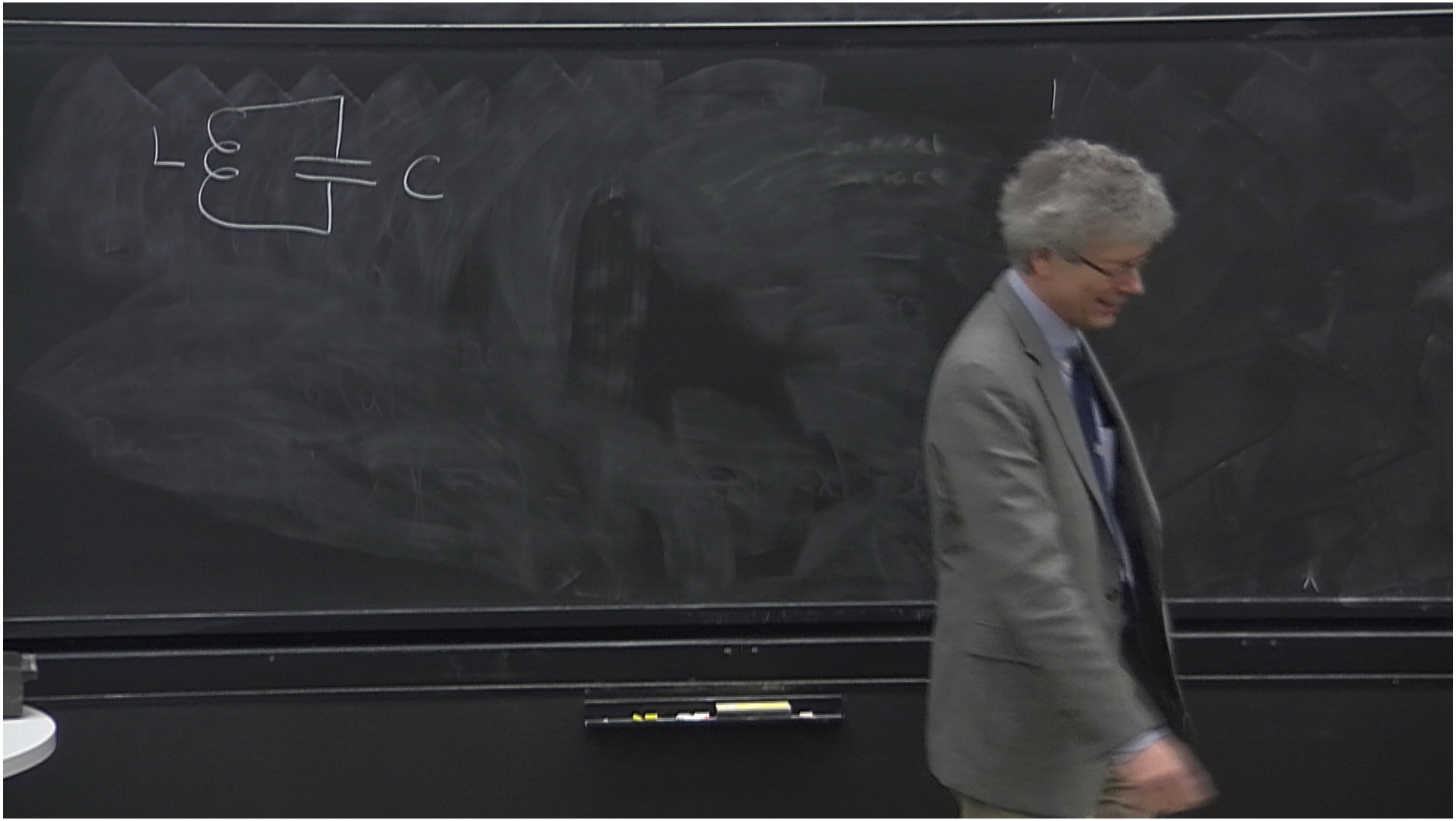
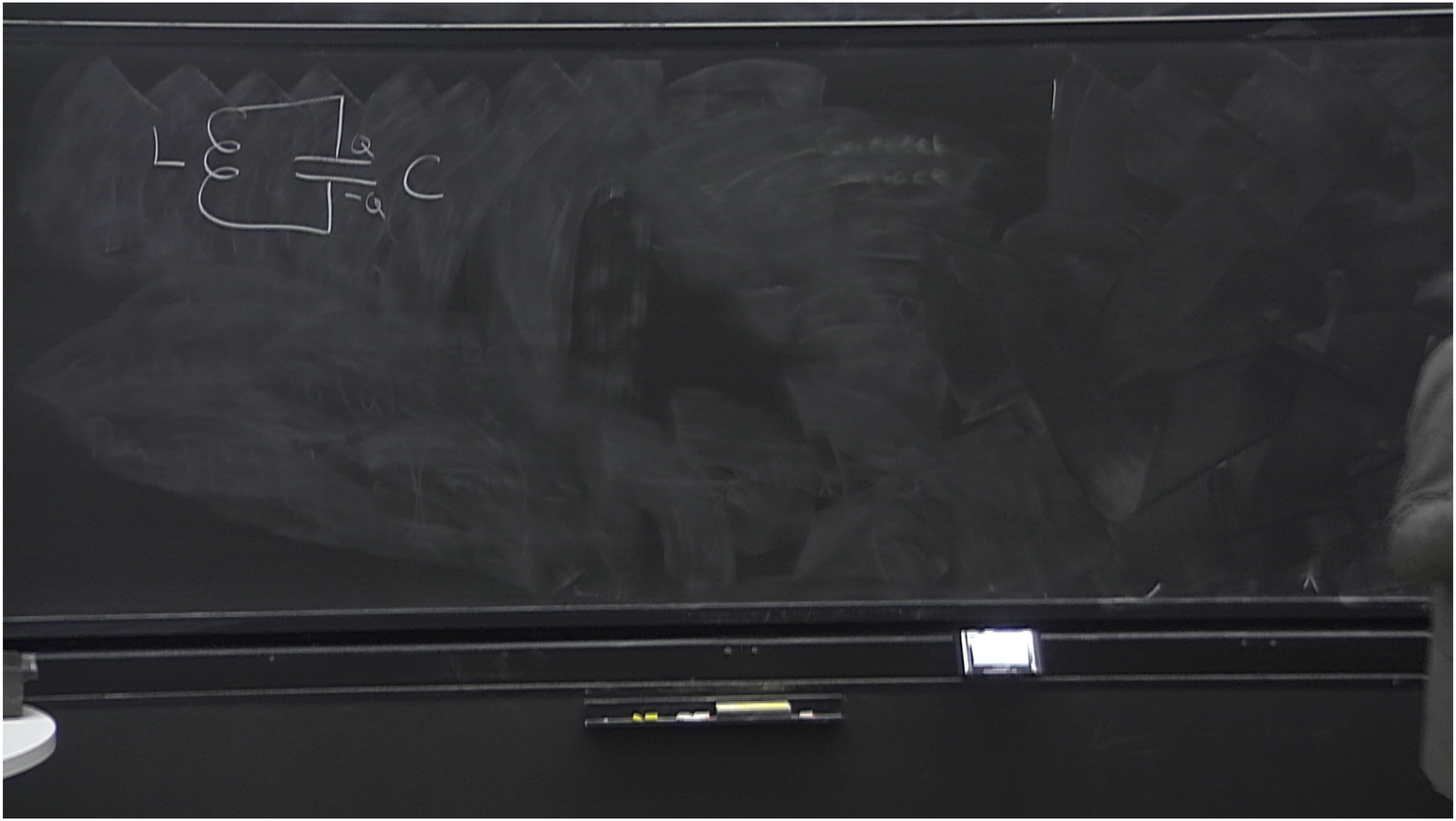
Title: 12/13 PSI Researcher Presentation

