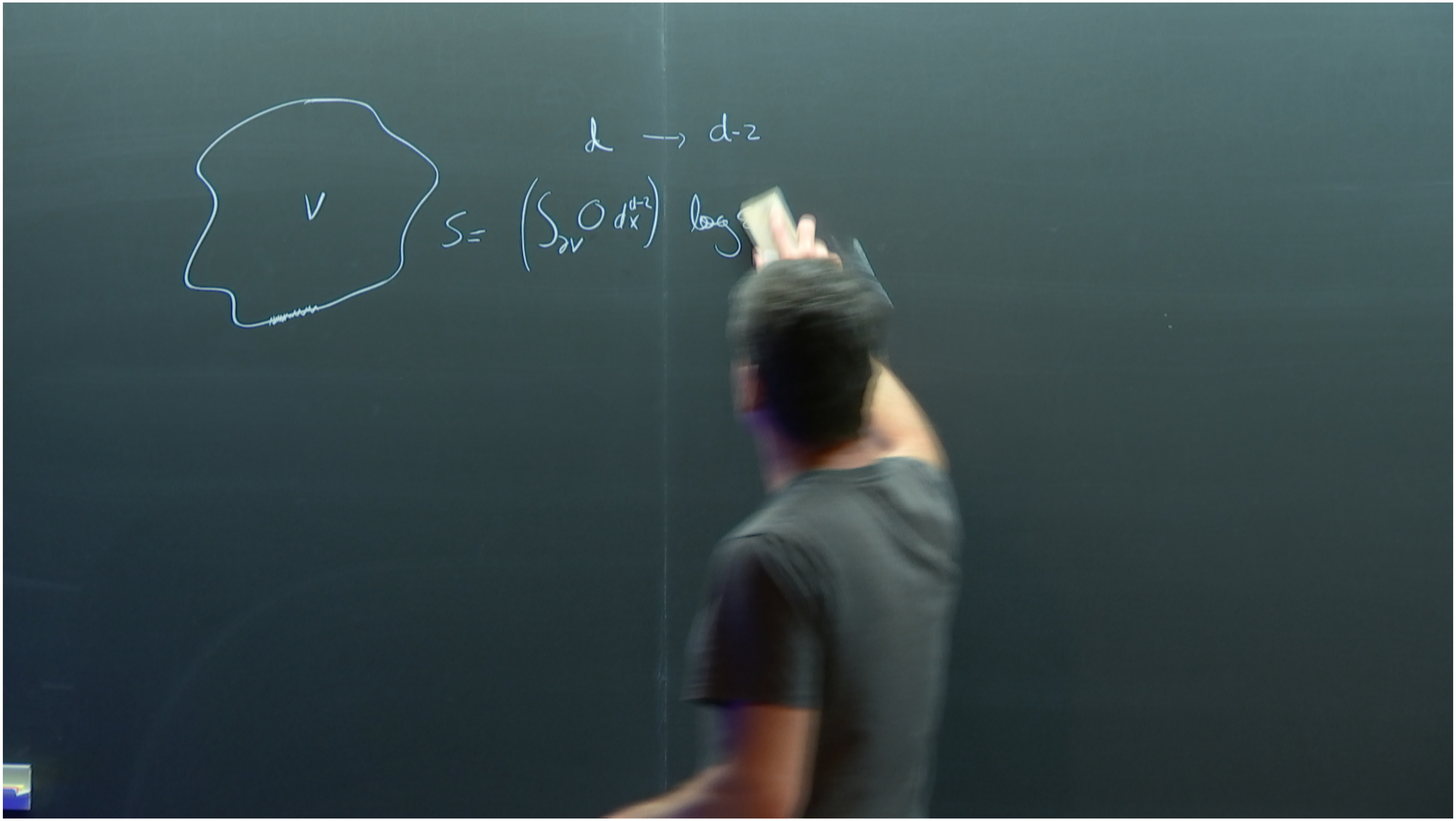
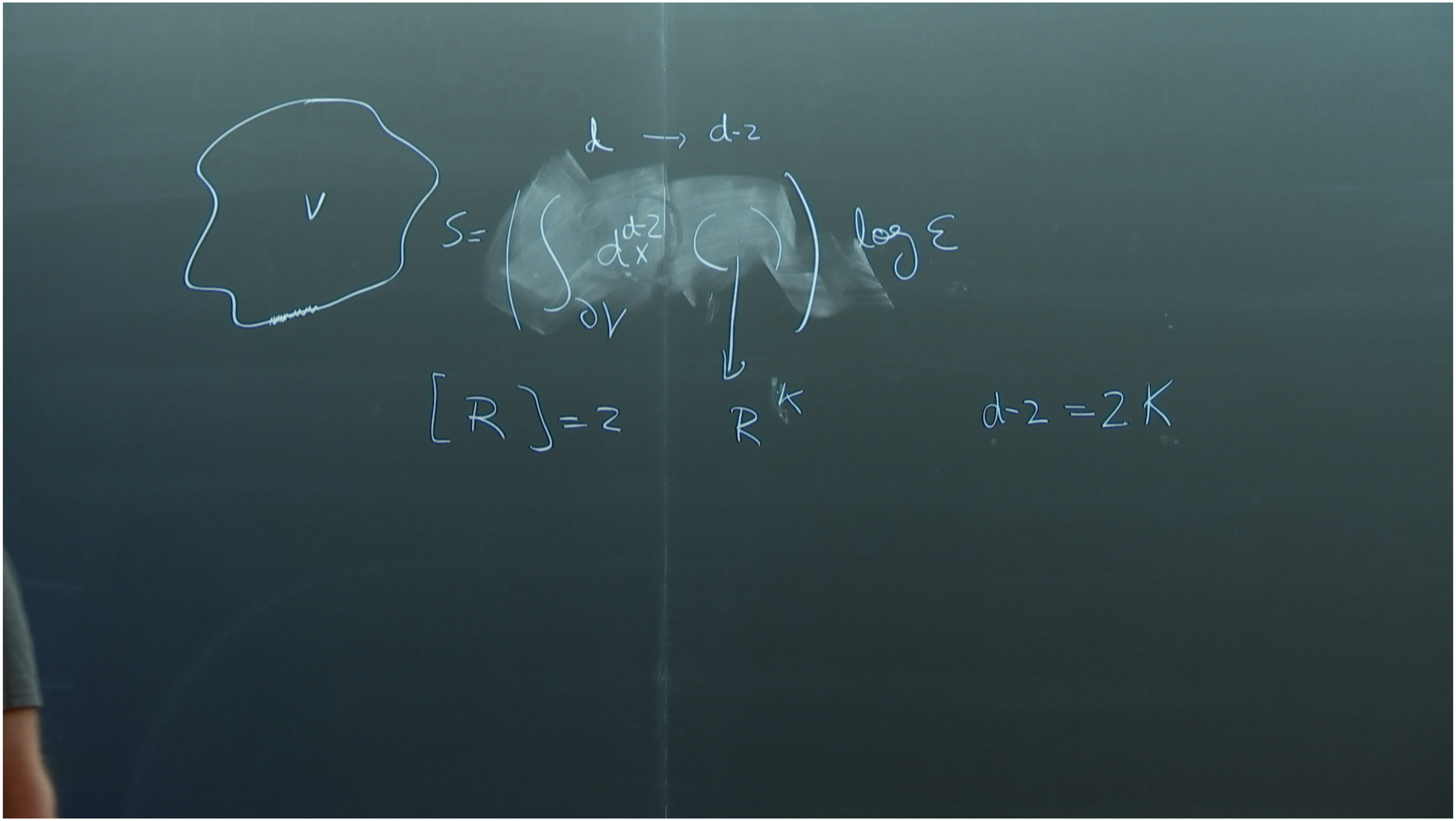
Title: Entanglement in QFT

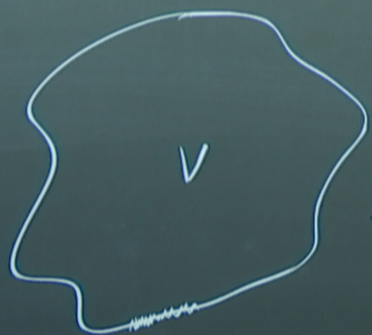
Date: Jul 21, 2016 11:00 AM

URL: http://pirsa.org/16070025

Abstract:


