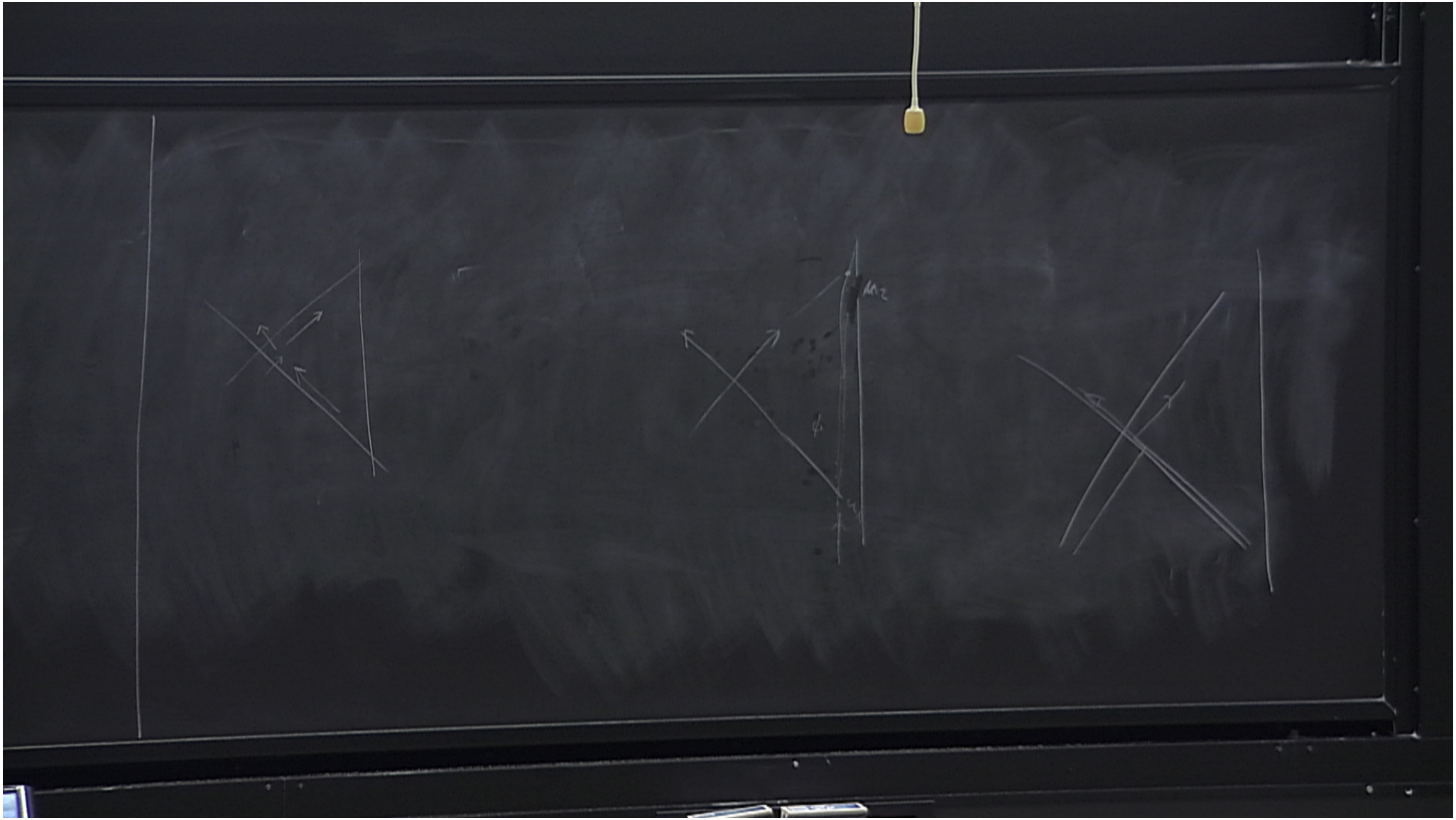
- THF E. $t = \tan\left(\frac{\pi \cdot 4}{\beta}\right)$

