

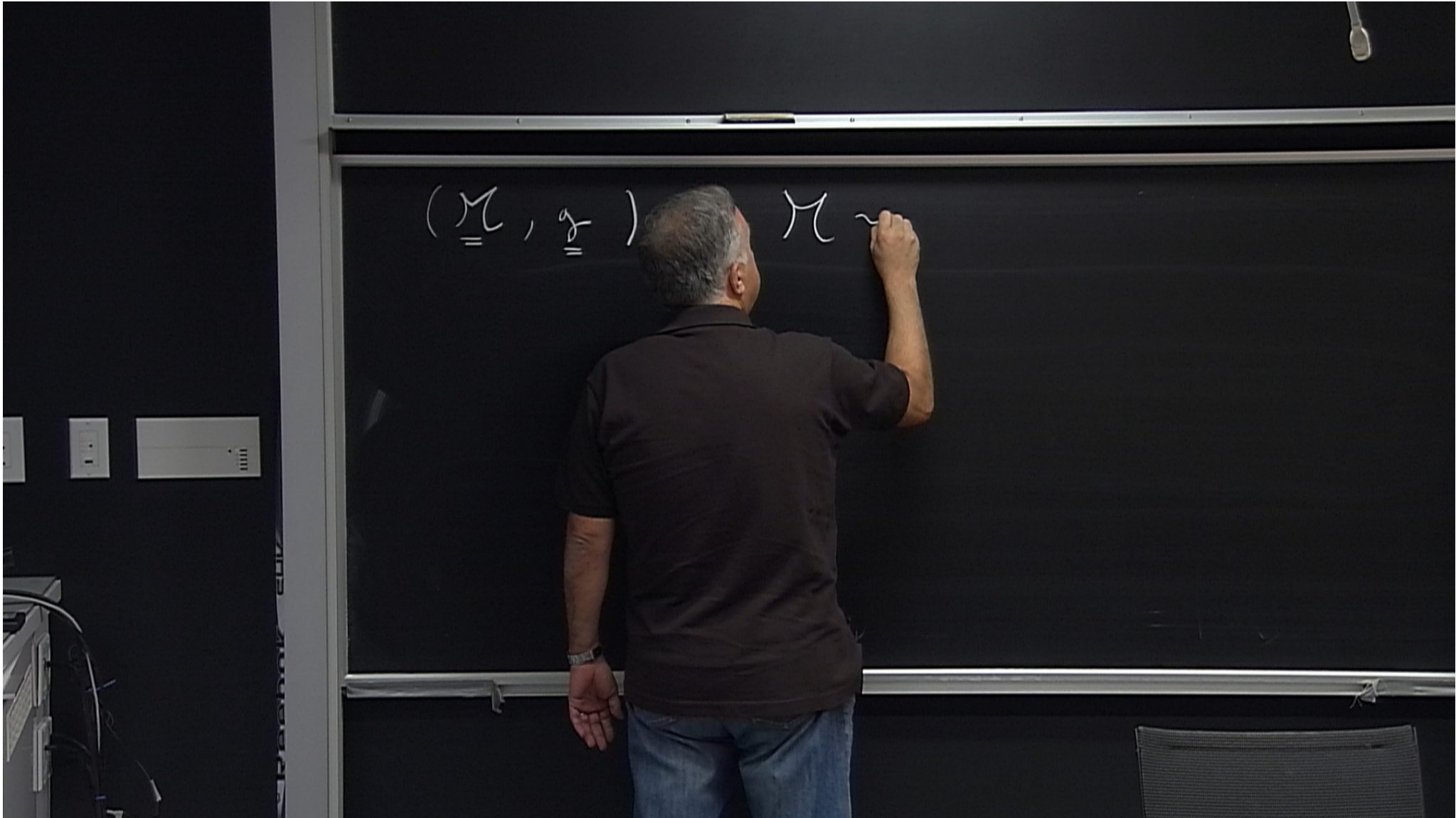
Title: Topics in QFT on Flat and Curved Spacetimes - Lecture 6

Date: Oct 09, 2013 10:00 AM

URL: <http://pirsa.org/13100016>

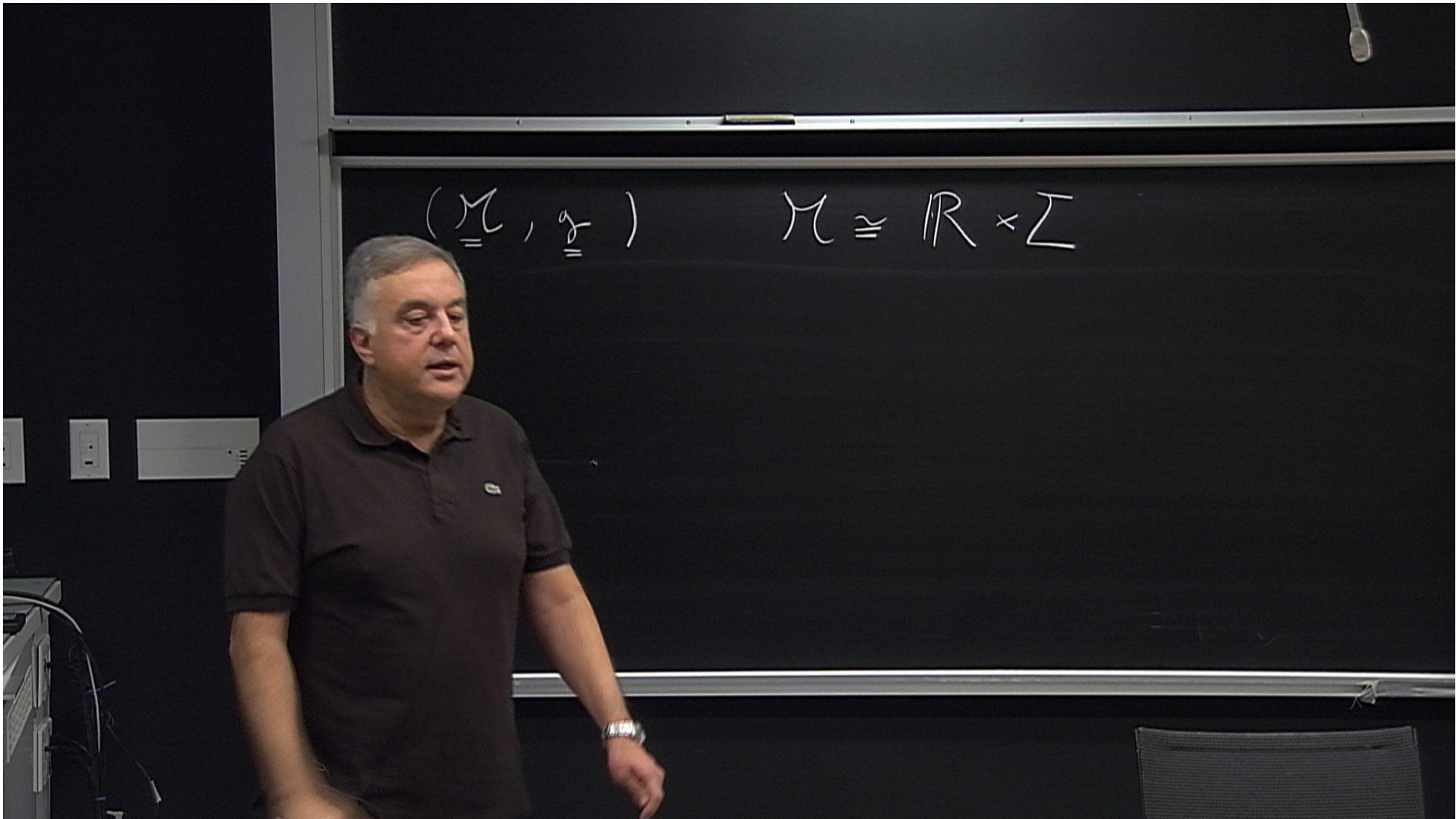
Abstract:

Spectral conditions \leftrightarrow Analyticity of the
correlation functions



$(\mathcal{M}, \mathcal{G})$

$$\mathcal{M} \cong \mathbb{R} \times \mathbb{Z}$$



$$(\underline{\mathcal{M}}, \underline{g})$$

$$\mathcal{M} \cong \mathbb{R} \times \Sigma$$

$$E(x, y)$$

$$(\underline{\mathcal{M}}, \underline{\mathcal{G}}) \leftarrow \mathcal{M} \cong \mathbb{R} \times \Sigma$$

$$\underline{E(x, y)} \Leftrightarrow \underline{C(x, y)}$$

$$[\phi(x), \phi(y)] = C(x, y) \perp\!\!\!\perp$$

1st - step

$$\underline{C(x, y)} \Leftrightarrow |C(x, y)| \quad \text{1} \quad \frac{n-1}{1}$$

$$[\phi(x), \phi(y)] = C(x, y) \quad \parallel$$

$$[\hat{\phi}(x), \hat{\phi}(y)] = C(x, y)$$

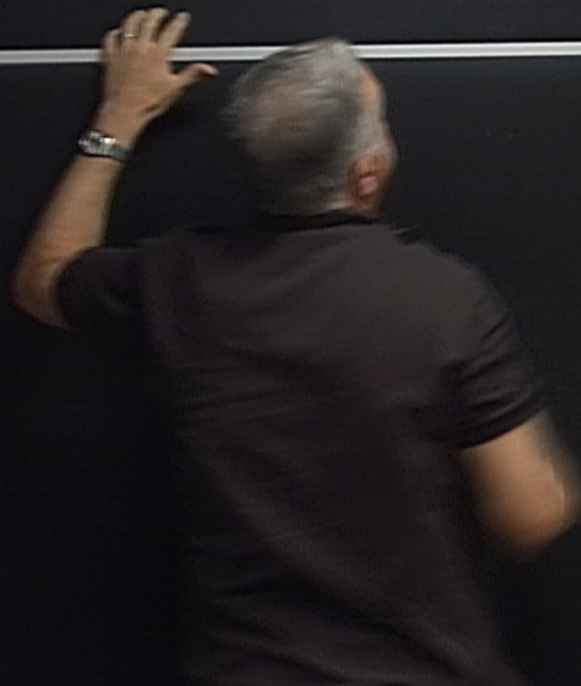
1st - step

$$\underline{\underline{C(x,y)}} \Leftrightarrow \underline{\underline{C(x,y)}} \quad \text{1} \quad \frac{n-1}{n}$$

$$[\phi(x), \phi(y)] = C(x,y) \quad \underline{\underline{1}}$$

1st-step

$$[\hat{\phi}(x), \hat{\phi}(y)] = C(x,y) \quad \underline{\underline{1}}_{\text{sc}}$$



$$\int W(x, y) \overline{f(x)} f(y) d^d x d^d y \geq b \quad f \in \mathcal{L}^2(\mathcal{X}, \mathbb{C})$$

$$\mathcal{J}_S(\mathcal{X}^{(1)})$$

$$\Phi(f) = \Phi^+(f) + \Phi T f$$

$$\Phi^+(f) \Psi$$

$$\int W(x, y) \overline{f(x)} f(y) d^d x d^d y \geq 0 \quad f \in \mathcal{C}(\mathcal{R}, \mathbb{C})$$

$$\mathcal{J}_S(\mathcal{R}^{(n)})$$

$$\Phi(f) = \Phi^+(f) + \Phi T f$$

$$[\Phi^+(f) \Psi]^{(n)} = \frac{1}{\sqrt{n}} \sum_{i=1}^n f(x_i)$$

$$\Phi(f) = \Phi^+(f) + \Phi^-(f)$$

$$[\Phi^+(f) \Psi]^{(n)} = \frac{1}{\sqrt{n}} \sum_{j=1}^n f(x_j) \Psi^{n-1}(x_1, \dots, \cancel{x_j}, \dots, x_n)$$

$$[\Phi^-(f) \Psi]^{(n)} = \frac{1}{\sqrt{n+1}} \int f(x) \Psi^{n+1}(x, x_1, \dots, x_n) dx$$

$$\phi(f) = \phi^+(f) + \phi^-(f)$$

$$[\phi^+(f) \psi]^{(n)} = \frac{1}{\sqrt{n}} \sum_{j=1}^n f(x_j) \psi^{n-1}(x_1, \dots, x_{j-1}, x_{j+1}, \dots, x_n)$$

$$[\phi^-(f) \psi]^{(n)} = \frac{1}{\sqrt{n+1}} \int W(x, y) f(x) \psi^{n+1}(x, x_1, \dots, x_n) dx$$

$$[\phi(x), \phi(y)] = C(x, y) \mathbb{1}$$

$$\rightarrow \boxed{C(x, y) + W(y, x)} \leftarrow$$

$$\int W(x, y) f(y) d^d x d^d y \geq 0 \quad f \in C_0^\infty(\mathcal{X}, \mathbb{R})$$

$$\exists_s (d^n)$$

$$\Phi(f) = \phi(f)$$

$$[\Phi^+(f)$$

$$\frac{1}{\sqrt{n}} \sum_{j=1}^n f(x_j) \Psi^{n-1}(x_1, \dots, x_j, \dots, x_n)$$

Spectral conditions \leftrightarrow Analyticity of the
correlation functions

$$C(x, y) = W(x, y) - W(y, x)$$

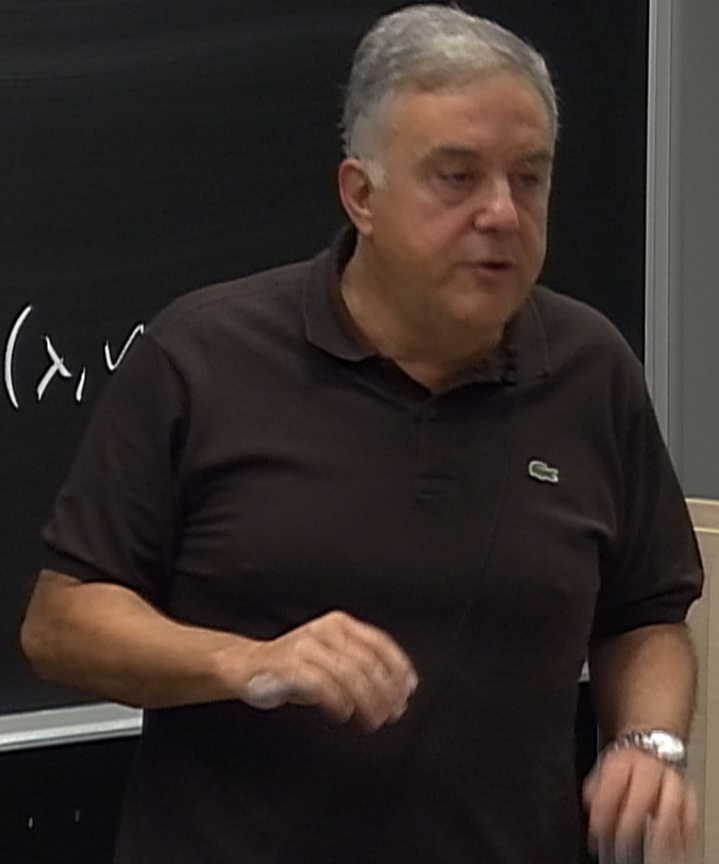
$$W(x, y) = \frac{1}{2} \underset{\uparrow}{C(x, y)} + \frac{1}{2} \underset{\uparrow}{S(x, y)}$$

$$\mathcal{L} = \frac{1}{2} (\nabla^\mu \phi \nabla_\mu \phi - m^2 \phi^2) \leftarrow$$

$$(\square + m^2) \phi \leftarrow$$

$$\downarrow$$

$$C(x, y) + S(x, y)$$



CAUTION

$$\mathcal{L} = \frac{1}{2} (\nabla^\mu \phi \nabla_\mu \phi - m^2 \phi^2) \leftarrow$$

$$\downarrow$$
$$(\square + m^2) \phi \leftarrow$$

$$\downarrow$$
$$C(x, y) + S(x, y)$$

CAUTION

$$[\Phi^+(f) \Psi]^{(n)} = \frac{1}{\sqrt{n}} \sum_{j=1}^n f(x_j) \Psi(x_1, \dots, x_n)$$

$$[\Phi^-(f) \Psi]^{(n)} = \sqrt{n+1} \int W(x, y) f(x) \Psi^{n+1}(x, x_1, \dots, x_n) dx$$

$$[\Phi(x, y)] = C(x, y) \mathbb{1} \langle \Psi_0 | \dots | \Psi \rangle$$



$$\Phi(f) = \Phi^+(f) + \Phi^-(f)$$

$$[\Phi^+(f) \Psi]^{(n)} = \frac{1}{\sqrt{n}} \sum_{j=1}^n f(x_j) \Psi^{n-1}(x_1, \dots, x_{j-1}, x_{j+1}, \dots, x_n)$$

$$[\Phi^-(f) \Psi]^{(n)} = \frac{1}{\sqrt{n+1}} \int W(x, y) f(x) \Psi^{n+1}(x, x_1, \dots, x_n) dx$$

$$W(x, y) = W(y, x)$$

$$[\phi^+(f) \psi]^{(n)} = \frac{1}{\sqrt{n}} \sum_{j=1}^n f(x_j) \psi(x_1, \dots, x_n)$$

$$[\phi^-(f) \psi]^{(n)} = \frac{1}{\sqrt{n+1}} \int W(x, y) f(x) \psi^{n+1}(x, x_1, \dots, x_n) dx$$

$$C(x, y) = W(x, y) - W(y, x) \quad dx$$

\downarrow GNS

$$\phi(f) \psi \quad \quad \quad d\phi^+ = W(?)$$

$$[\phi^+(f) \psi]^{(n)} = \frac{1}{\sqrt{n}} \sum_{j=1}^n f(x_j) \psi(x_1, \dots, x_n)$$

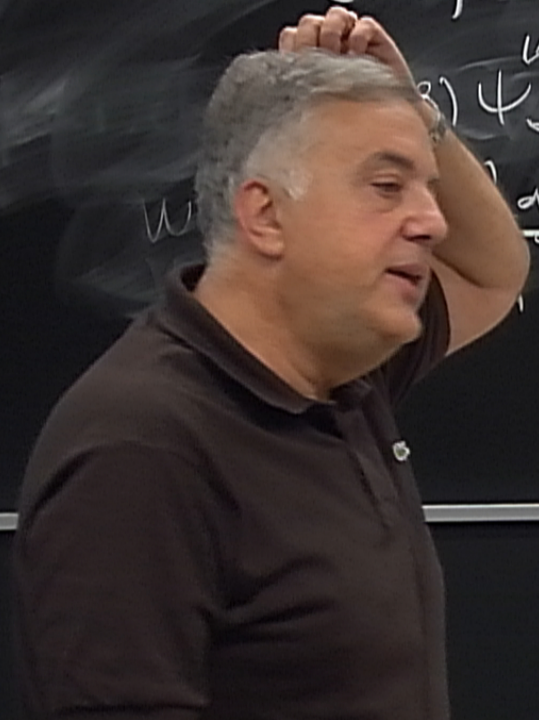
$$[\phi^-(f) \psi]^{(n)} = \frac{1}{\sqrt{n+1}} \int W(x, y) f(x) \psi^{n+1}(x, x_1, \dots, x_n) dx$$

$$C(x, y) = W(x, y) - W(y, x) \quad dx$$

GNS

$$d^+ \phi^+ = W(?)$$

$$[\phi(x), \phi(y)] = C(x, y)$$

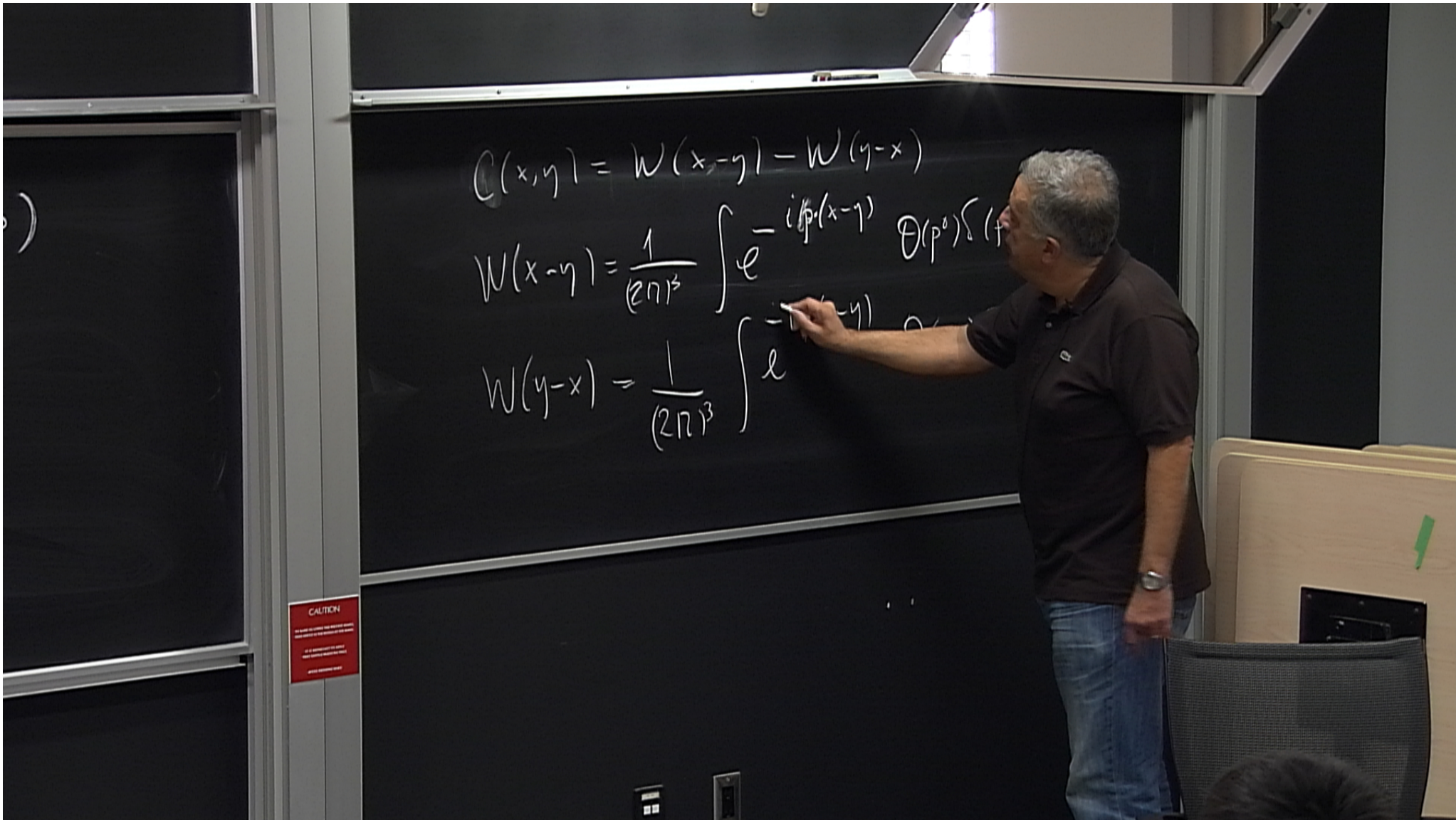


1) Translation invariant states

$$C(x \stackrel{\sim}{-} y) = W(x \stackrel{\sim}{-} y) - W(y \stackrel{\sim}{-} x)$$

$$\int e^{i p \xi} C(\xi) d\xi = \tilde{C}(p) = -\tilde{C}(-p)$$

$$\begin{aligned}\tilde{C}(p) &= f(p)\tilde{C}(p) - f(-p)\tilde{C}(-p) \\ &= (f(p) + f(-p))\tilde{C}(p)\end{aligned}$$