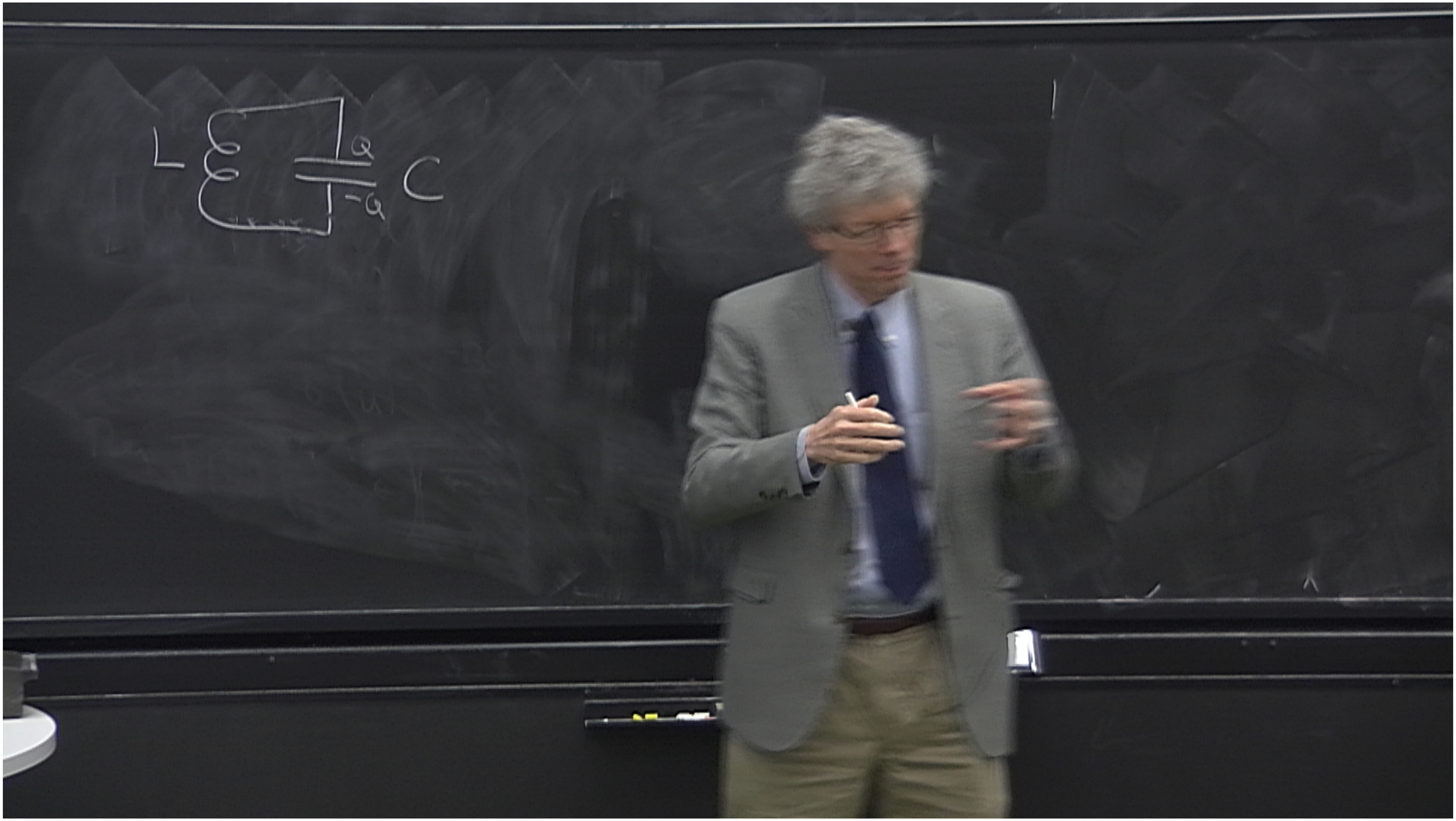
Date: Nov 28, 2012 01:00 PM

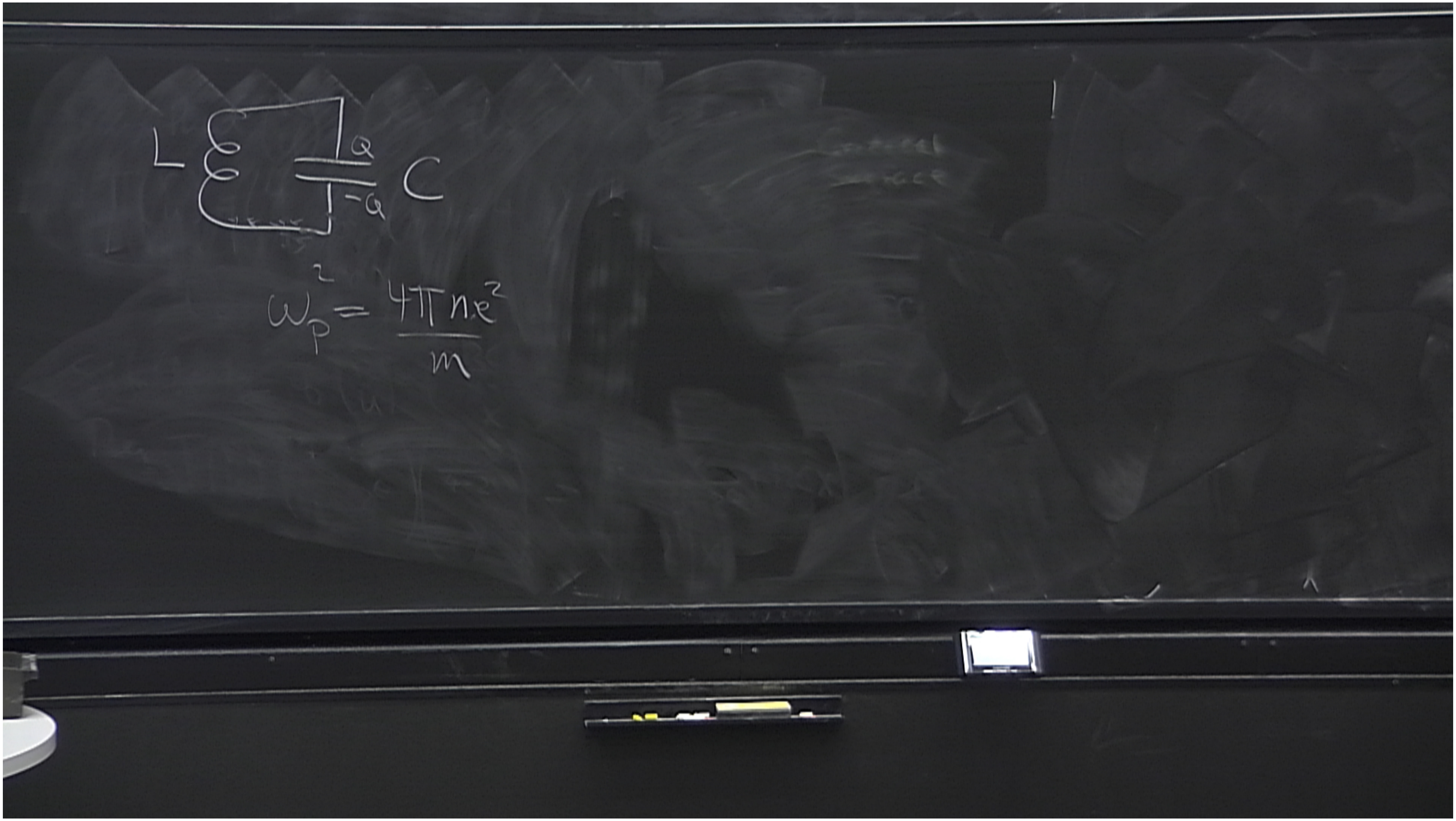
URL: http://www.pirsa.org/12110093

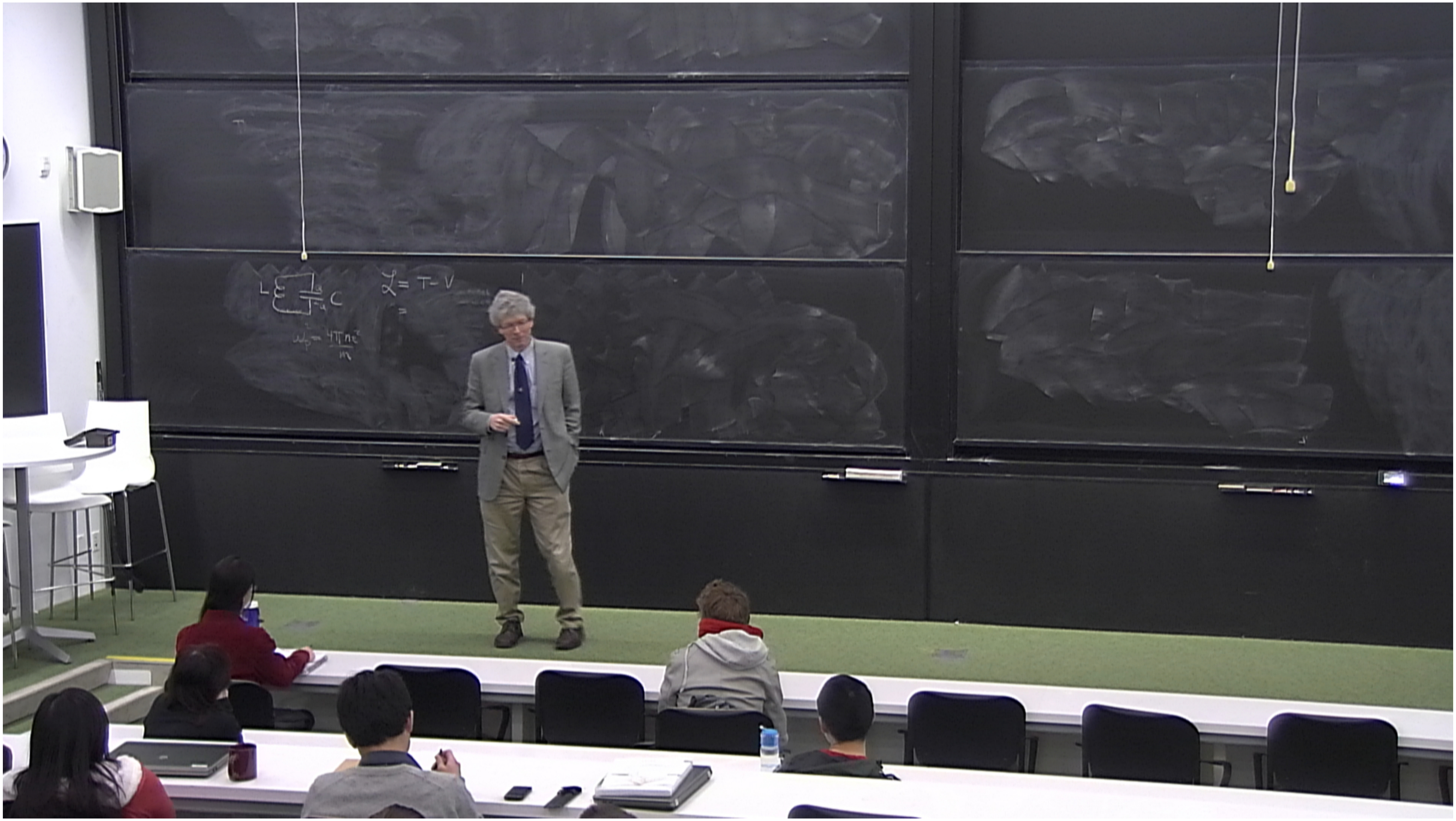
Abstract:

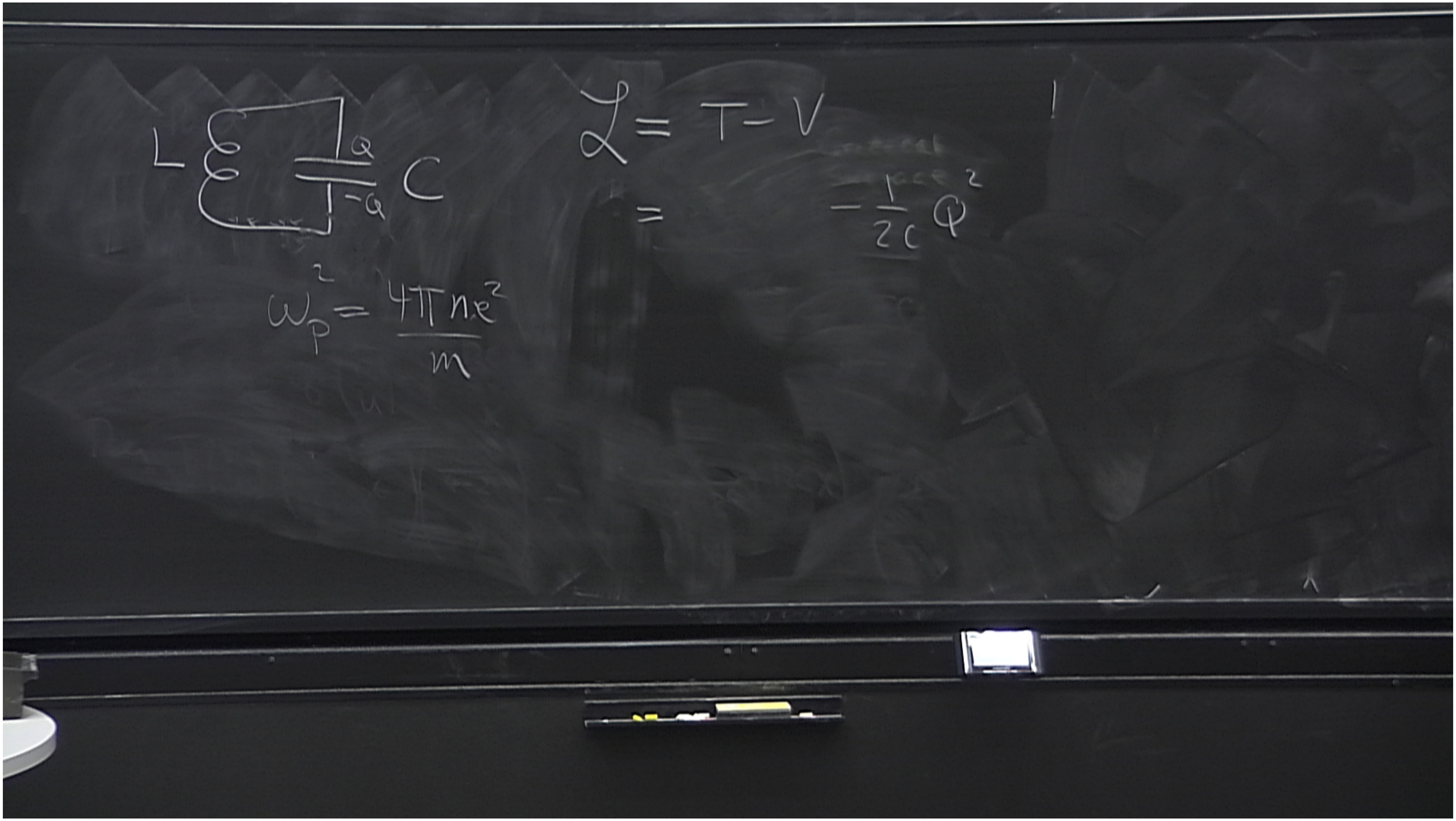

L
C

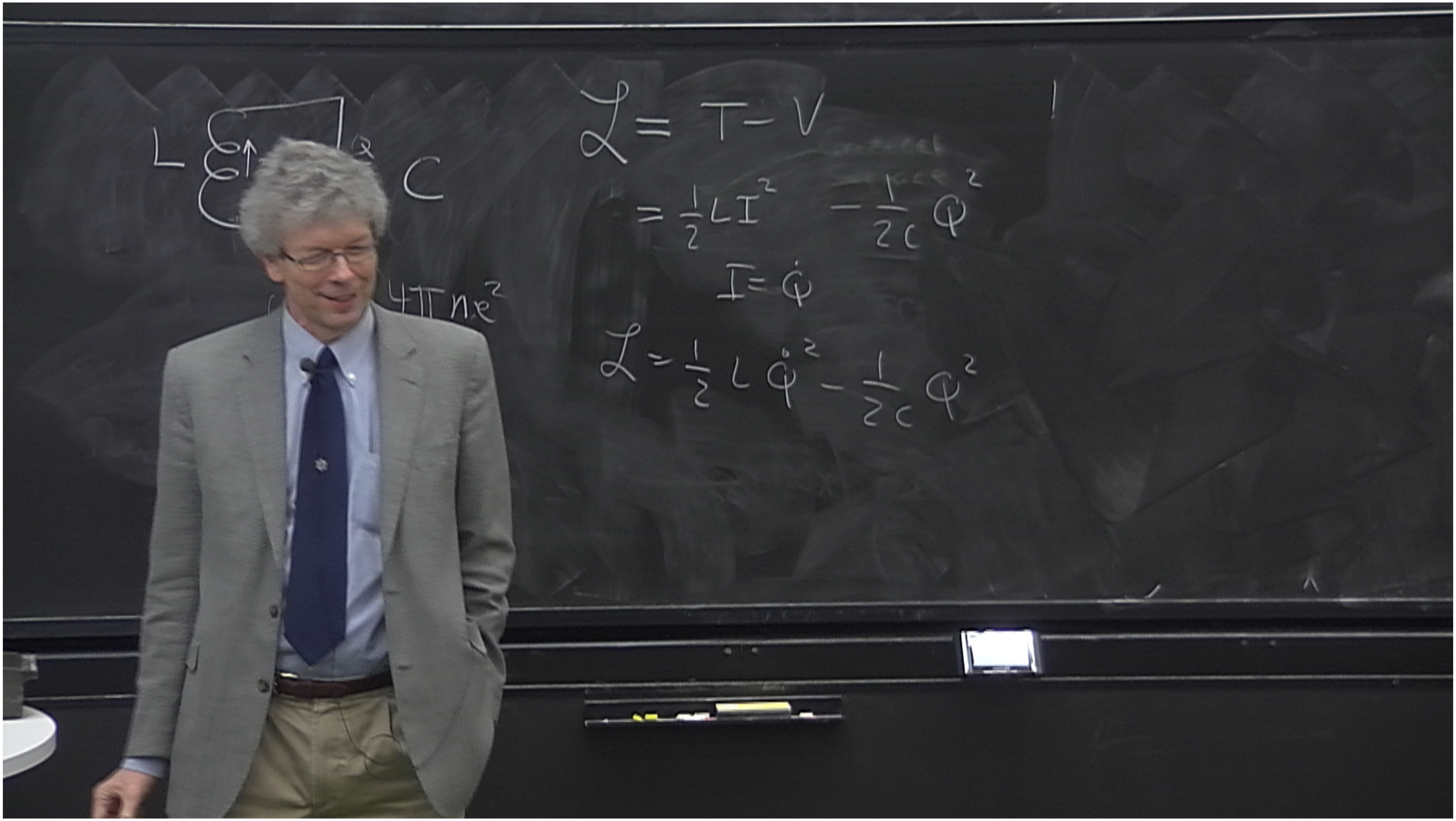

L
Q
-Q
C

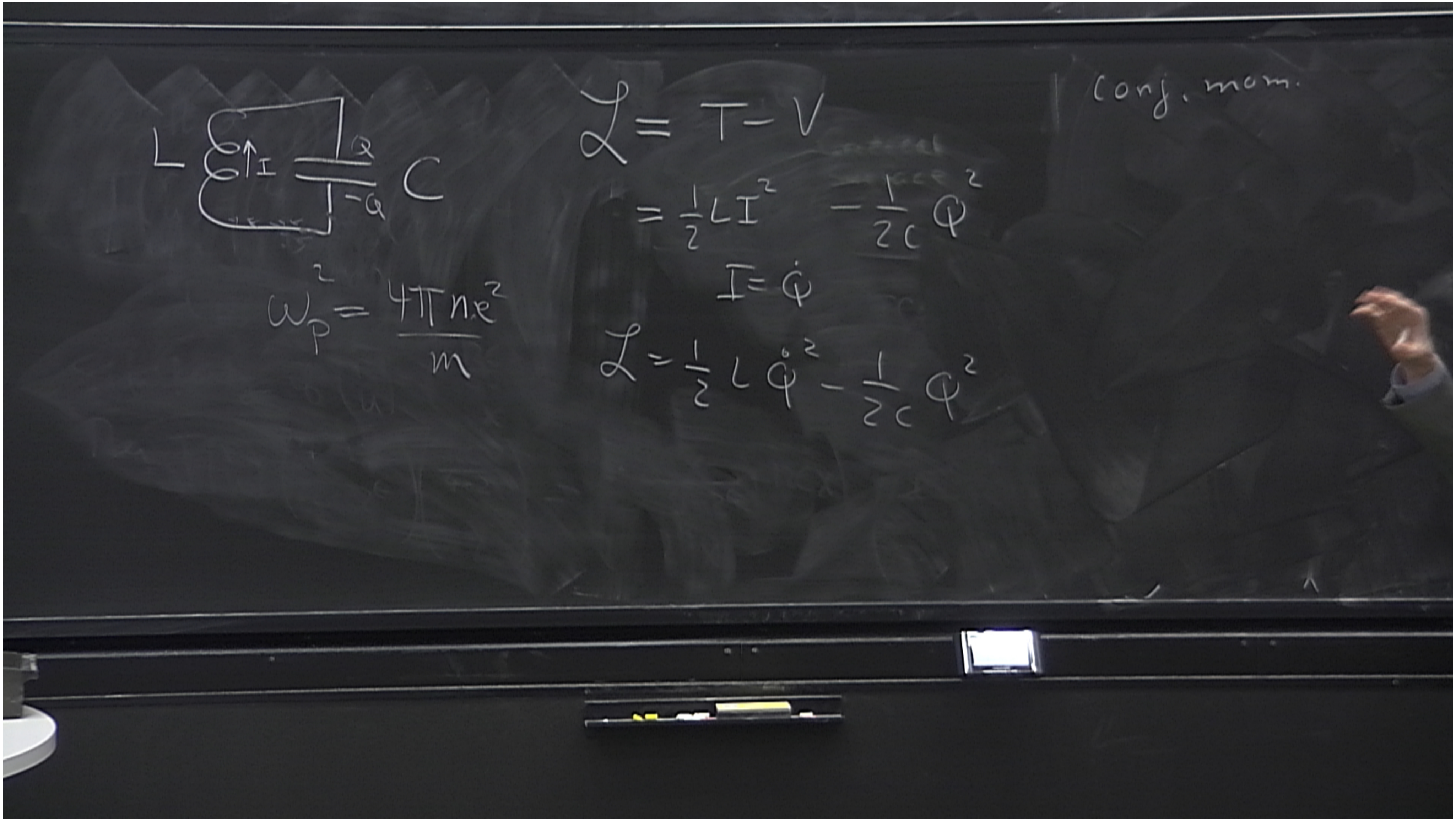

L
Q
-Q
C

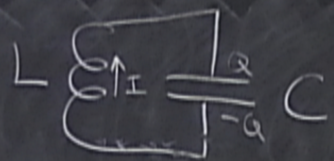

L
Q
-Q
C
$\omega_p^2 = \frac{4\pi n e^2}{m}$




L
Q
-Q
C
ℒ = T − V
= − 1/2C Q²
ω_p² = 4πne²/m


L
C
4πne²
ℒ = T − V
= ½ L I² − (1/2C) Q²
I = Q̇
ℒ = ½ L Q̇² − (1/2C) Q²


L
I
Q
-Q
C
conj. mom.
𝓛 = T − V
= ½ L I² − (1/2C) Q²
I = Q̇
𝓛 = ½ L Q̇² − (1/2C) Q²
ω_p² = 4π n e² / m