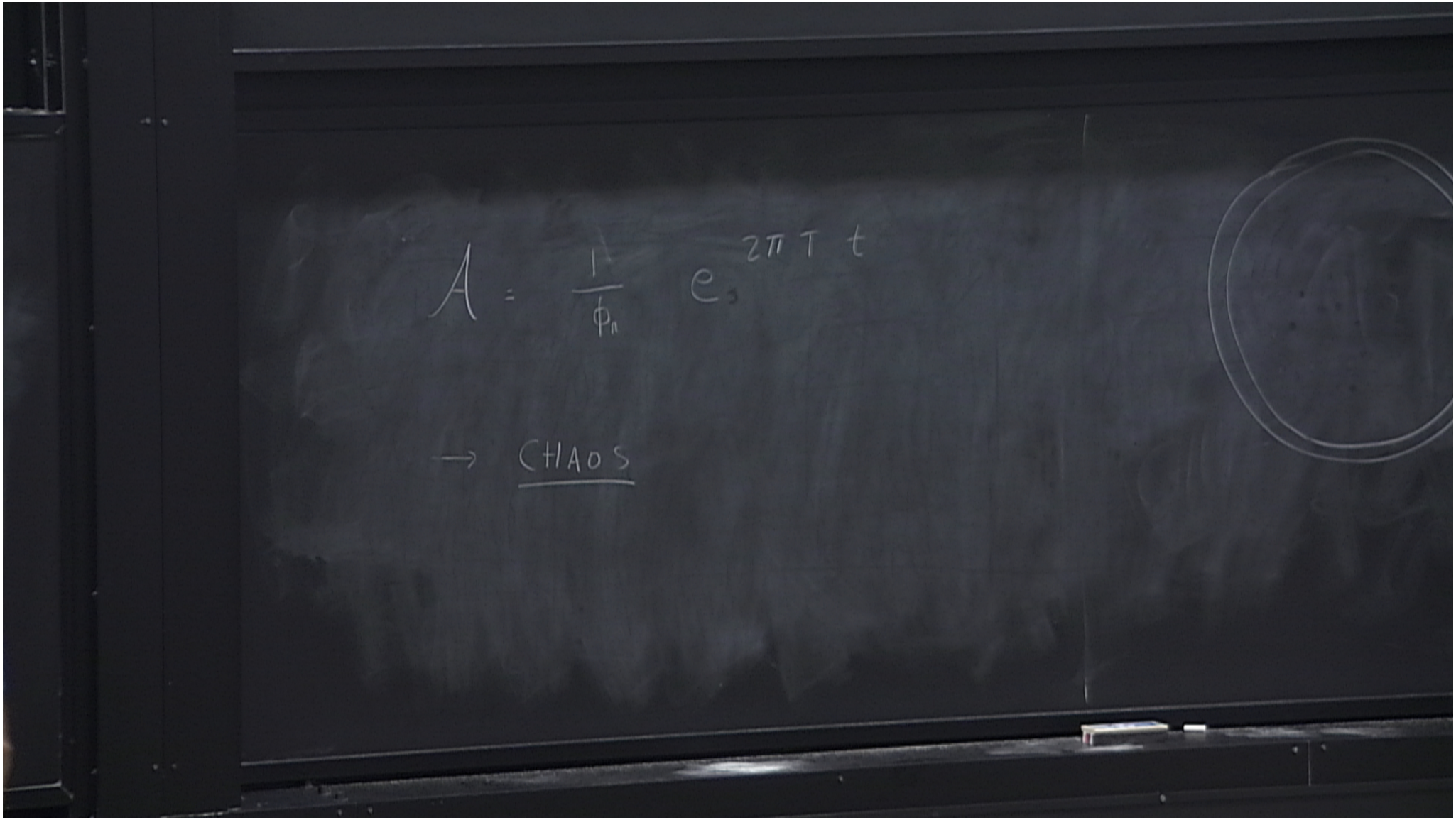
$S = \underbrace{\phi_R}_{1/J} T + S_0$

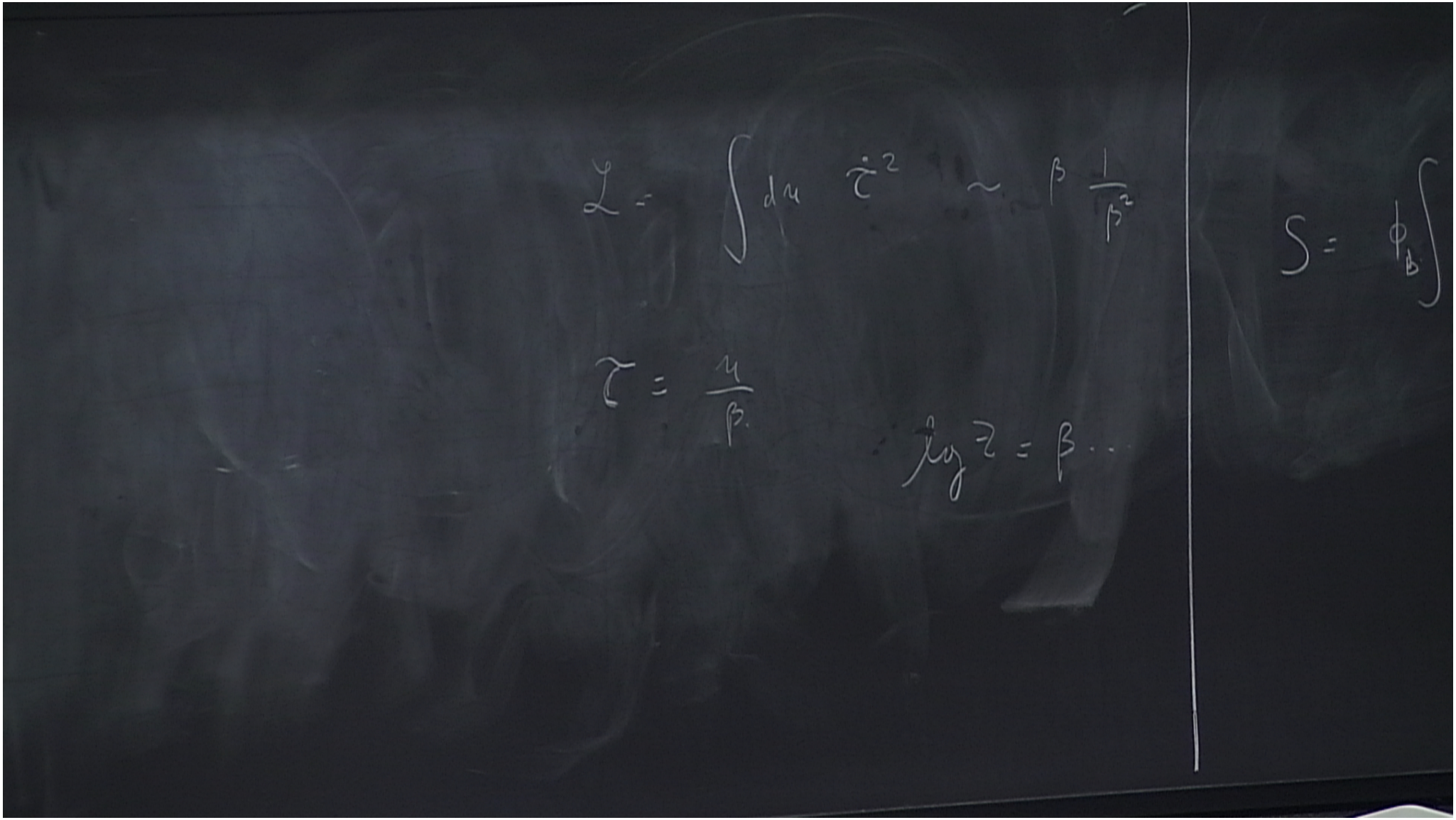
- GRAV CORR TO 4pt FNS.