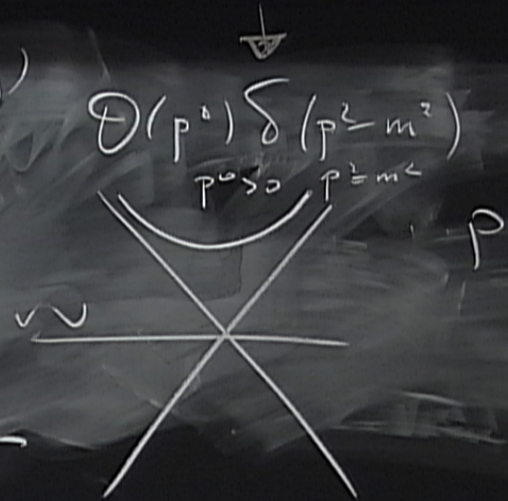
$$[\phi^{-1}(14)]^n = \sqrt{n+1} \int W(x, y) f(x, y) dx, y$$

$$W(\xi) = \int p(x-y) \Theta(p^0) \delta(p^2 - m^2)$$

$$\phi(x) = \frac{1}{(2\pi)^2} \int e^{+ikx} u^+(k)$$

$$[\phi^{-1}(14)]^n = \sqrt{n+1} \int W(x, \eta) f(x) \phi(x, x_1, \dots, x_n)$$

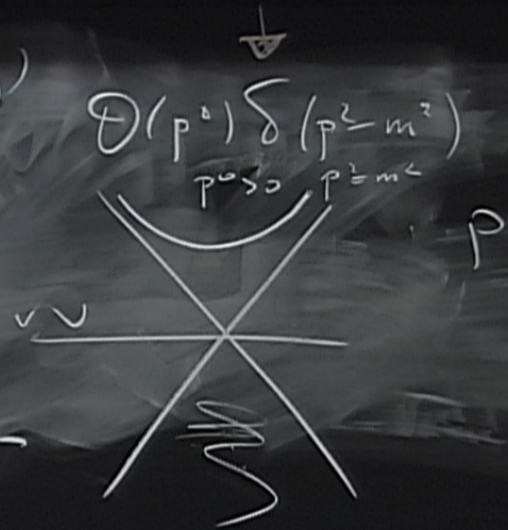
$$W(\vec{\xi}) = \int \frac{e^{-ip(x-y)}}{(2\pi)^3} \Theta(p^0) \delta(p^2 - m^2)$$



$$[\psi^{-1}(1)4]^{n+1} = \sqrt{n+1} \int W(x, y) f(x) \psi(x, x_1, \dots, x_n)$$

$$W(\vec{x}) = \int \frac{e^{-ip(x-y)}}{(2\pi)^3} \Theta(p^0) \delta(p^2 - m^2)$$

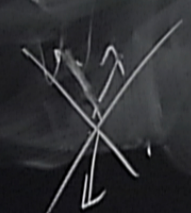
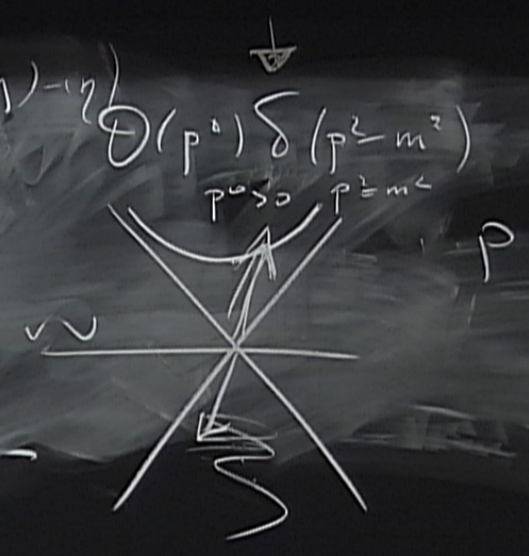
$$-ip(x-y)$$



$$[\phi^{-1}(y)]^{(n)} = \sqrt{n+1} \int W(x, \eta) f(x) \phi(x, x_1, \dots, x_n)$$

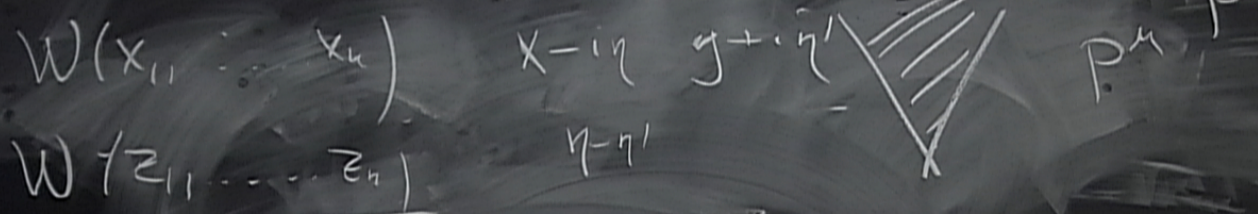
$$W(\vec{x}) = \int \frac{e^{-ip(x-\eta)-i\eta}}{(2\pi)^3} \Theta(p^0) \delta(p^2 - m^2)$$

$$e^{-ip(x-\eta)-i\eta}$$



$$[\phi^{-1}(y)]' = \sqrt{n+1} \int W(x, \eta) f(x) \phi(x, x_1, \dots, x_n)$$

$$W(\vec{x}) = \int \frac{e^{-ip[(x-\eta)-\eta]}}{(2\pi)^n} \Theta(p^0) \delta(p^2 - m^2) = \underline{\underline{W(z)}}$$



$$W(x_1, \dots, x_n)$$

$$W(z_1, \dots, z_n)$$

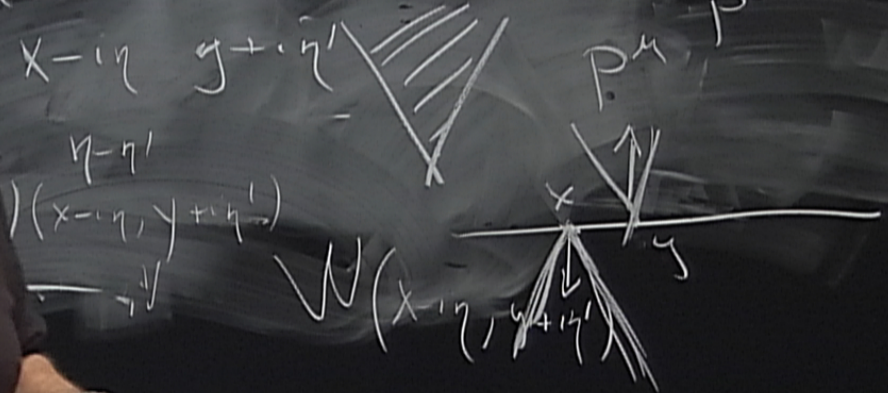
$$[\phi^{-1}(y)]^{(n)} = \sqrt{n+1} \int W(x, \eta) f(x, y) (x, x_1, \dots, x_n)$$

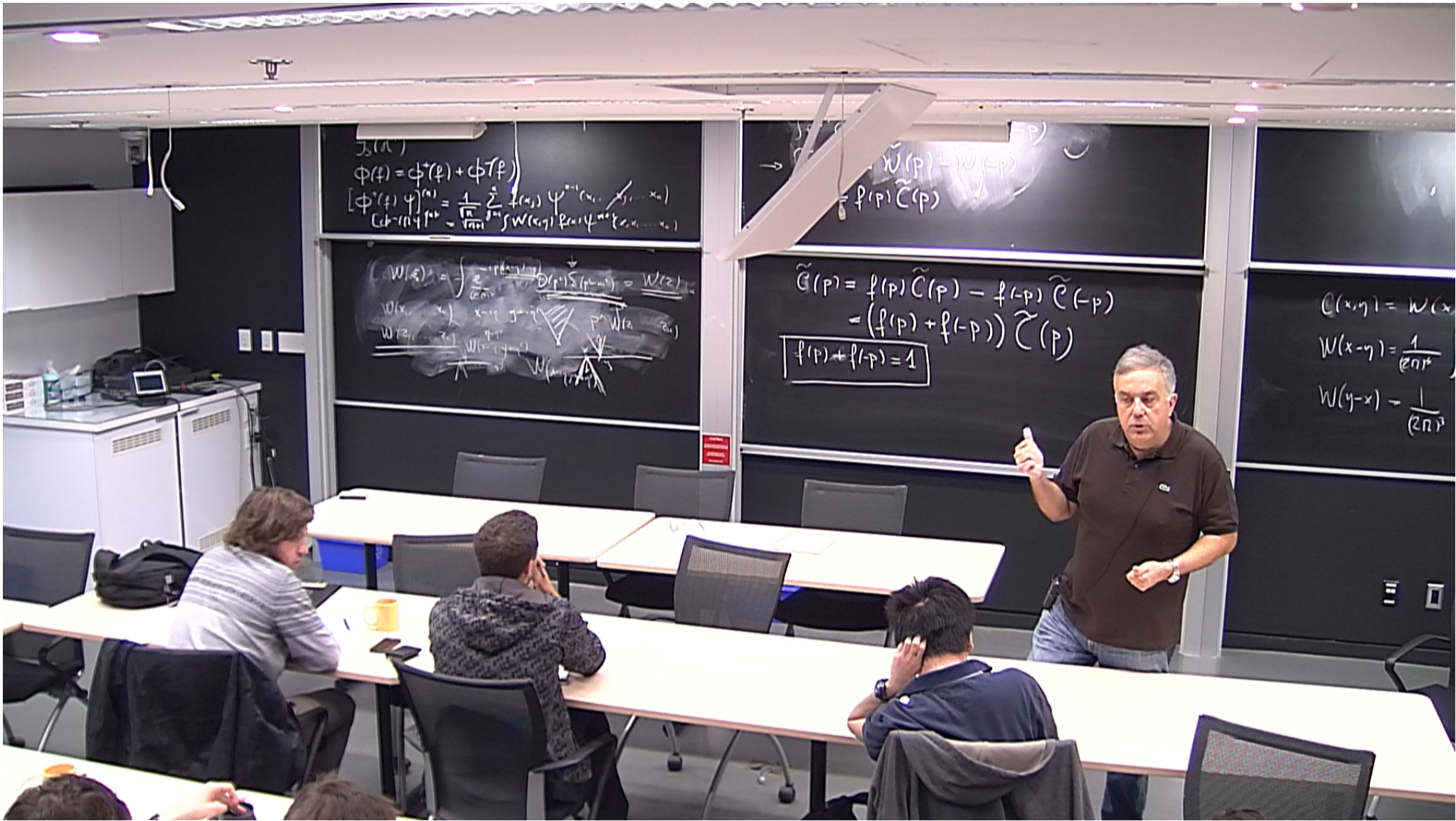
$$W(\xi)$$

$$W(x, \dots)$$

$$W(z)$$

$$\int \frac{e^{-ip(x-\eta)-i\eta}}{(2\pi)^2} \Theta(p^0) \delta(p^2 - m^2) = \underline{\underline{W(z)}}$$



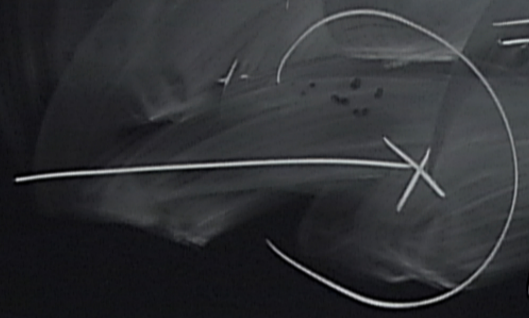


$$[\psi^{-1}(n, y)]^n = \sqrt{n+1} \int W(x, y) f(x) \psi(x, x_1, \dots, x_n)$$

$$W(x, y) = \frac{1}{(2\pi)^2}$$

$$e^{-ik^0(t-\tau)} \Theta(k^0) \delta(k^2)$$

z^2



$$= \dots = W(\dots, z_{ii})$$

$$[\phi^{-1}(y)]^{(n)} = \sqrt{n+1} \int W(x, y) f(x) \phi(x, x_1, \dots, x_n)$$

$$W(x, y) = \frac{1}{(2\pi)^3} \int e^{-ik(t-t_0)} \Theta(k) \delta(k^2)$$

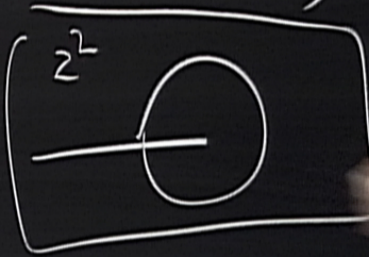
$$\frac{1}{4\pi^2} \frac{1}{z^2} = W(z) \quad (z_0)$$

$$W(x, y) = \int_{\text{Im} z_1 < V} \int_{\text{Im} z_2 < V} b_V W(z_1, z_2)$$

$$W(y, x) = \int_{\text{Im} z_2 < V} \int_{\text{Im} z_1 < V} b_V W(z_1, z_2)$$

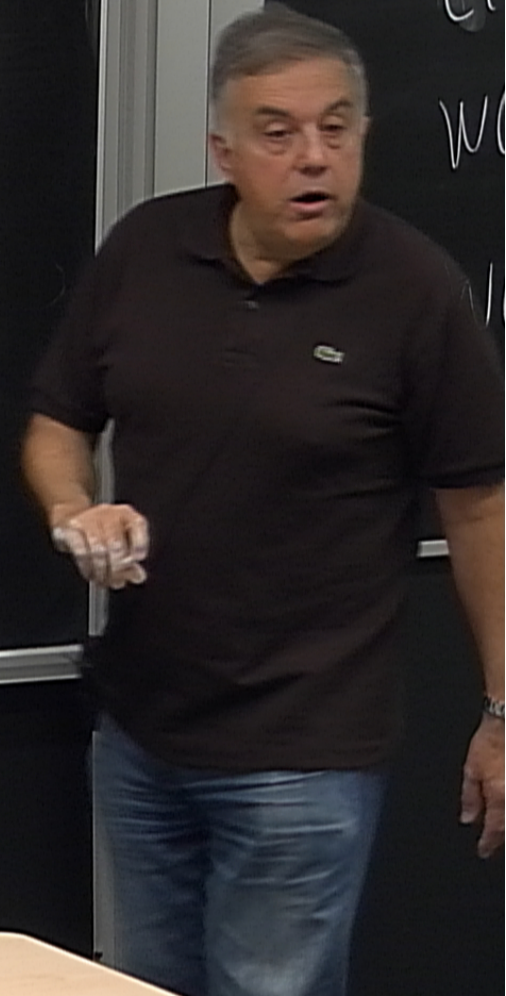
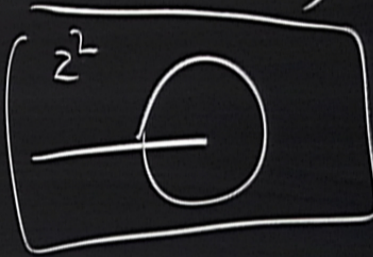
$$\begin{aligned}\tilde{C}(p) &= f(p)\tilde{C}(p) - f(-p)\tilde{C}(-p) \\ &= (f(p) + f(-p))\tilde{C}(p)\end{aligned}$$

$$f(p) + f(-p) = 1$$



$$\begin{aligned}\tilde{C}(p) &= f(p)\tilde{C}(p) - f(-p)\tilde{C}(-p) \\ &= (f(p) + f(-p))\tilde{C}(p)\end{aligned}$$

$$f(p) + f(-p) = 1$$



$$\left[\psi^{(n)} \right]_{p=0} = \frac{\sqrt{n}}{\sqrt{n+1}} \int_{y=1}^{\infty} W(x, y) f(x) \psi^{n+1}(x, x_1, \dots, x_n)$$

$$f(p) + f(-p) = 1$$

$$f(p) = \Theta(p^2)$$

$$f(p) = a \Theta(p^0) - b \Theta(-p^0)$$

$$\int \psi^{n+1}(x, x_1, \dots, x_n) = \frac{\sqrt{n}}{\sqrt{n+1}} \int W(x, y) f(x) \psi^n(x, x_1, \dots, x_n)$$

$$f(p) + f(-p) = 1$$

$$f(p) = \frac{1}{1 - e^{-\beta p a}}$$

$$[\psi^{-1}(p)]^{(n)} = \frac{\sqrt{n}}{\sqrt{n+1}} \int_{y=1}^{\infty} W(x, y) f(x) \psi^{n+1}(x, x_1, \dots, x_n)$$

$$f(p) + f(-p) = 1$$

$$f(p) = \frac{1}{1 - e^{-\beta p^2}}$$

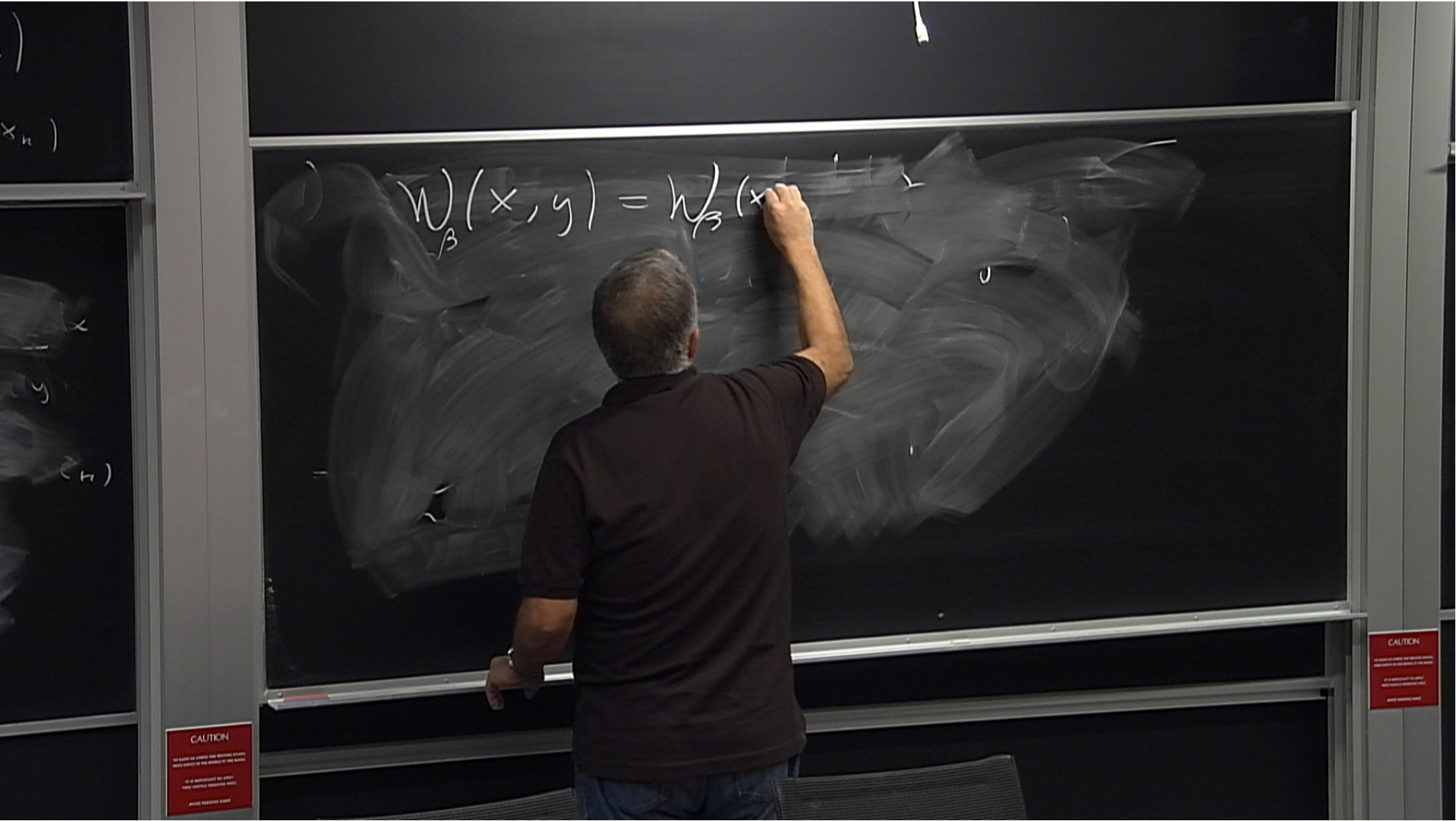
$$\frac{1}{1 - e^{-\beta p^2}} + \frac{1}{1 - e^{-\beta (-p)^2}}$$

Translation invariant
quantity

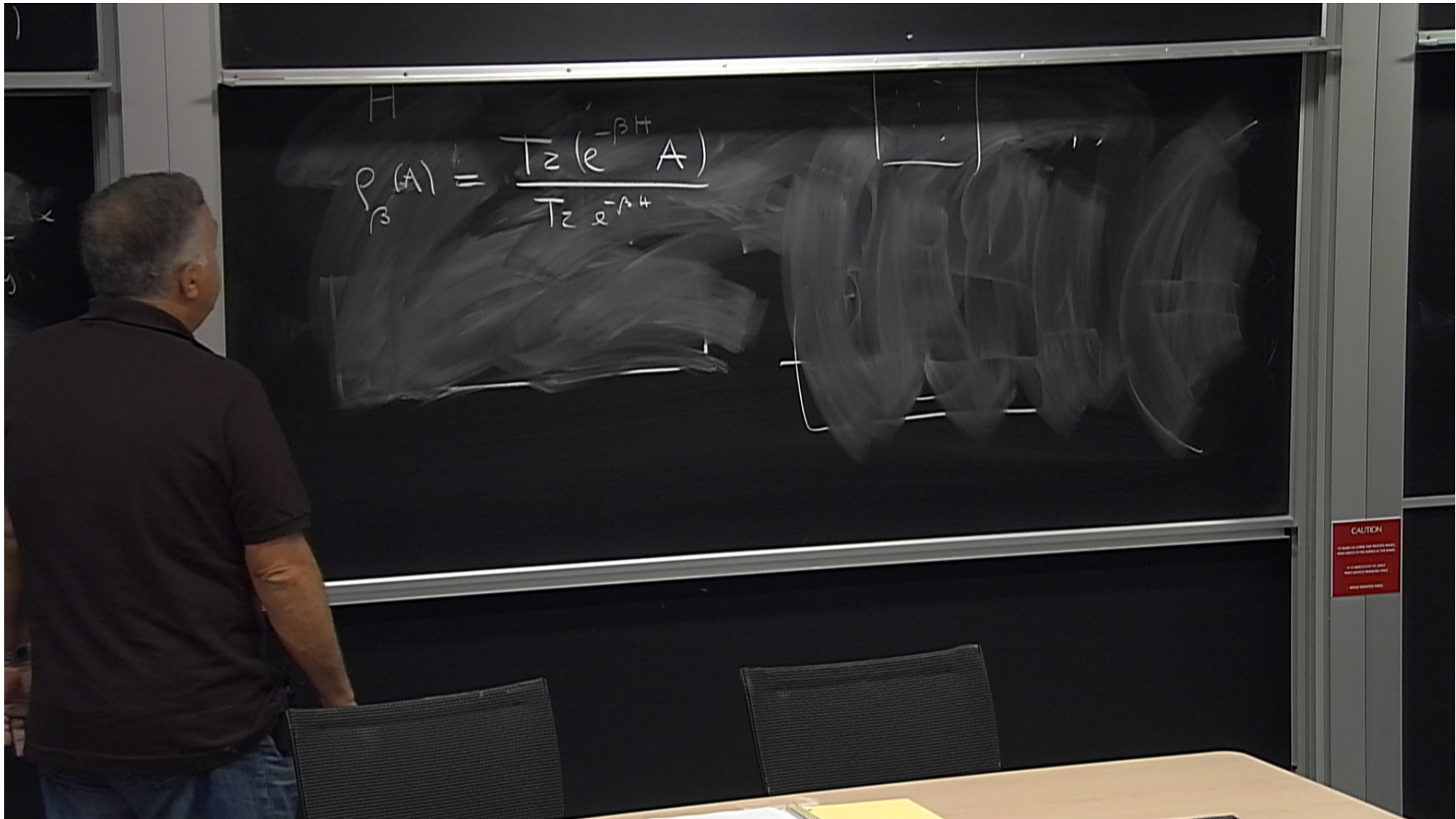
$\alpha - 1$

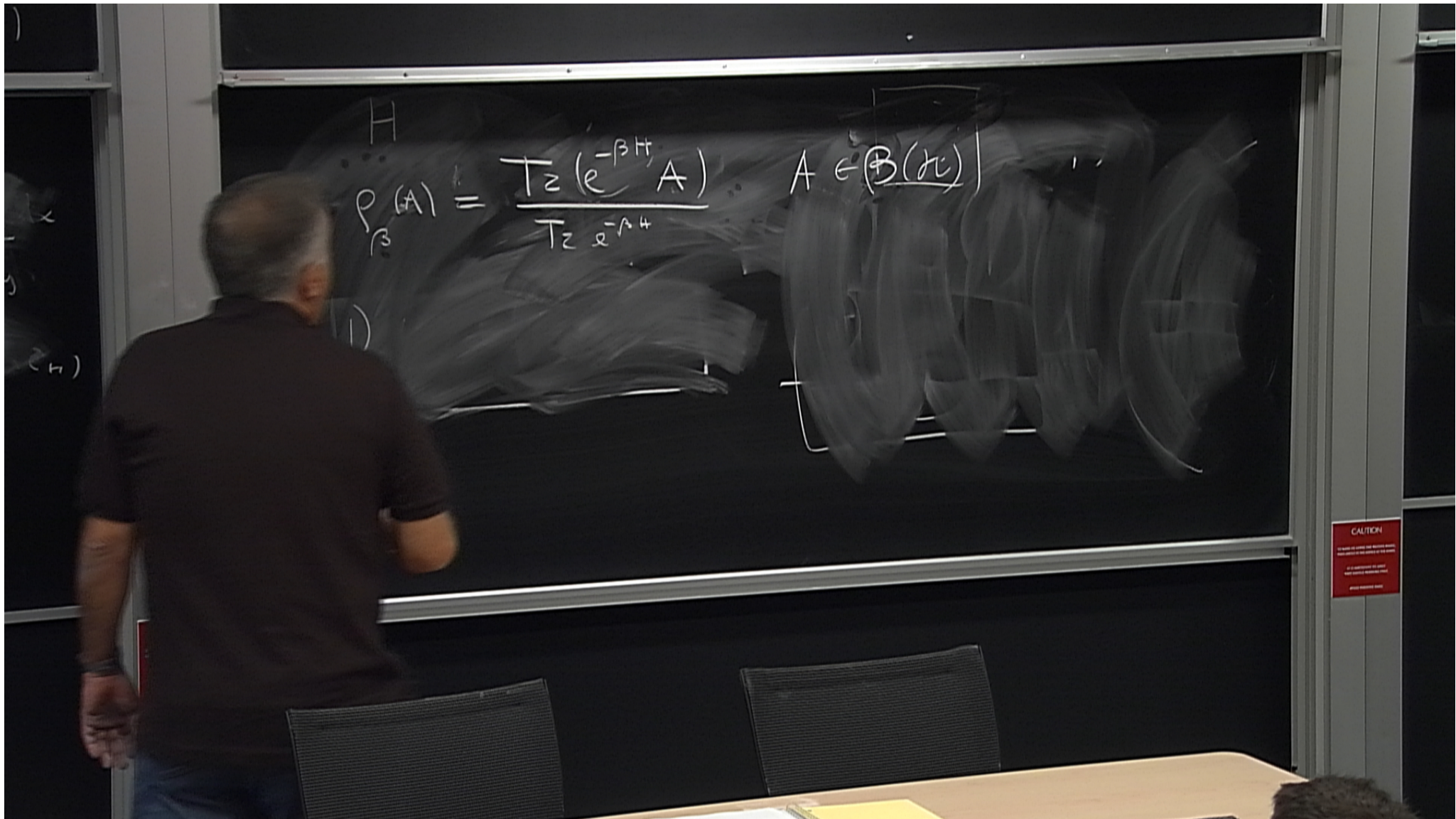
y

(n)



$$\begin{aligned}
 W_{\beta}(x, y) &= W_{\beta}(x-y) \\
 &= \frac{1}{(2\pi)^3} \int e^{-ik(x-y)} \frac{\epsilon(p^0)}{4 - e^{-\beta p^0}} \delta(p^2 - m^2)
 \end{aligned}$$