V
d → d-2
S = (∫∂V O d^{d-2}x) log


V
d → d-2
S = (∫∂V d^{d-2}x ( )) log ε
[R] = 2
R^K
d-2 = 2K

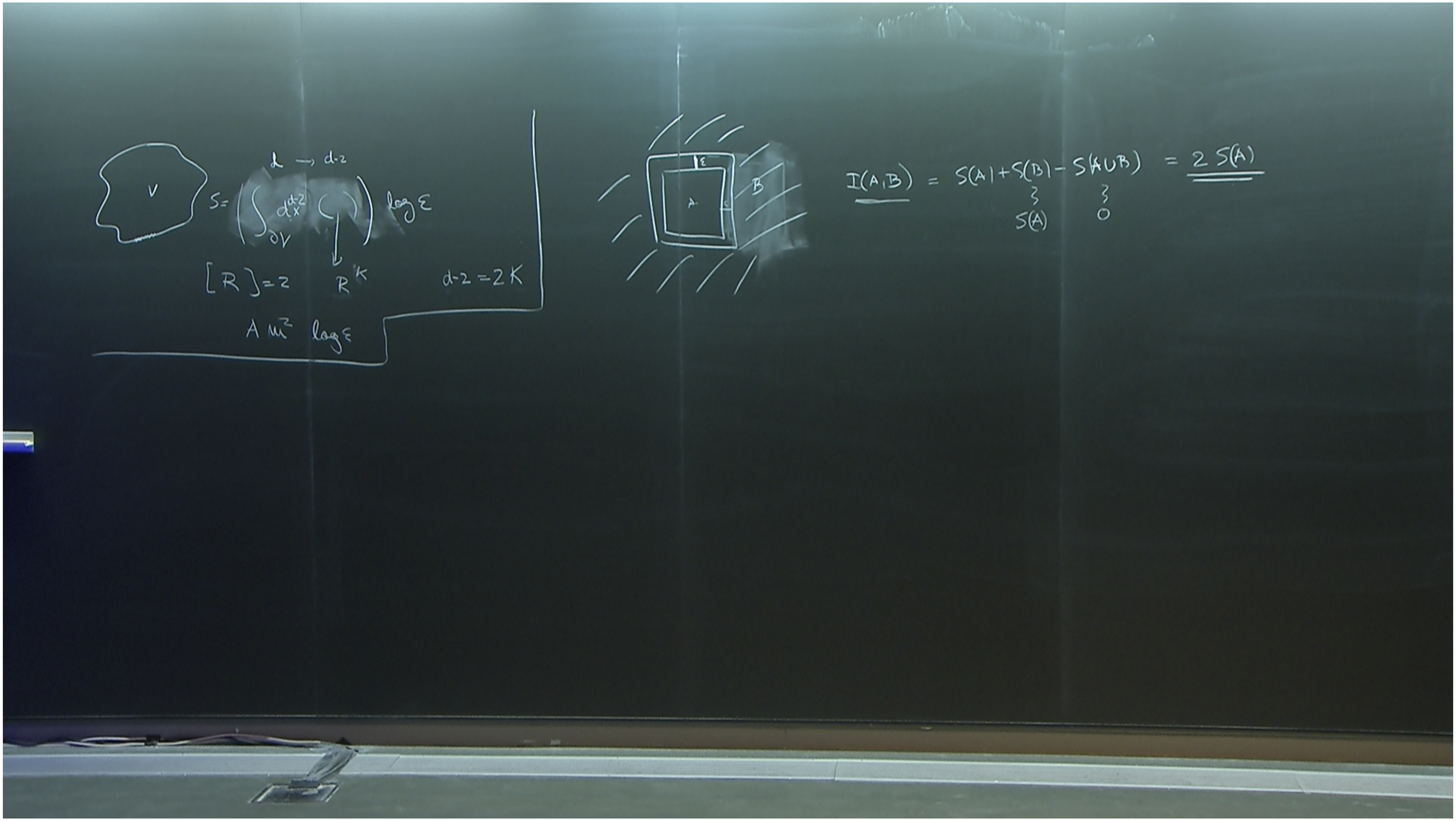


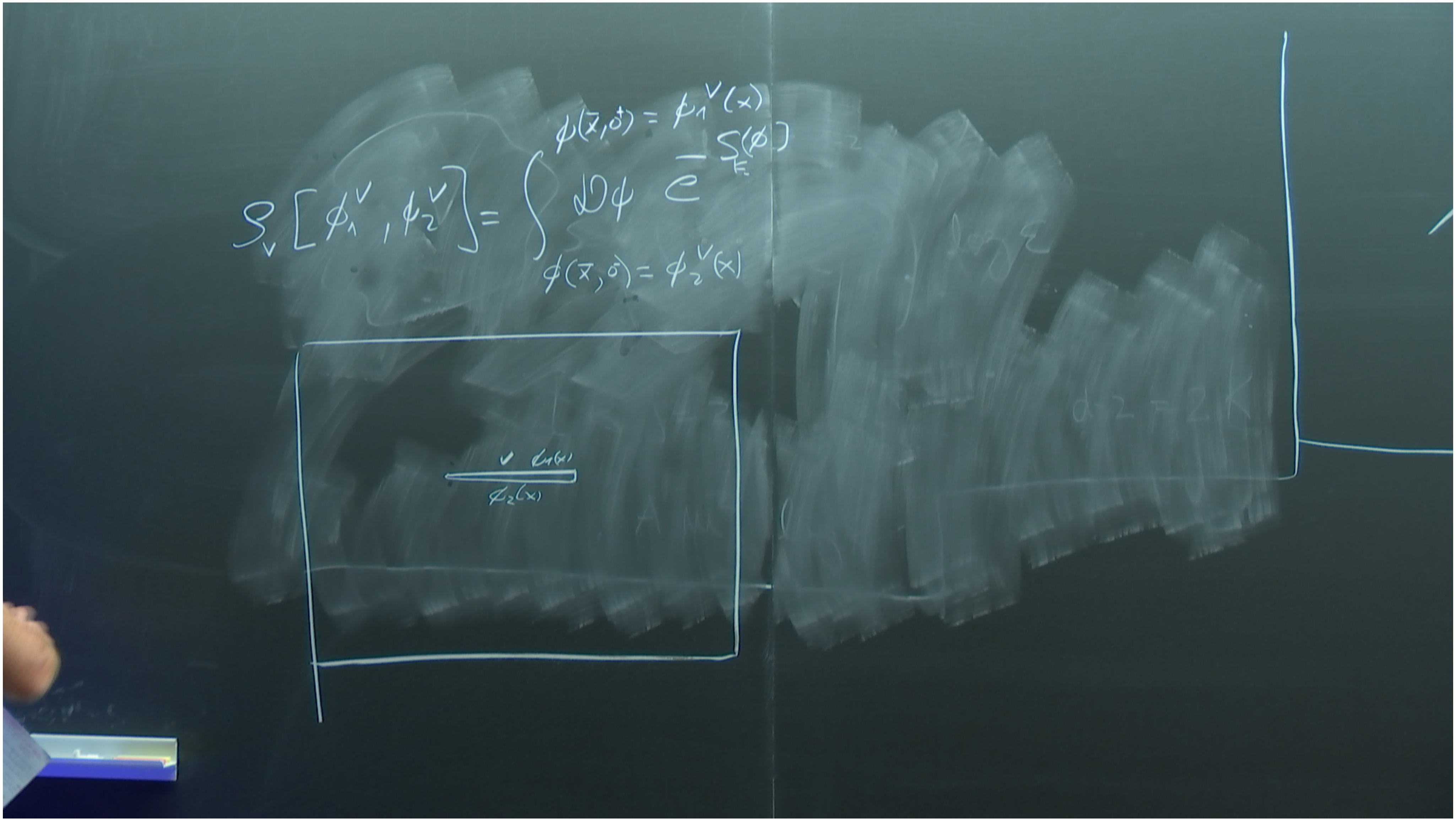
$$d \to d-2$$

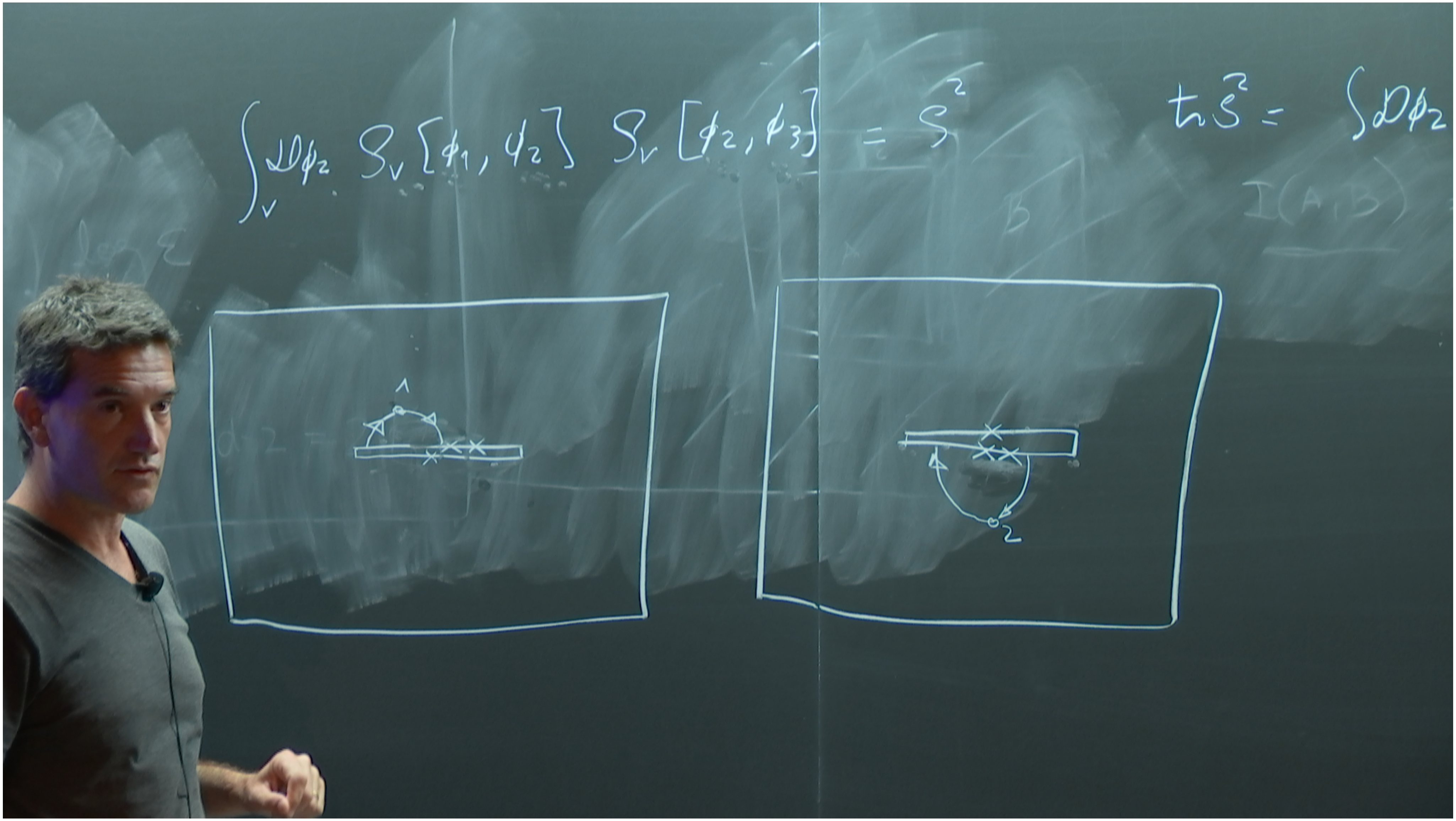
$$S = \left(\int_{\partial V} d^{d-2}x \; (\quad) \right) \log \varepsilon$$