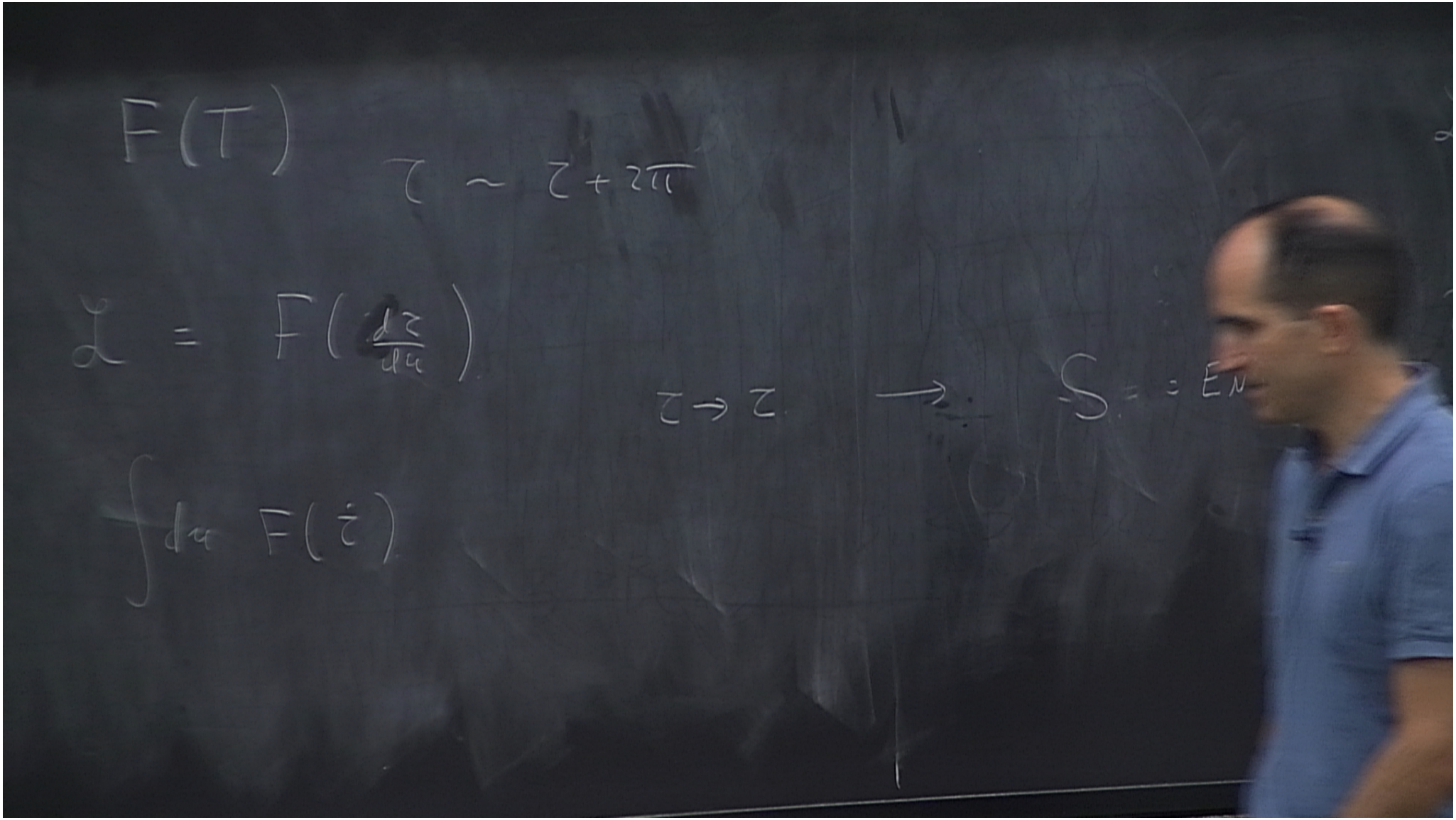
$S =$

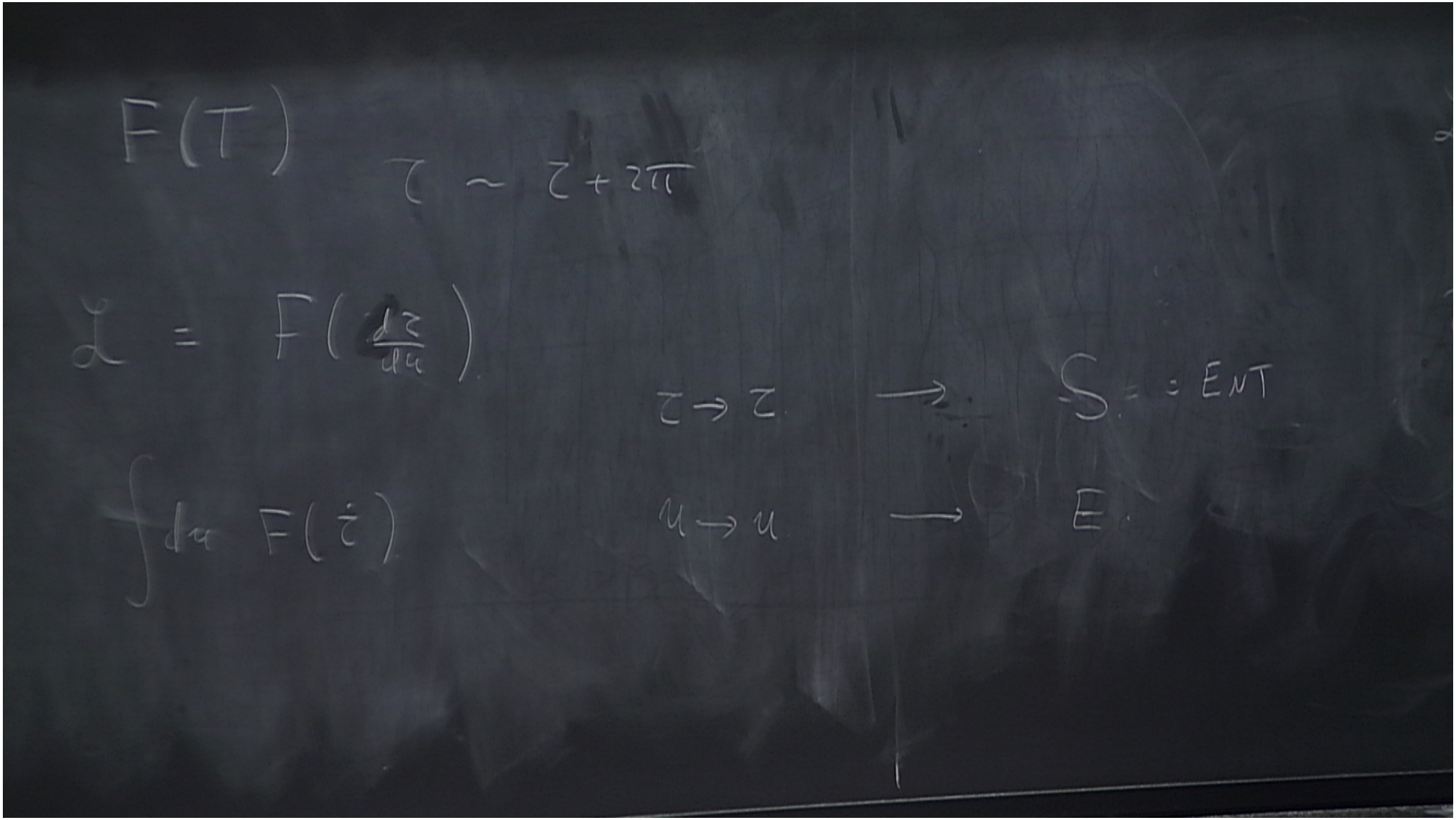


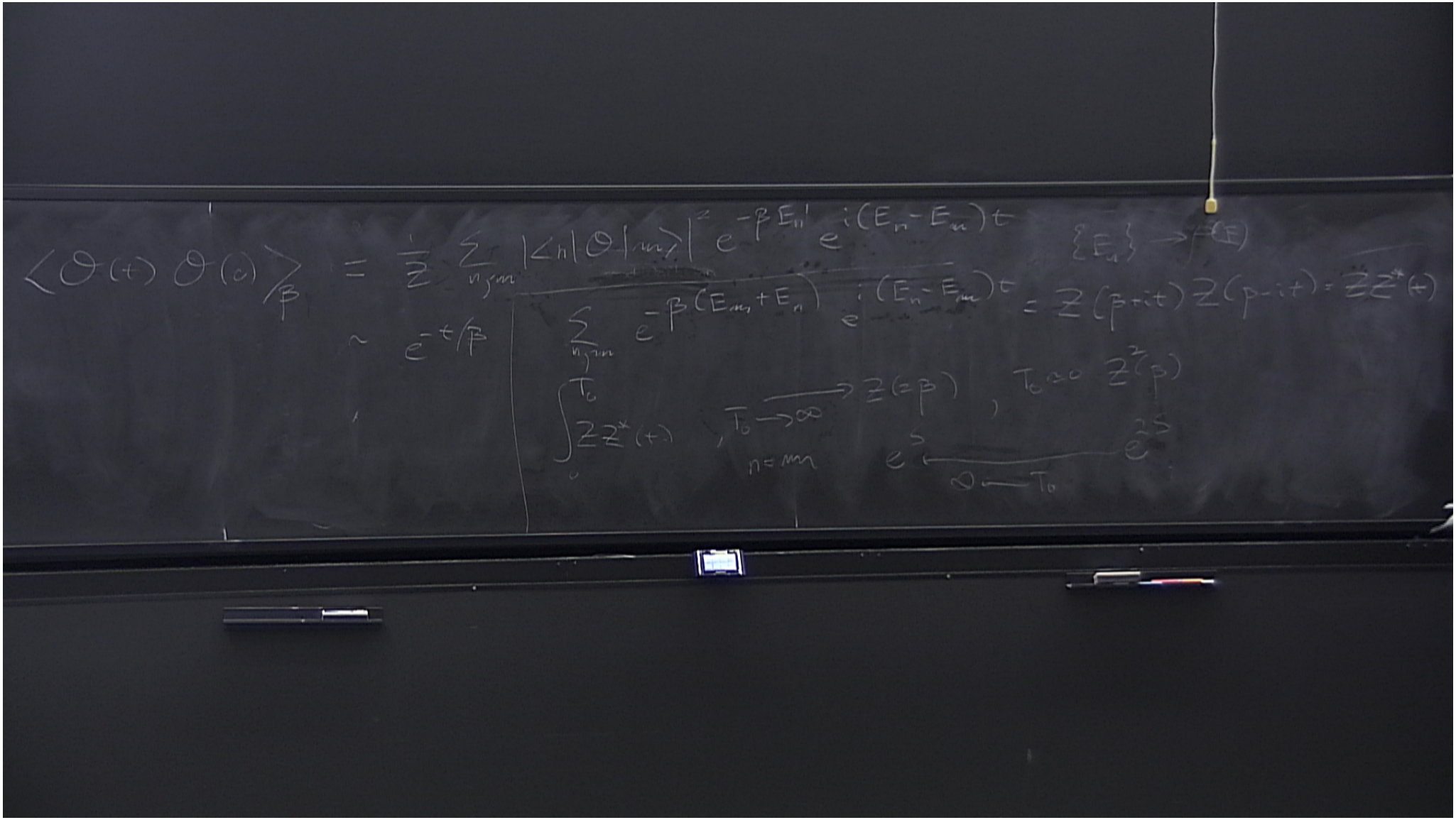