$$\omega_p^2 = \frac{4\pi n e^2}{m}$$

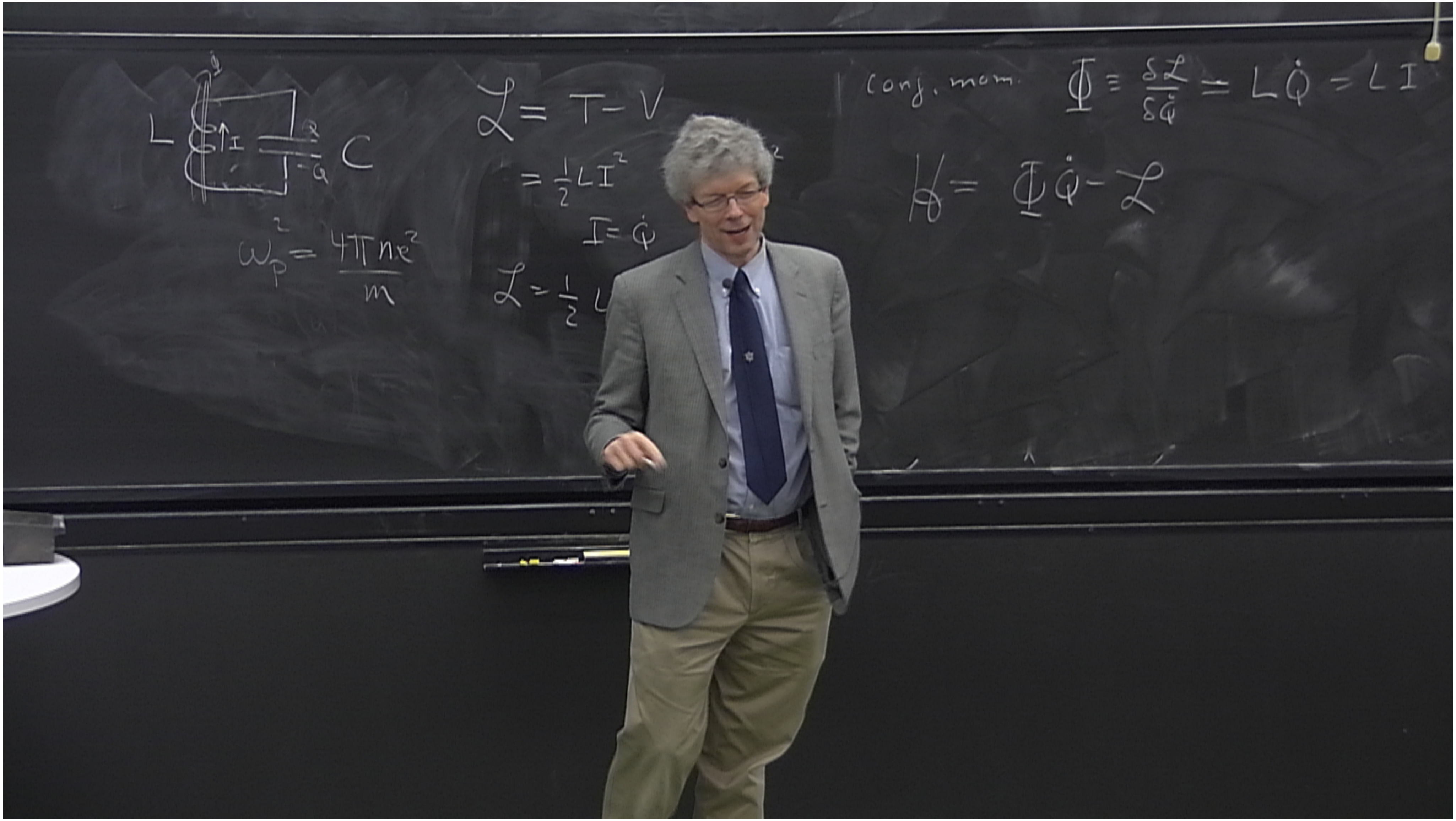
$$\mathcal{L} = T - V$$

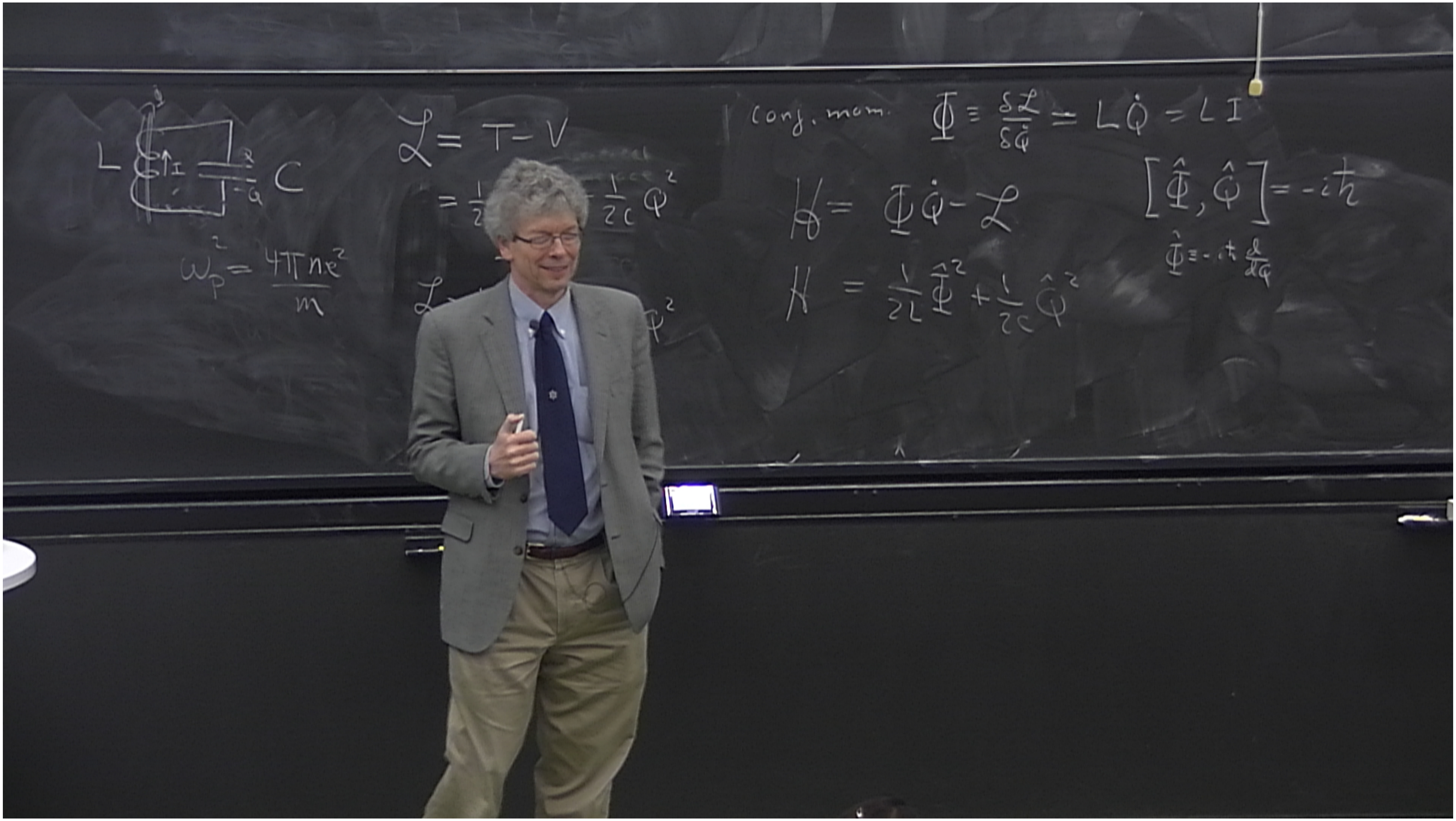
$$= \frac{1}{2} L I^2 - \frac{1}{2C} Q^2$$

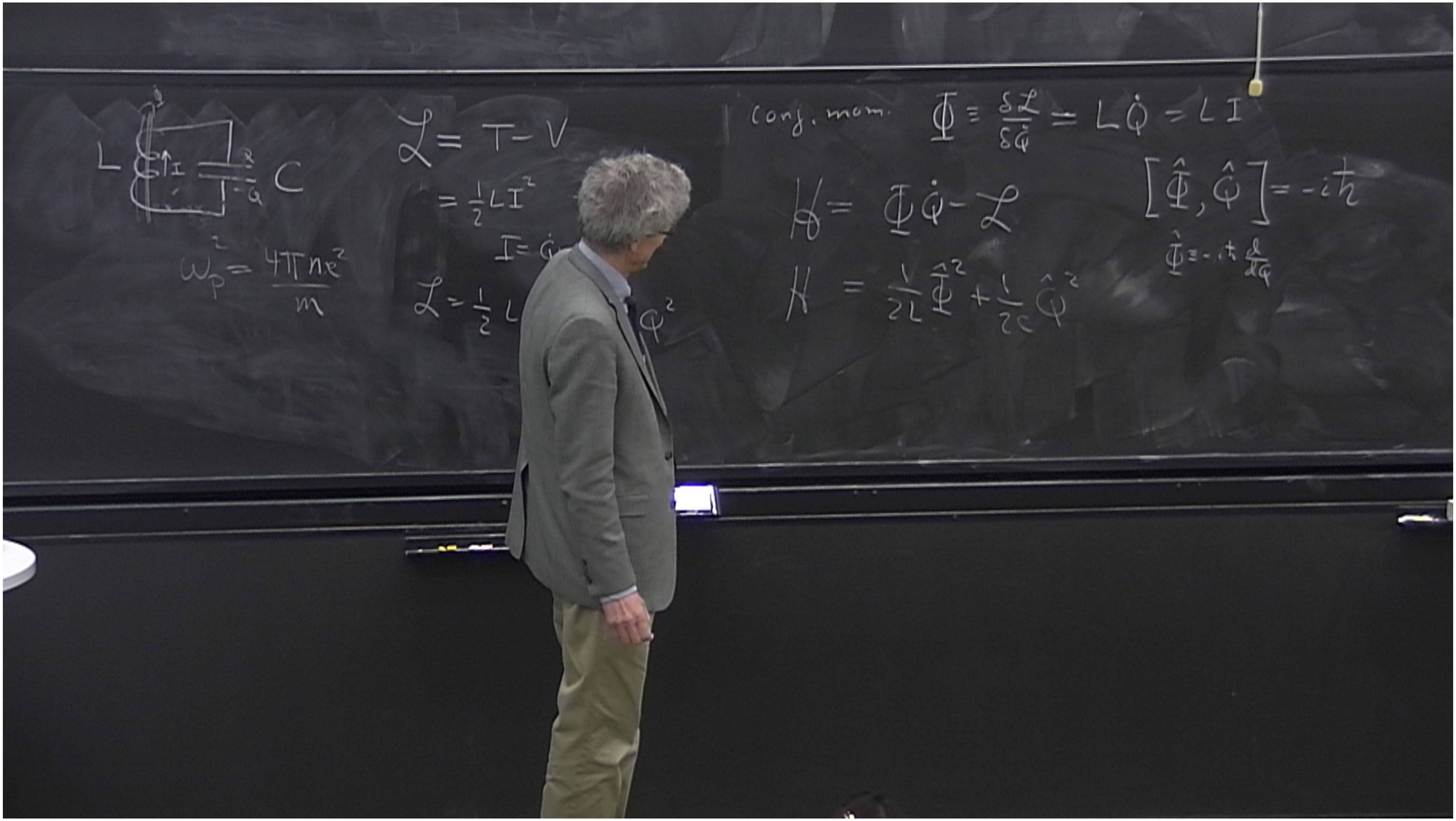
$$I = \dot{Q}$$

$$\mathcal{L} = \frac{1}{2} L \dot{Q}^2 - \frac{1}{2C} Q^2$$

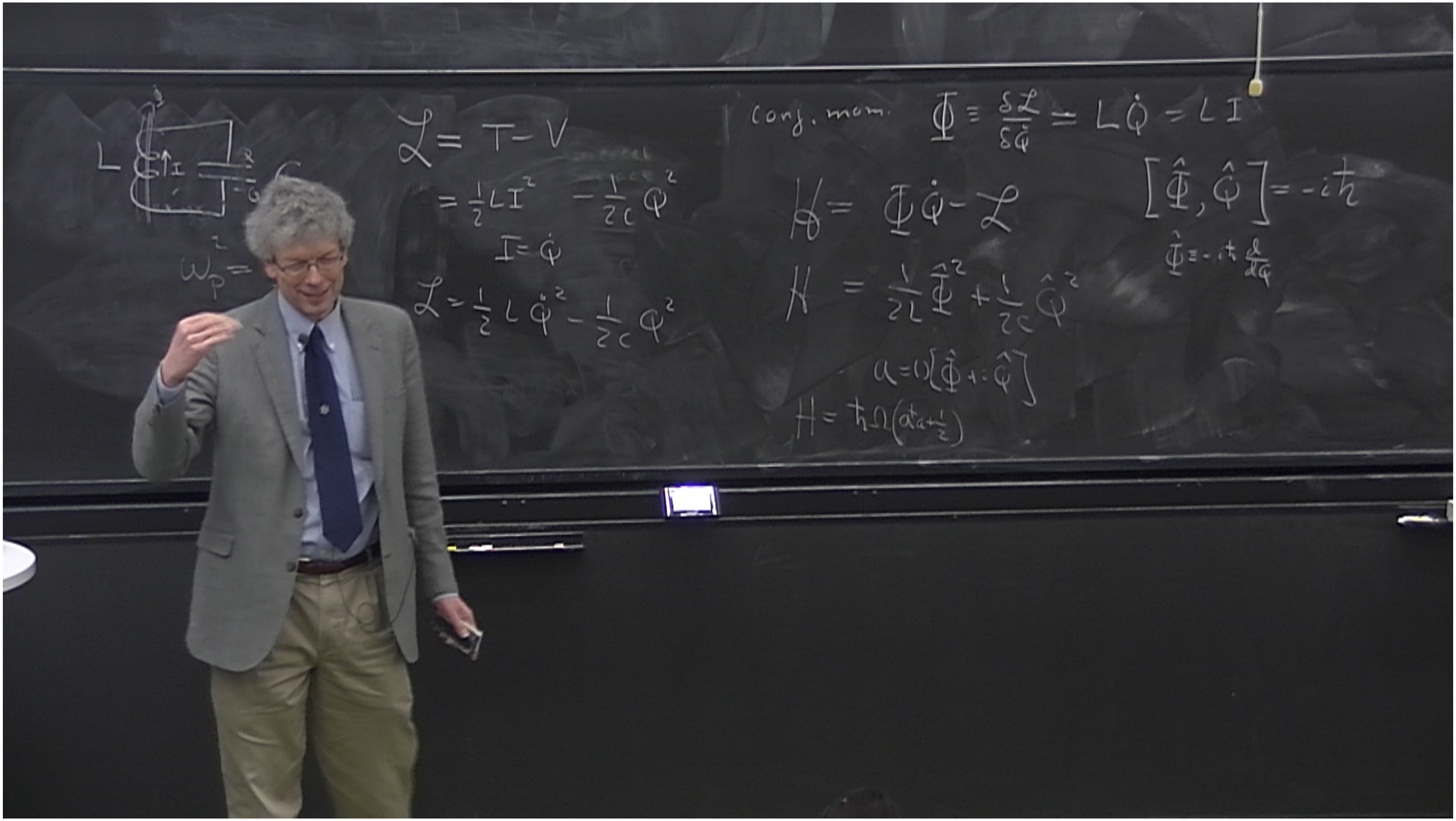
conj. mom. $\Phi \equiv \frac{\delta \mathcal{L}}{\delta \dot{Q}} = L\dot{Q} = LI$