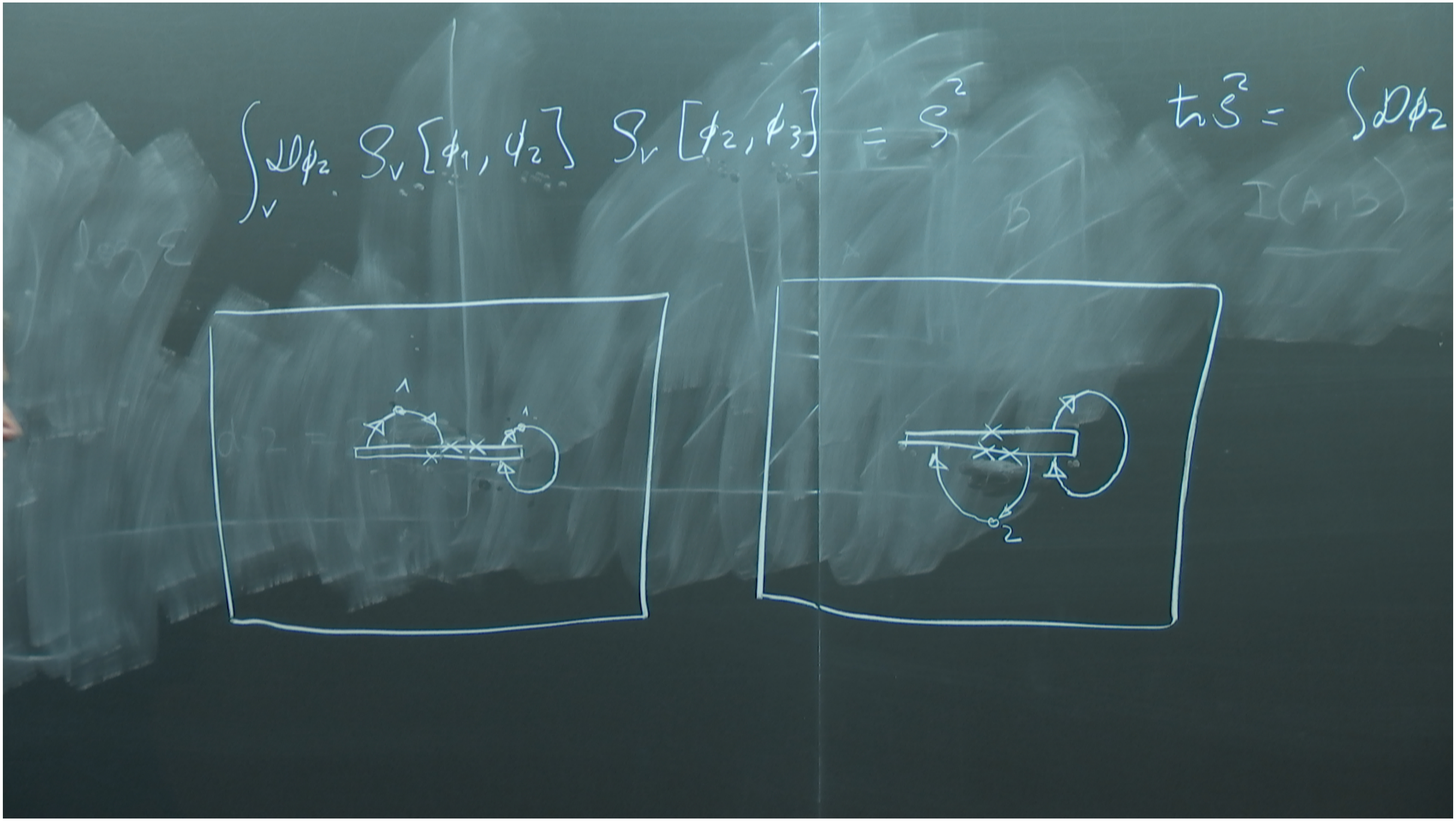
$$[R] = 2 \qquad R^K \qquad d-2 = 2K$$

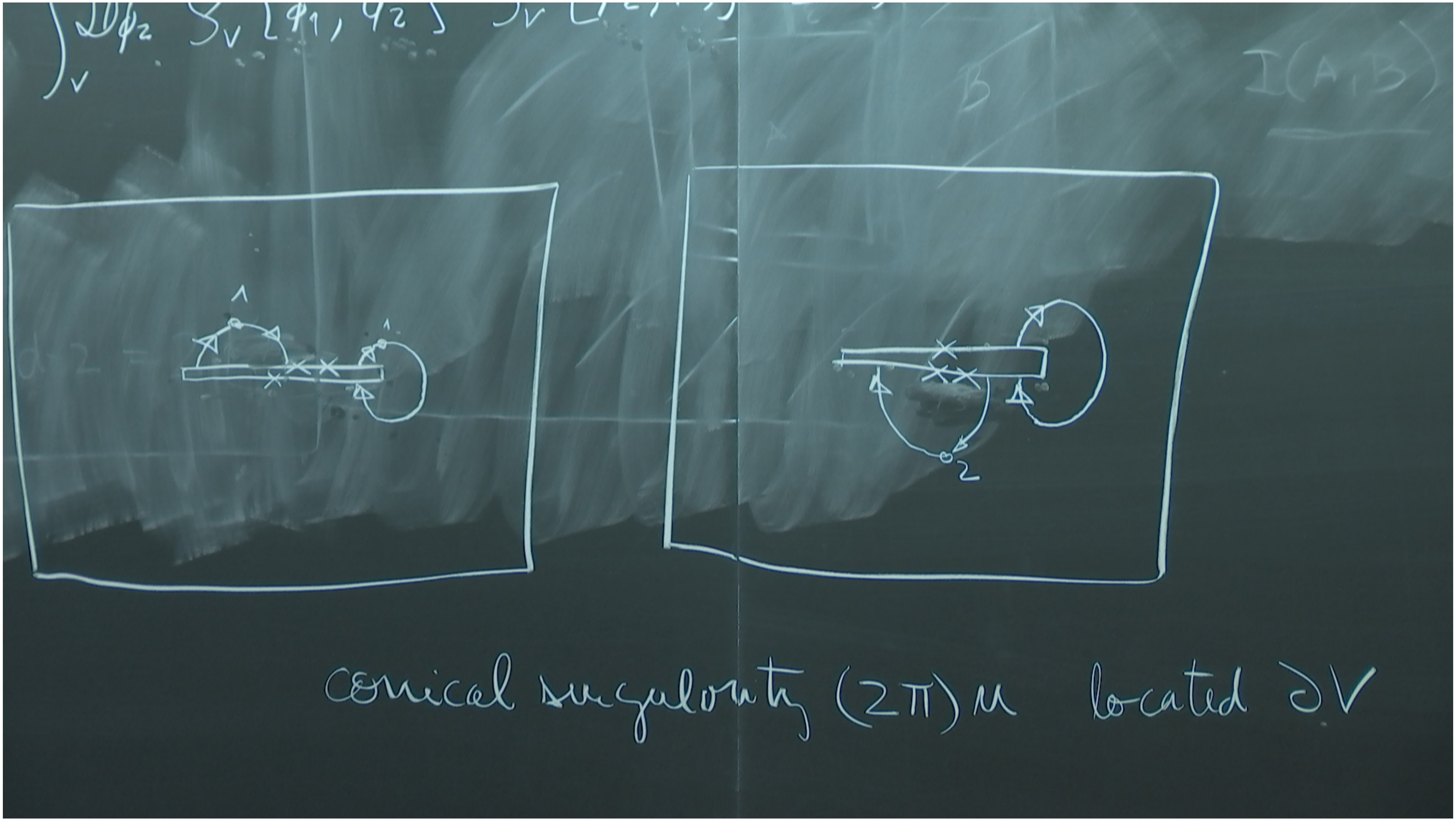
$$A\, m^2 \log \varepsilon$$