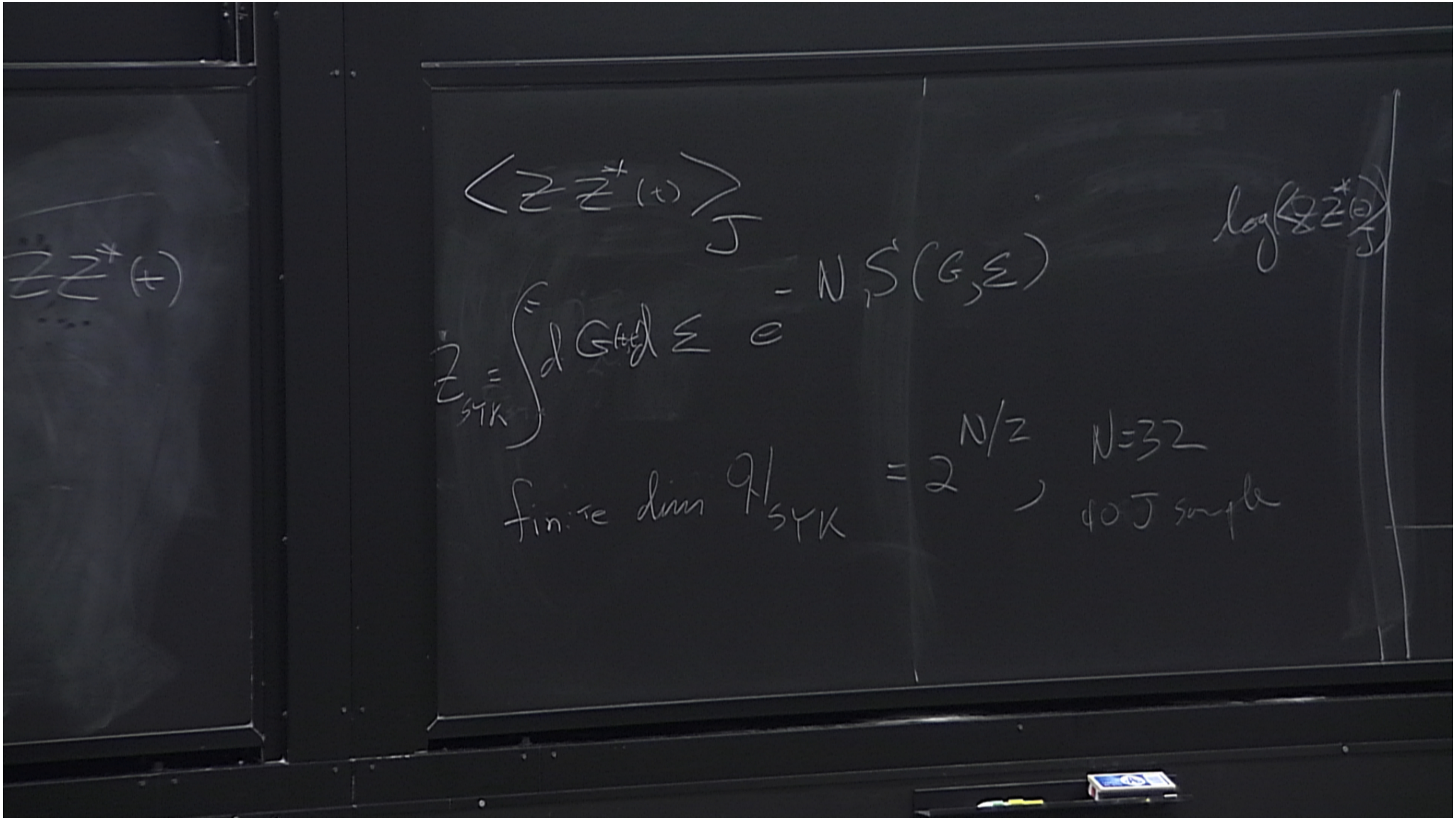

$A = \frac{1}{\phi_n} e^{2\pi T t}$
→ CHAOS

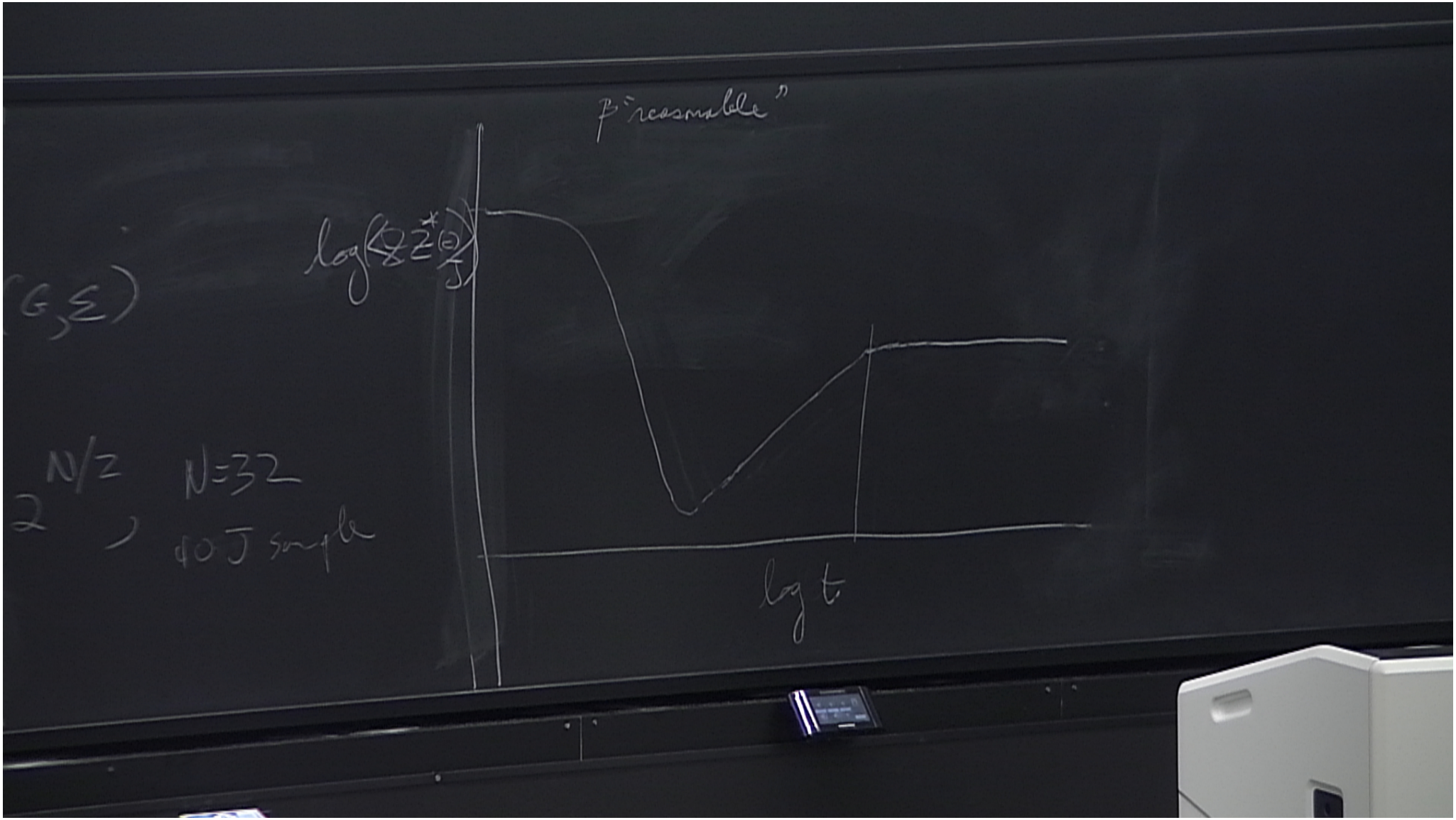

$\mathcal{L} = \int du\ \dot{\tau}^2 \sim \beta \frac{1}{\beta^2}$
$S = \phi_b \int$
$\tau = \frac{u}{\beta}$
$i_y z = \beta \ldots$