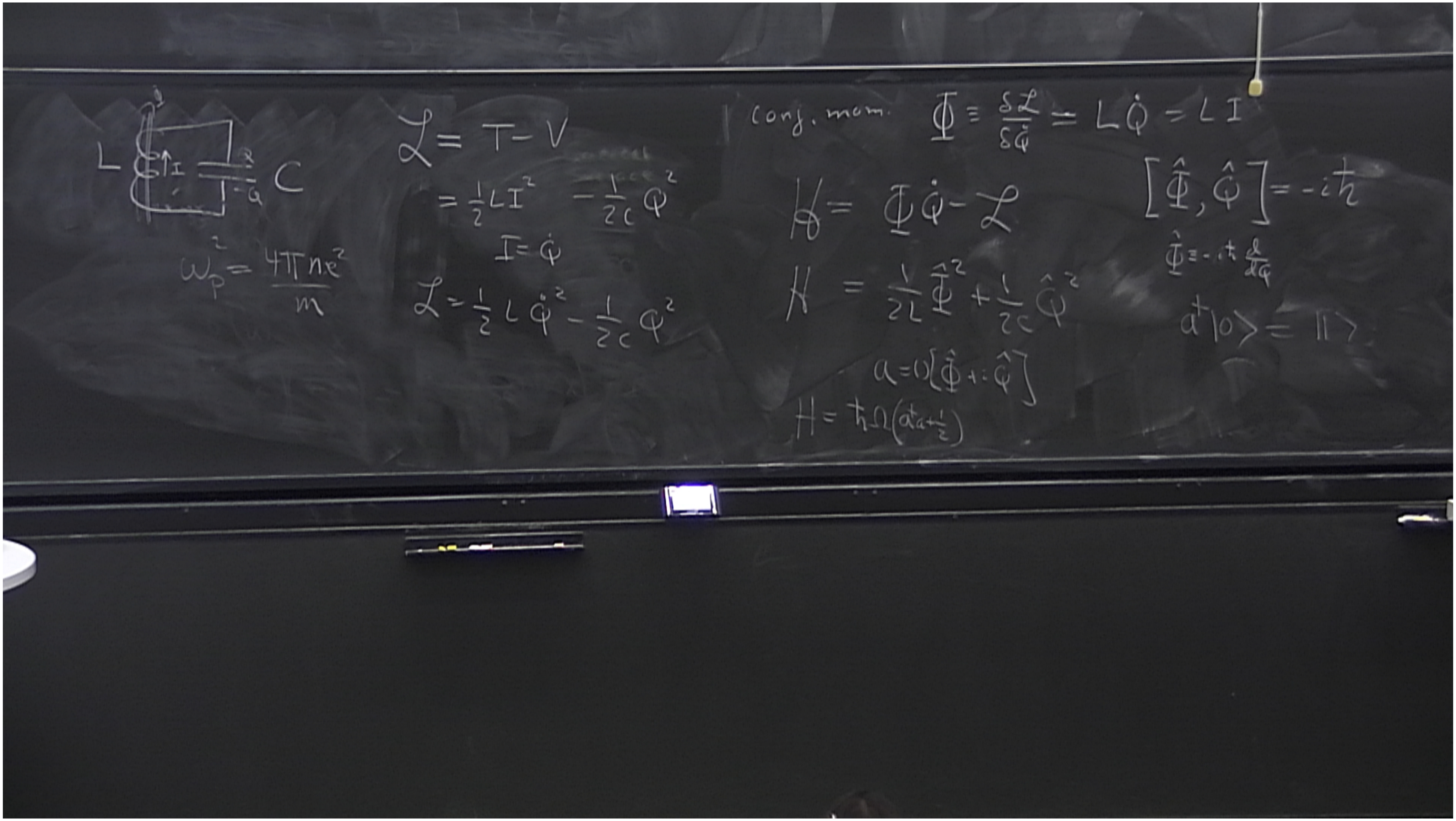

L
C
Q
-Q
I
$\mathcal{L} = T - V$
$= \frac{1}{2} L I^2$
$I = \dot{Q}$
$\omega_p^2 = \frac{4\pi n e^2}{m}$
conj. mom.
$\Phi \equiv \frac{\delta \mathcal{L}}{\delta \dot{Q}} = L\dot{Q} = LI$
$\mathcal{H} = \Phi \dot{Q} - \mathcal{L}$

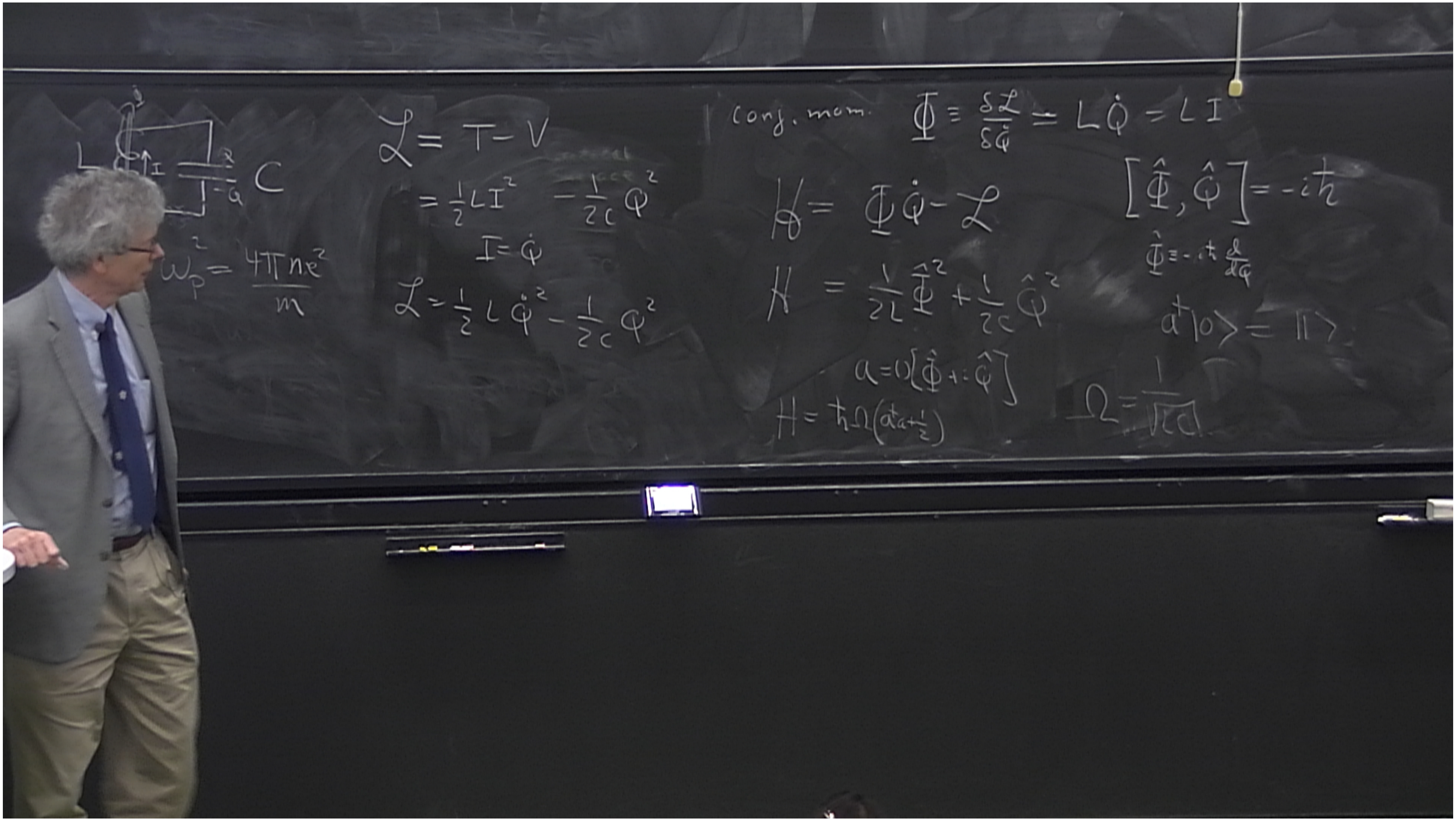

conj. mom.

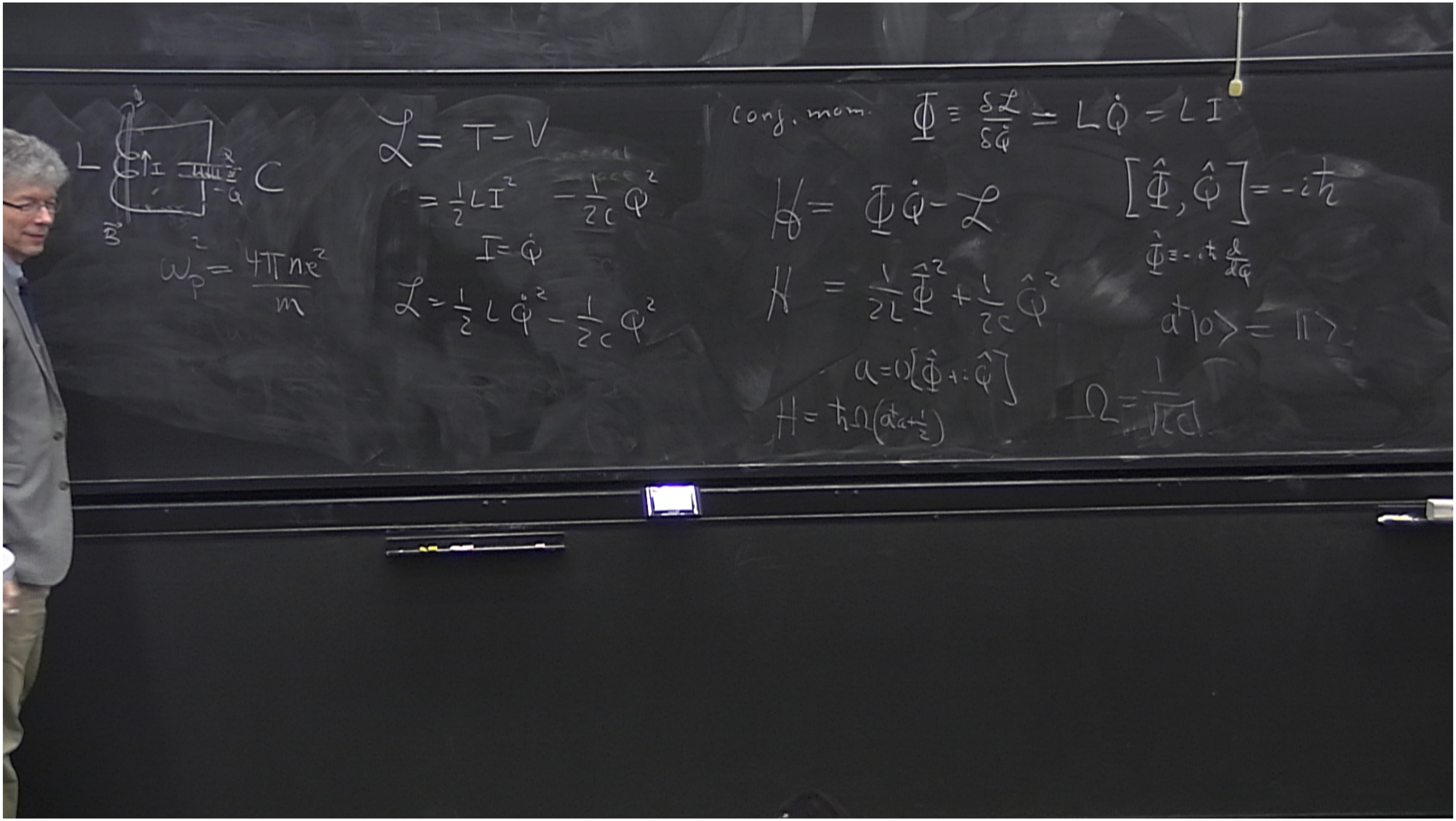


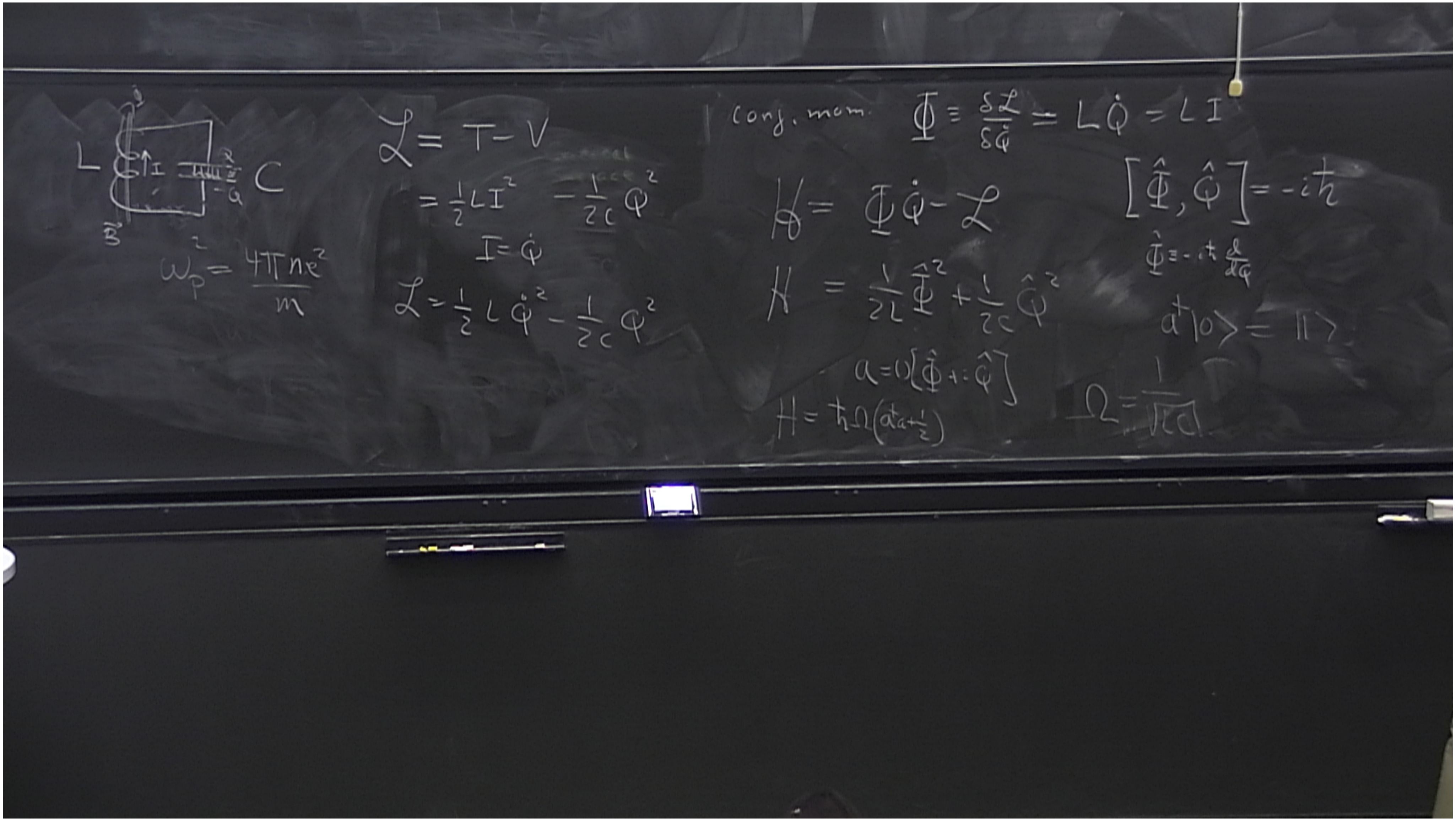
ℒ = T − V
= ½ L I²
conj. mom.
Φ ≡ δℒ/δQ̇ = L Q̇ = L I
[Φ̂, Q̂] = −iħ
H = Φ Q̇ − ℒ
H = (1/2L) Φ̂² + (1/2C) Q̂²