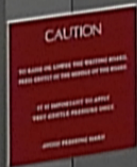
$$H$$
$$P_{\beta}(A) = \frac{T_2(e^{-\beta H} A)}{T_2 e^{-\beta H}} \quad A \in \mathcal{B}(H)$$

KMS property

A, B

$$F(t) = \text{Tr} \left(e^{-\beta H} B \alpha_t(A) \right)$$

$$G(t) = \text{Tr} \left(e^{-\beta H} \alpha_t(A) B \right)$$

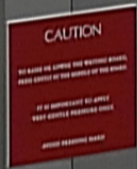


KMS property

A, B

$$F(t) = \int_{\mathbb{Z}} (e^{-\beta t} B \alpha_t(A)) \Rightarrow F(z) \propto \ln z$$

$$G(t) = \int_{\mathbb{Z}} (e^{-\beta t} \alpha_t(A) B)$$



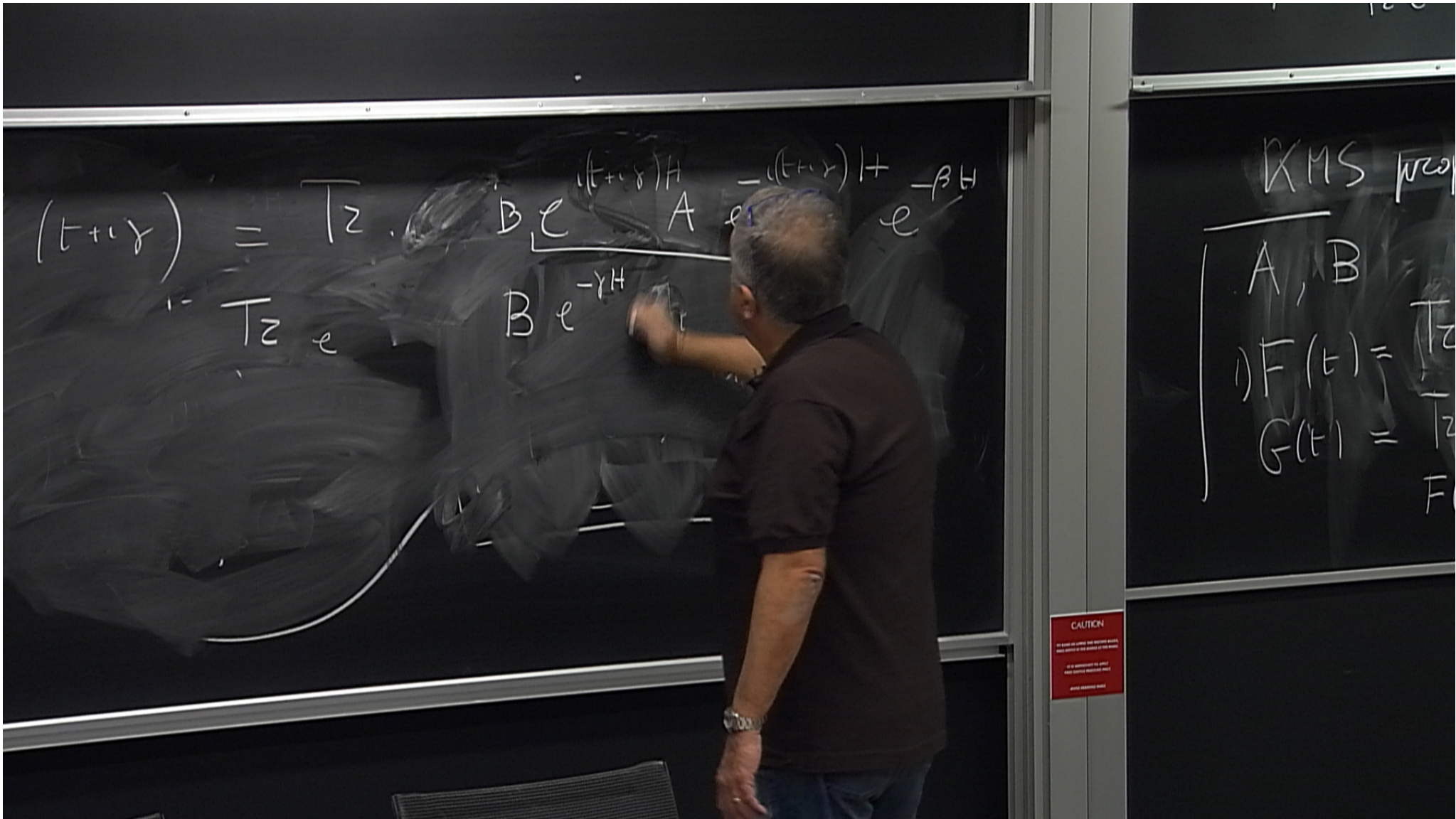
KMS property

A, B

$$F(t) = \int_{\mathbb{Z}} (e^{-\beta t} B \alpha_t(A)) \Rightarrow F(z) \propto \ln z$$

$$G(t) = \int_{\mathbb{Z}} (e^{-\beta t} \alpha_t(A) B) \Rightarrow G(z)$$

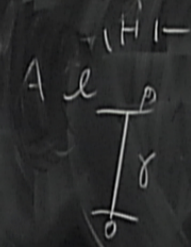
CAUTION
DO NOT TOUCH THE BOARD OR THE BOARDER
WHEN LIGHTS ARE ON OR THE BOARD IS ON
DO NOT TOUCH THE BOARD OR THE BOARDER
WHEN LIGHTS ARE OFF OR THE BOARD IS OFF
AVOID READING BOARD



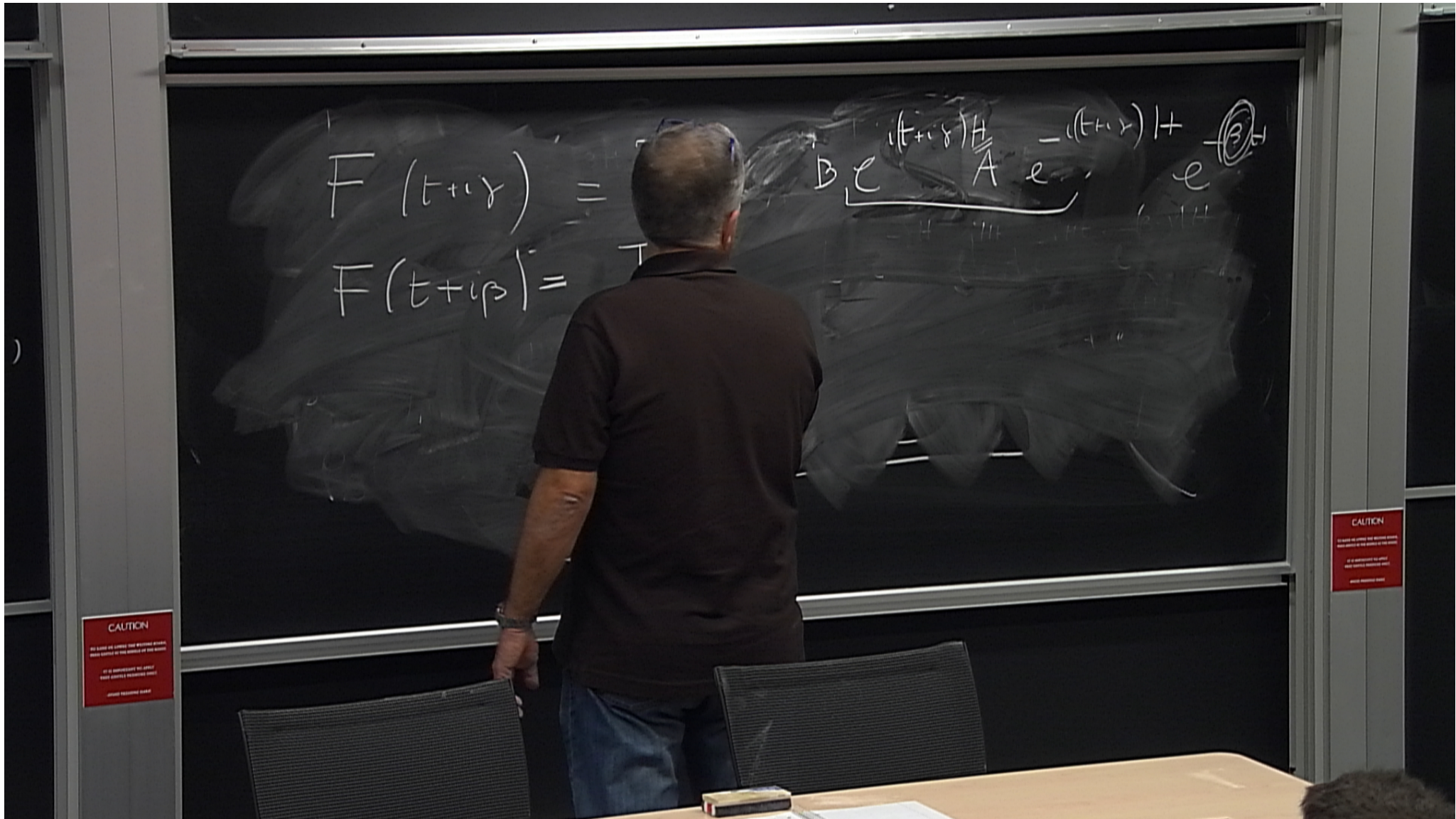
$$F(t+i\gamma) = \frac{1}{Tz} \left[B e^{(t+i\gamma)H} + A e^{-((t+i\gamma)H - \beta H)} \right]$$

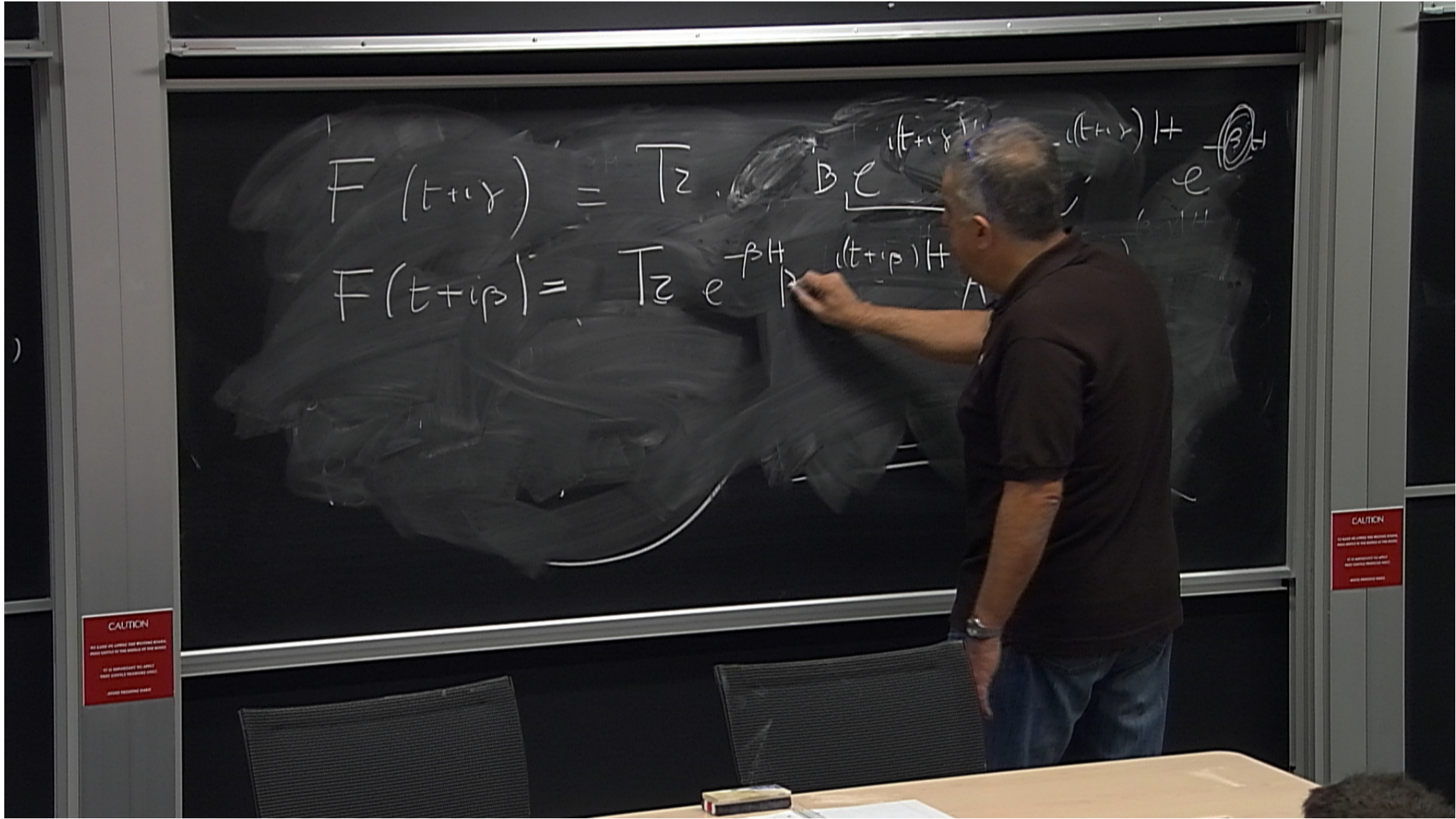
$$F(z) = \frac{1}{Tz} \left[B e^{-\gamma H} e^{iHt} + A e^{-iHt} e^{-(\beta-\gamma)H} \right]$$

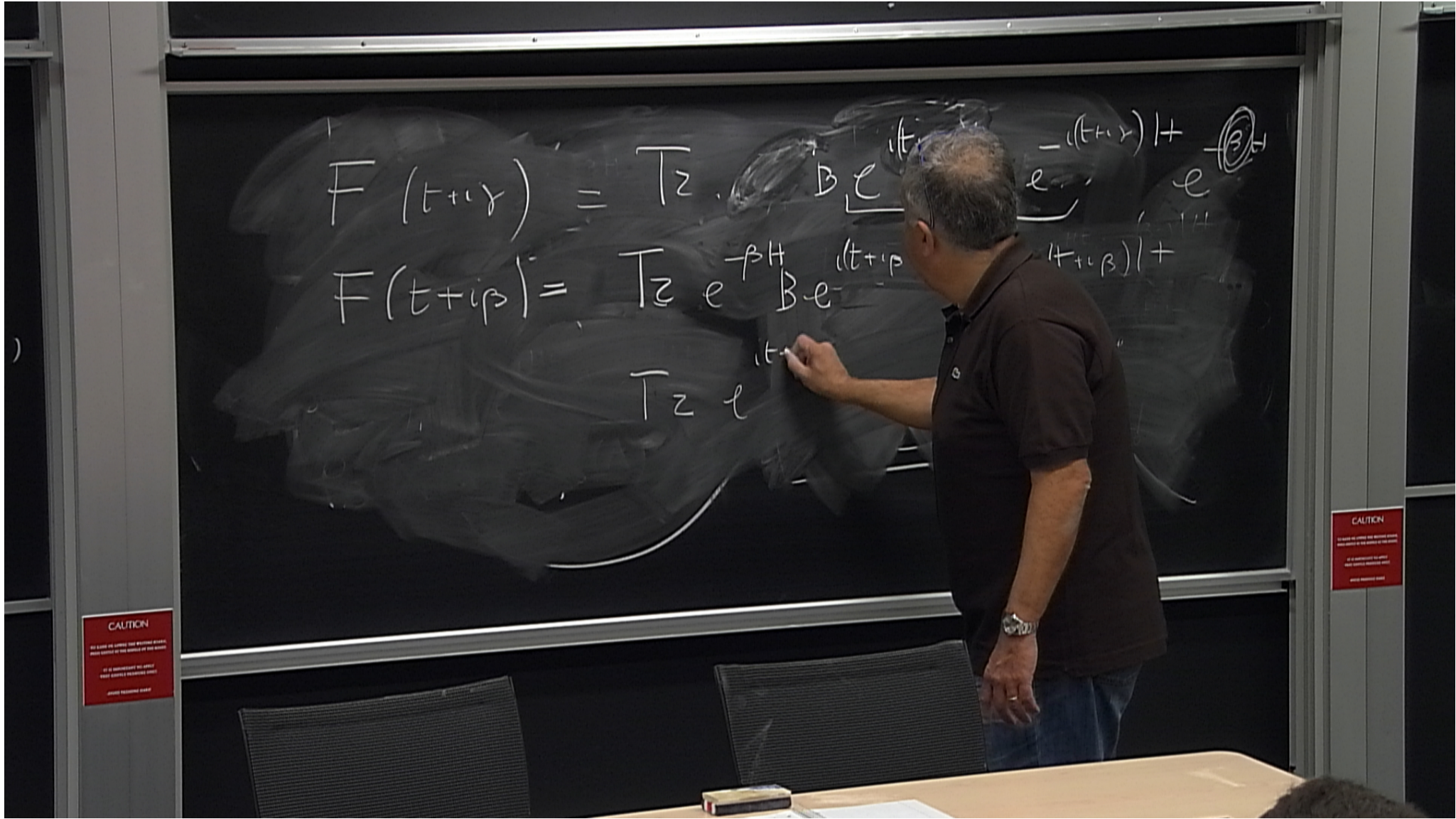
$$0 < \text{Im } z < \beta$$



CAUTION
 DO NOT TOUCH THE BOARD WHEN IT IS HOT
 IT IS HOTTER THAN YOU THINK
 PLEASE BE CAREFUL







$$F(t+i\gamma) = Tz \cdot B e^{it} e^{-(t+i\gamma)t} e^{i\beta t}$$
$$F(t+i\beta) = Tz e^{-\beta t} B e^{it+i\beta t}$$
$$Tz e^{it}$$

CAUTION
DO NOT TOUCH THE BOARD WHEN IT IS HOT
IF IT IS NECESSARY TO OPEN THE BOARD, PLEASE CONTACT THE STAFF

CAUTION
DO NOT TOUCH THE BOARD WHEN IT IS HOT
IF IT IS NECESSARY TO OPEN THE BOARD, PLEASE CONTACT THE STAFF

$$F(t+i\gamma) = Tz \cdot \left[B e^{(t+i\gamma)H} + A e^{-(t+i\gamma)H} \right]$$

$$F(t+i\beta) = Tz e^{-\beta H} \left[B e^{(t+i\beta)H} + A e^{-(t+i\beta)H} \right]$$

$$Tz e^{(t+i\beta)H} + A e^{-(t+i\beta)H}$$

CAUTION
 DO NOT STAND ON CHAIRS OR OTHER OBJECTS.
 ALWAYS HOLD ON TO THE HANDLE OF THE CHAIR.
 ALWAYS HOLD ON TO THE HANDLE OF THE CHAIR.