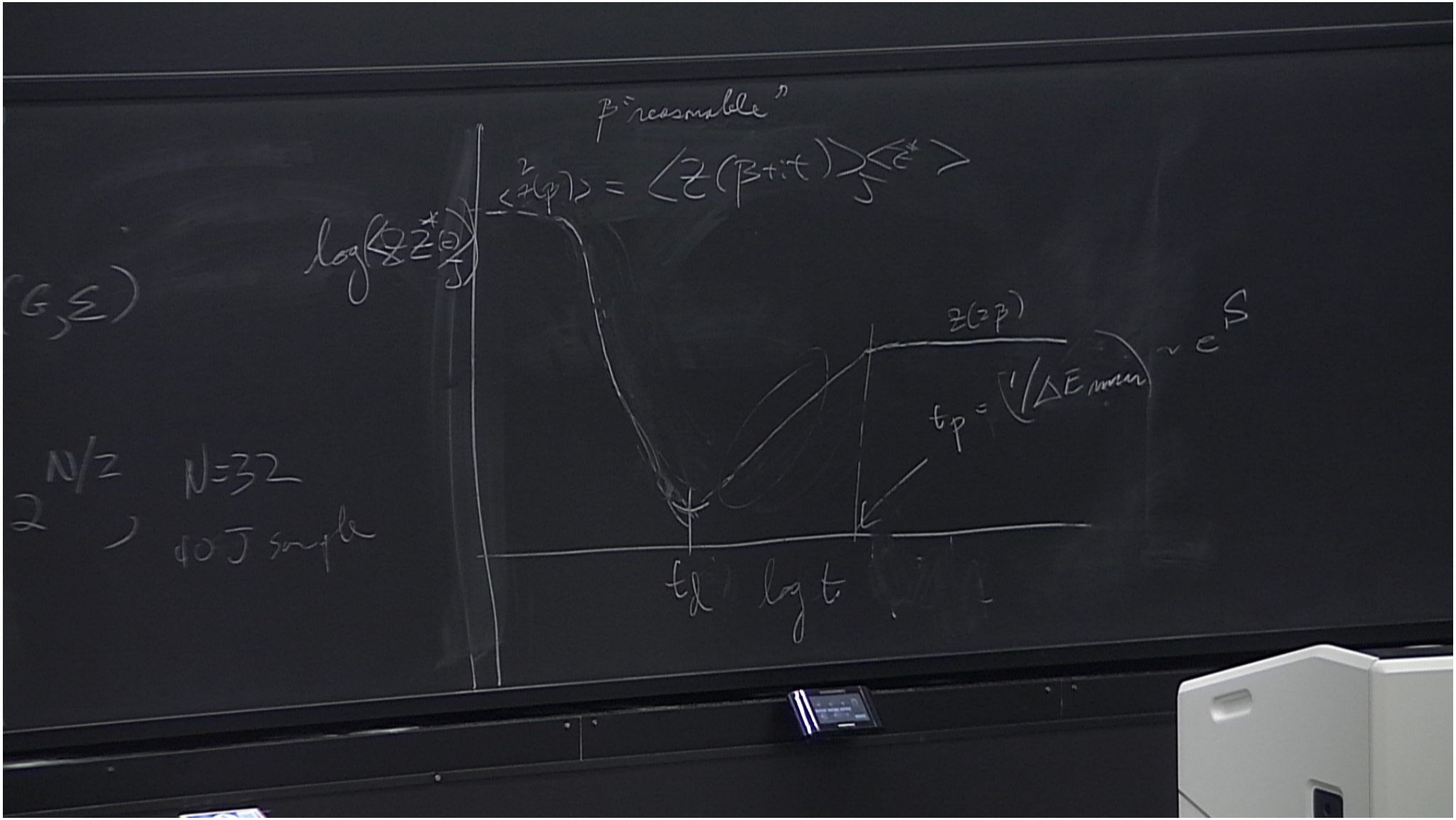

F(T)
τ ~ τ + 2π
L = F(dτ/dt)
τ → τ
S = EN
∫dt F(τ̇)


F(T)
τ ~ τ + 2π
L = F(dτ/du)
τ → τ → S = : ENT
∫du F(τ̇)
u → u → E.


$\langle \mathcal{O}(t)\,\mathcal{O}(0)\rangle_\beta = \frac{1}{Z}\sum_{n,m} |\langle n|\mathcal{O}|m\rangle|^2 e^{-\beta E_n} e^{i(E_n - E_m)t}$
$\{E_n\} \to f(E)$
$\sim e^{-t/\beta}$
$\sum_{n,m} e^{-\beta(E_m + E_n)} e^{i(E_n - E_m)t} = Z(\beta + it)\,Z(\beta - it) = ZZ^*(t)$
$\int_0^{T_0} ZZ^*(t)$, $T_0 \to \infty$
$Z(2\beta)$, $T_0 \to 0$ $Z^2(\beta)$
$n = m$
e^S
e^{2S}
$0 \to T_0$

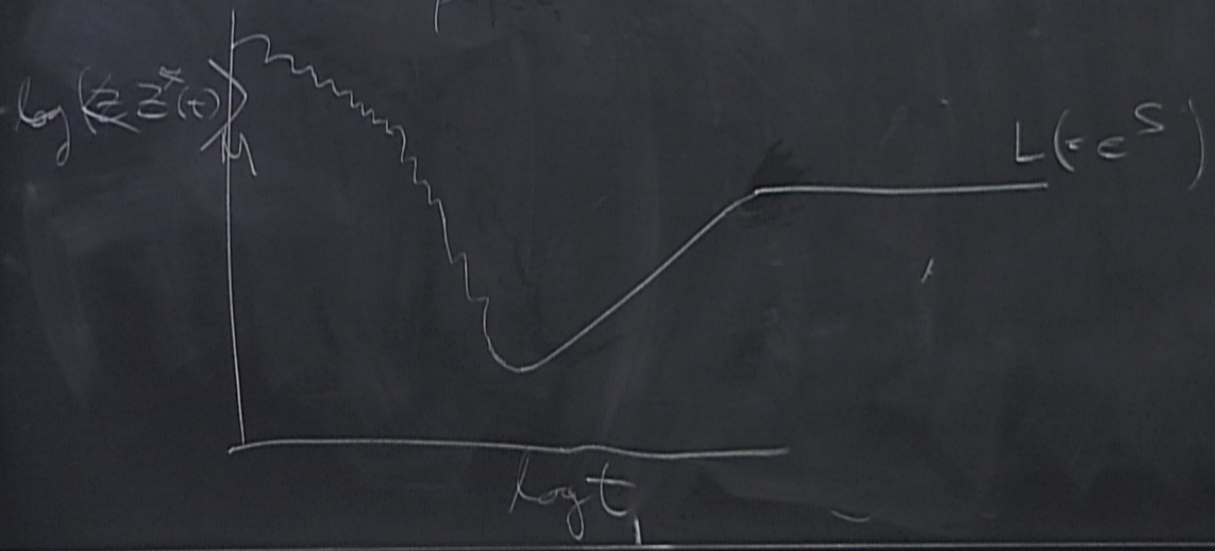

$\langle Z Z^*(t) \rangle_J$
$Z_{SYK} = \int d\mathcal{G}_{t\bar{t}} d\Sigma \; e^{-N_1 S(G,\Sigma)}$
finite dim $\mathcal{H}_{SYK} = 2^{N/2}$
$N = 32$
40 J sum