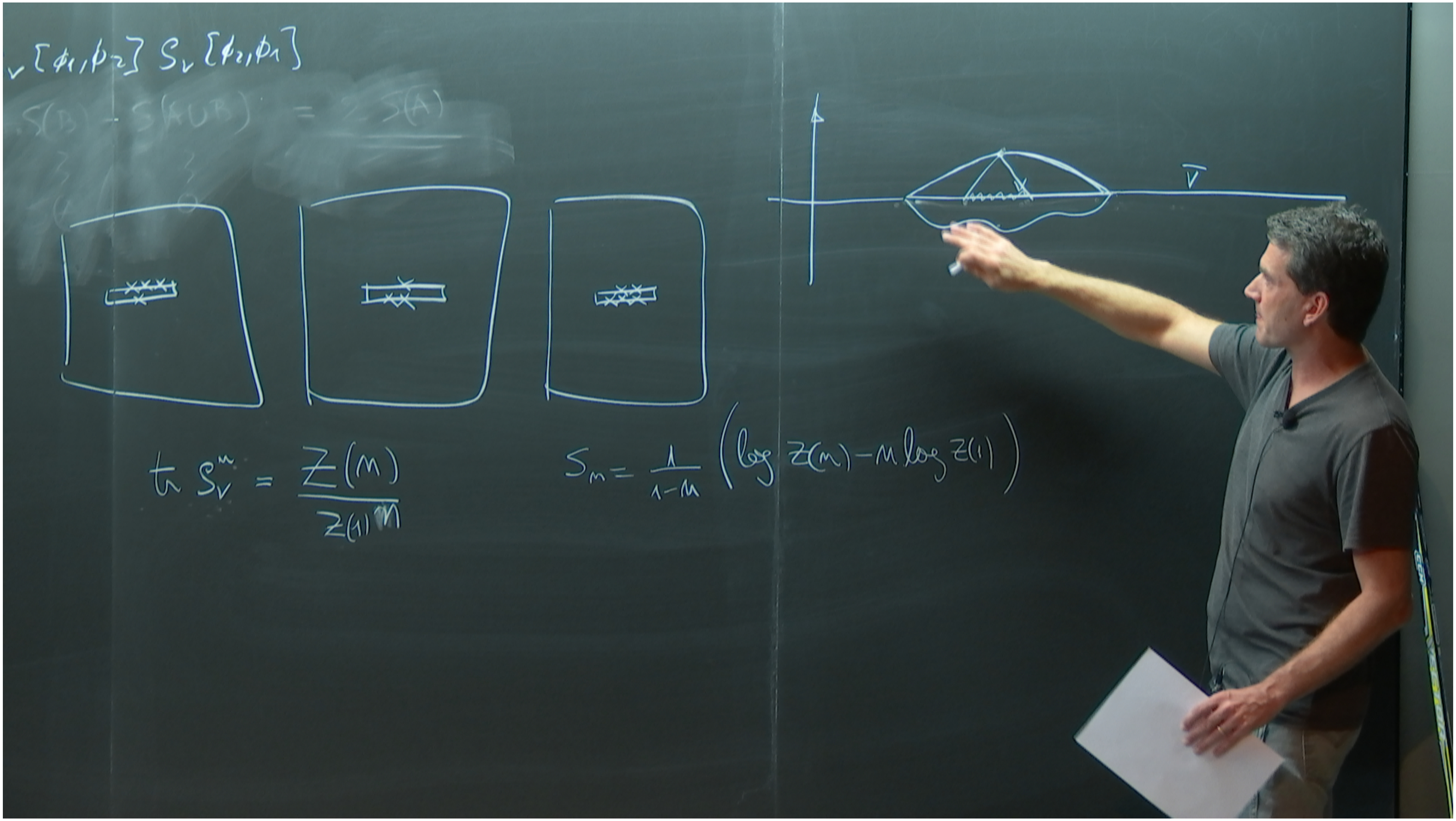

d → d-2
V
S= (∫∂V d^{d-2}x ( )) log ε
[R]=2   R^K   d-2 = 2K
A m² log ε
ε
A
B
I(A,B) = S(A)+S(B) − S(A∪B) = 2 S(A)
S(A)
0