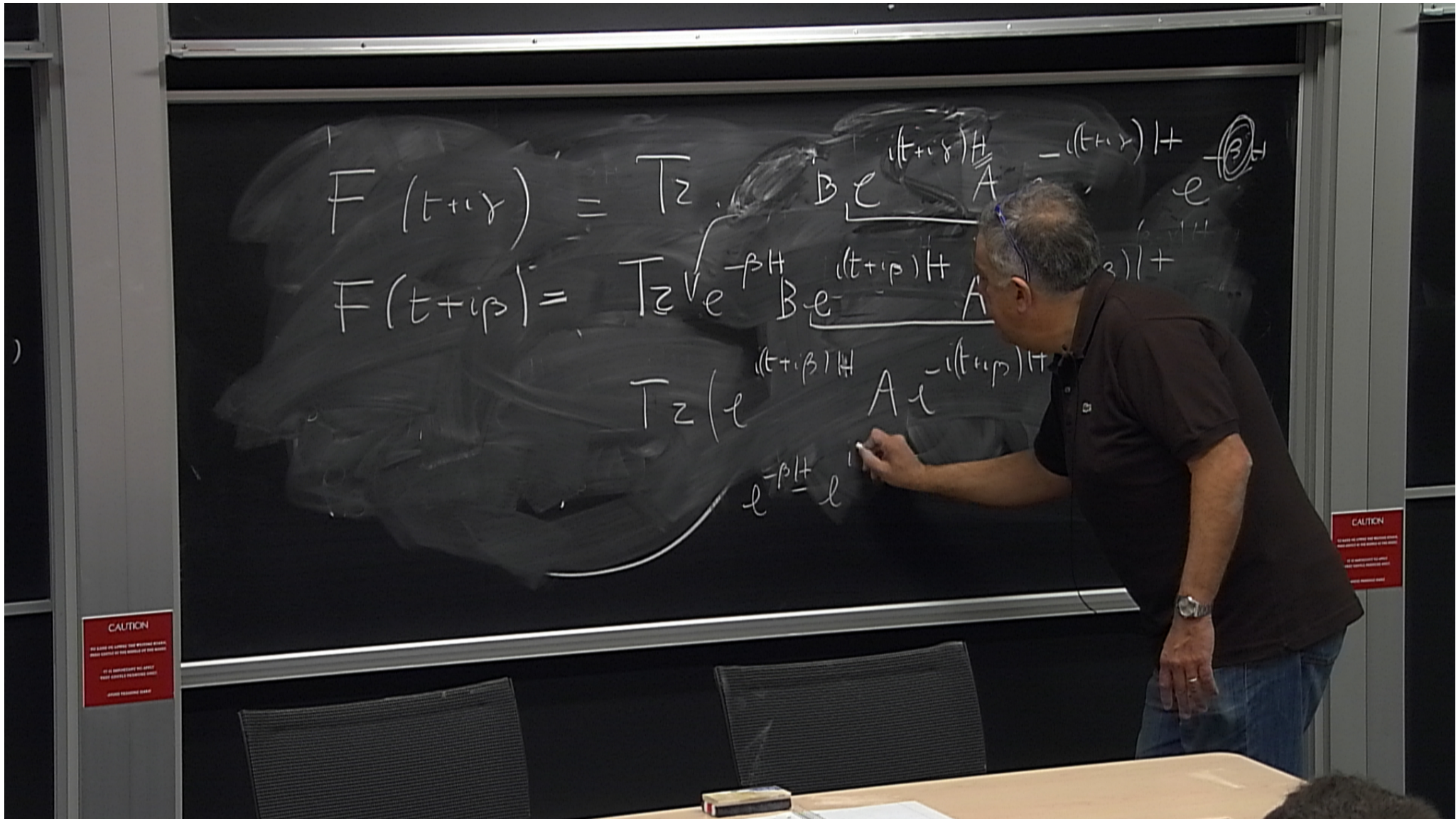
$$F(t+i\gamma) = Tz \cdot \left(B e^{(t+i\gamma)H} + A e^{-(t+i\gamma)H} \right) e^{-\beta t}$$

$$F(t+i\beta) = Tz e^{-\beta t} \left(B e^{(t+i\beta)H} + A e^{-(t+i\beta)H} \right)$$

$$Tz \left(e^{(t+i\beta)H} + A e^{-(t+i\beta)H} \right) e^{-\beta t} B$$



CAUTION
 DO NOT RE-ENTER THE ROOM UNTIL YOU HAVE BEEN ADVISED TO DO SO
 IF YOU REQUIRE THE USE OF THIS ROOM, PLEASE CONTACT THE OFFICE OF THE DEAN



$$F(t+i\gamma) = Tz \cdot \frac{B e^{(t+i\gamma)H}}{A e^{-(t+i\gamma)H}}$$

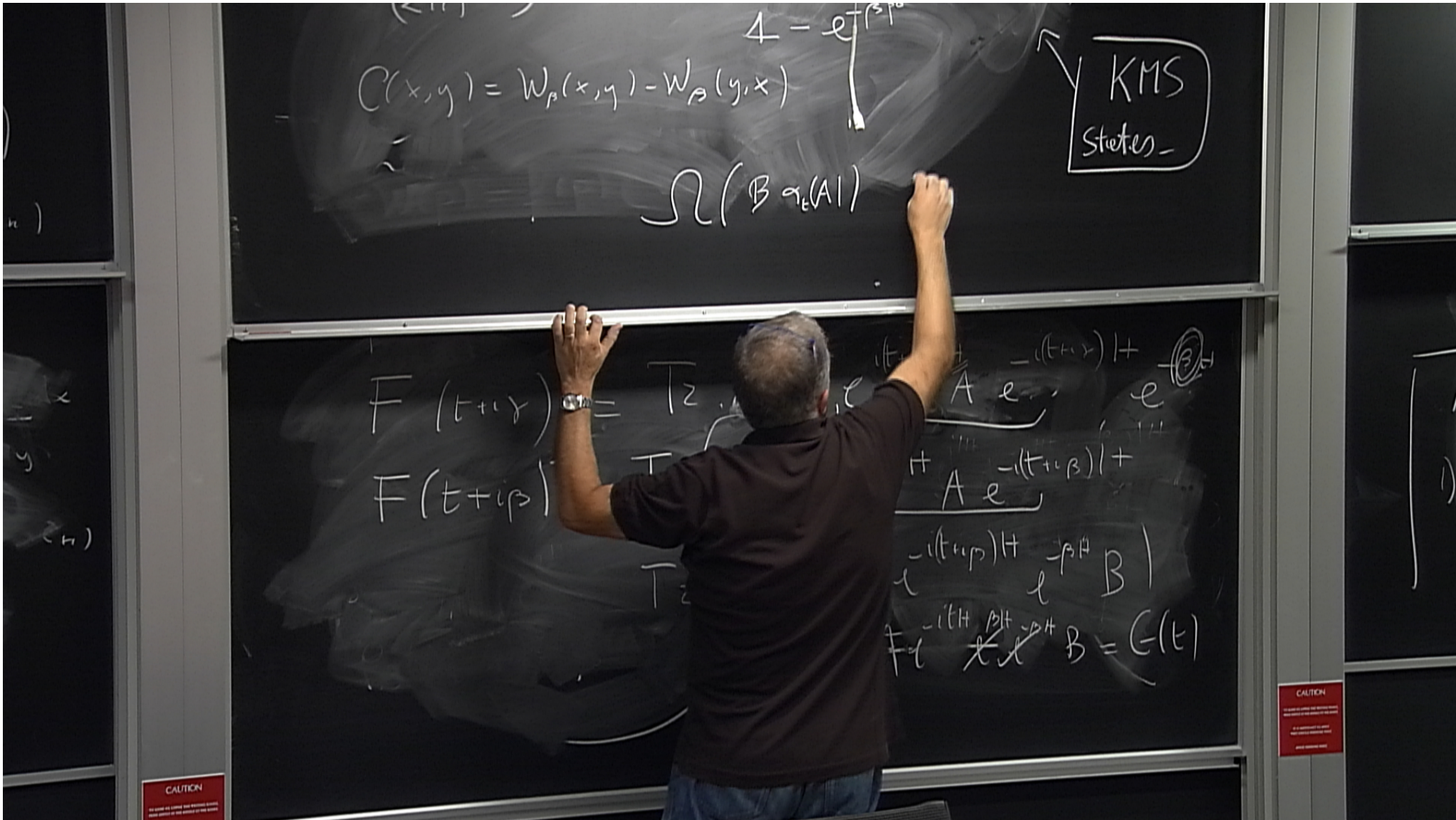
$$F(t+i\beta) = Tz \cdot \frac{B e^{-\beta H}}{A e^{(t+i\beta)H}}$$

$$Tz \cdot \frac{e^{(t+i\beta)H}}{A e^{-(t+i\beta)H}}$$

$$e^{-\beta H} = e^{-\beta H}$$

CAUTION
 DO NOT LEAN ON THE BOARD OR WRITE ON IT.
 IT IS PROHIBITED TO WRITE ON THE BOARD.
 PLEASE RESPECT THE BOARD.

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 IT IS PROHIBITED TO WRITE ON THE BOARD.
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$$C(x, y) = W_\rho(x, y) - W_\rho(y, x)$$

$$4 - e^{i\beta H}$$

KMS States

$$\Omega(B \alpha_\beta(A))$$

$$F(t+i\gamma) = T_2 \dots A e^{-i(t+i\gamma)H} e^{i\beta H}$$

$$F(t+i\beta) = T_2 \dots A e^{-i(t+i\beta)H} e^{i\beta H}$$

$$F(t) = T_2 \dots B e^{-i(t+i\beta)H} e^{i\beta H} B = C(t)$$

CAUTION
Do not lean on the chalkboard.
Do not touch the chalkboard.

CAUTION
Do not lean on the chalkboard.
Do not touch the chalkboard.

$$C(x, y) = W_p(x, y) - W_p(y, x)$$

KMS States

$$\int \Omega(B \alpha_t(A)) \quad \int$$

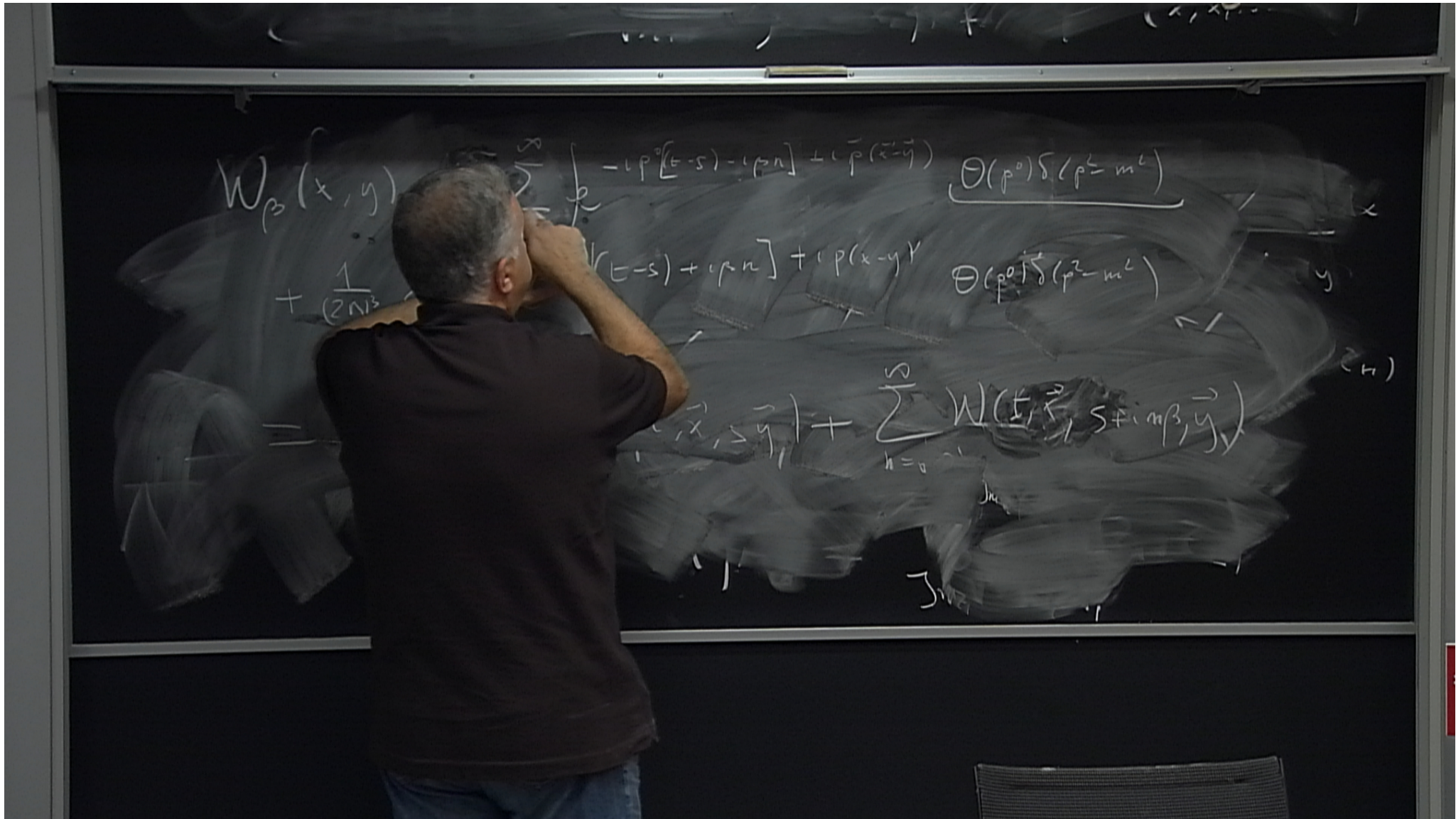
$$\int \Omega(\alpha_t(A) B) \quad \int$$

$$F(t+i\gamma) = T_2 \left[e^{(t+i\gamma)H} A e^{-(t+i\gamma)H} \right]$$

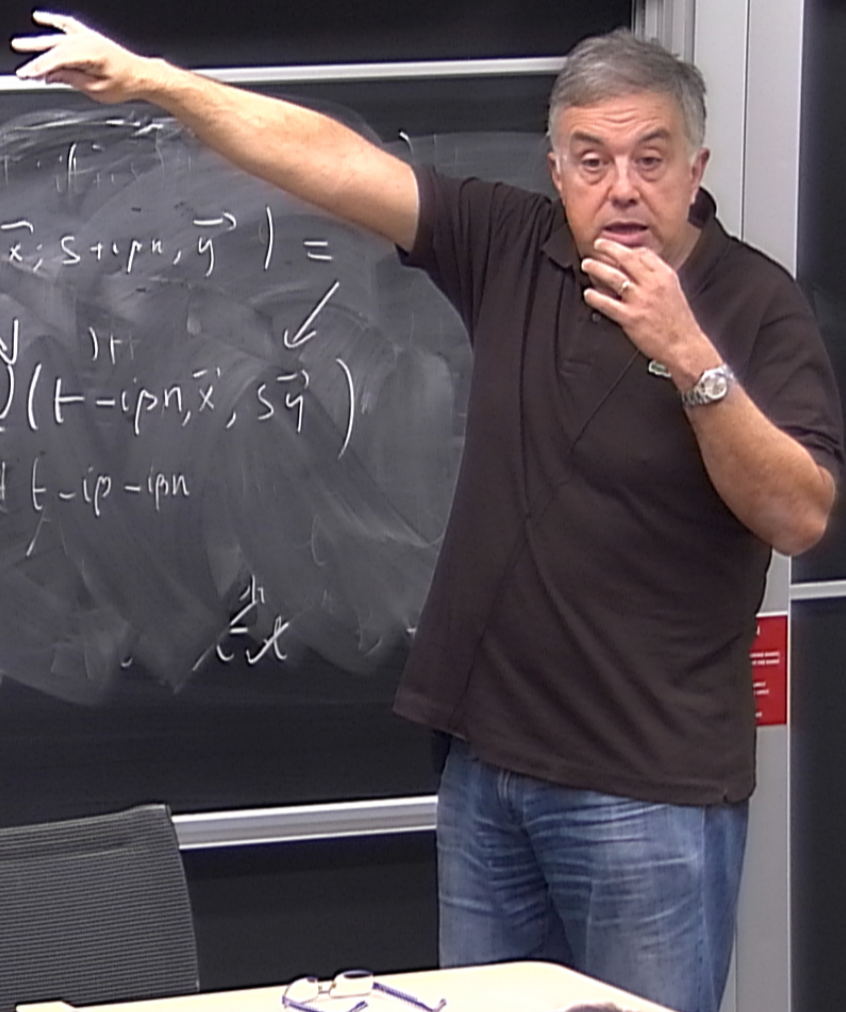
$$F(t+i\beta) = T_2 \left[e^{(t+i\beta)H} A e^{-(t+i\beta)H} \right]$$

$$A e^{-(t+i\beta)H} e^{-\beta H} B$$

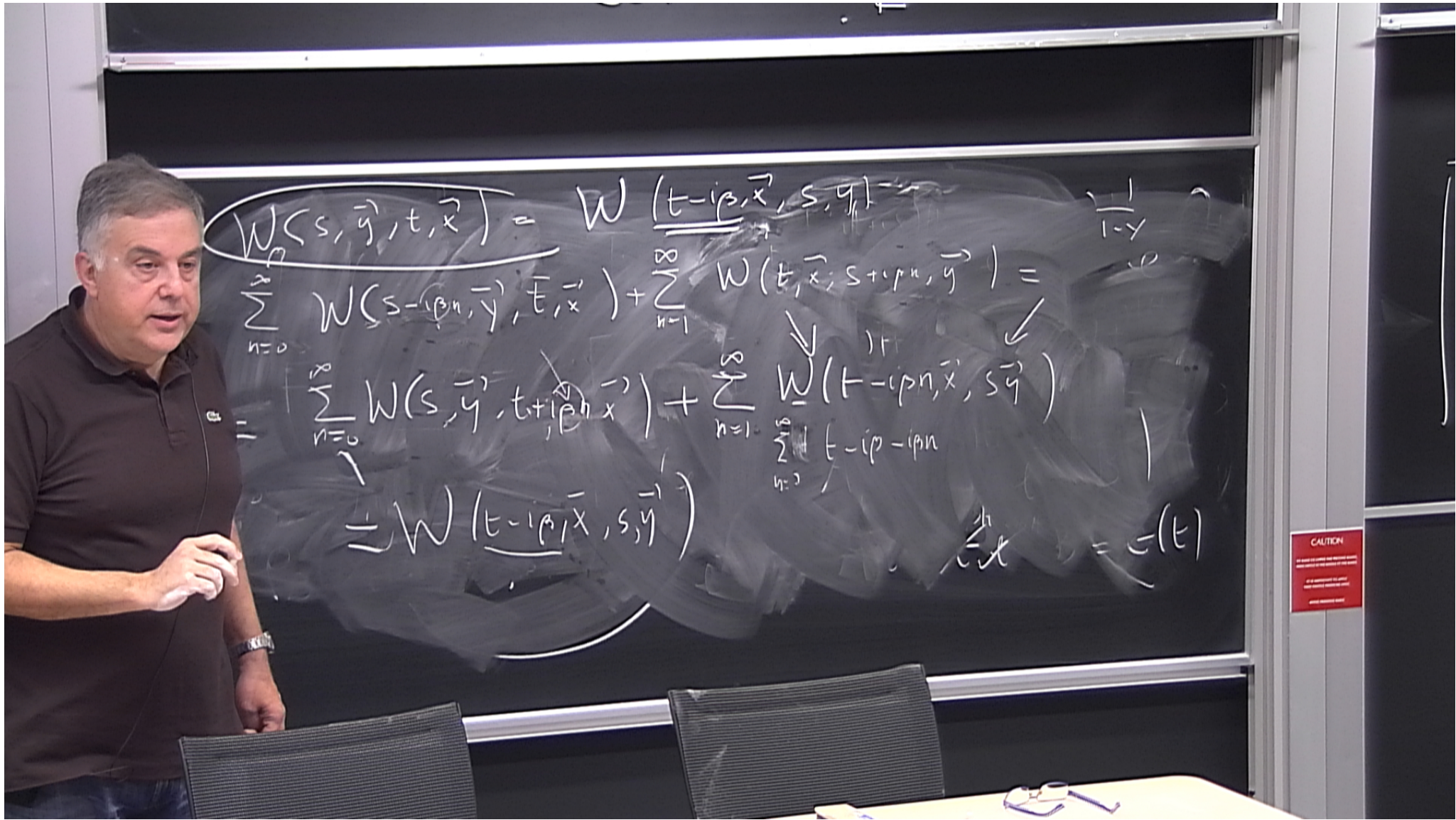
$$A e^{-itH} e^{\beta H} B = C(t)$$



$$\begin{aligned}
 W(s, \vec{y}, t, \vec{x}) &= \\
 &= \sum_{n=0}^{\infty} W(s - ipn, \vec{y}, t, \vec{x}) + \sum_{n=1}^{\infty} W(t, \vec{x}, s + ipn, \vec{y}) = \\
 &= \sum_{n=0}^{\infty} W(s, \vec{y}, t + ipn, \vec{x}) + \sum_{n=1}^{\infty} W(t - ipn, \vec{x}, s, \vec{y}) \\
 &= W(t - ip, \vec{x}, s, \vec{y})
 \end{aligned}$$



CAUTION
 DO NOT REARMS THE SAFETY OF THE SYSTEMS
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 PLEASE REMAIN SEATED



$$[\phi(x), \phi(y)] = C(x, y)$$

$$X^M(\tau)$$

$$\begin{matrix} \uparrow E_n \\ \uparrow E_{n-1} \\ \uparrow E_0 \end{matrix}$$

$$\begin{matrix} \downarrow E_n \\ \downarrow E_{n-1} \\ \downarrow E_0 \end{matrix}$$

$$\uparrow \phi$$

$$J(x, y)$$

$$z(t)$$

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$$[\phi(x), \phi(y)] = C(x, y)$$

$$x^M(\tau)$$

$$\hat{\phi}$$

$$E_n$$

$$E_{n-1}$$

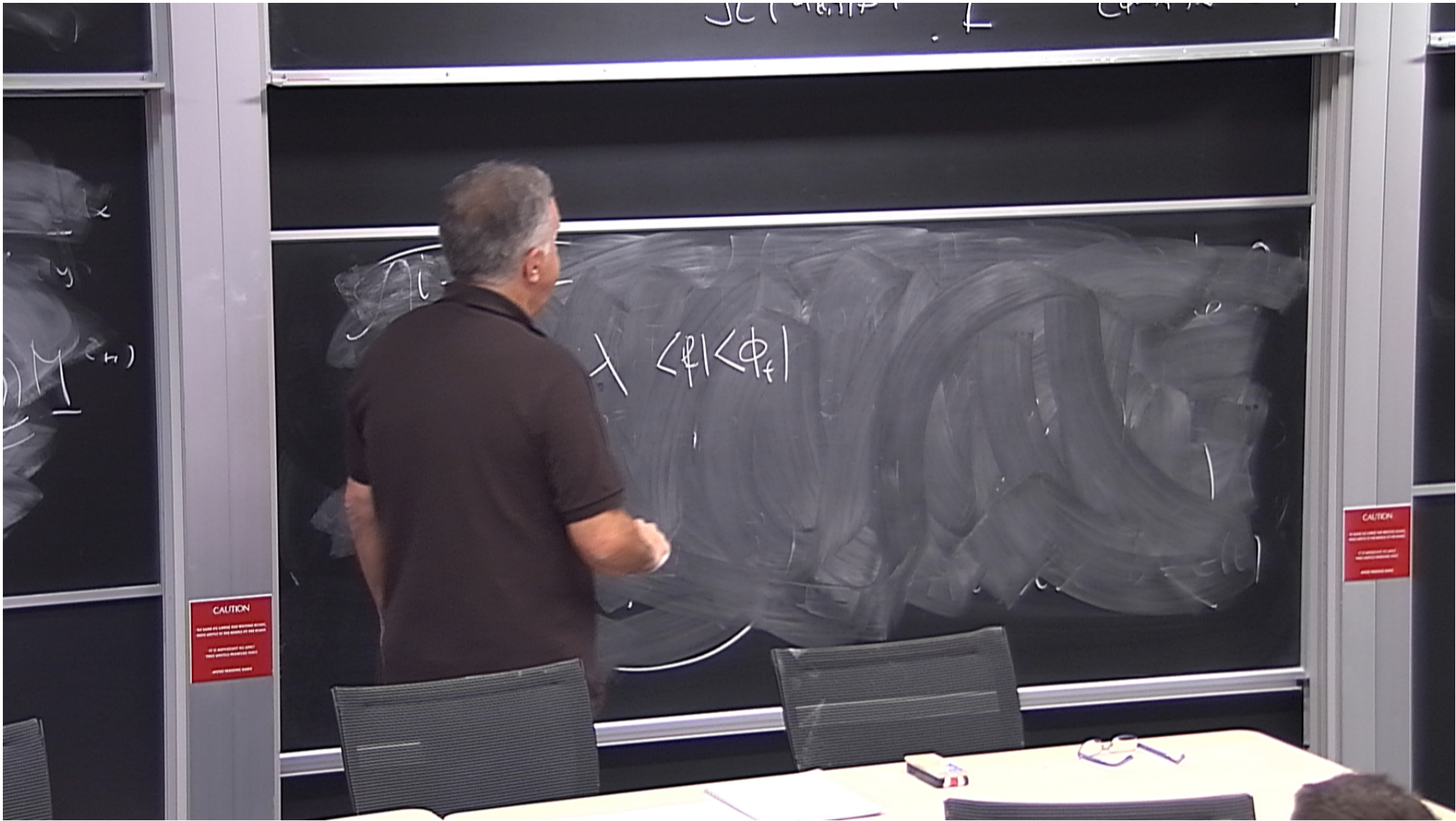
$$E_0$$

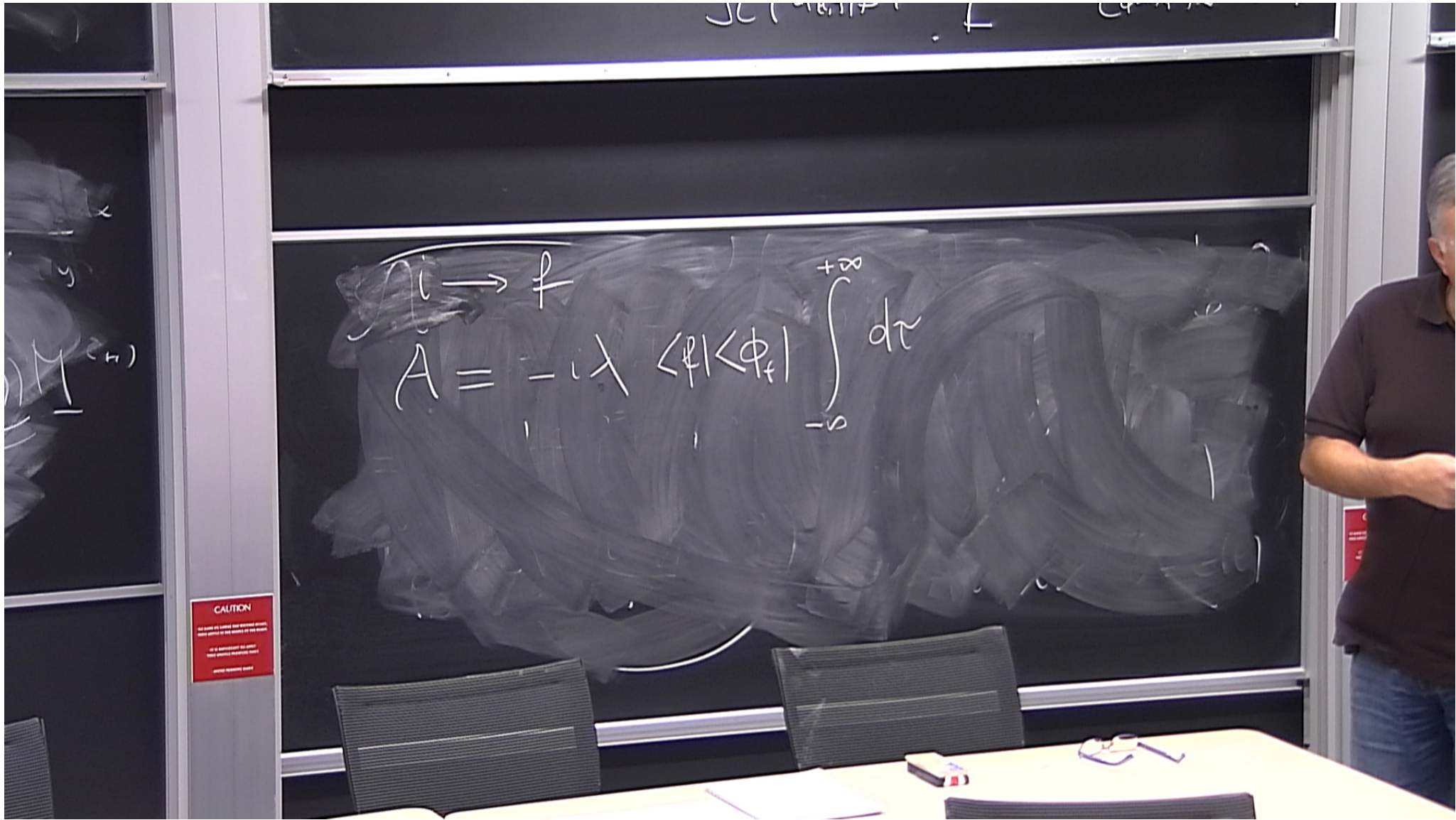
$$W(x, y)$$

$$H_0$$

$$(x(\tau)) Y(\tau)$$

CAUTION
 ALL SPACES ARE LOCKED AND SECURED AGAINST
 UNAUTHORIZED ACCESS AT ALL TIMES
 AT ALL TIMES
 ALL SPACES ARE LOCKED AND SECURED AGAINST
 UNAUTHORIZED ACCESS AT ALL TIMES





$$A \rightarrow f$$

$$A = -i\lambda \langle \phi | \langle \phi_f | \int_{-\infty}^{+\infty} d\tau M(\tau) \phi(x(\tau)) |\phi\rangle | \phi_f \rangle$$