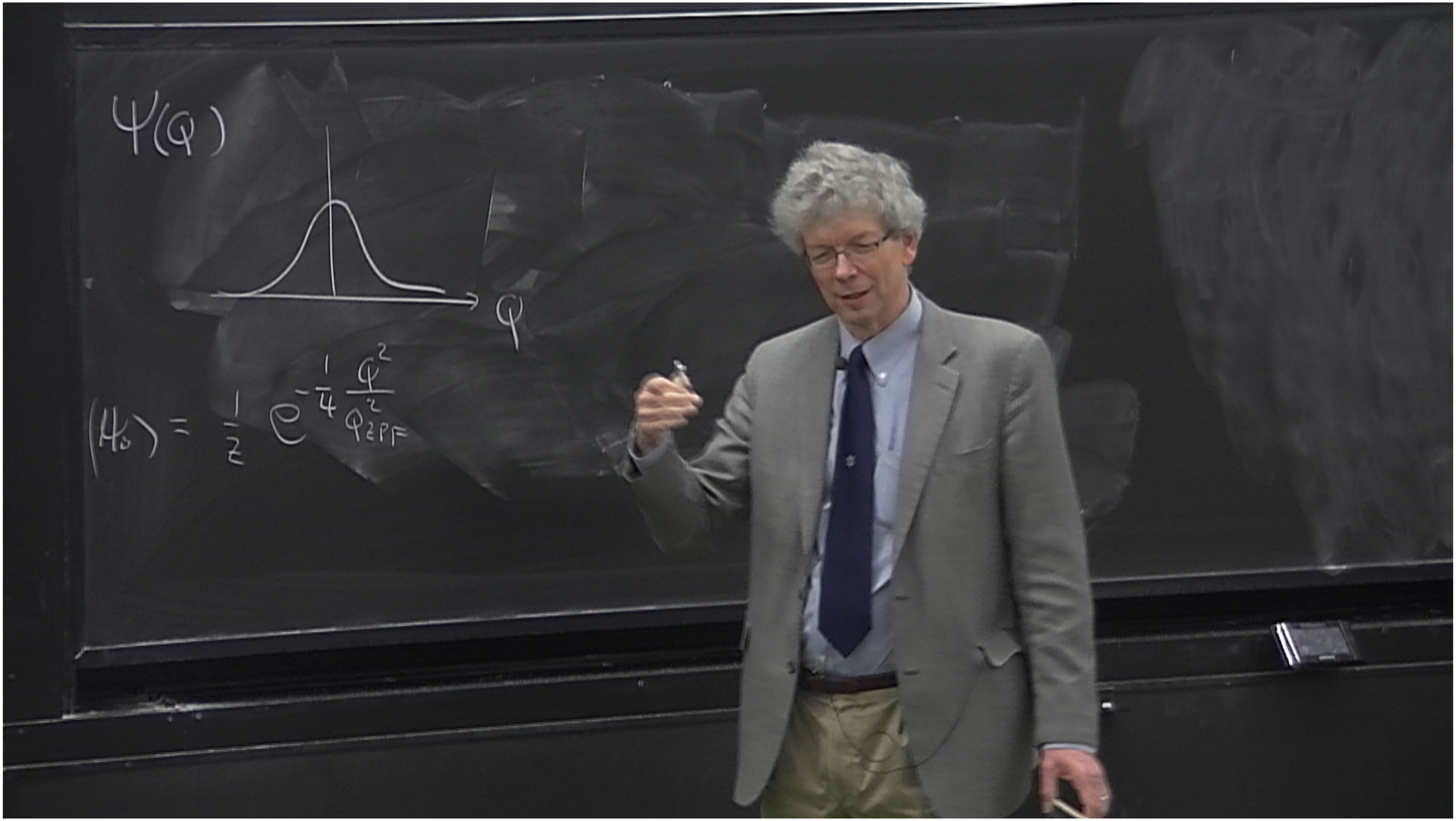

L = T − V
conj. mom.


L
C
$\omega_p^2 = \frac{4\pi n e^2}{m}$
$\mathcal{L} = T - V$
$= \frac{1}{2} L I^2 - \frac{1}{2C} Q^2$
$I = \dot{Q}$
$\mathcal{L} = \frac{1}{2} L \dot{Q}^2 - \frac{1}{2C} Q^2$
conj. mom. $\Phi \equiv \frac{\delta \mathcal{L}}{\delta \dot{Q}} = L\dot{Q} = L I$
$H = \Phi \dot{Q} - \mathcal{L}$
$H = \frac{1}{2L} \hat{\Phi}^2 + \frac{1}{2C} \hat{Q}^2$
$H = \hbar \Omega (a^\dagger a + \frac{1}{2})$
$[\hat{\Phi}, \hat{Q}] = -i\hbar$
$\hat{\Phi} = -i\hbar \frac{\partial}{\partial Q}$
$a^\dagger |0\rangle = |1\rangle$

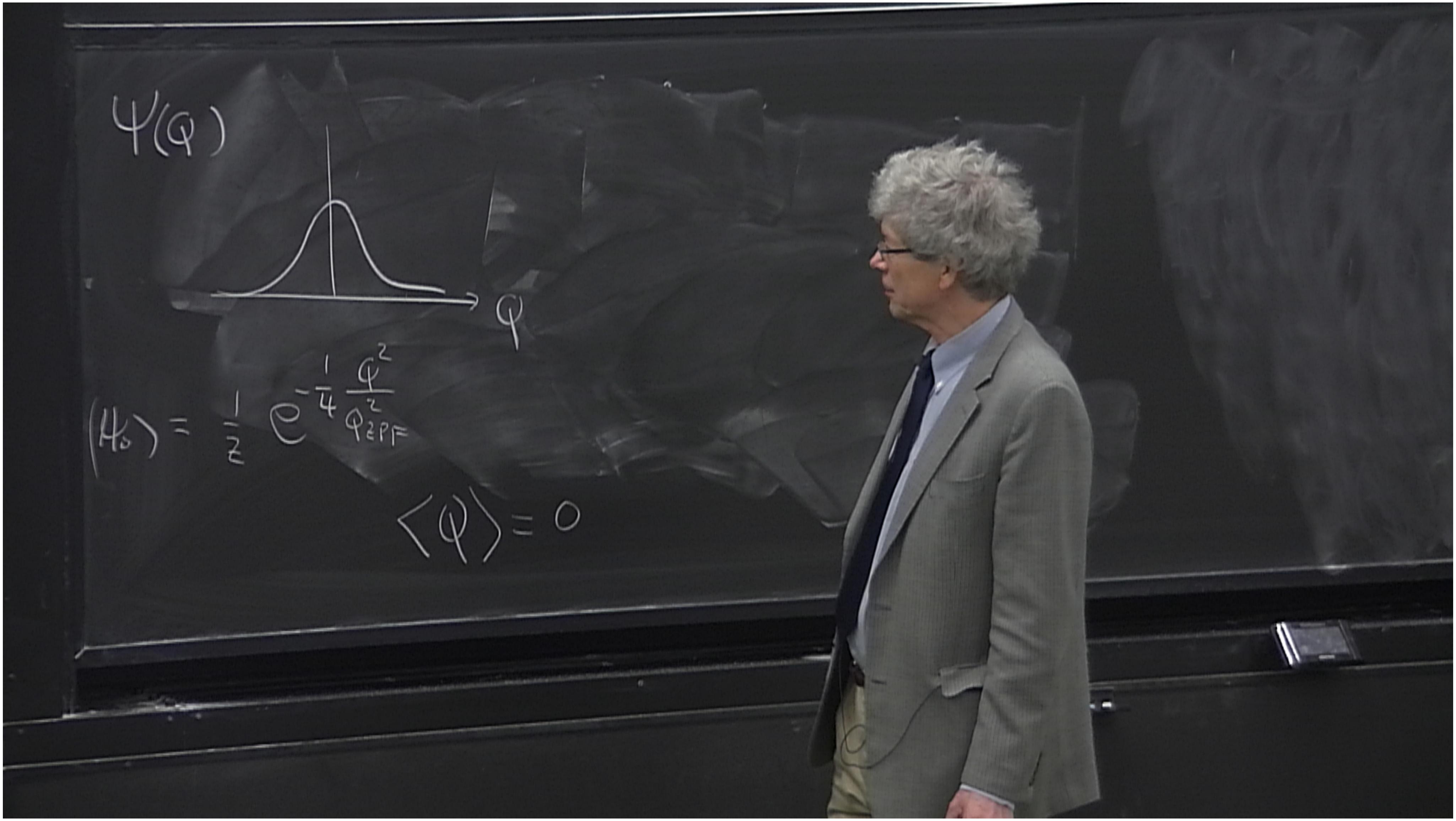

$\mathcal{L} = T - V$
$= \frac{1}{2} L I^2 - \frac{1}{2C} Q^2$
$I = \dot{Q}$
$\mathcal{L} = \frac{1}{2} L \dot{Q}^2 - \frac{1}{2C} Q^2$
$\omega_p^2 = \frac{4\pi n e^2}{m}$
conj. mom. $\Phi \equiv \frac{\delta \mathcal{L}}{\delta \dot{Q}} = L\dot{Q} = LI$
$H = \Phi \dot{Q} - \mathcal{L}$
$H = \frac{1}{2L}\hat{\Phi}^2 + \frac{1}{2C}\hat{Q}^2$
$[\hat{\Phi}, \hat{Q}] = -i\hbar$
$a^\dagger|0\rangle = |1\rangle$
$\Omega = \frac{1}{\sqrt{LC}}$
$H = \hbar\Omega(a^\dagger a + \frac{1}{2})$

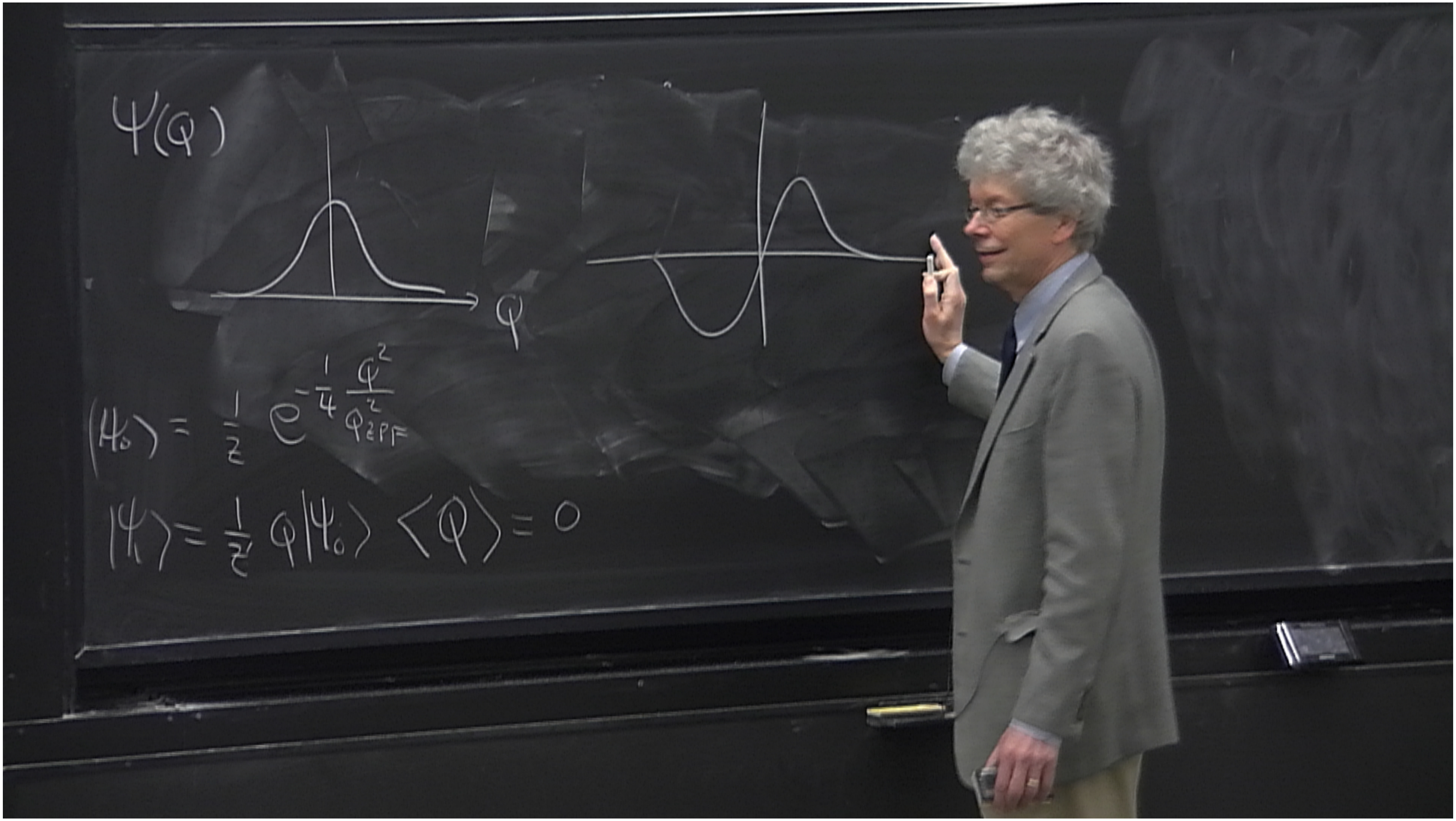

L
I
Q
-Q
C
B
ωp² = 4πne²/m
𝓛 = T − V
= ½ L I² − (1/2C) Q²
I = Q̇
𝓛 = ½ L Q̇² − (1/2C) Q²
conj. mom. Φ ≡ δ𝓛/δQ̇ = L Q̇ = L I
H = Φ Q̇ − 𝓛
H = (1/2L) Φ̂² + (1/2C) Q̂²
a = ()[Φ̂ + i Q̂]
H = ħΩ(a†a + ½)
[Φ̂, Q̂] = −iħ
Φ̂ ≡ −iħ d/dQ
a†|0> = |1>
Ω = 1/√(LC)