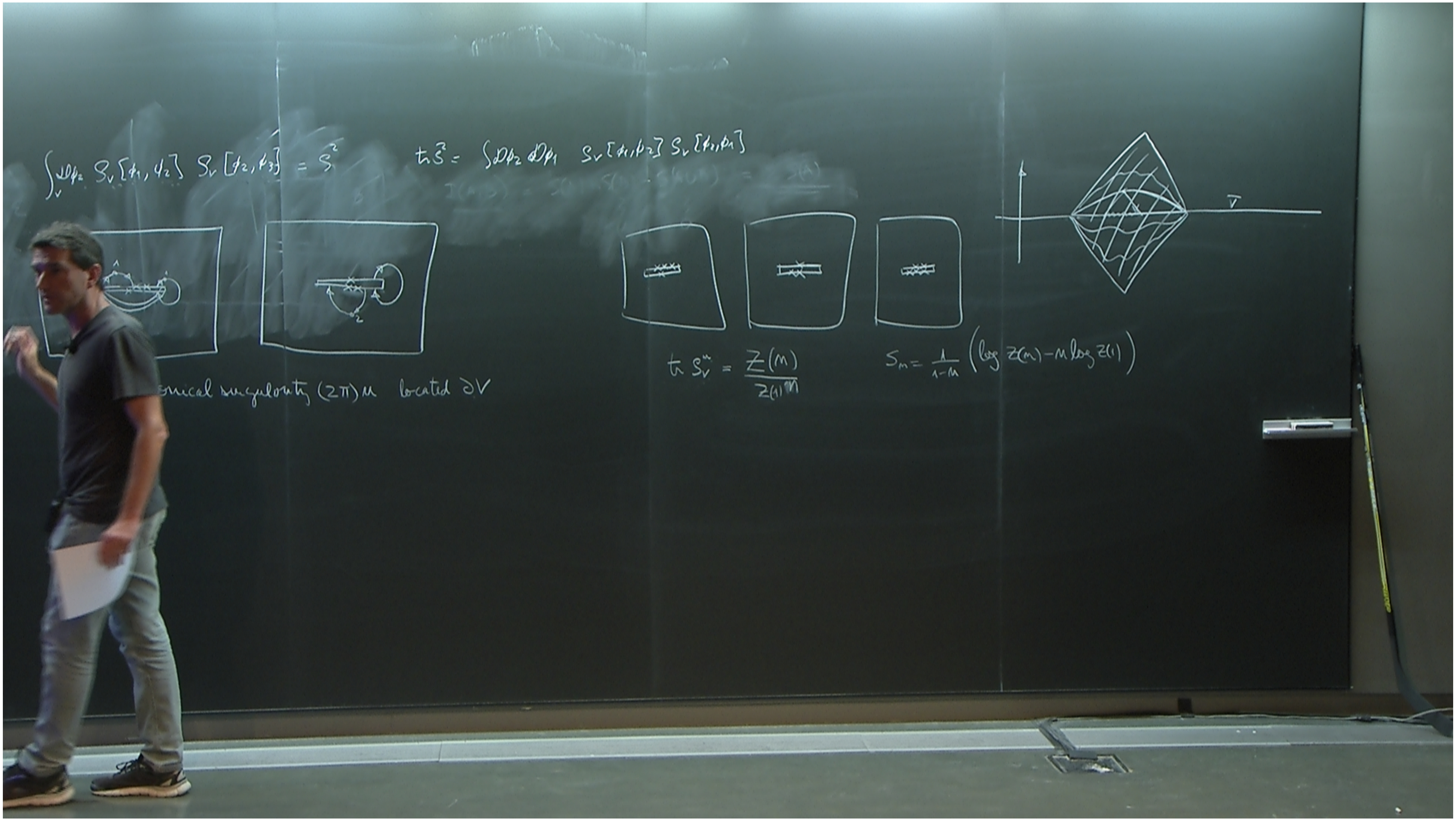

$\rho_V[\phi_1^V, \phi_2^V] = \int_{\phi(\bar{x},0^-) = \phi_2^V(x)}^{\phi(\bar{x},0^+) = \phi_1^V(x)} \mathcal{D}\phi \, e^{-S_E(\phi)}$
V $\phi_1(x)$
$\phi_2(x)$


$\int_V \mathcal{D}\phi_2 \, \rho_V[\phi_1, \phi_2] \, \rho_V[\phi_2, \phi_3] = \rho^2$
$\mathrm{tr}\,\rho^2 = \int \mathcal{D}\phi_2$


$\int_V \mathcal{D}\phi_2 \, \rho_V[\phi_1, \phi_2] \, \rho_V[\phi_2, \phi_3] = \rho^2$
$\mathrm{tr}\, \rho^2 = \int \mathcal{D}\phi_2$


I(A,B)
B
conical singularity (2π)n located ∂V


v [ϕ1, ϕ2] Sv [ϕ2, ϕ1]
tr Sv^n = Z(n) / Z(1)^n
Sn = 1/(1−n) (log Z(n) − n log Z(1))
v̄


tr S_V^n = Z(n) / Z(1)^n
S_n = 1/(1-n) (log Z(n) - n log Z(1))
located ∂V

$\mathcal{H}_A \otimes \mathcal{H}_B$

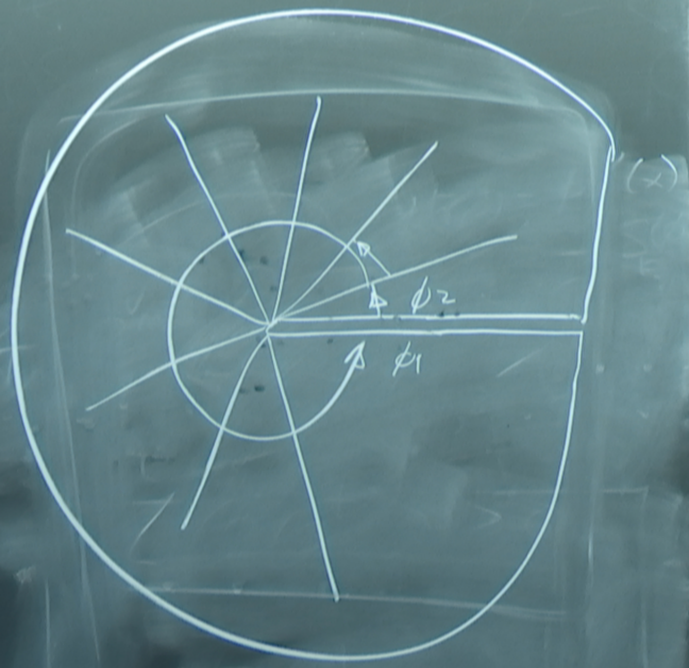
n copies $\quad |0\rangle = \otimes^n |0_i\rangle$

$\{ |e_a^i\rangle \otimes |f_b^i\rangle \}$

$$\to \mathcal{O}_A^{(n)} = \left(\bigotimes_i \sum_a |e_a^{i+1}\rangle\langle e_a^i| \otimes 1_B \right)$$