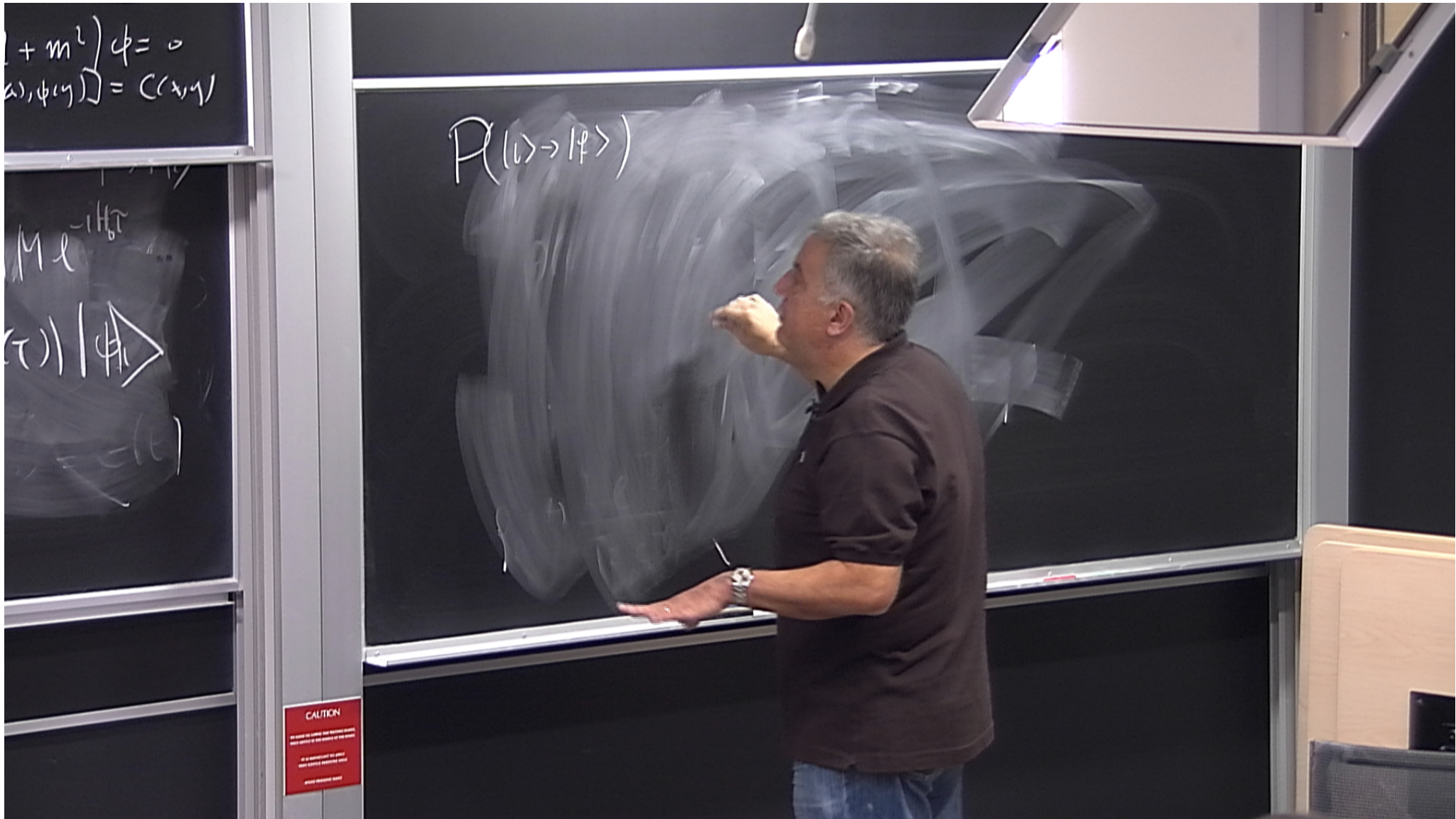
$$= -i\lambda \langle \phi | M | \phi \rangle \int e^{(E_f - E_i)\tau}$$

$$M(\tau) = e^{iH_0\tau} M e^{-iH_0\tau}$$

KMS
A, B
 $F(t) =$
 $G(t) =$



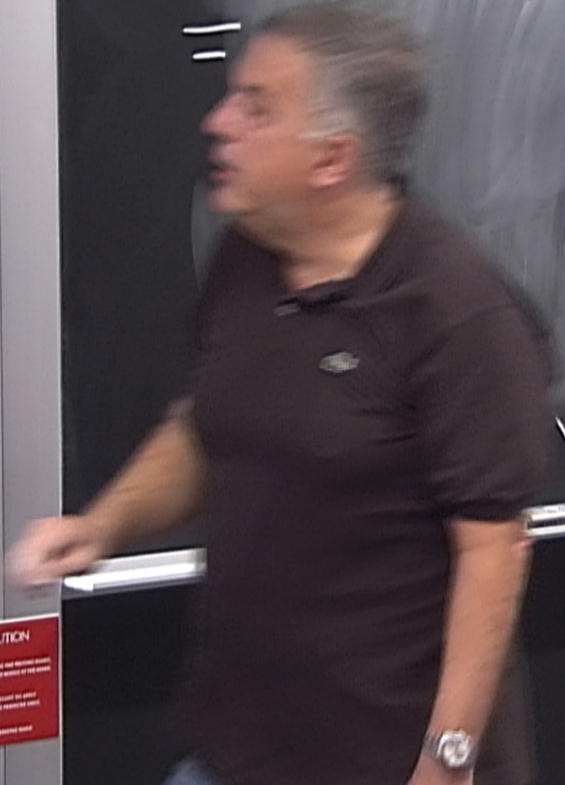
CAUTION
 Do not use candles and scented items.
 Do not use any items that contain flammable liquids.
 Please do not smoke.



$$\begin{aligned} & + m^2 \phi = 0 \\ & \psi(x, y) = C(x, y) \end{aligned}$$

$$\begin{aligned} & M e^{-iH_0 \tau} \\ & \langle \tau | \phi \rangle \end{aligned}$$

$$P(|i\rangle \rightarrow |f\rangle) = \lambda^2 |\langle f | M | i \rangle|^2$$



CAUTION
DO NOT TOUCH THE BOARD OR THE CHALK
IF IS NECESSARY DO NOT
USE FORCEFUL HANDS
PLEASE REPORT DAMAGE

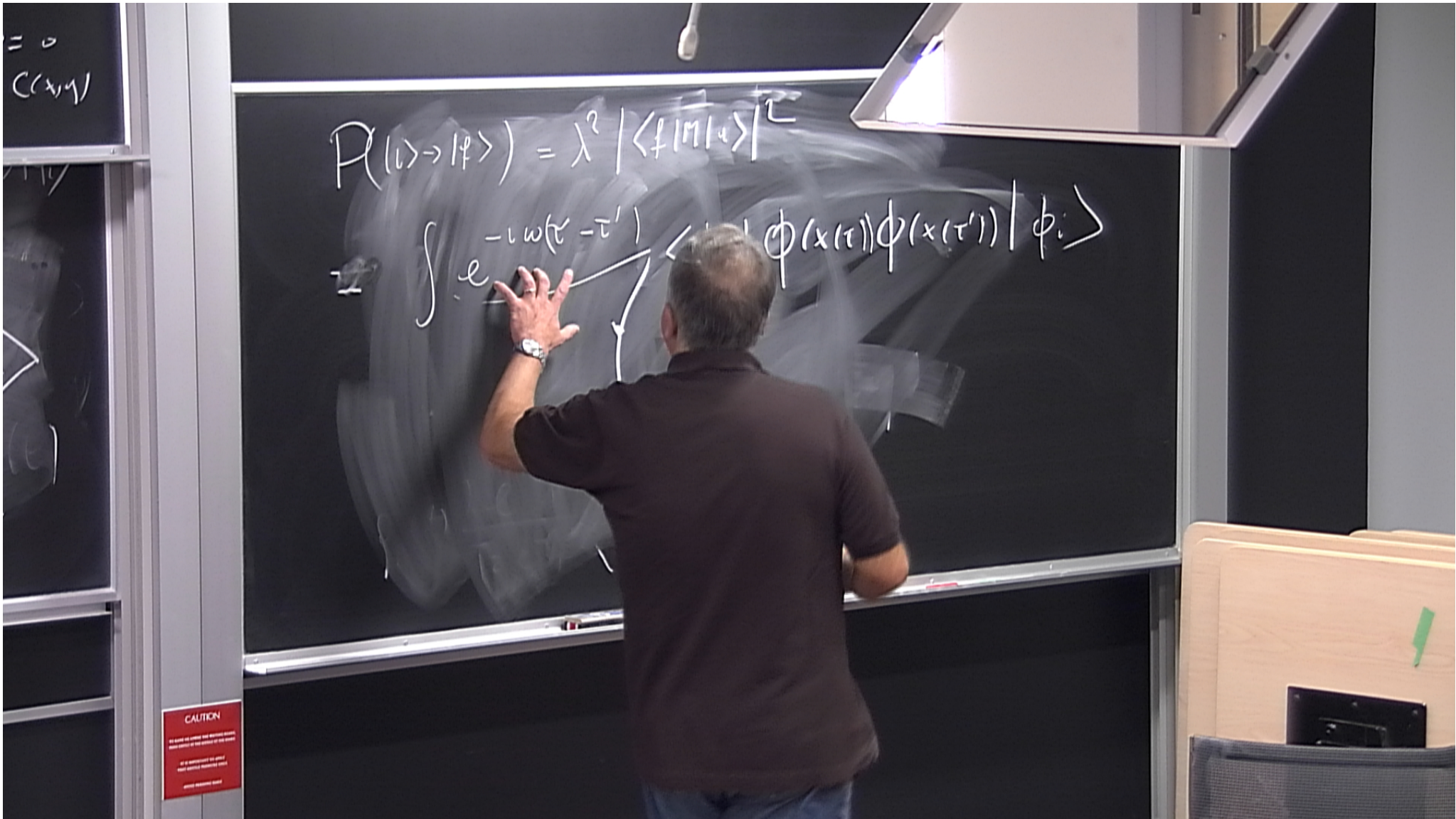
$$\left. \begin{aligned} &+ m^2 \phi = 0 \\ &\psi(x, y) = C(x, y) \end{aligned} \right\}$$

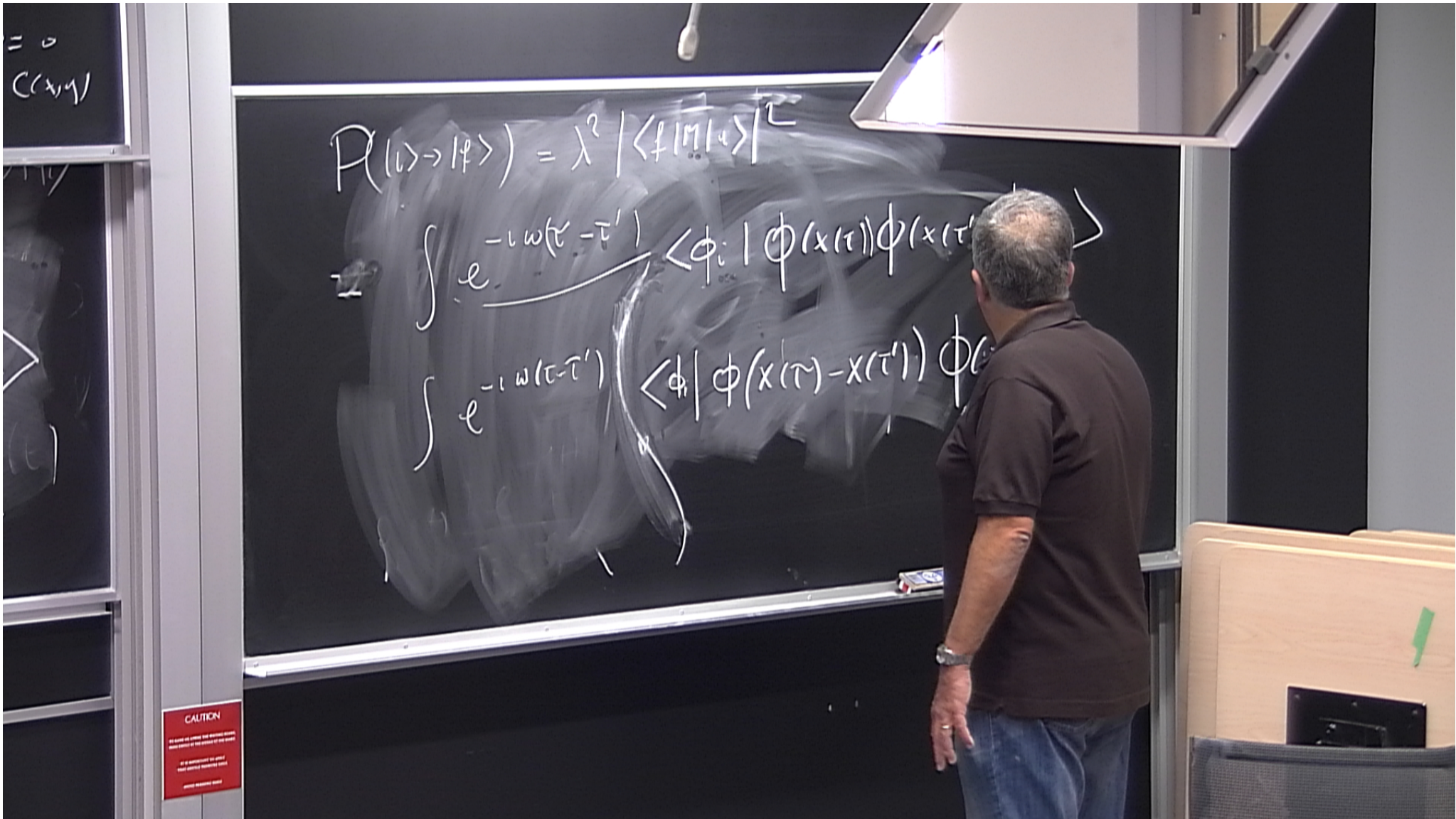
$$M e^{-iH_0 \tau} |\psi_0\rangle$$

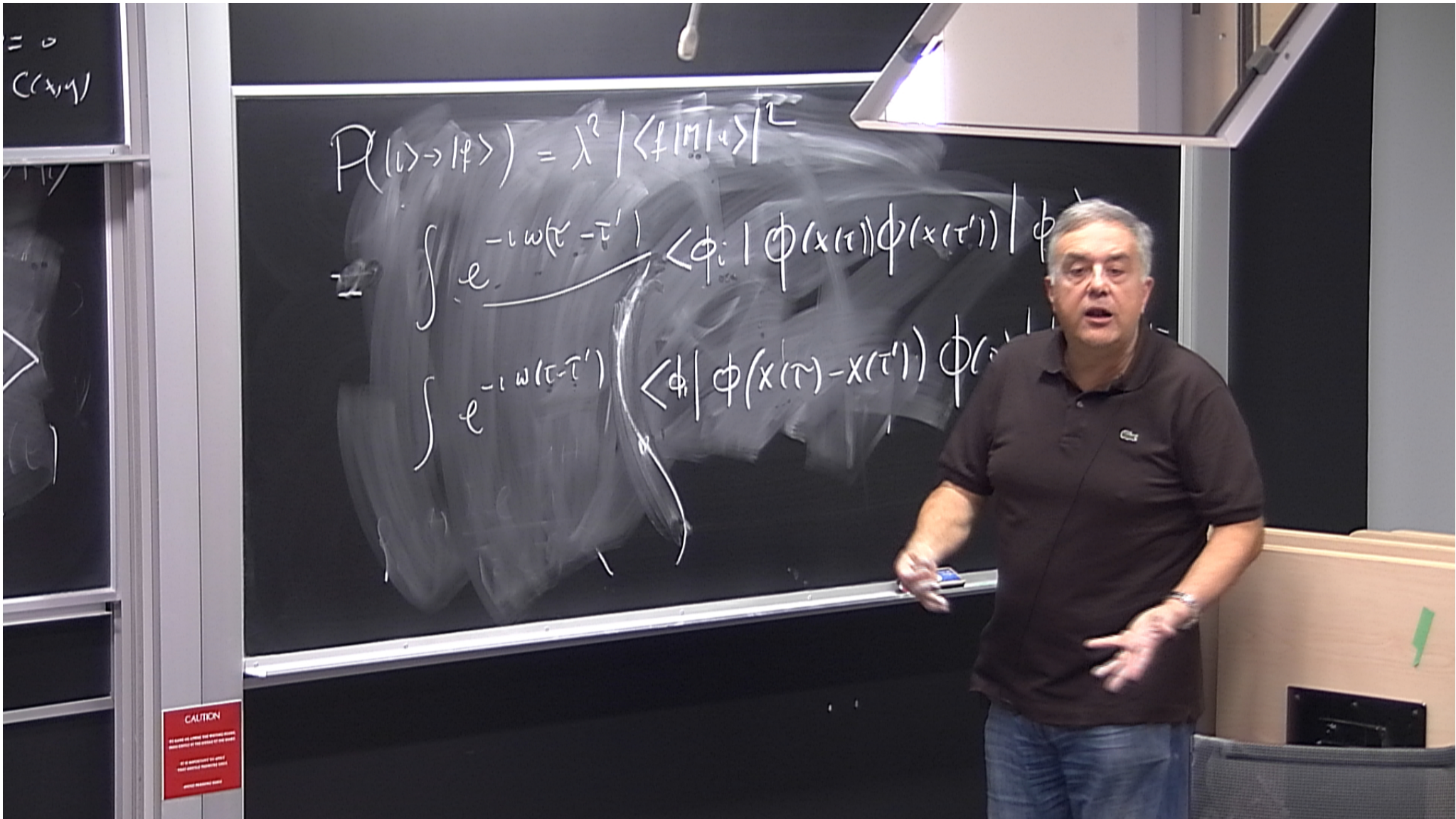
$$P(|\omega\rangle \rightarrow |\varphi\rangle) = \lambda^2 |\langle \varphi | m | \omega \rangle|^2$$

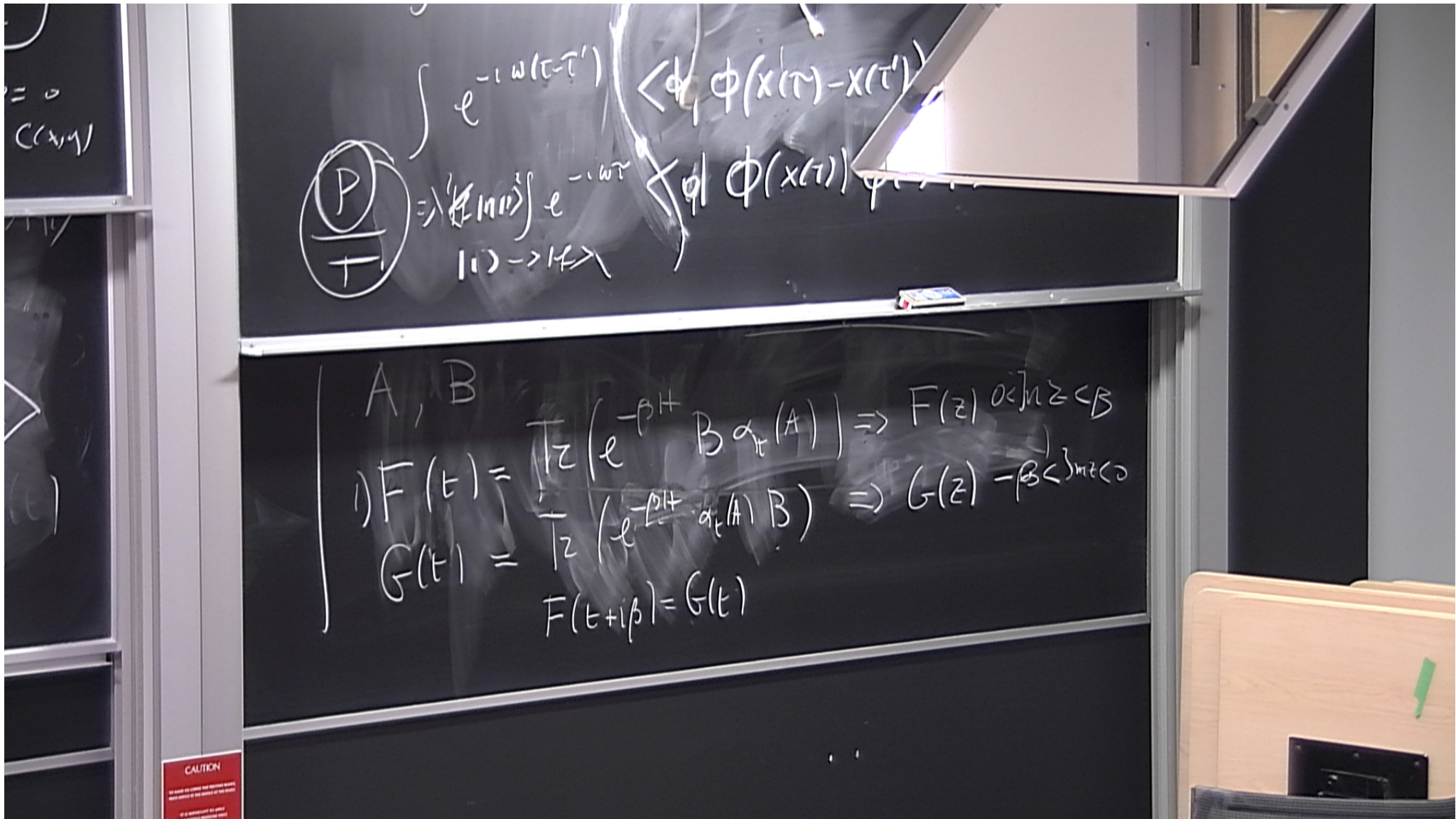
$$\int e^{-i\omega(\tau - \tau')} \langle \varphi |$$