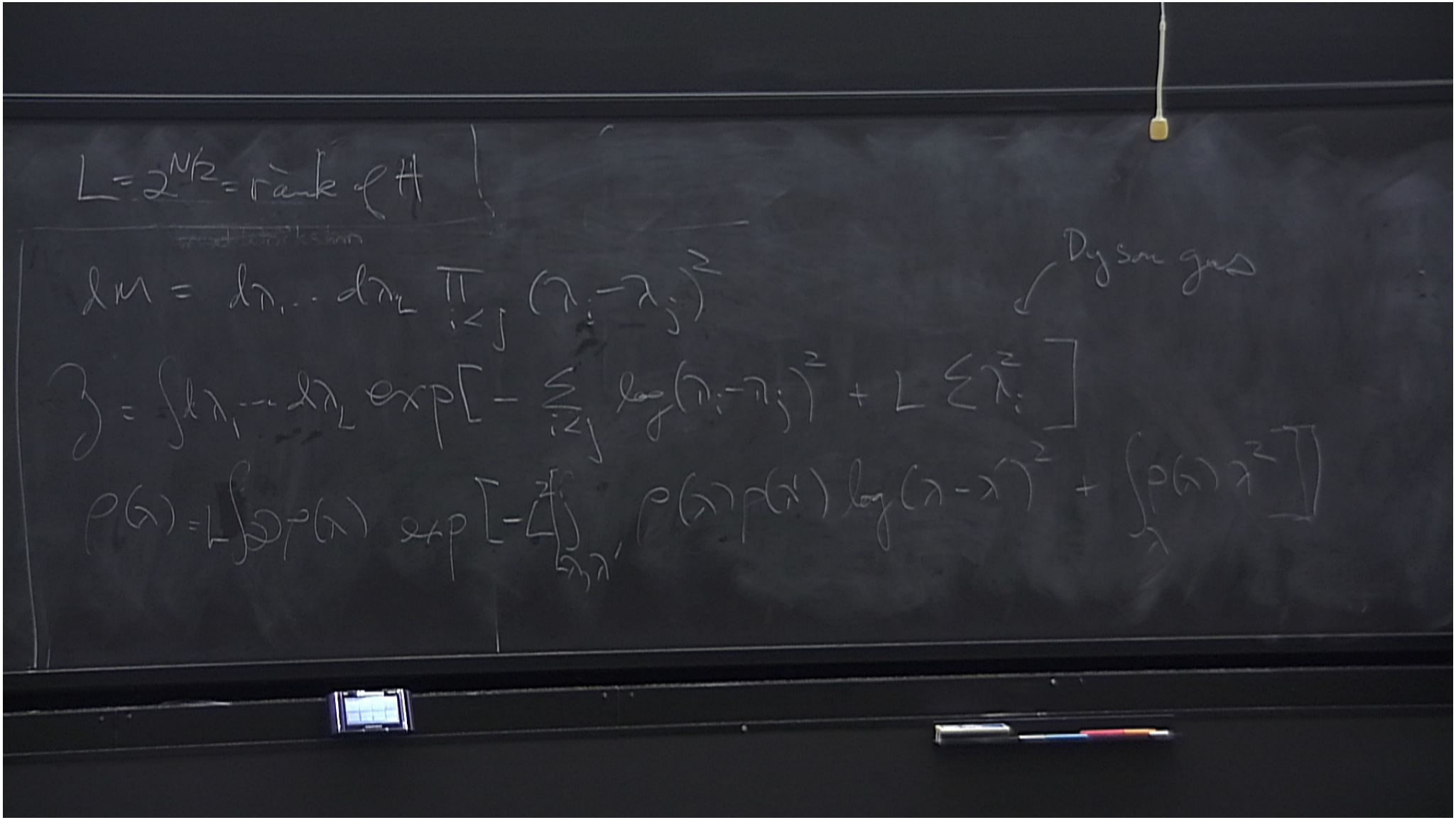

β "reasonable"
log(
log t

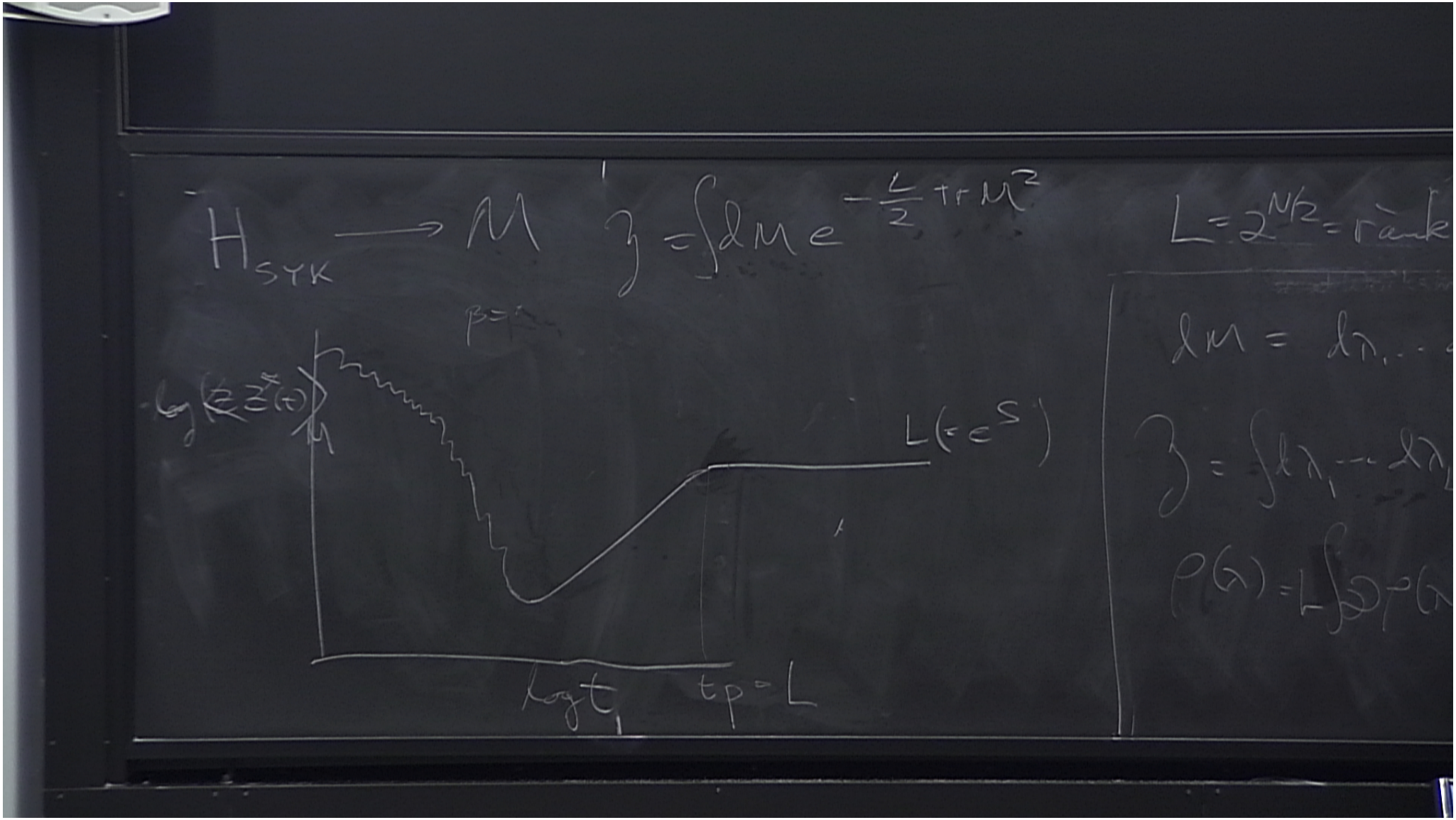

β "reasonable"
log(Σ Z*(Θ))
Z(β)
t_p = (1/ΔE_min) ~ e^S
N=32
40 J sample
log t

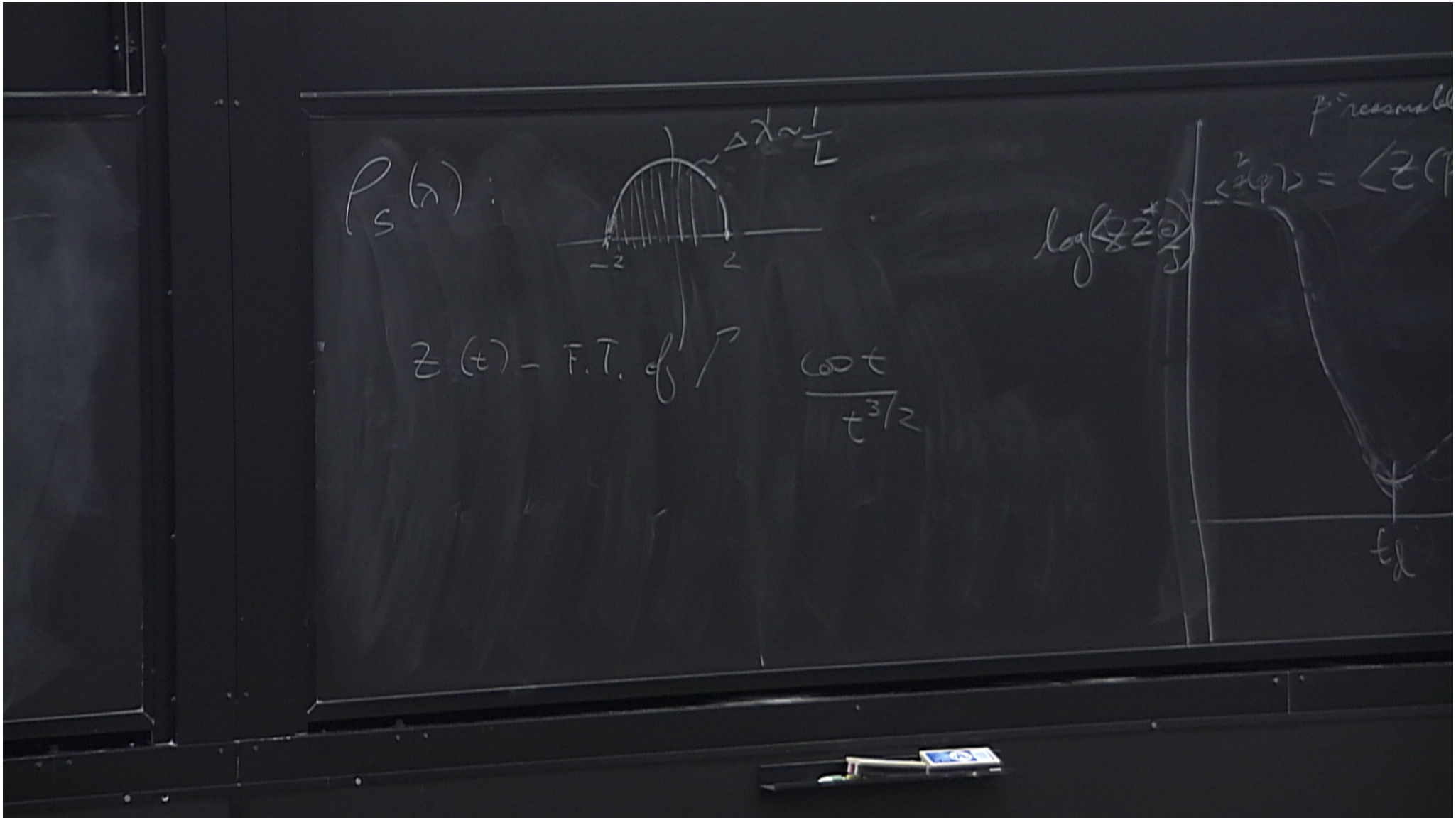
$H_{SYK} \longrightarrow M$ $\int dM e^{-\frac{L}{2} \mathrm{Tr} M^2}$ $L = 2^{N/2} = \mathrm{rank}\ \mathcal{H}$