$$\mathrm{tr}(\rho_A^n) = \langle \mathcal{O}_A^{(n)} \rangle$$

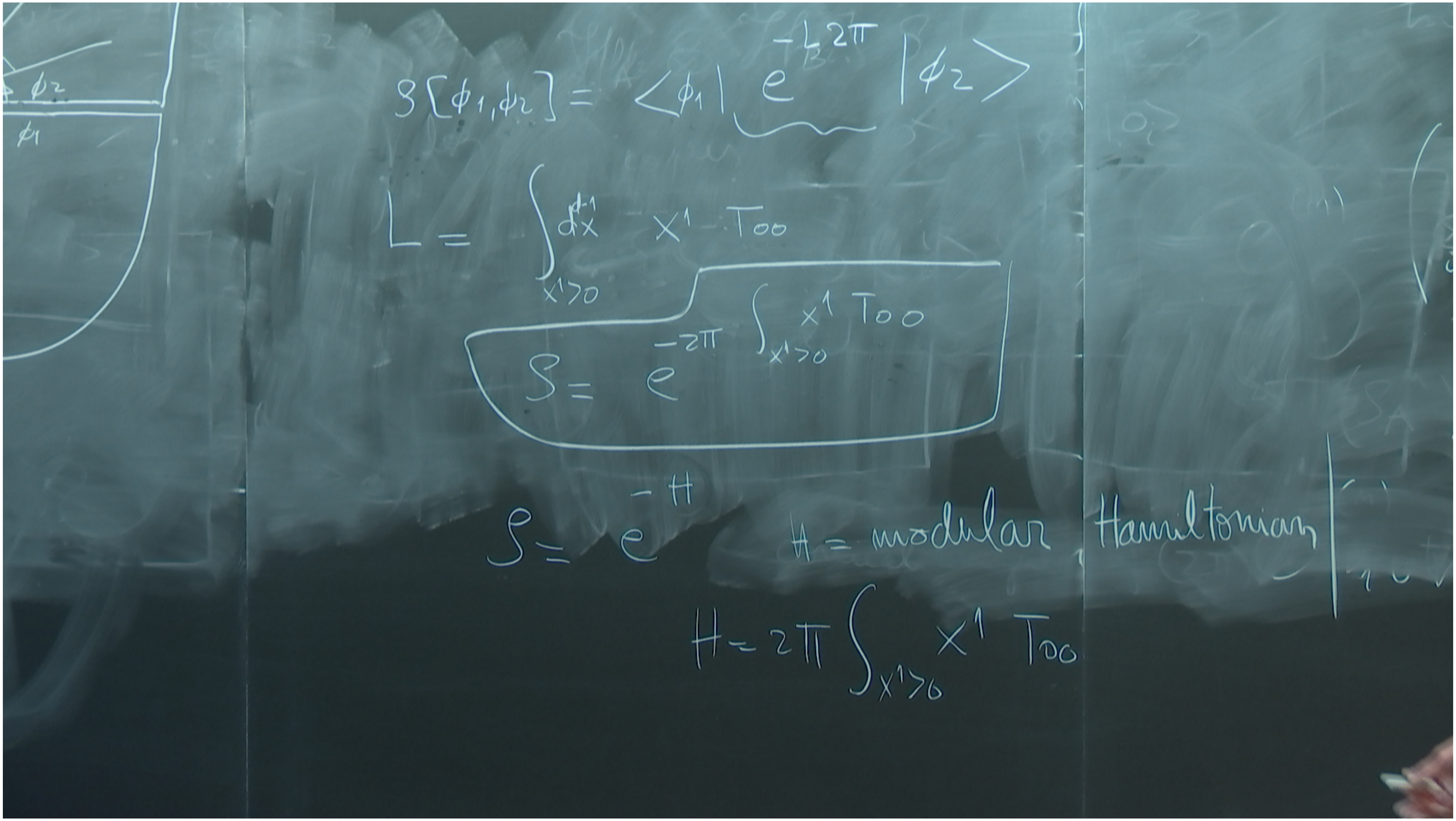
$$\mathcal{O}^{(n)}_{V_1 \cup V_2} = \mathcal{O}^{(n)}_{V_1} \otimes \mathcal{O}^{(n)}_{V_2}$$

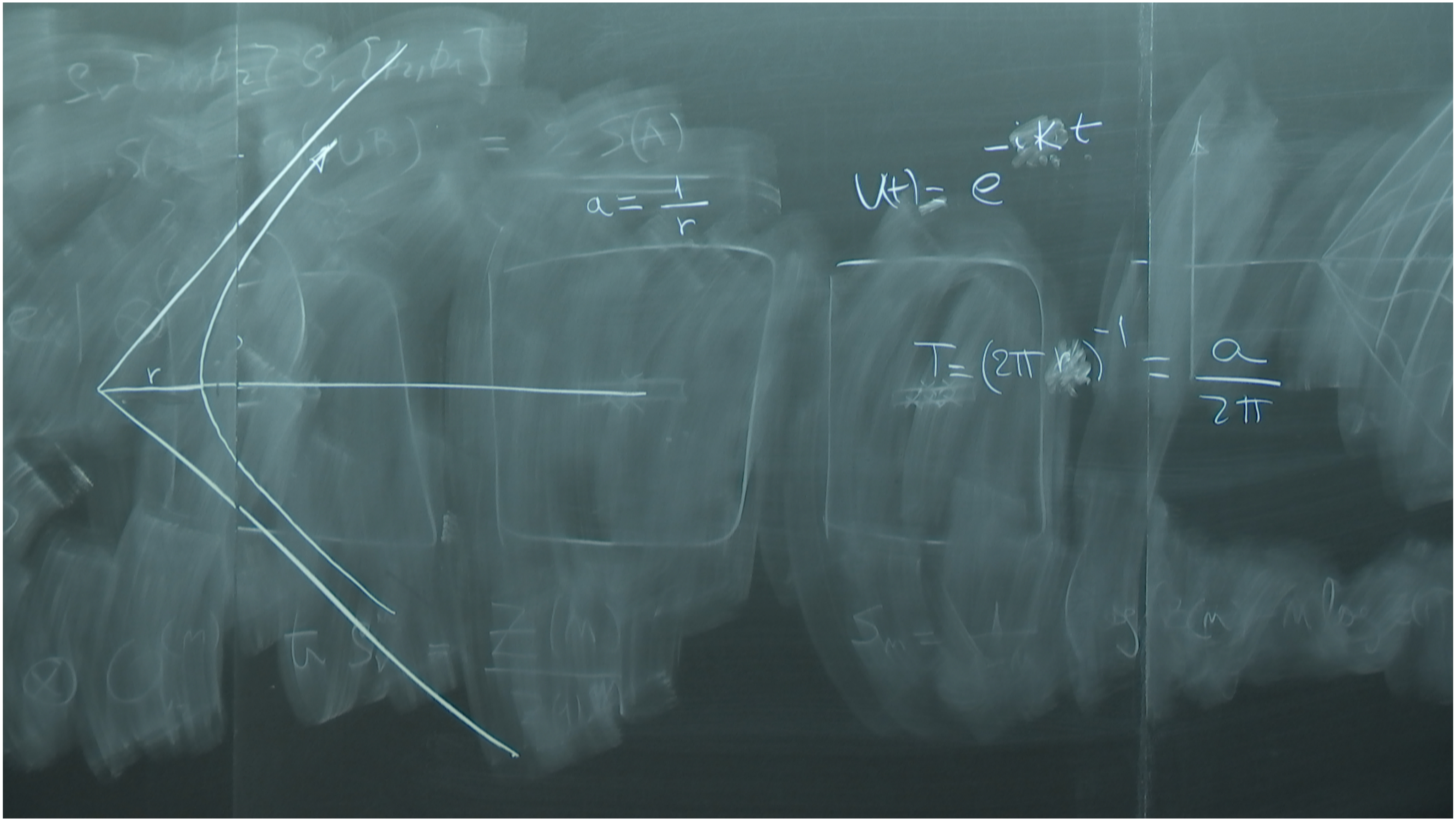


$$\rho[\phi_1,\phi_2] = \langle \phi_1 | \underbrace{e^{-L\,2\pi}} | \phi_2 \rangle$$