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 OR THE BOARD FRAME
 IT IS PROHIBITED TO WRITE
 ANYTHING ON THE BOARD









$$\int e^{-i\omega(t-\tau')} \langle \phi, \phi(x(\tau) - x(\tau')) \rangle$$

$\textcircled{P} \Rightarrow \langle \phi, \phi(x(t)) \rangle$
 $|t\rangle \rightarrow |t+\lambda\rangle$

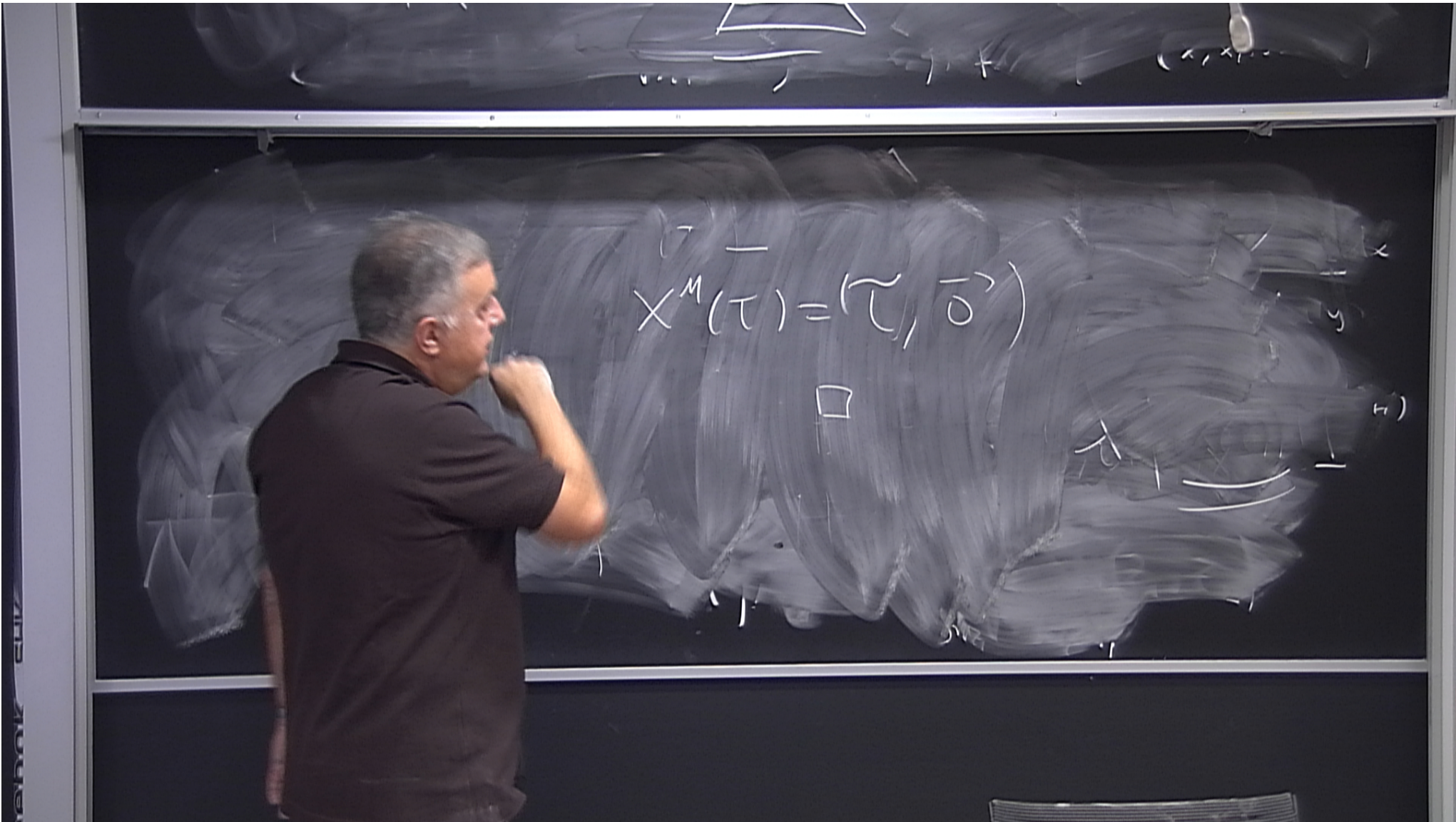
A, B

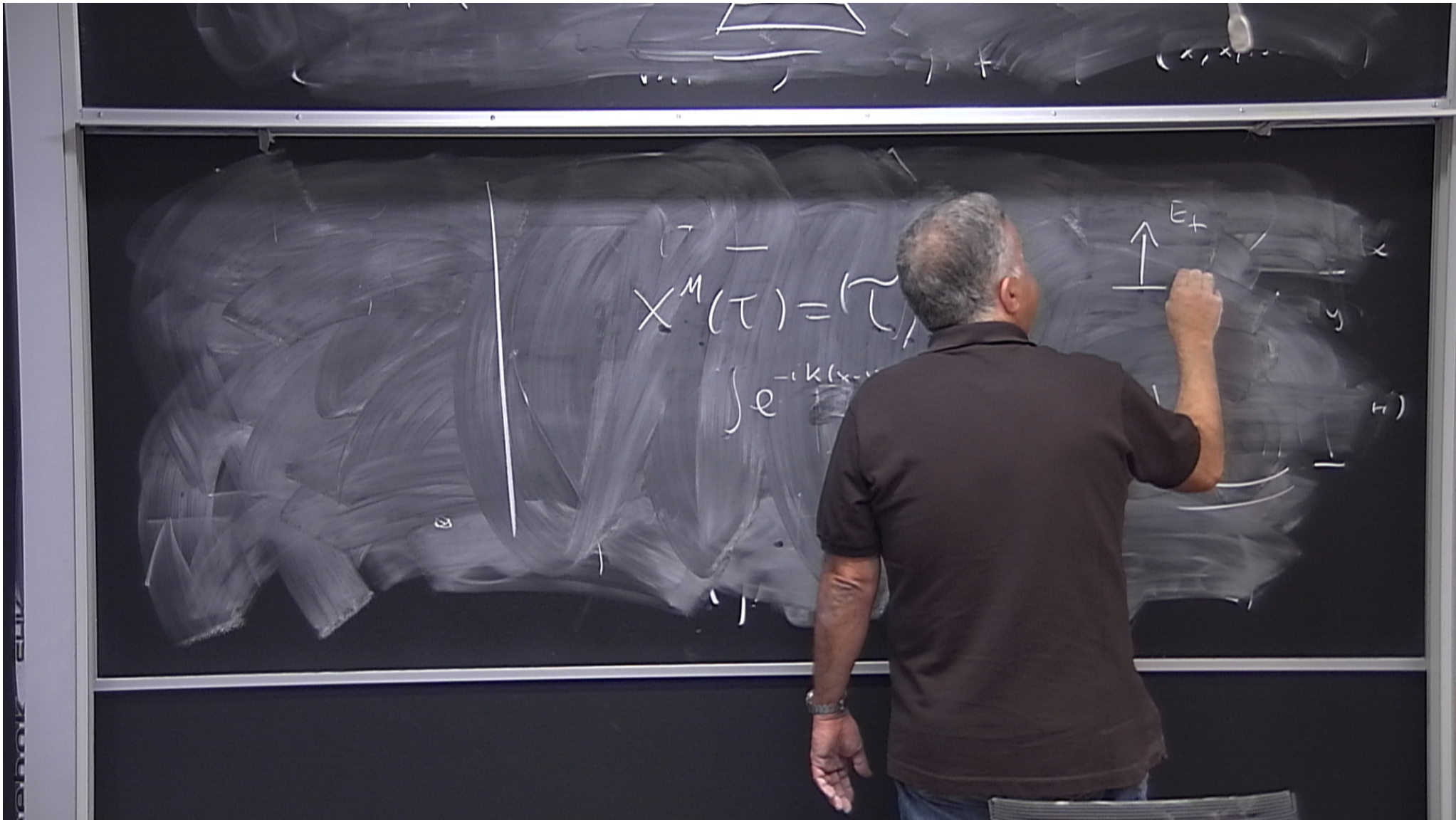
$$1) F(t) = \frac{1}{Tz} (e^{-\beta t} B \alpha_t(A)) \Rightarrow F(z) \propto |z| < \beta$$

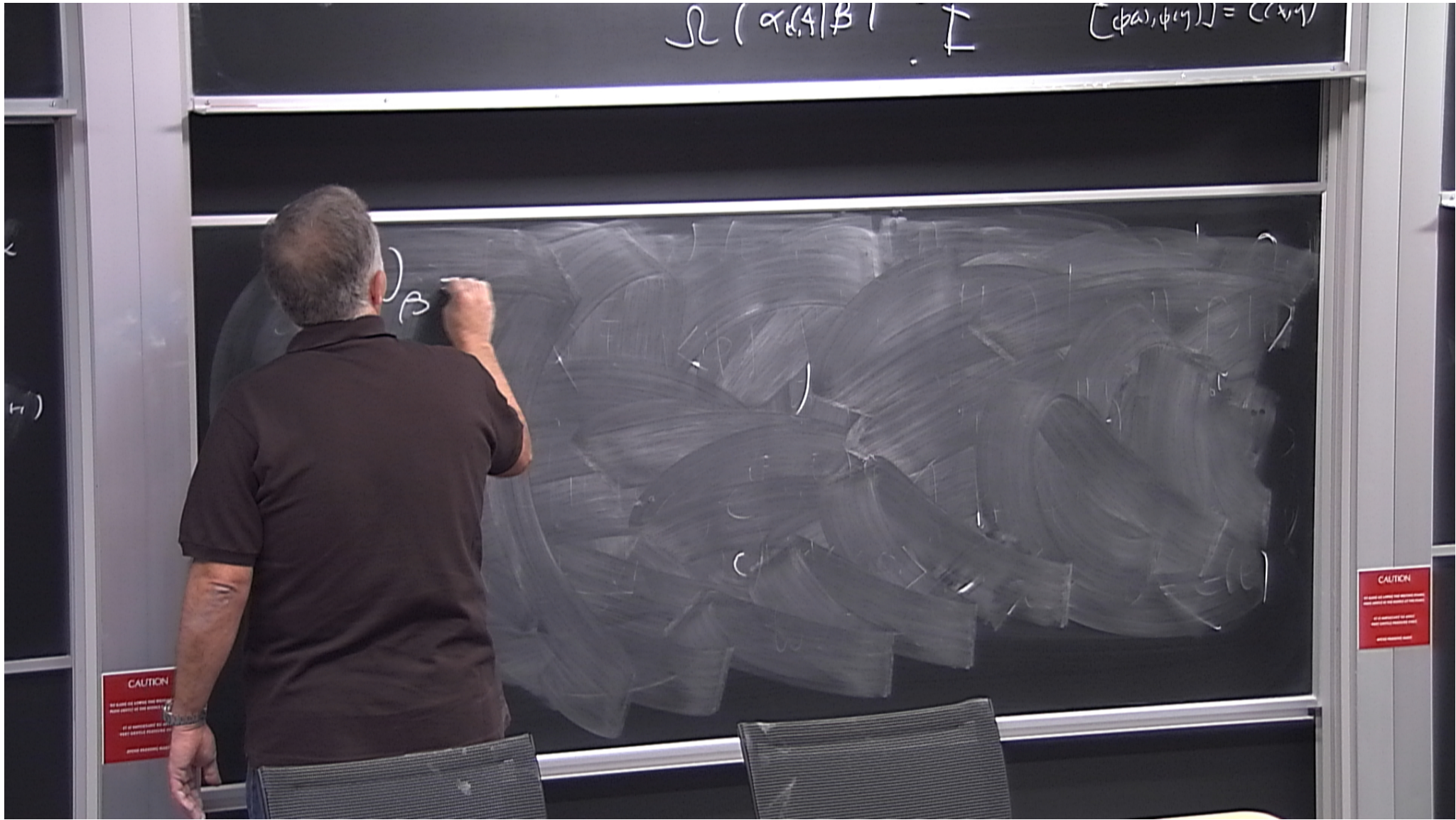
$$G(t) = \frac{1}{Tz} (e^{-\beta t} \alpha_t(A) B) \Rightarrow G(z) \propto |z| > \beta$$