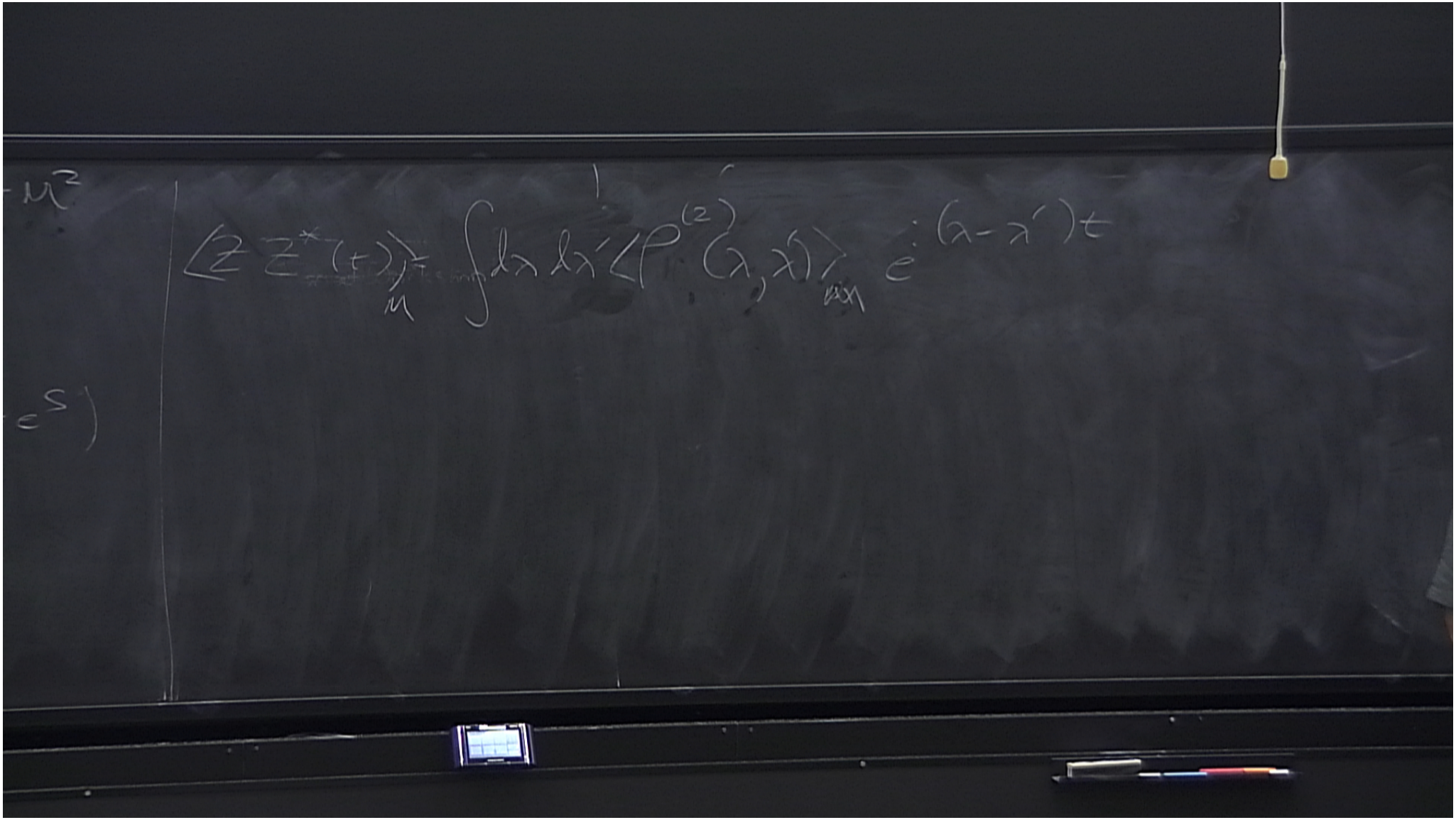
$\beta =$

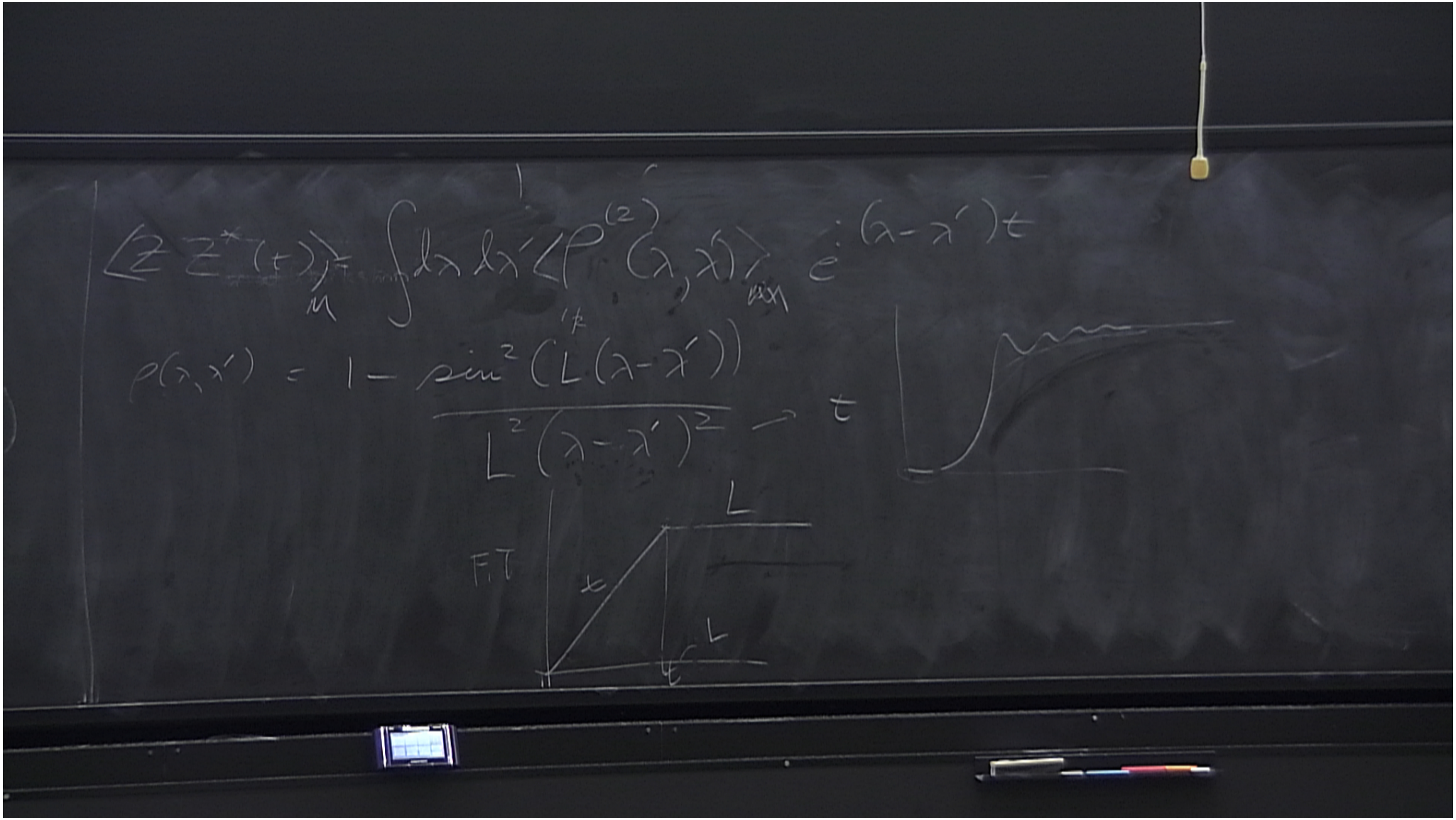



$L = 2^{N/2} = \text{rank of } H$
$dM = d\lambda_1 \dots d\lambda_L \prod_{i<j} (\lambda_i - \lambda_j)^2$
Dyson gas
$Z = \int d\lambda_1 \dots d\lambda_L \exp\left[- \sum_{i<j} \log(\lambda_i - \lambda_j)^2 + L \sum_i \lambda_i^2 \right]$
$\rho(\lambda) = L \int \mathcal{D}\rho(\lambda) \exp\left[-L^2 \int_{\lambda,\lambda'} \rho(\lambda)\rho(\lambda') \log(\lambda - \lambda')^2 + \int_\lambda \rho(\lambda) \lambda^2 \right]$


H_{SYK}
M
$Z = \int dM e^{-\frac{L}{2} \mathrm{Tr} M^2}$
$L = 2^{N/2} = \mathrm{rank}$
$dM = d\tau_1 \ldots$
$Z = \int d\tau_1 \ldots d\tau_L$
$\rho(\tau) = \frac{1}{L} \int \ldots$
$\beta =$
$\log \langle \epsilon \tilde{z}^2(t) \rangle$
$L(\epsilon^S)$
$\log t_1$
$t_p = L$


$\rho_s(\lambda)$:
$\sim \Delta\lambda \sim \frac{1}{L}$
-2
2
$z(t)$ - F.T. of ρ
$\frac{\cos t}{t^{3/2}}$
$\log\langle z(0) z^*(t)\rangle$
$\langle z(t) z^*(0)\rangle = \langle z($
t_d


$-\mu^2$
$\epsilon^S)$
$\langle z z^*(t) \rangle = \int d\lambda d\lambda' \langle \rho^{(2)}(\lambda,\lambda') \rangle e^{i(\lambda-\lambda')t}$


$\langle z z^*(t) \rangle = \int d\lambda d\lambda' \langle \rho^{(2)}(\lambda,\lambda') \rangle e^{i(\lambda-\lambda')t}$
$\rho(\lambda,\lambda') = 1 - \frac{\sin^2(L(\lambda-\lambda'))}{L^2(\lambda-\lambda')^2} \to t$
F.T
L
t
L
t