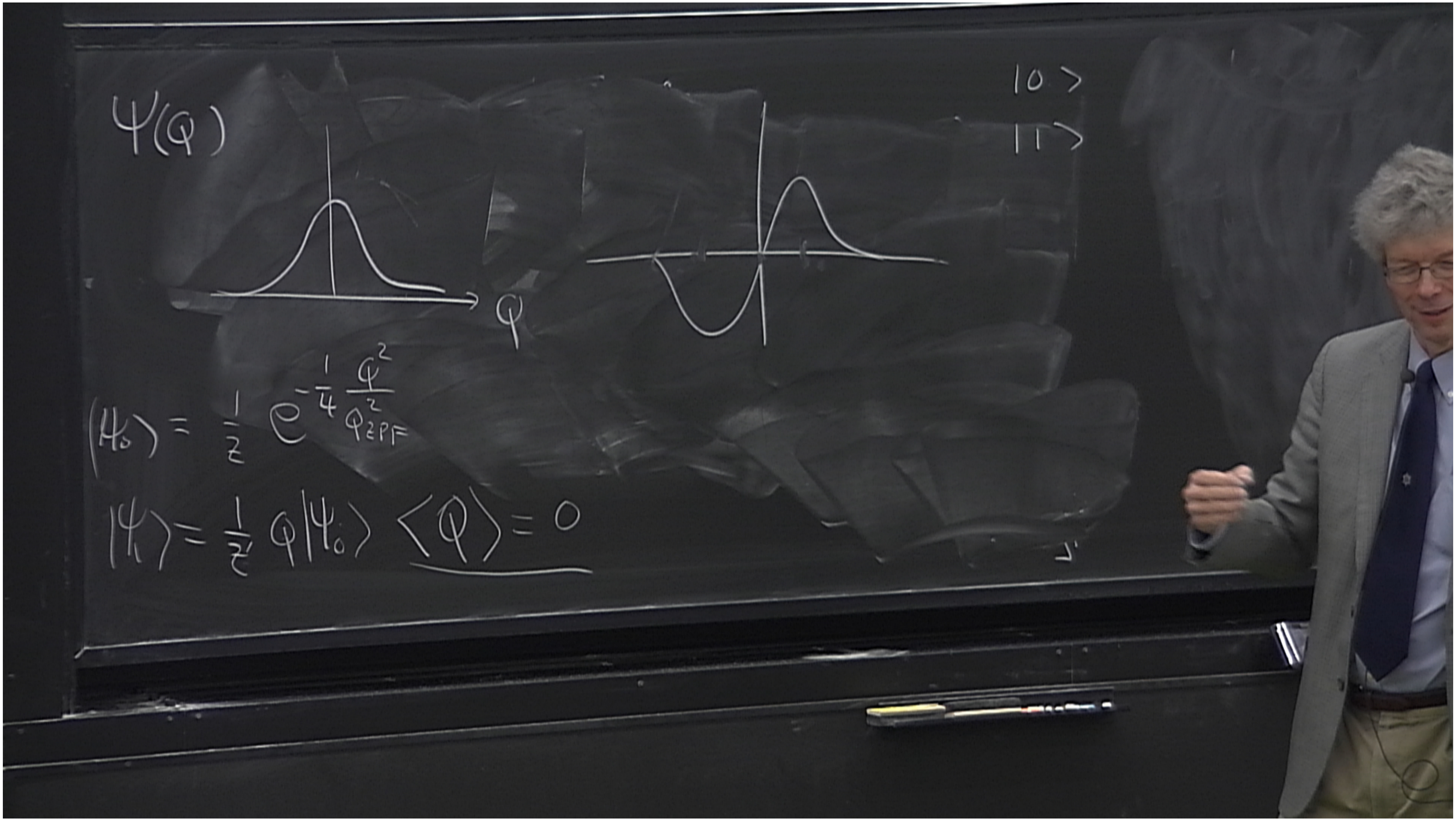

L
C
I
Q
-Q
B
ω_p² = 4πne²/m
𝓛 = T − V
= ½ L I² − (1/2C) Q²
I = Q̇
𝓛 = ½ L Q̇² − (1/2C) Q²
conj. mom. Φ ≡ δ𝓛/δQ̇ = L Q̇ = L I
H = Φ Q̇ − 𝓛
H = (1/2L) Φ̂² + (1/2C) Q̂²
[Φ̂, Q̂] = −iℏ
Φ̂ = −iℏ ∂/∂Q
a†|0⟩ = |1⟩
H = ℏΩ(a†a + ½)
Ω = 1/√(LC)

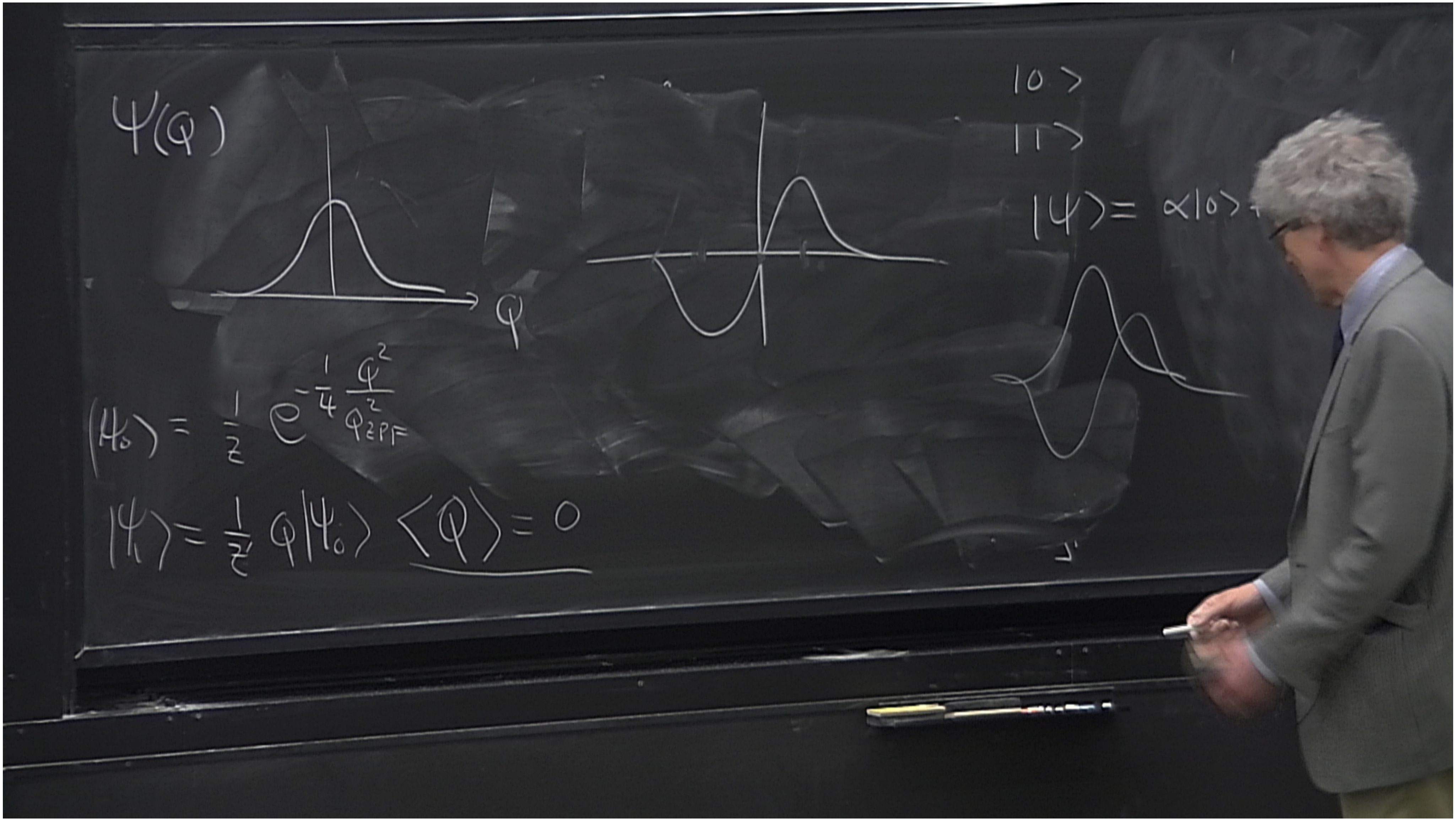


Ψ(Q)
Q
|4₀⟩ = ½ e^{-¼ Q²/Q²_ZPF}

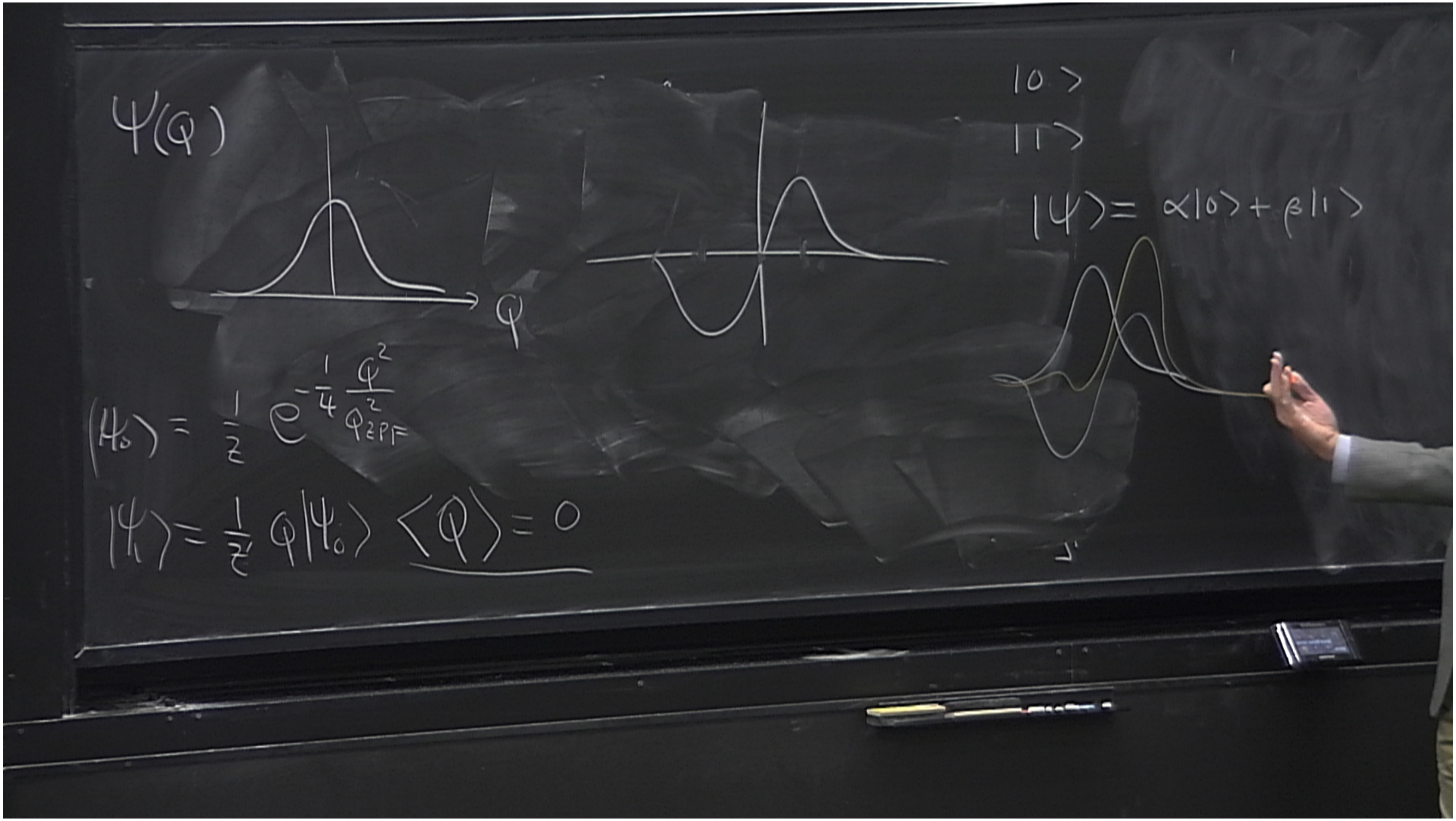

Ψ(φ)
φ
$|H_0\rangle = \frac{1}{2} e^{-\frac{1}{4}\frac{\varphi^2}{\varphi^2_{ZPF}}}$
$\langle\varphi\rangle = 0$

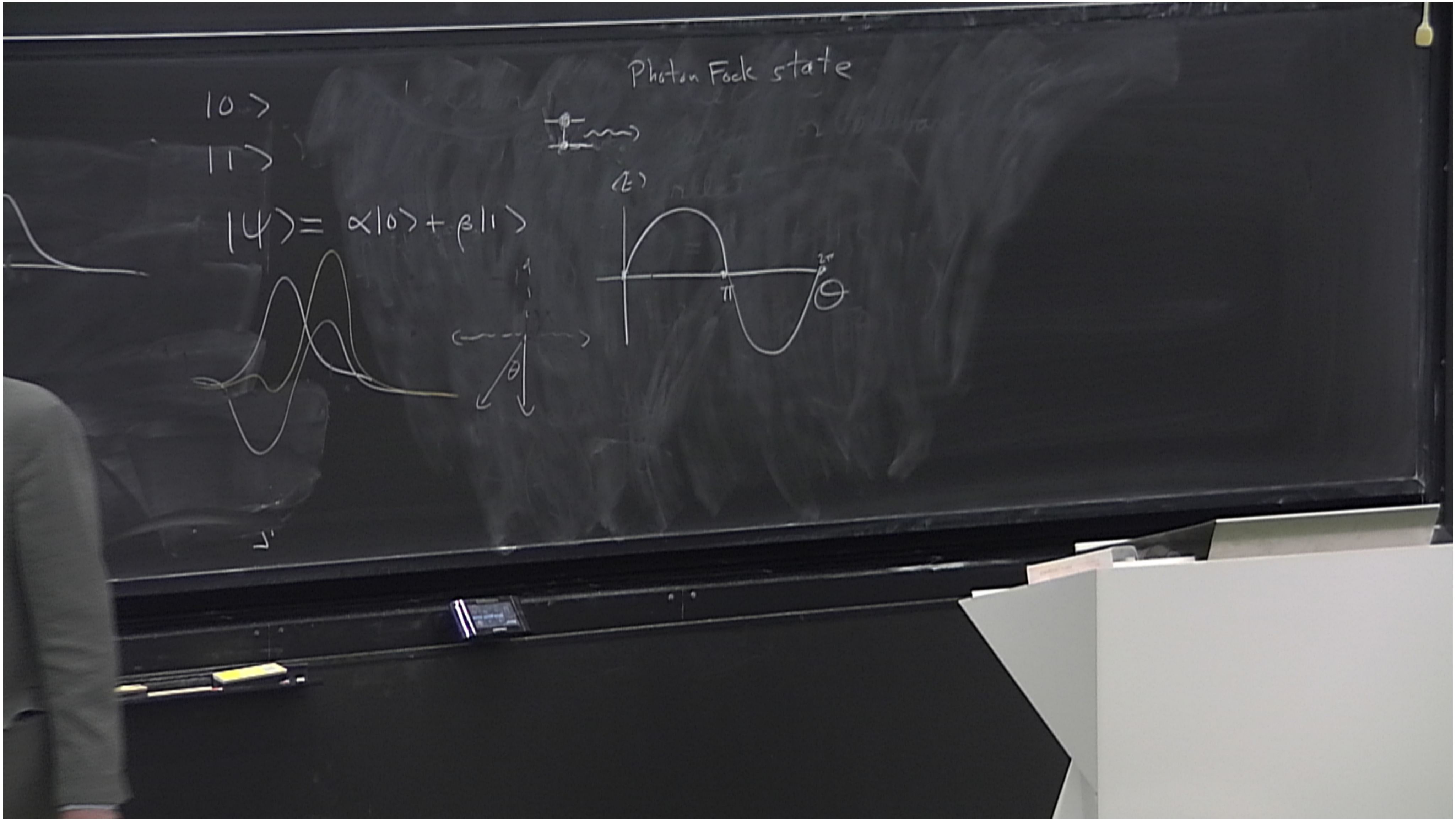

Ψ(Q)
Q
$|\Psi_0\rangle = \frac{1}{Z} e^{-\frac{1}{4}\frac{Q^2}{Q_{ZPF}^2}}$
$|\Psi_1\rangle = \frac{1}{Z'} Q|\Psi_0\rangle \quad \langle Q\rangle = 0$