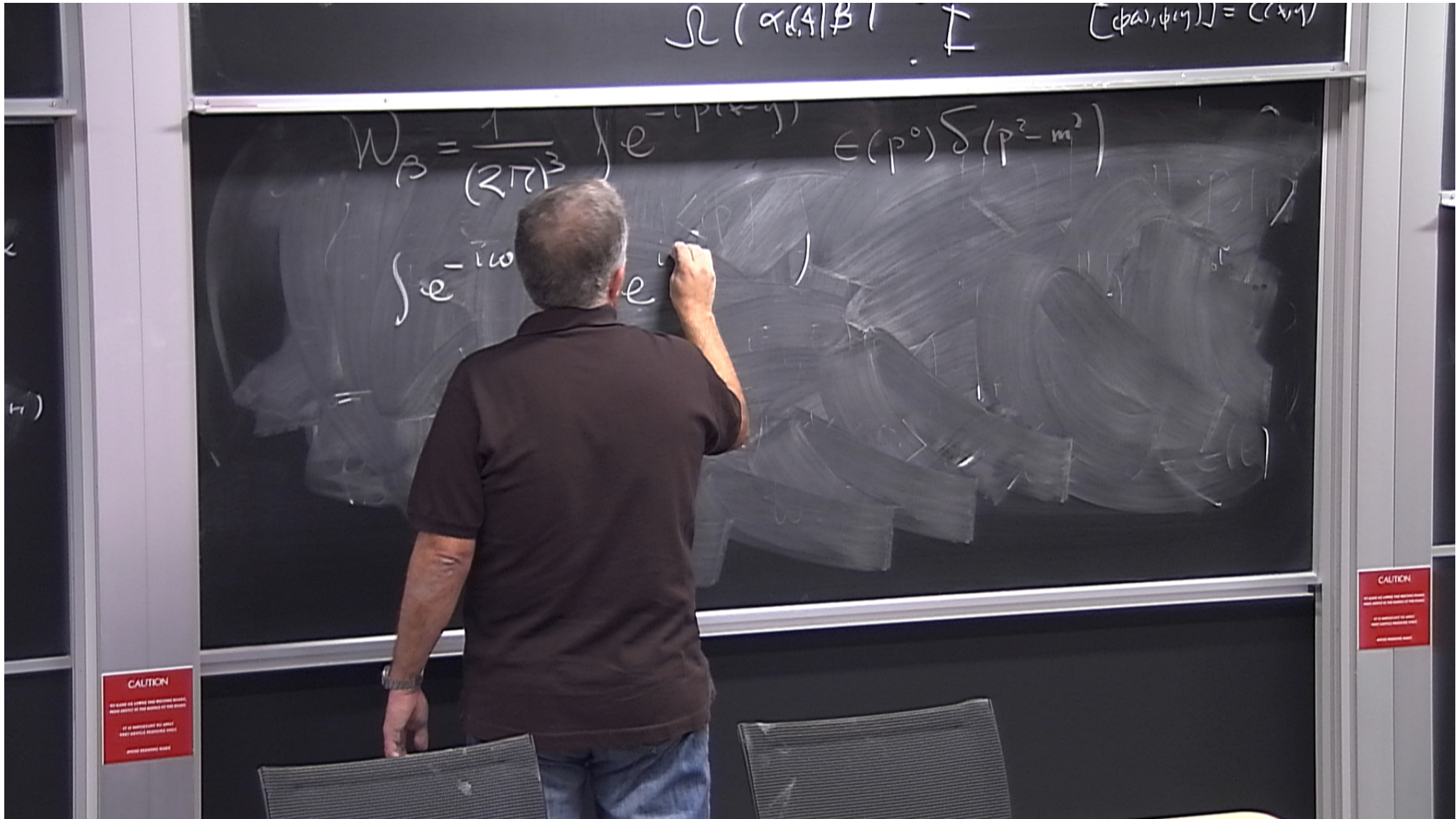
$$F(t+i\beta) = G(t)$$

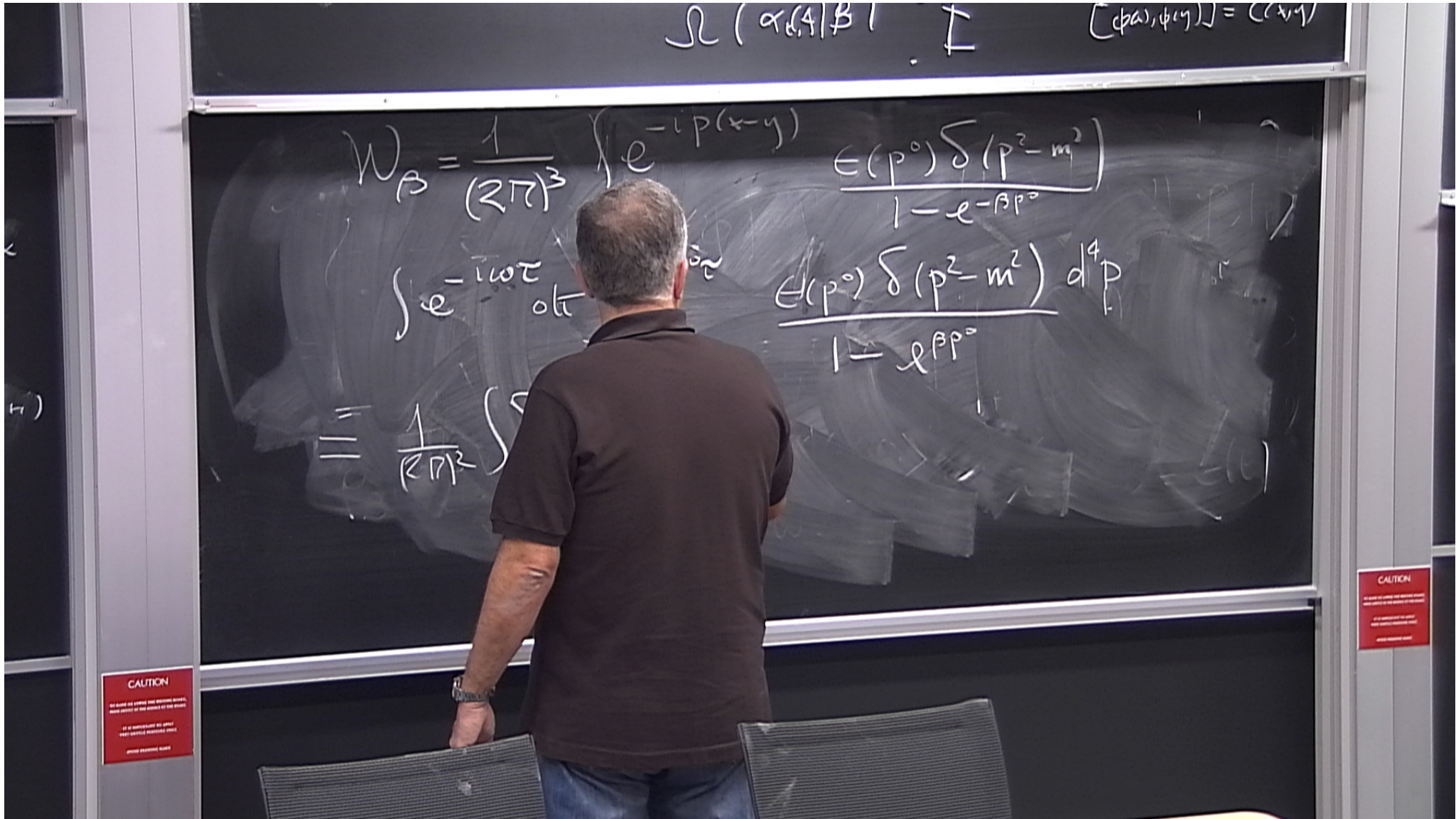
CAUTION

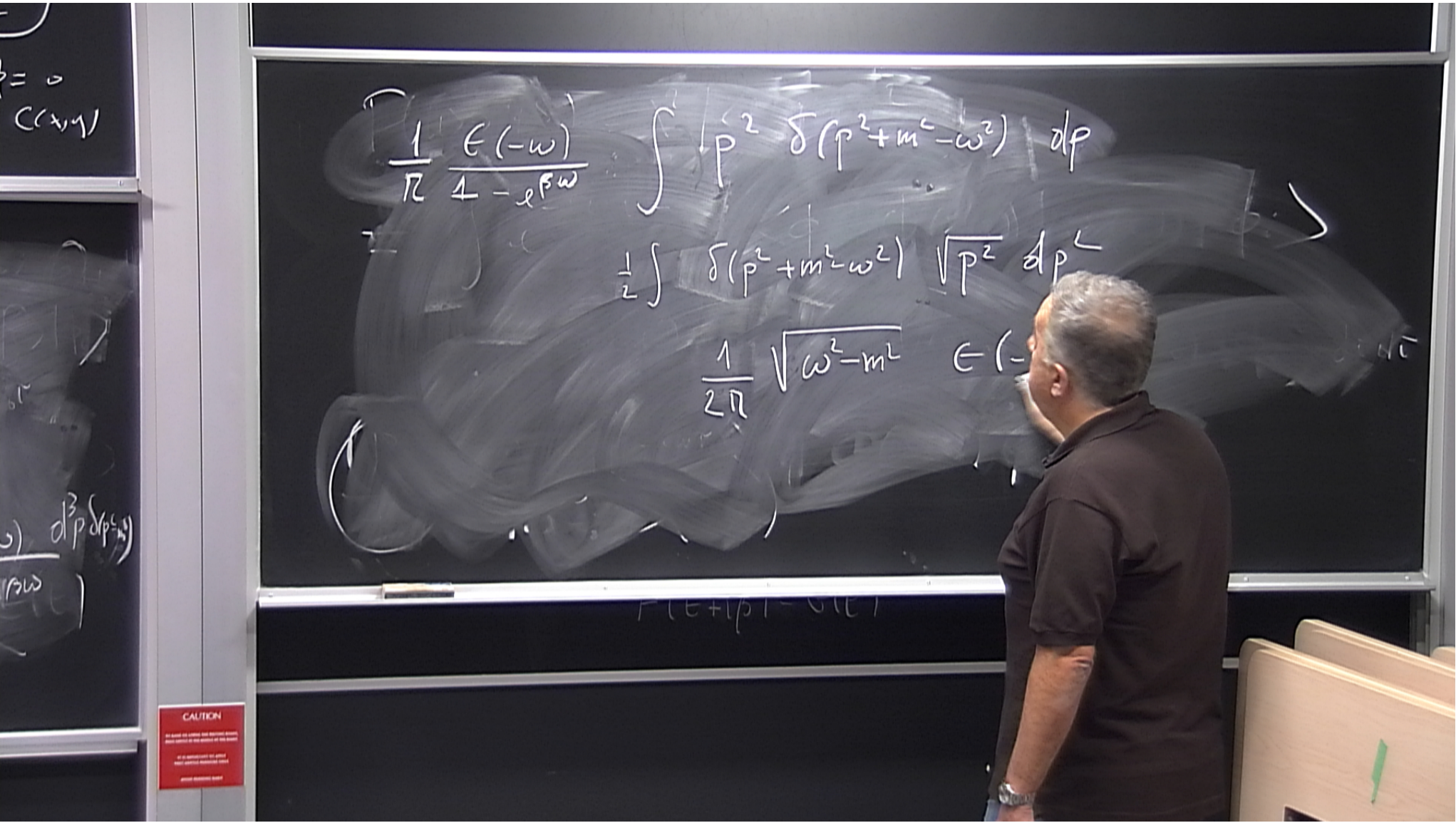












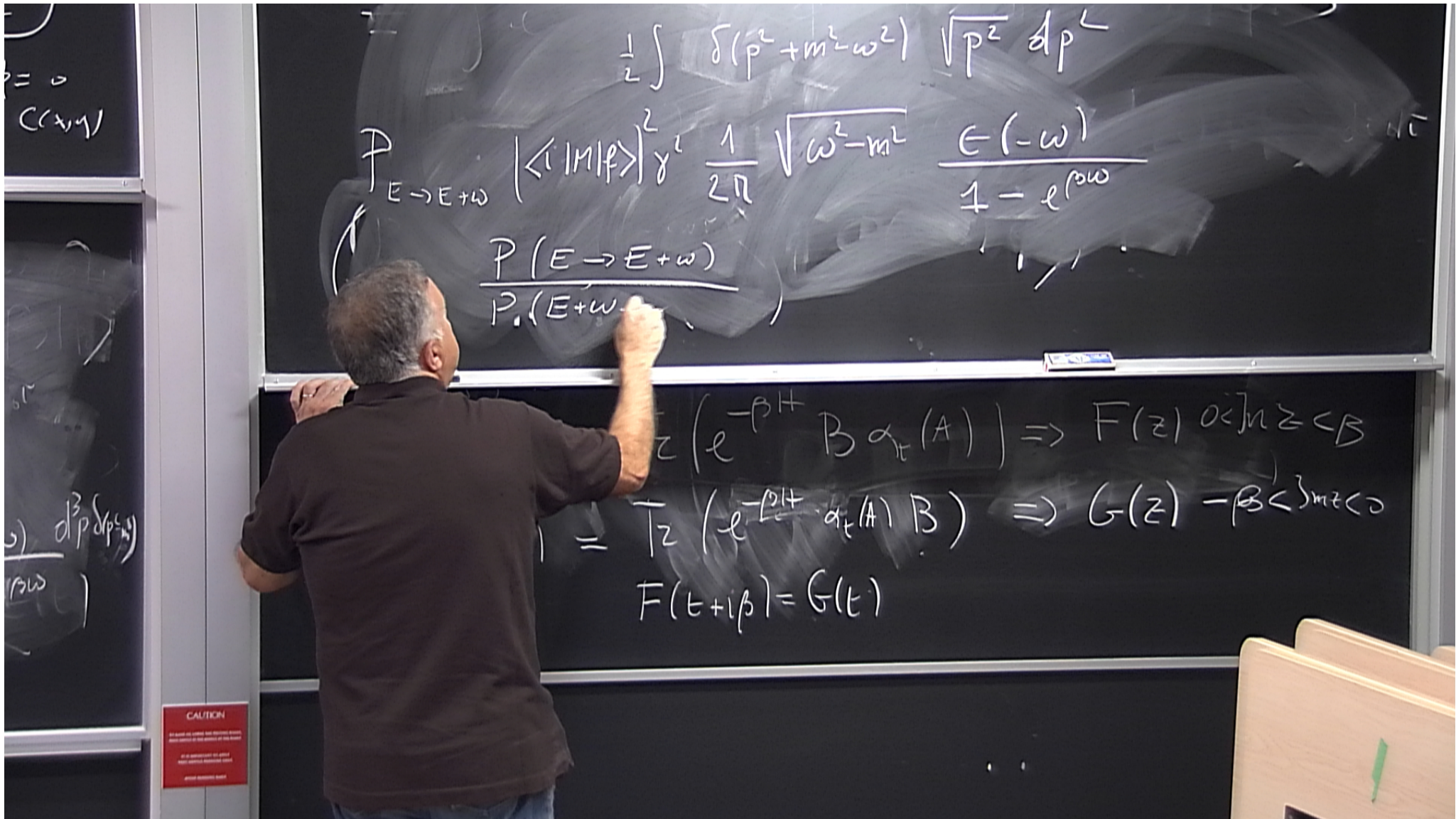
$$\frac{1}{\pi} \frac{\epsilon(-\omega)}{4 - e^{i\beta\omega}}$$

$$\int p^2 \delta(p^2 + m^2 - \omega^2) dp$$

$$\frac{1}{2} \int \delta(p^2 + m^2 - \omega^2) \sqrt{p^2} dp^L$$

$$\frac{1}{2\pi} \sqrt{\omega^2 - m^2} \epsilon(-)$$

CAUTION
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 WHEN WORKING IN THE BOARD OR THE BOARDER
 IT IS DANGEROUS TO TOUCH
 THE BOARD OR THE BOARDER
 WHEN WORKING IN THE BOARD



$$\frac{1}{2} \int \delta(p^2 + m^2 - \omega^2) \sqrt{p^2} dp^L$$

$$P_{E \rightarrow E+\omega} \left(\langle \psi | \psi \rangle \right)^2 \frac{1}{2\pi} \sqrt{\omega^2 - m^2} \frac{e^{-\beta\omega}}{1 - e^{-\beta\omega}}$$

$$\frac{P(E \rightarrow E+\omega)}{P_+(E+\omega)}$$

$$\int_C (e^{-\beta z} B \alpha_T(A)) dz \Rightarrow F(z) \text{ for } 0 < \text{Im} z < \beta$$

$$= \int_C (e^{-\beta z} \alpha_T(A) B) dz \Rightarrow G(z) \text{ for } -\beta < \text{Im} z < 0$$

$$F(t+i\beta) = G(t)$$

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 ALL RIGHTS RESERVED

$p = 0$
 $C(x, y)$
 $d^3p \delta(p^2 - m^2)$
 $(\beta \omega)$

$$\frac{1}{2} \int \delta(p^2 + m^2 - \omega^2) \sqrt{p^2} dp^L$$

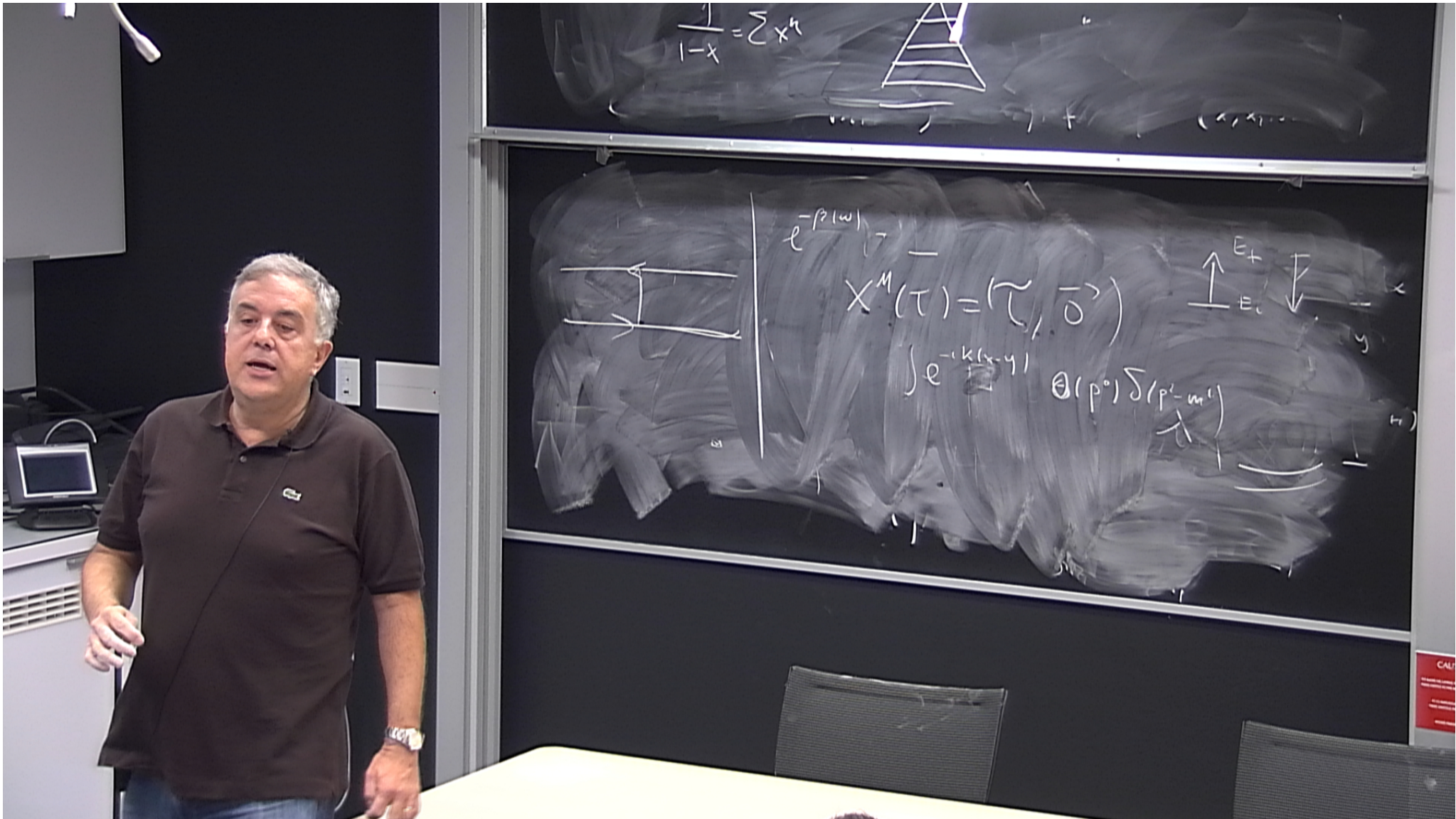
$$P_{E \rightarrow E+\omega} \left(\langle |M|^2 \rangle \right)^2 \gamma^L \frac{1}{2\pi} \sqrt{\omega^2 - m^2} \frac{E(-\omega)}{1 - e^{\beta\omega}}$$

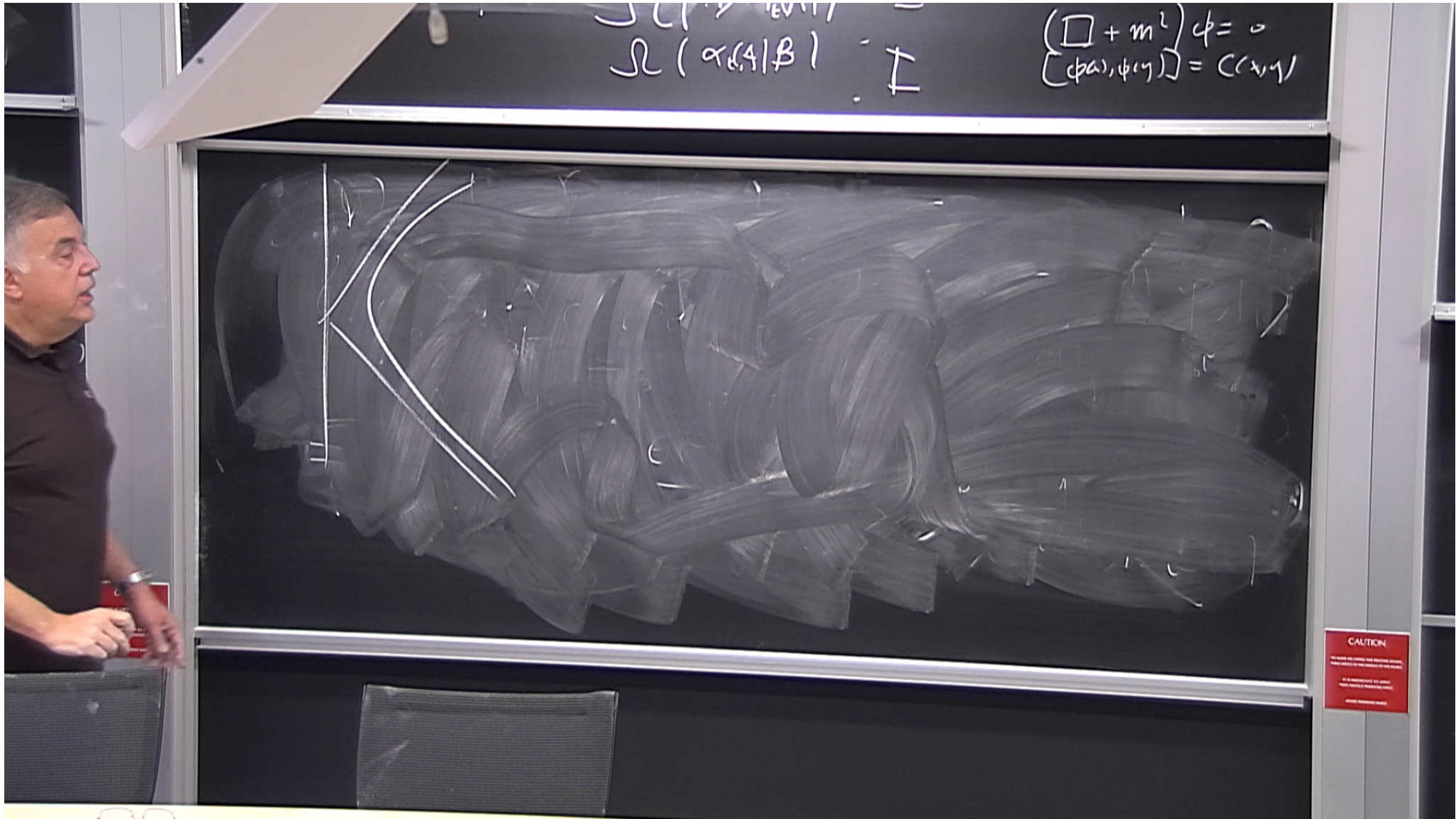
$$\frac{P(E \rightarrow E+\omega)}{P_*(E+\omega \rightarrow E)} = e^{-\beta\omega}$$

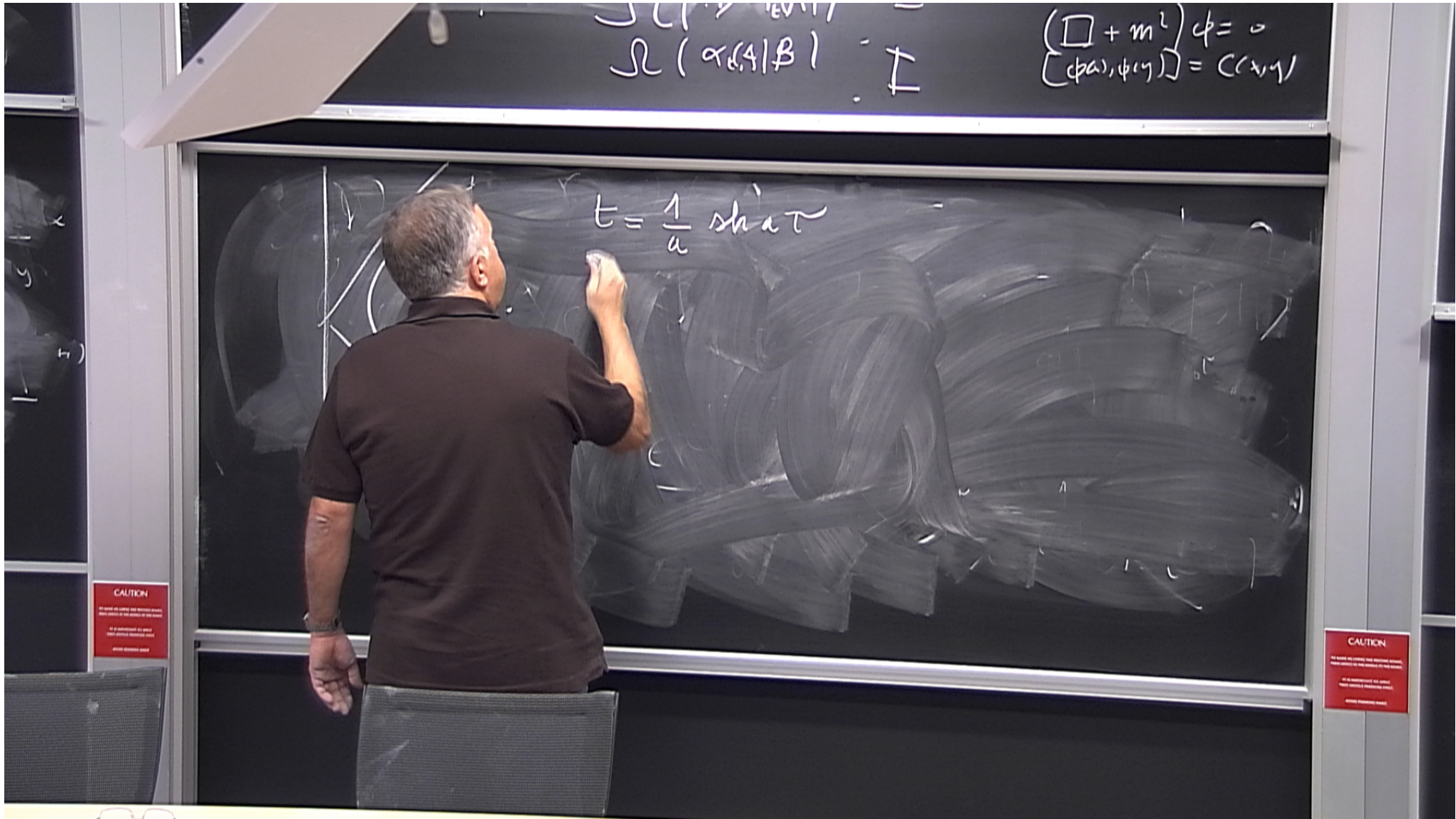
$$F(z) = \int_A^B \frac{dz}{z} \Rightarrow F(z) \text{ for } 0 < \text{Im} z < B$$

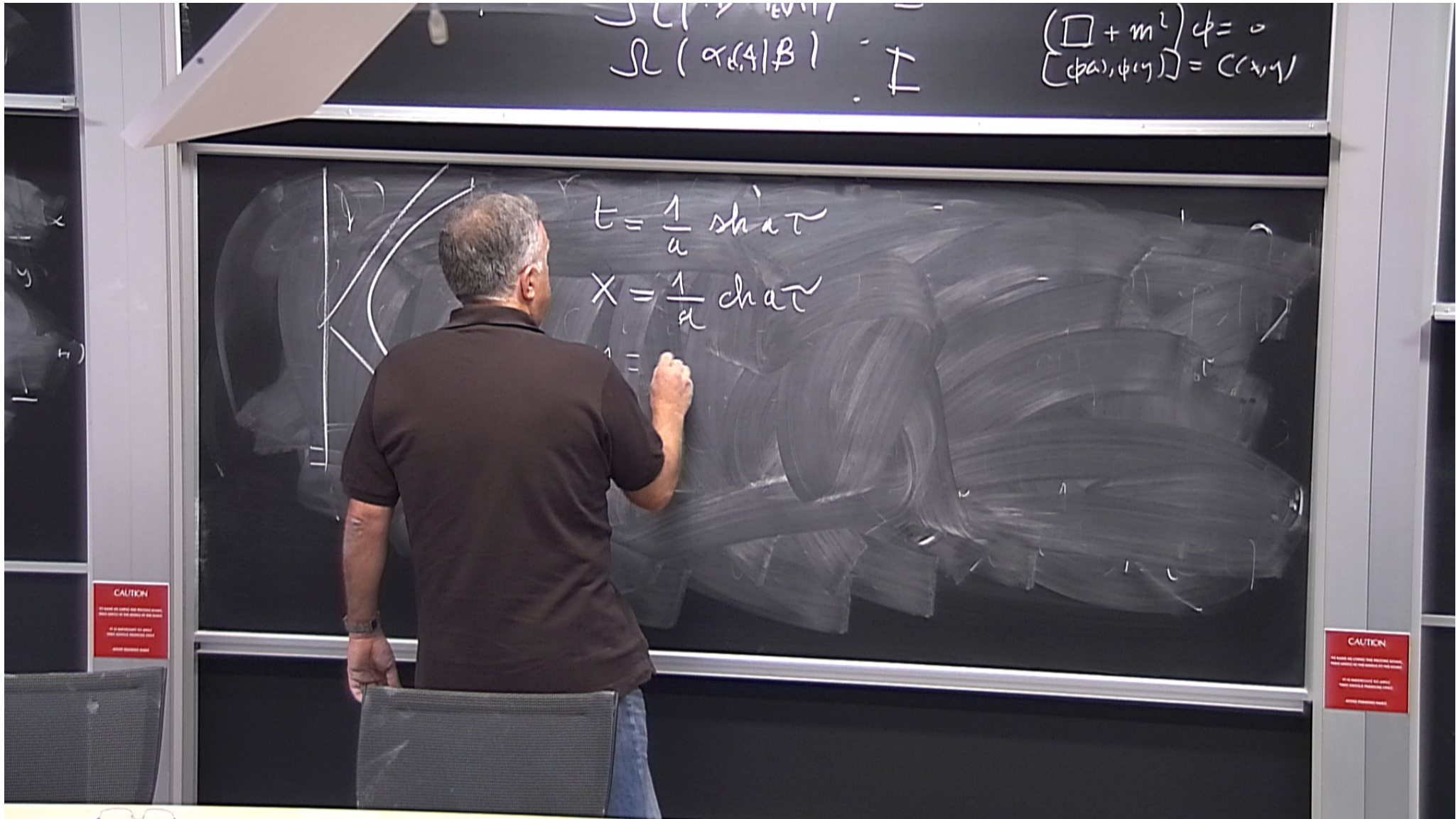
$$G(z) = \int_C^D \frac{dz}{z} \Rightarrow G(z) \text{ for } -\beta < \text{Im} z < 0$$

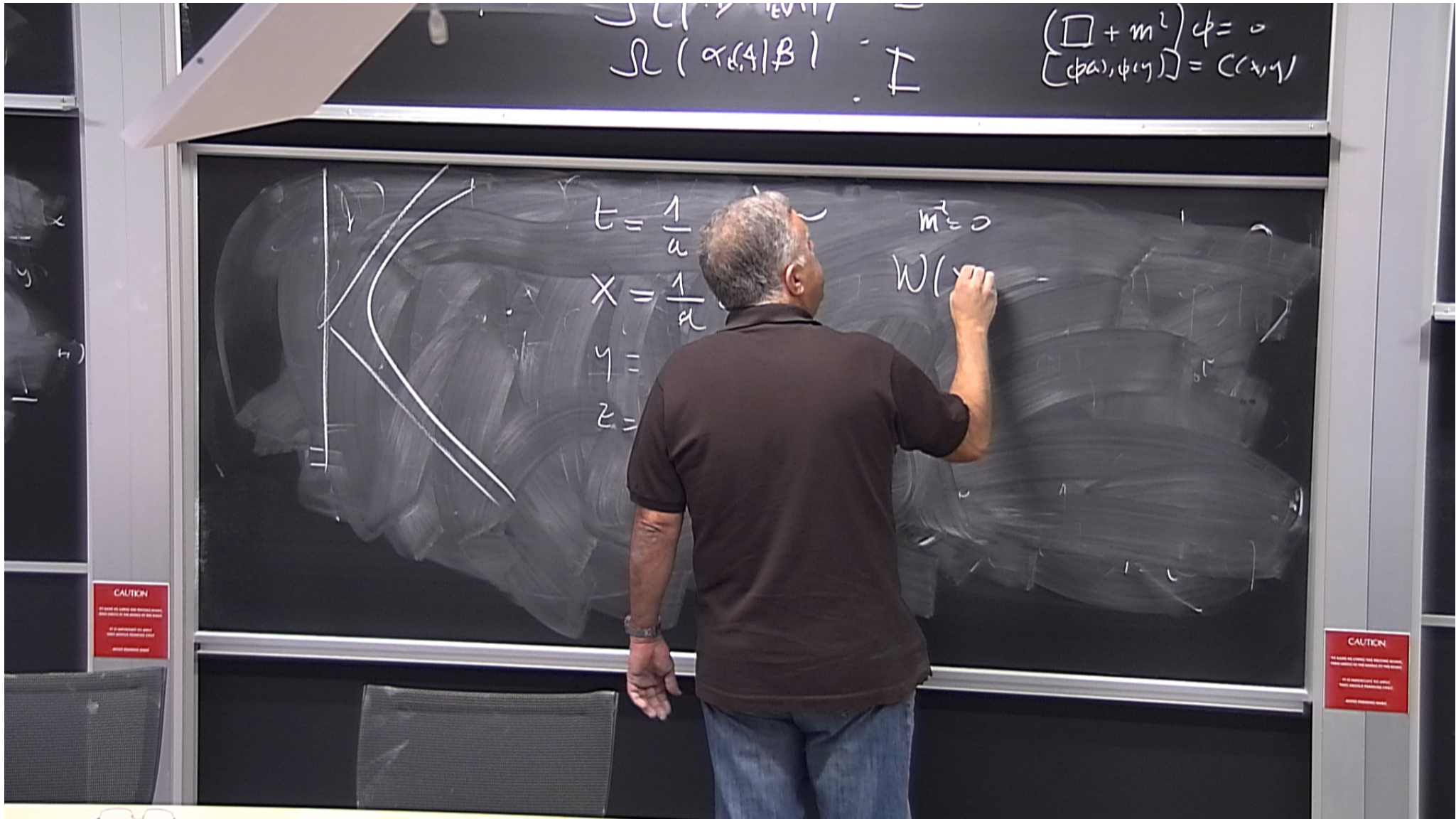
CAUTION
 DO NOT STAND ON TABLES AND CHAIRS.
 PLEASE BE CAREFUL AT THE FRONT OF THE ROOM.
 DO NOT DRINK FROM THE WATER BOTTLES.
 THANK YOU FOR YOUR ATTENTION.











$$\Omega(\alpha, \beta) = \int$$

$$(\square + m^2)\psi = 0$$
$$[\psi(x), \psi(y)] = C(x, y)$$

$$t = \frac{1}{a}$$

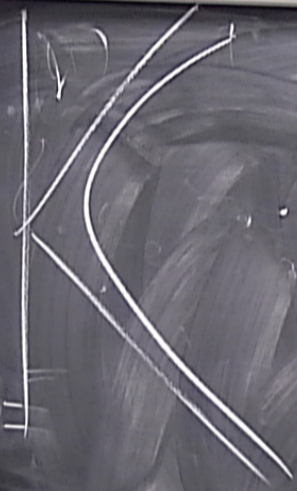
$$x = \frac{1}{a}$$

$$y =$$

$$z =$$

$$m^2 = 0$$

$$W(x)$$



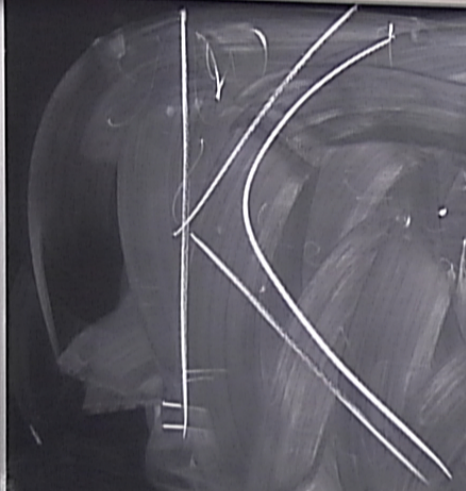
CAUTION
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WHEN IT IS HOT OR WHEN IT IS BEING
CLEANED.