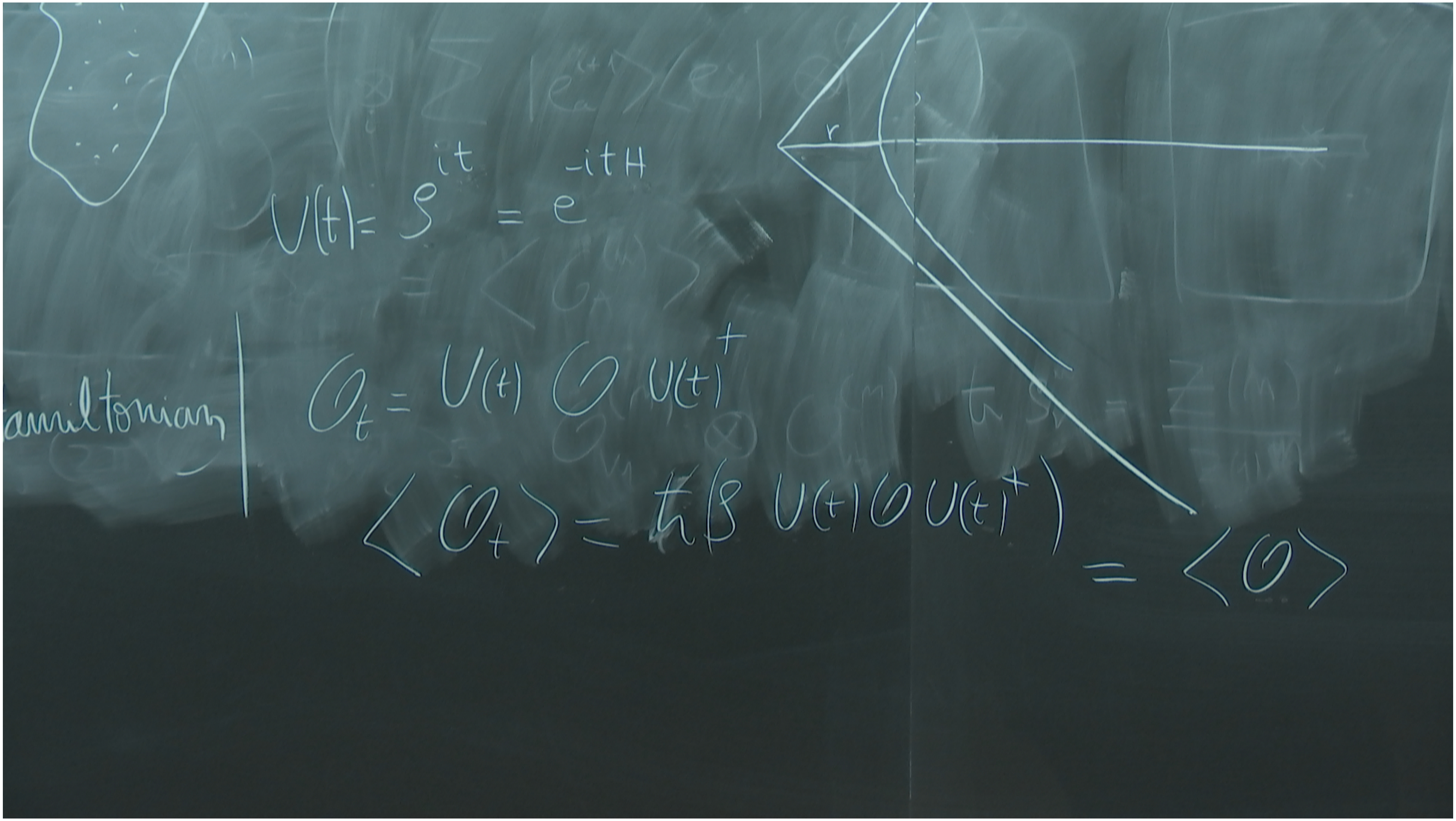
$$L = \int_{x^1>0} d^{d-1}x \; x^1 \, T_{00}$$

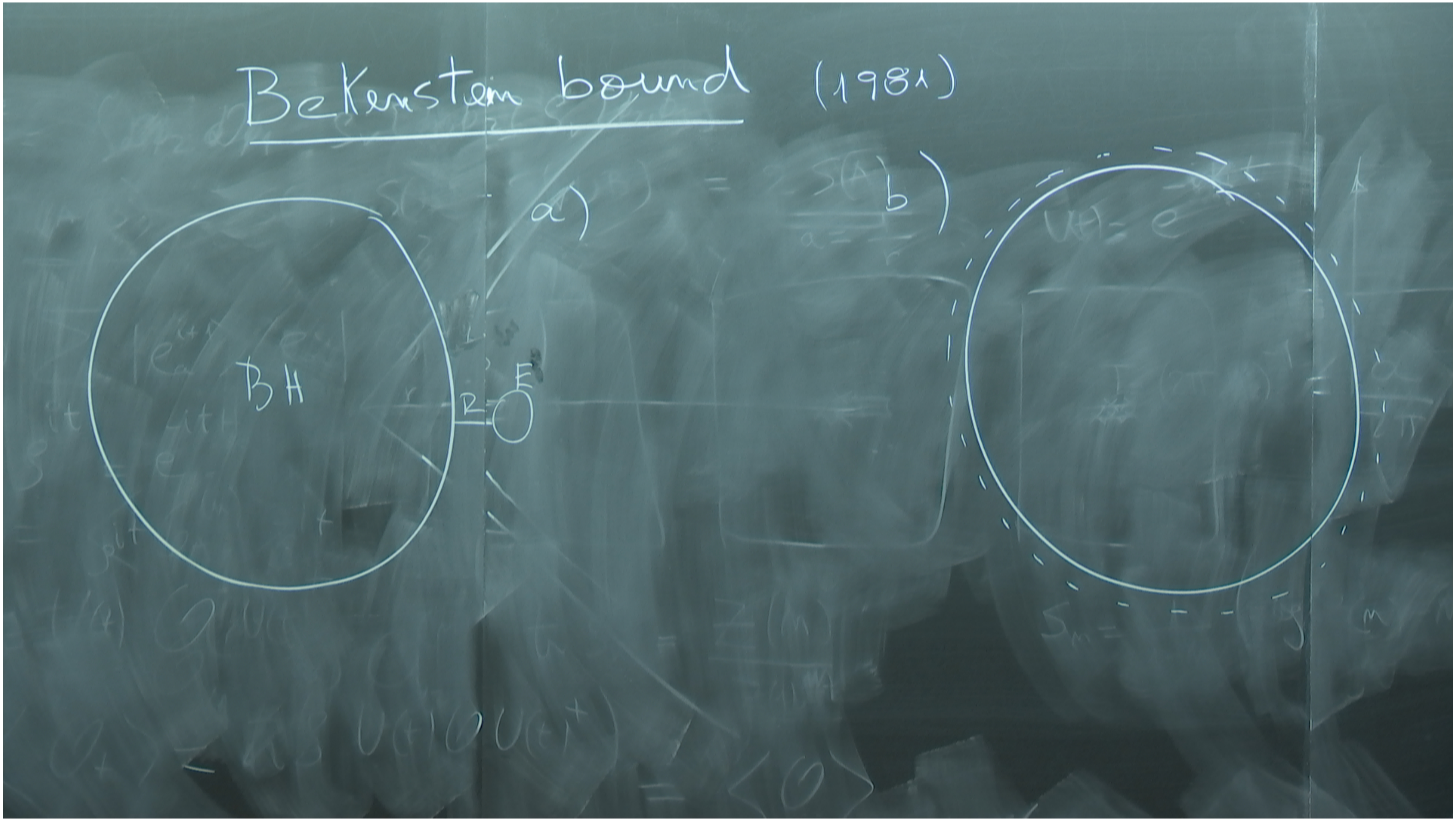
$$\boxed{\rho = e^{-2\pi \int_{x^1>0} x^1 T_{00}}}$$