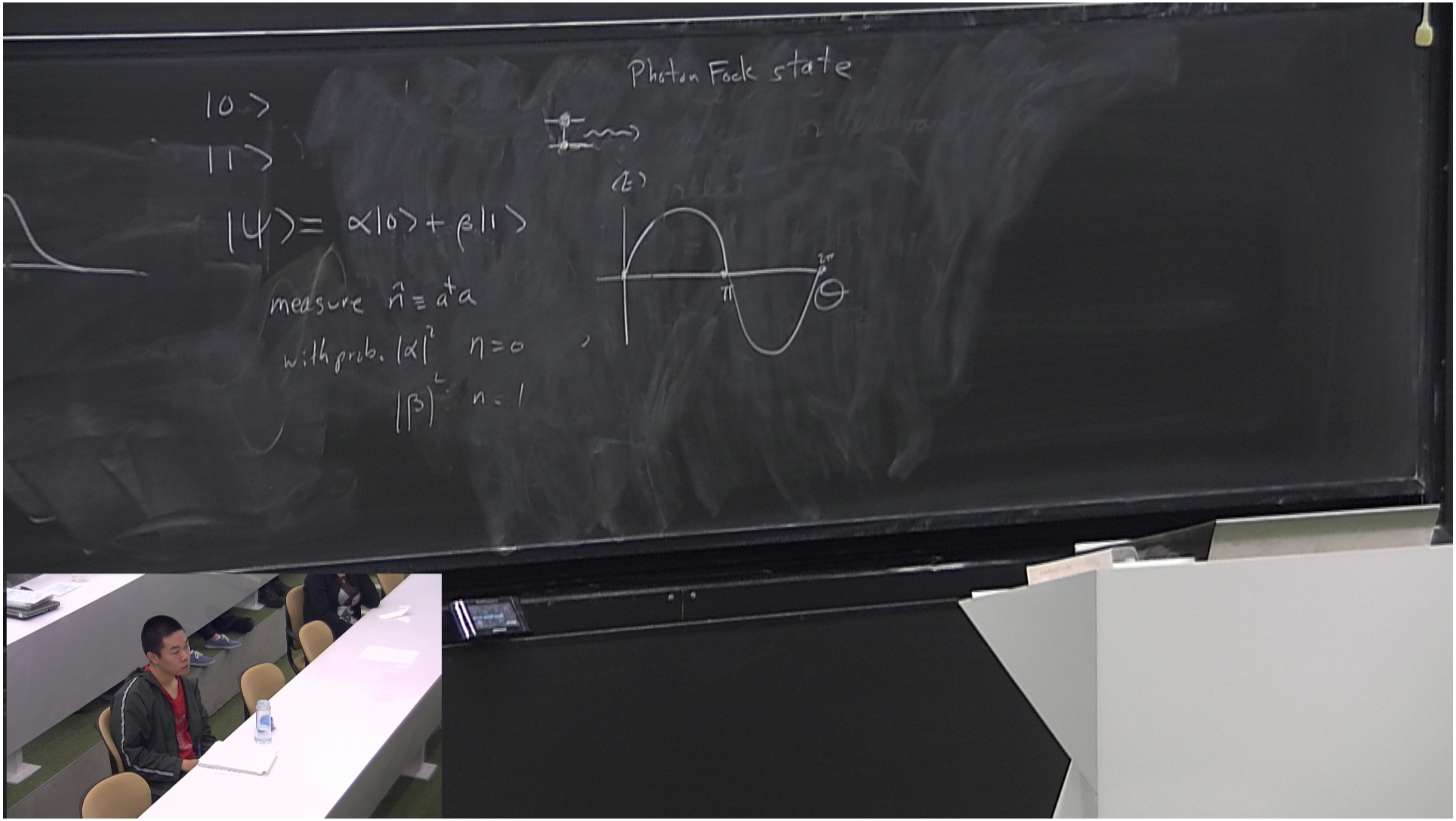

Ψ(Q)
Q
|0⟩
|1⟩
|ψ₀⟩ = 1/Z e^(−¼ Q²/Q²ZPF)
|ψ₁⟩ = 1/Z' Q|ψ₀⟩ ⟨Q⟩ = 0

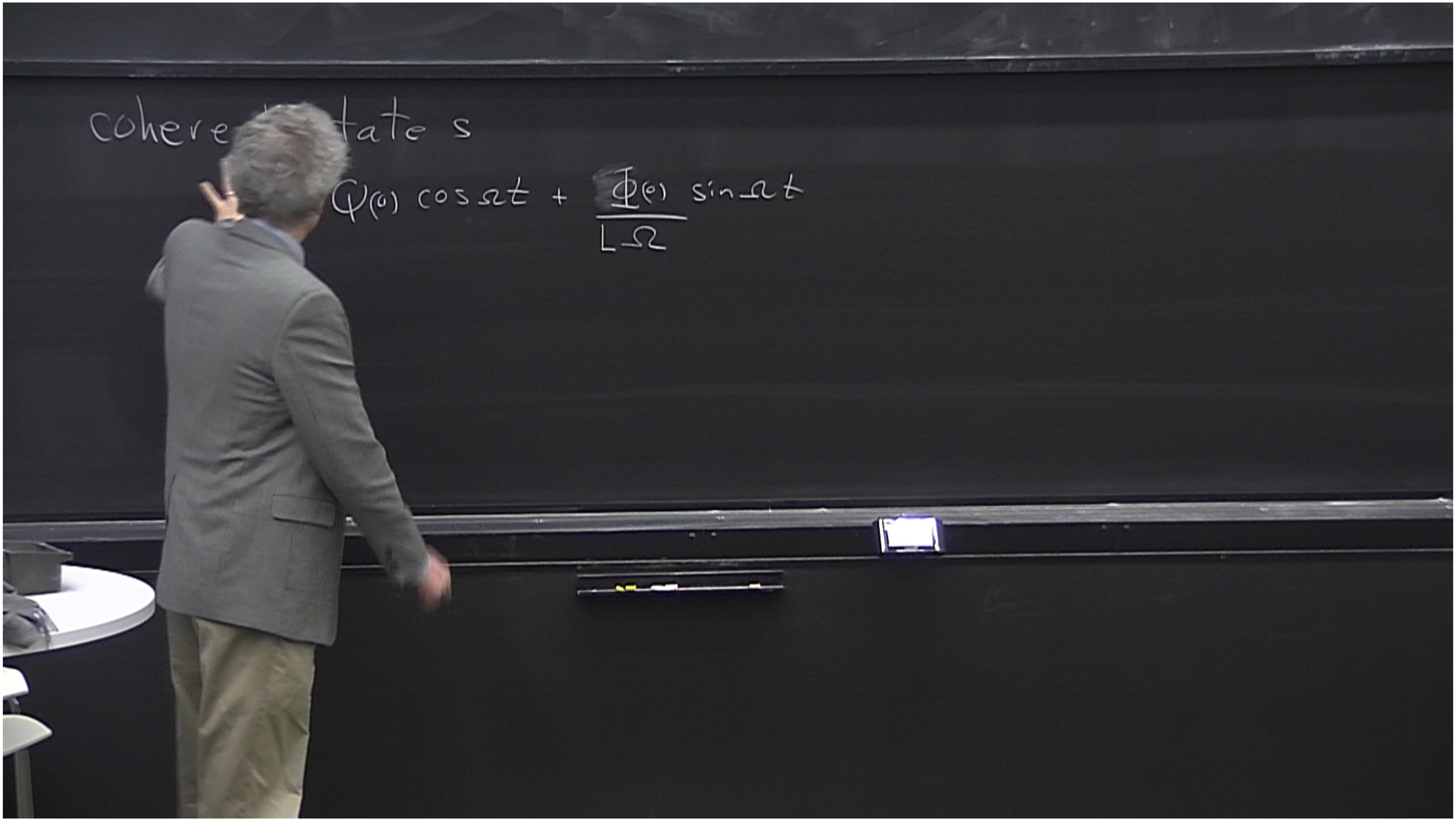


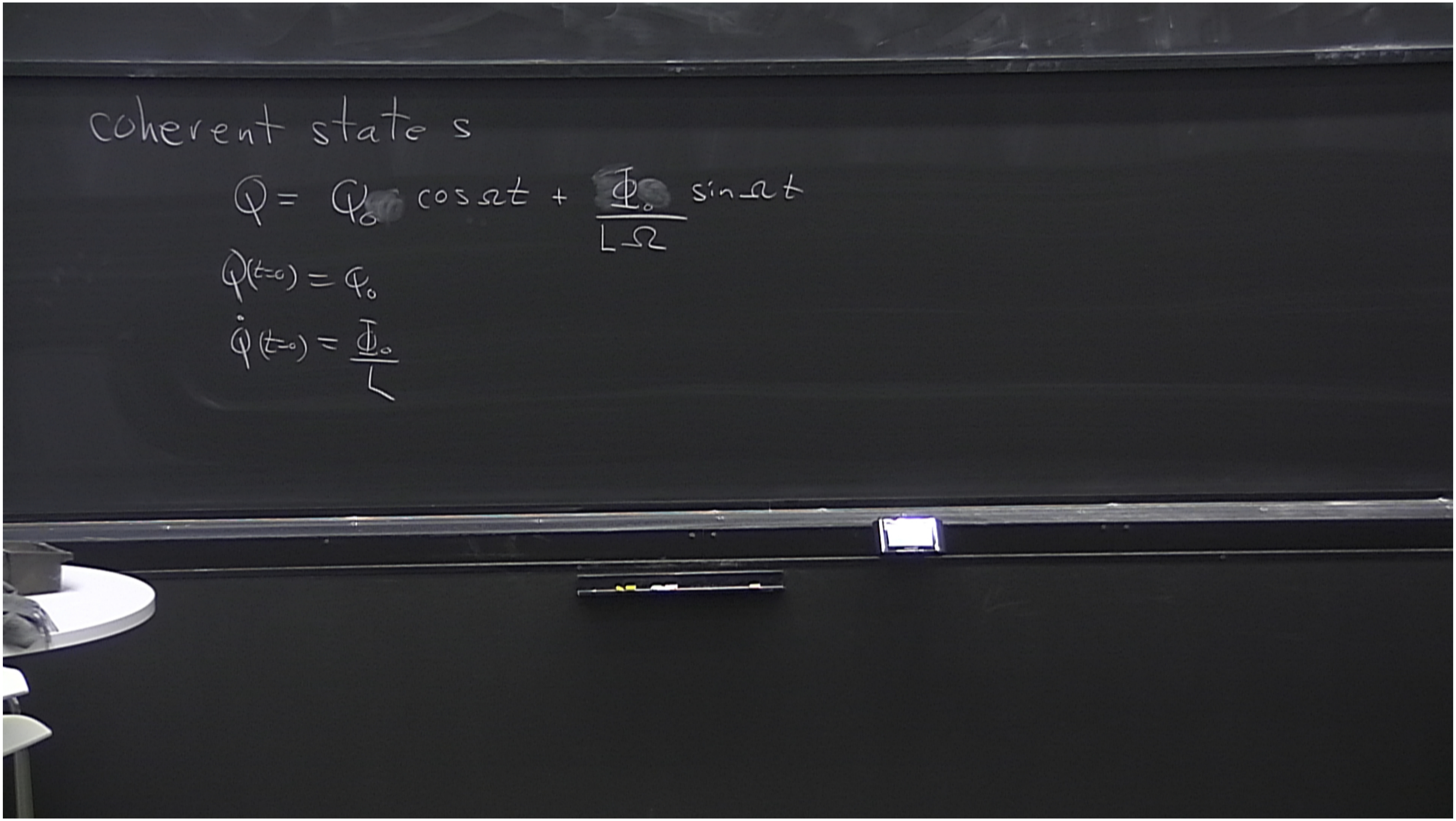
|0>
|1>
|ψ>= α|0> +
ψ(Q)
Q
|ψ₀> = 1/Z e^(-1/4 Q²/Q²ZPF)
|ψ₁> = 1/Z' Q|ψ₀> <Q> = 0

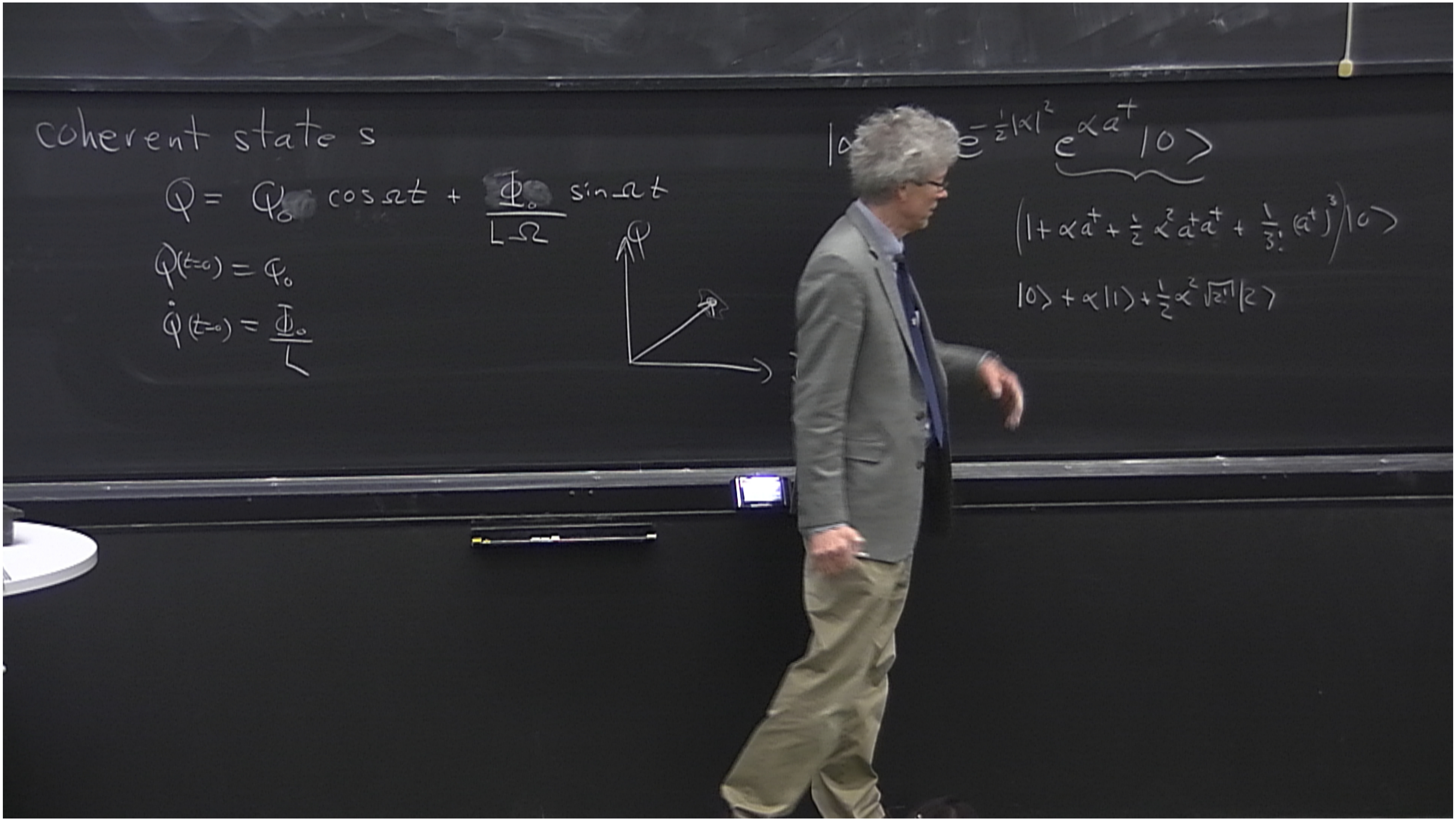

Ψ(Q)
Q
|0>
|1>
|ψ> = α|0> + β|1>
|ψ0> = 1/Z e^(-1/4 Q^2/Q_ZPF^2)
|ψ1> = 1/Z' Q|ψ0>
<Q> = 0