CAUTION
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CLEANED.

$$\Omega(\alpha, \beta) = \int$$

$$\left(\square + m^2 \right) \phi = 0$$

$$[\phi(x), \phi(y)] = C(x, y)$$



$$t = \frac{1}{a} \operatorname{sh} a\tau$$

$$m^2 = 0$$

$$X = \frac{1}{a} \operatorname{ch} a\tau$$

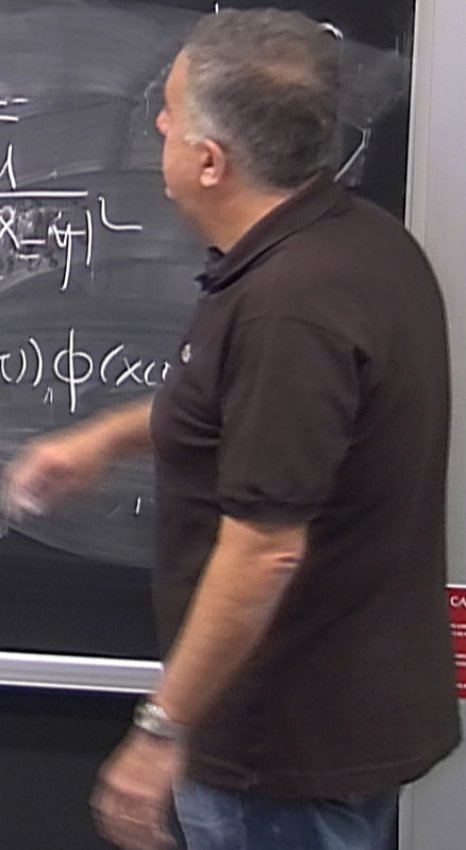
$$W(z) =$$

$$y = 0$$

$$= -\frac{1}{4\pi^2} \frac{1}{(x-y)^2}$$

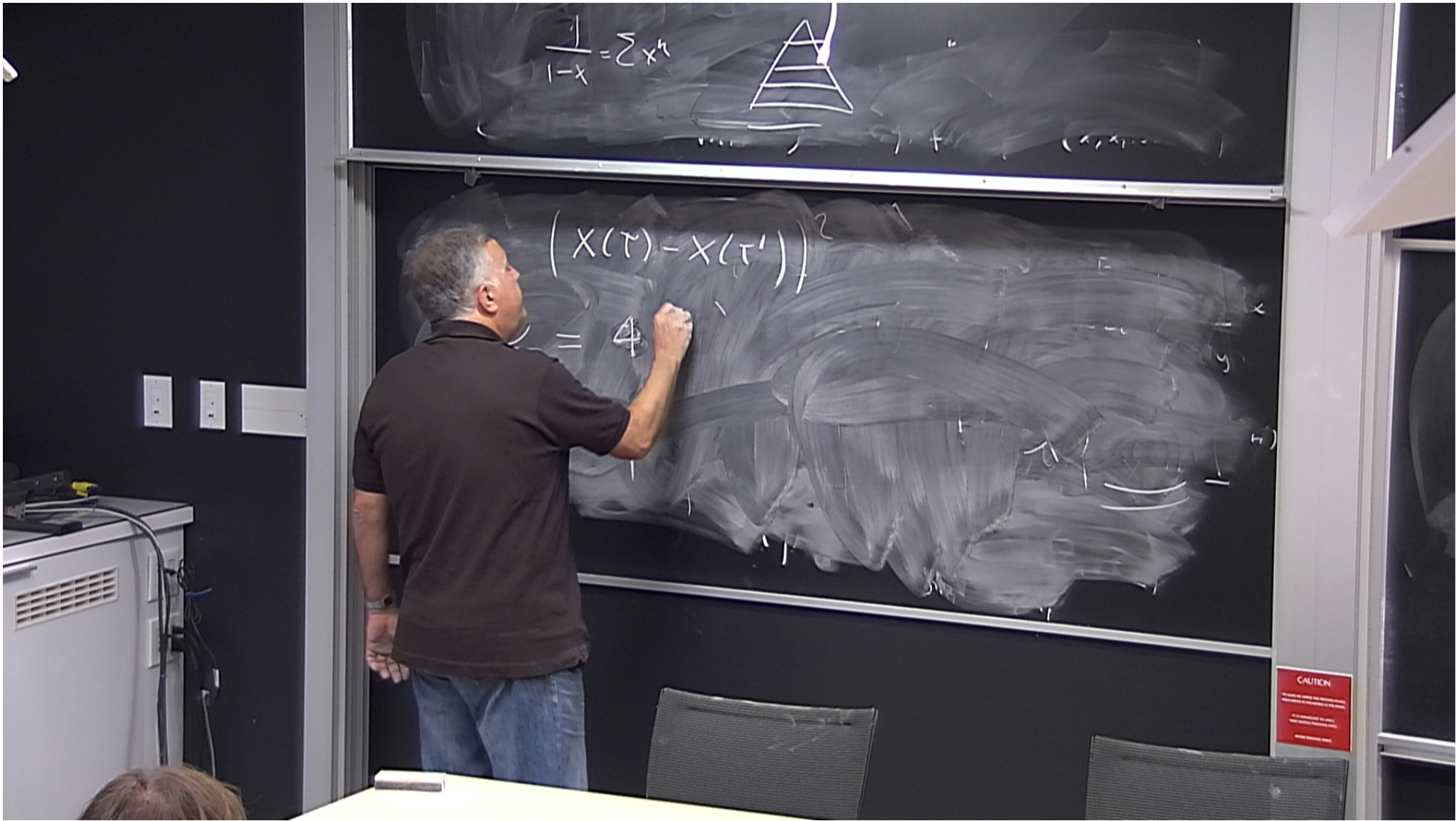
$$z = 0$$

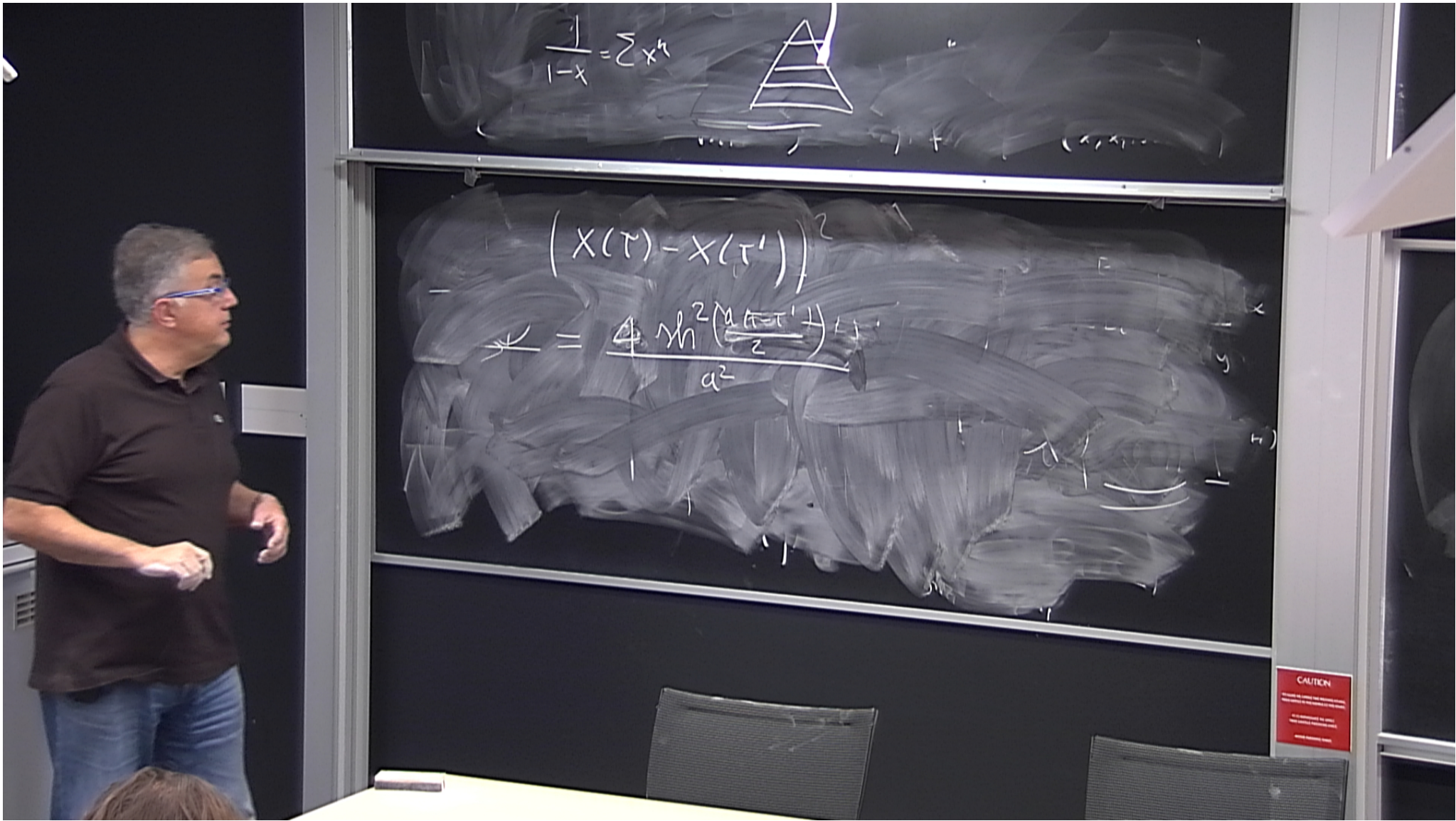
$$\int e^{-i\omega\tau} \langle 0 | \phi(x(\tau)) \phi(x_0) | 0 \rangle$$

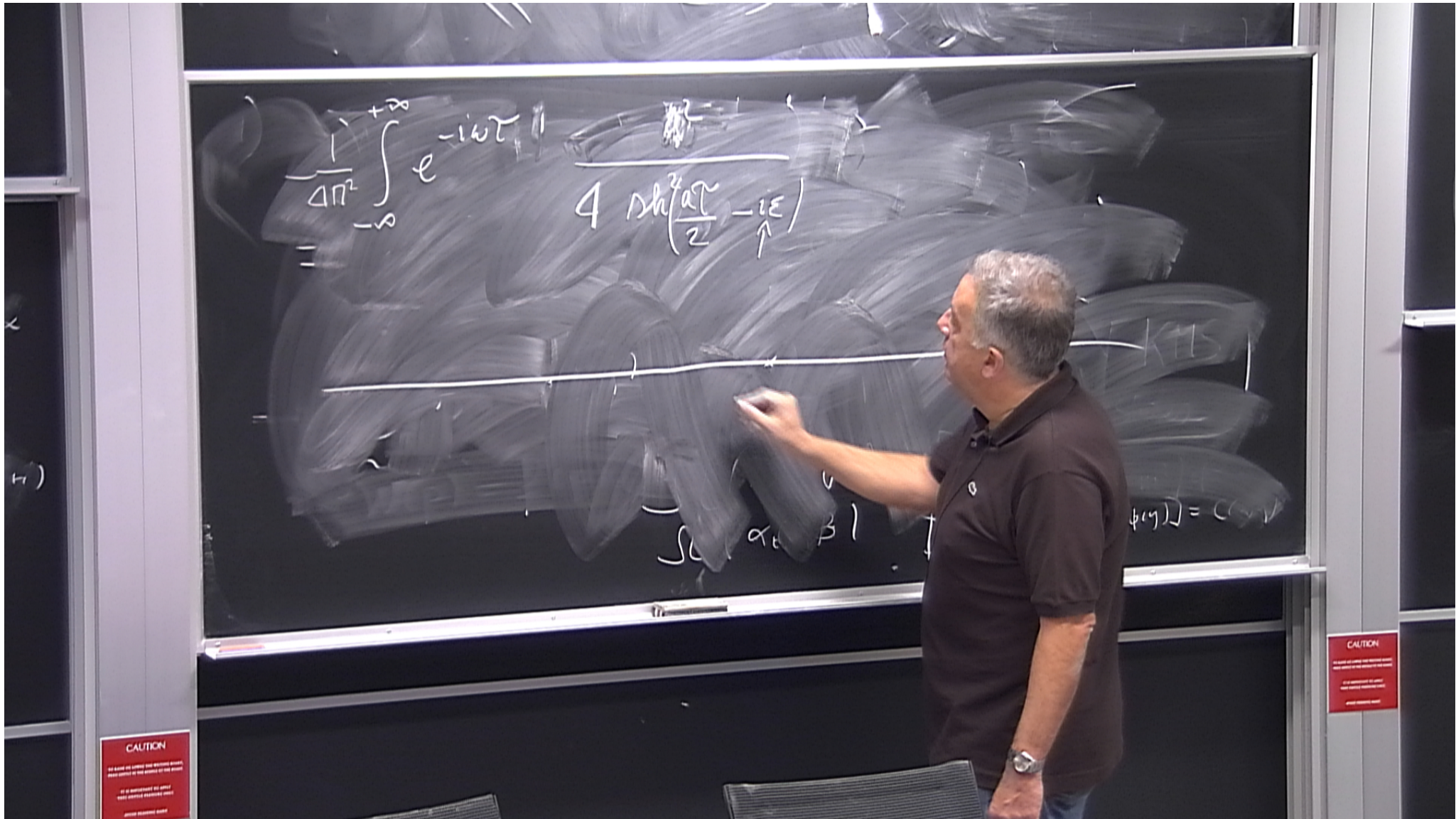


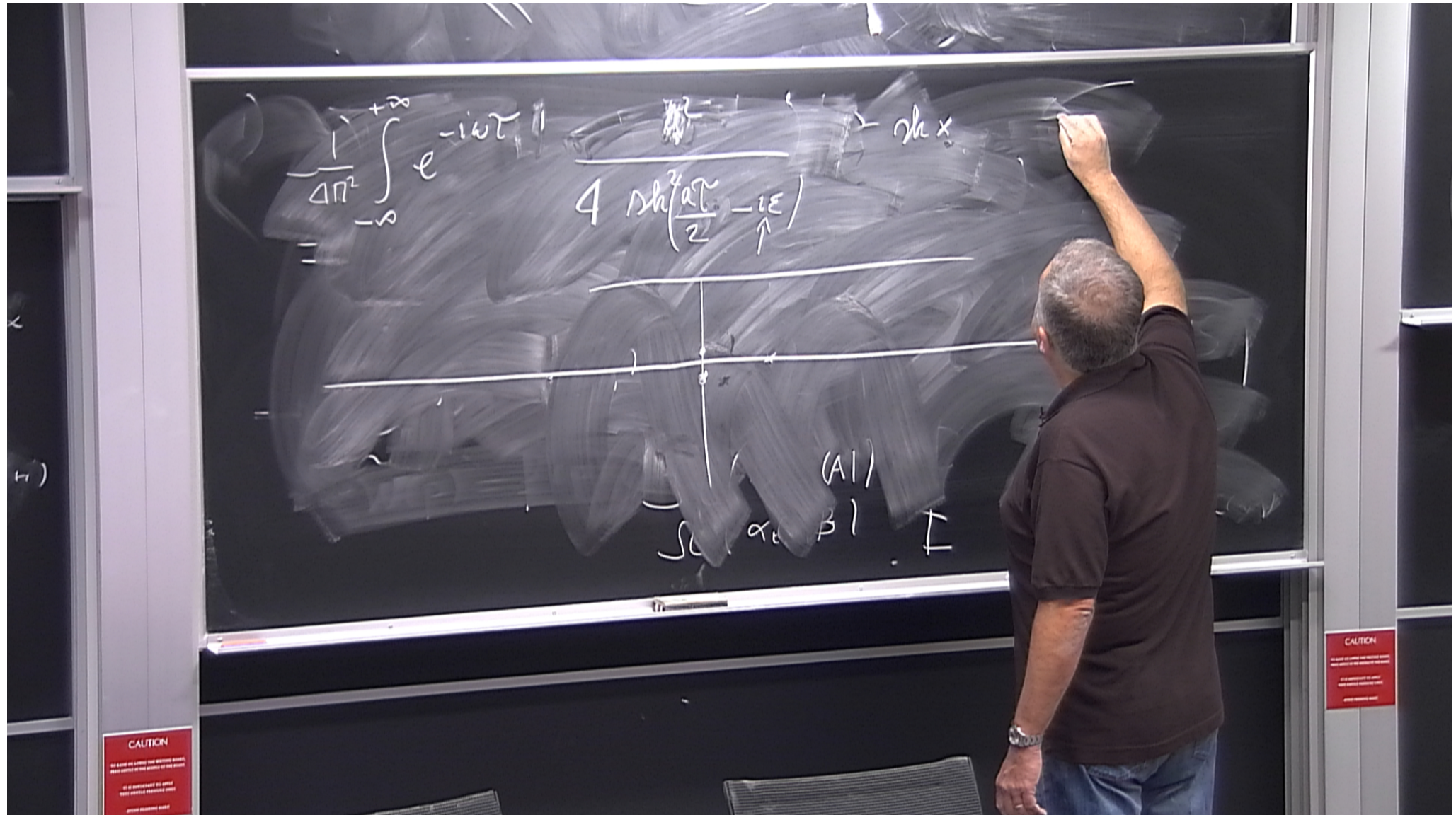
CAUTION
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you are instructed to do so.
Do not touch the chalkboard unless
you are instructed to do so.

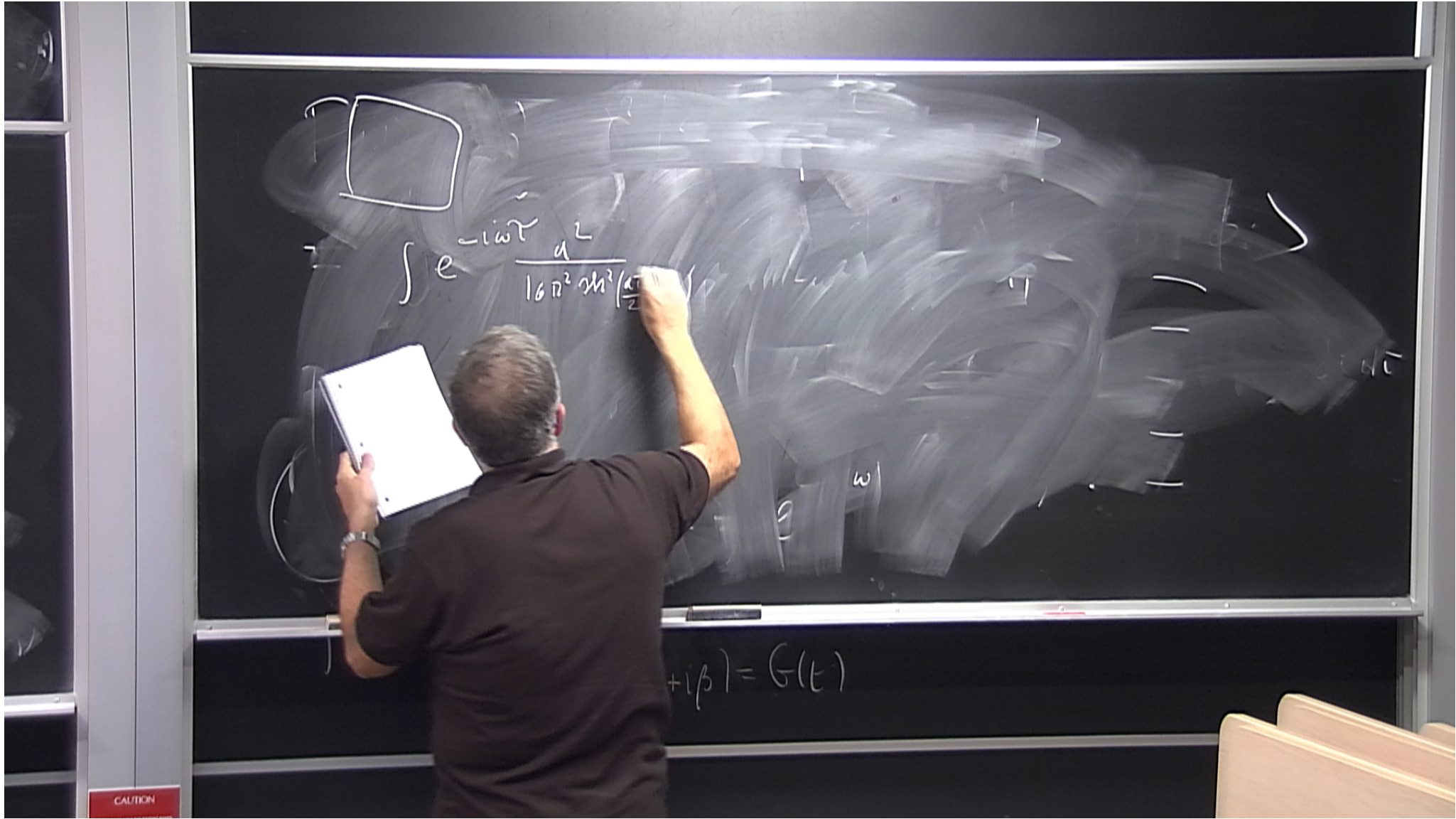
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Do not touch the chalkboard unless
you are instructed to do so.











$$\int e^{-i\omega t} \frac{z^2}{16\pi^2 \omega^2 (\frac{a\tau}{2} - i\epsilon)}$$

$$- e^{-i\omega t} \frac{z^2}{1 - i\omega a}$$

$$\int e^{-i\omega t} \frac{z^2}{1 - i\omega a}$$

$$F(t+i\beta) = G$$