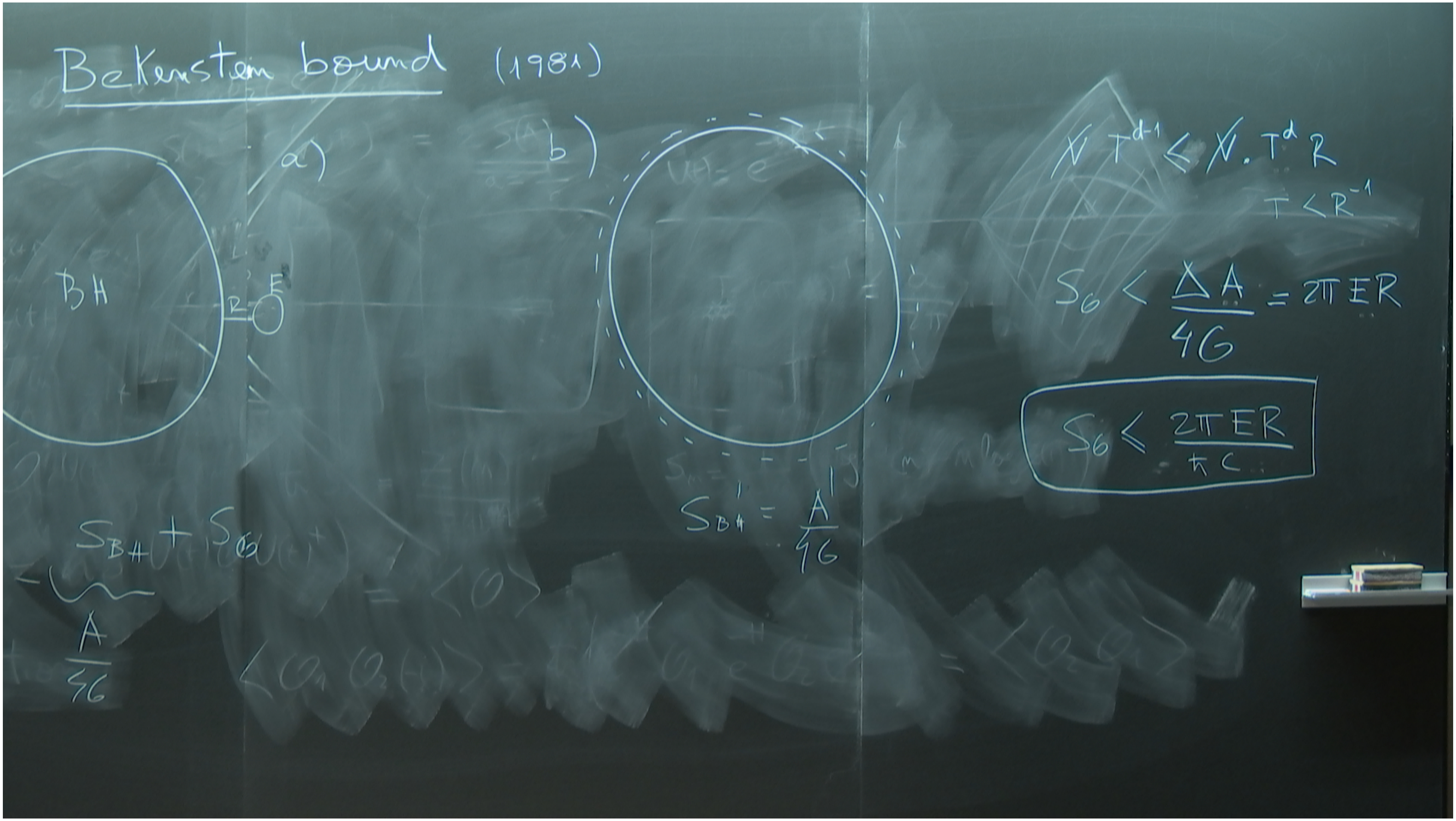

$\rho[\phi_1, \phi_2] = \langle \phi_1 | \underbrace{e^{-L\,2\pi}} | \phi_2 \rangle$
$L = \int_{x^1>0} d^{d-1}x \; x^1 \, T_{00}$
$\boxed{\rho = e^{-2\pi \int_{x^1>0} x^1 T_{00}}}$
$\rho = e^{-H}$
H = modular Hamiltonian
$H = 2\pi \int_{x^1>0} x^1 \, T_{00}$

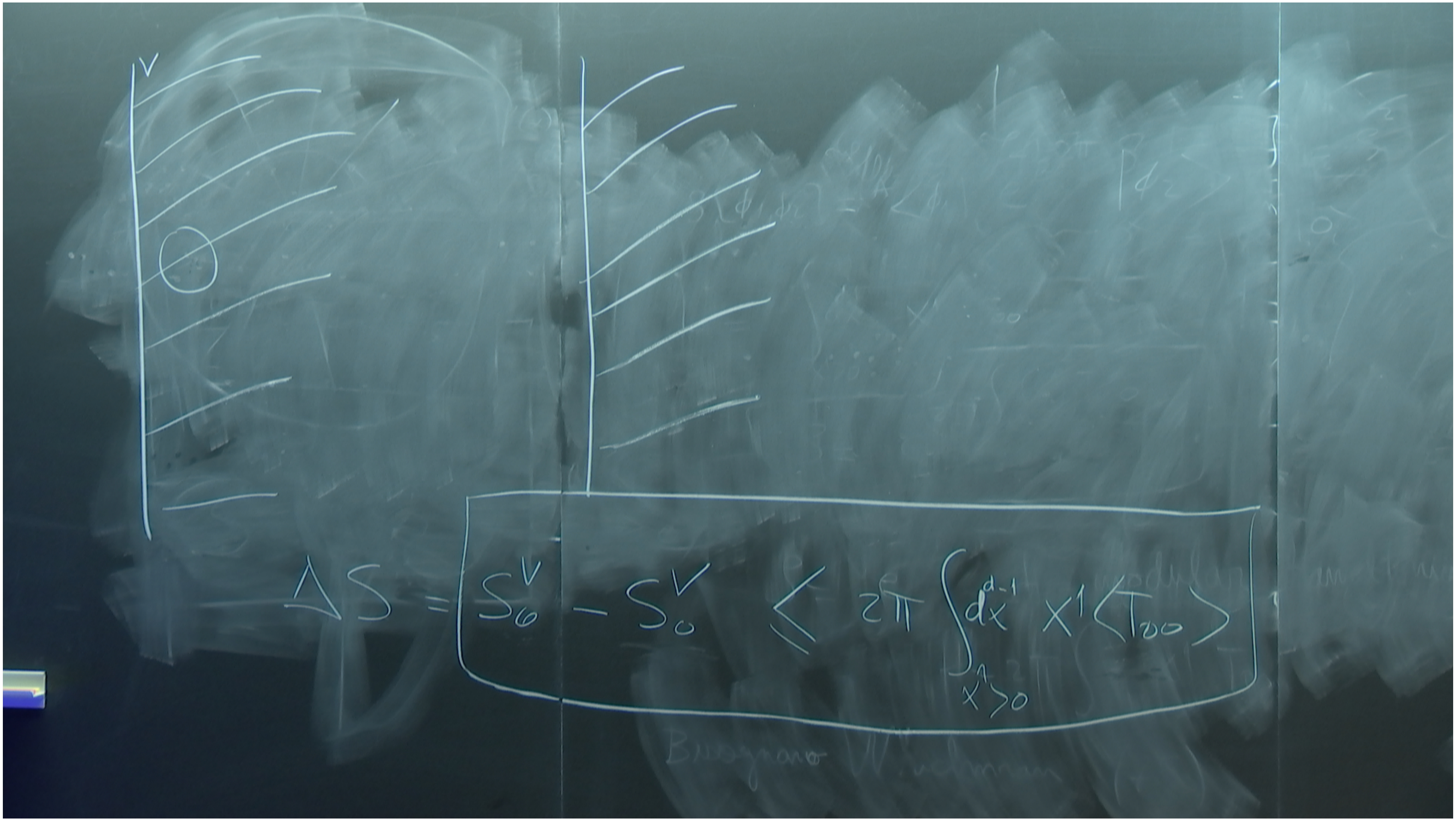


$a = \frac{1}{r}$
$U(t) = e^{-iKt}$
$T = (2\pi r)^{-1} = \frac{a}{2\pi}$
r


$U(t) = \rho^{it} = e^{-itH}$
r
amiltonian
$O_t = U(t)\, O\, U(t)^{+}$
$\langle O_t \rangle = \mathrm{tr}\big(\rho\, U(t)\, O\, U(t)^{+}\big) = \langle O \rangle$


Bekenstein bound (1981)
a)
b)
BH
R
E


Bekenstein bound (1981)
BH
R
E
a)
b)
$\mathcal{N}\, T^{d-1} \leqslant \mathcal{N}\, T^{d} R$
$T < R^{-1}$
$S_G < \frac{\Delta A}{4G} = 2\pi E R$
$S_G \leqslant \frac{2\pi E R}{\hbar c}$
$S_{BH} = \frac{A}{4G}$
$S_{BH} + S_G$
$\frac{A}{4G}$


V
$\Delta S = S^V_\rho - S^V_0 \leq 2\pi \int_{x^1>0} d^{d-1}x \, x^1 \langle T_{00} \rangle$

Bekenstein bound (1981)

$$S(\rho \| \rho_0) = \mathrm{tr}(\rho \log \rho - \rho \log \rho_0)$$

$$\mathrm{tr}(\rho \log \rho - \rho_0 \log \rho_0 + \rho_0 \log \rho_0 - \rho \log \rho_0)$$

$$S(\rho \| \rho_0) = \mathrm{tr}(\rho \log \rho - \rho \log \rho_0) \qquad \rho_0 = e^{-H}$$

$$\mathrm{tr}\left(\overbrace{\rho \log \rho - \rho_0 \log \rho_0} + \underbrace{\rho_0 \log \rho_0 - \rho \log \rho_0}\right)$$

$$\underline{-S(\rho) + S(\rho_0)} + \langle H \rangle - \langle H \rangle_0$$

$$\mathrm{tr}(\rho H) - \mathrm{tr}(\rho_0 H)$$

$$\Delta \langle H \rangle - \Delta S \geq 0$$

a)

b)