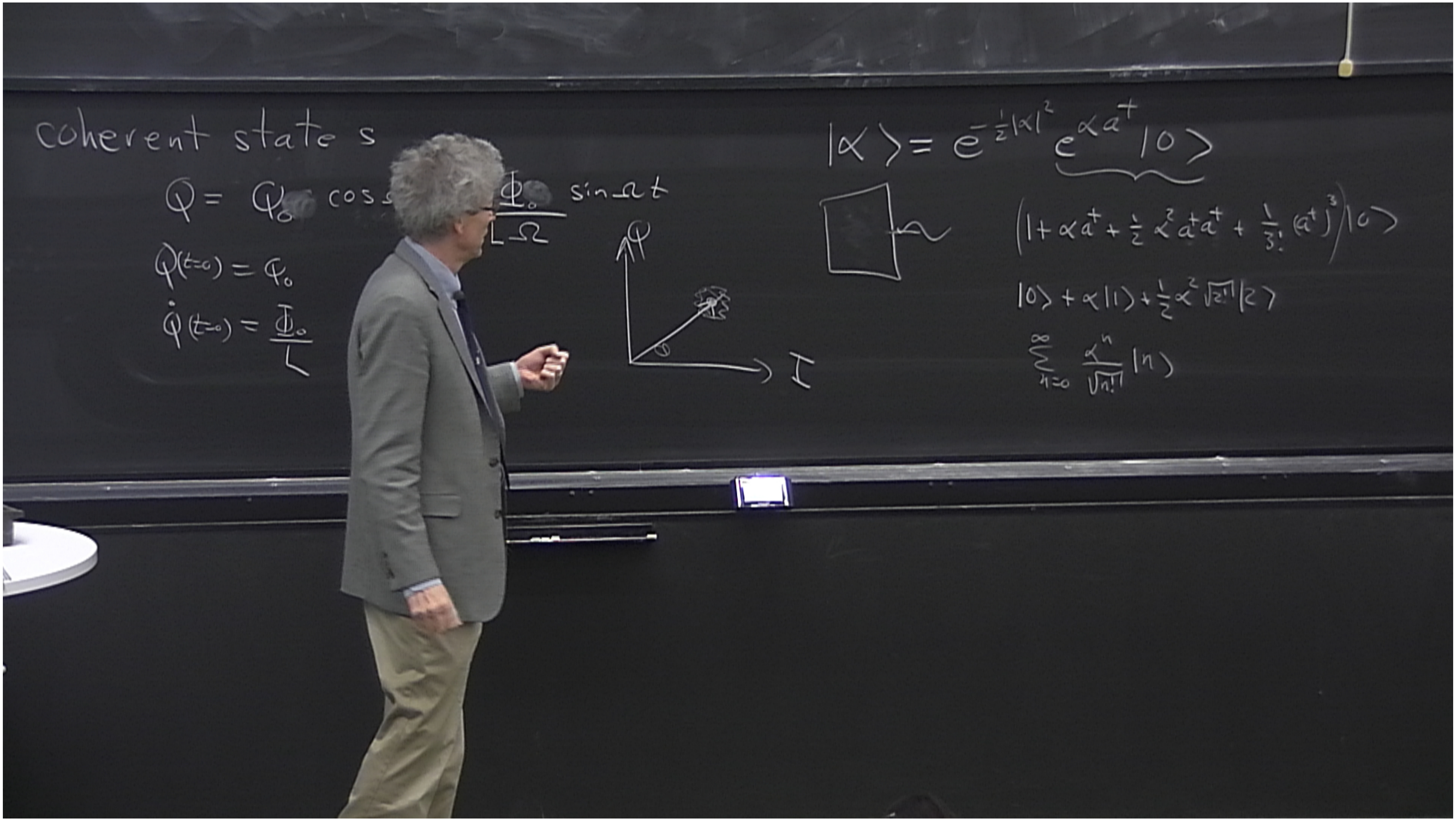

Photon Fock state
|0>
|1>
|ψ>= α|0> + β|1>
θ
π
2π
θ

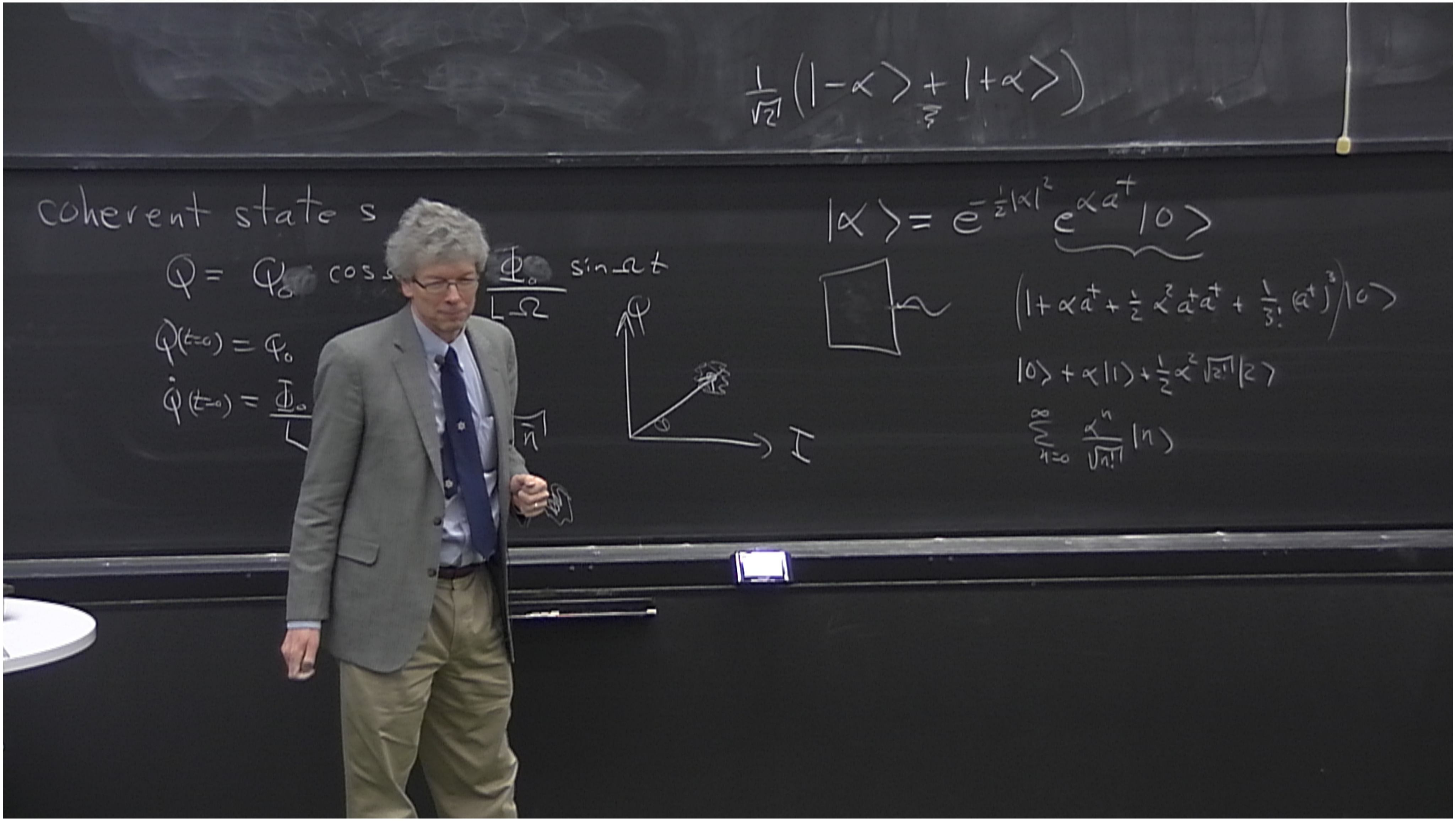

Photon Fock state
|0>
|1>
|ψ>= α|0> + β|1>
measure n̂ ≡ a†a
with prob. |α|² n=0
|β|² n=1
π
2π
θ


cohere
tate s
φ(0) cos Ωt + Φ(0) sin Ωt
LΩ


coherent states
Q = Q₀ cos Ωt + (Φ₀ / LΩ) sin Ωt
Q(t=0) = Q₀
Q̇(t=0) = Φ₀ / L


coherent states
$Q = Q_0 \cos \Omega t + \frac{\Phi_0}{L\Omega} \sin \Omega t$
$Q(t=0) = Q_0$
$\dot{Q}(t=0) = \frac{\Phi_0}{L}$
$e^{-\frac{1}{2}|\alpha|^2} e^{\alpha a^+} |0\rangle$
$\left(1 + \alpha a^+ + \frac{1}{2} \alpha^2 a^+ a^+ + \frac{1}{3!} (a^+)^3\right) |0\rangle$
$|0\rangle + \alpha |1\rangle + \frac{1}{2} \alpha^2 \sqrt{2!} |2\rangle$


coherent states
|α⟩ = e^{-½|α|²} e^{αa†} |0⟩
(1 + αa† + ½ α² a†a† + 1/3! (a†)³) |0⟩
|0⟩ + α|1⟩ + ½ α² √2! |2⟩
Σ_{n=0}^{∞} αⁿ/√n! |n⟩


coherent states
Q = Q₀ cos
sinΩt
Q(t=0) = Q₀
|α⟩ = e^{-½|α|²} e^{αa†} |0⟩
(1 + αa† + ½ α² a†a† + 1/3! (a†)³) |0⟩
|0⟩ + α|1⟩ + ½ α² √2! |2⟩
Σ_{n=0}^{∞} αⁿ/√n! |n⟩
1/√2 (|−α⟩ ± |+α⟩)

$$\frac{1}{\sqrt{2}}\left(|-\alpha\rangle \pm |+\alpha\rangle\right)$$

coherent states

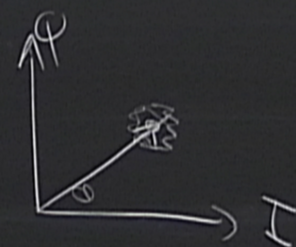
$$Q = Q_0 \cos\Omega t + \frac{\Phi_0}{L\Omega}\sin\Omega t$$

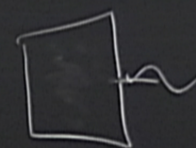
$$Q(t=0) = Q_0$$

$$\dot{Q}(t=0) = \frac{\Phi_0}{L}$$

$\bar{n}$

$\delta n \sim \sqrt{\bar{n}}$



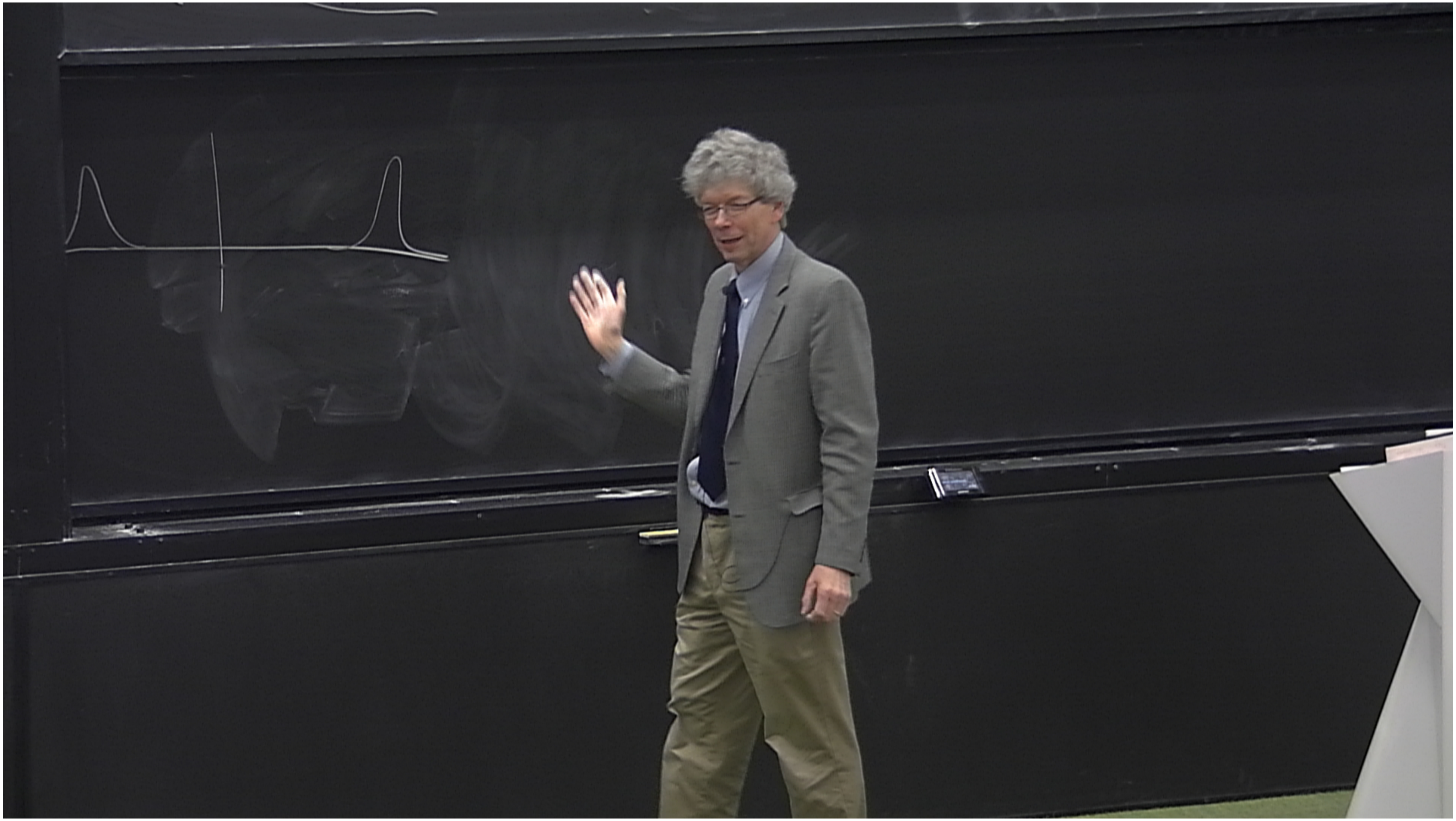


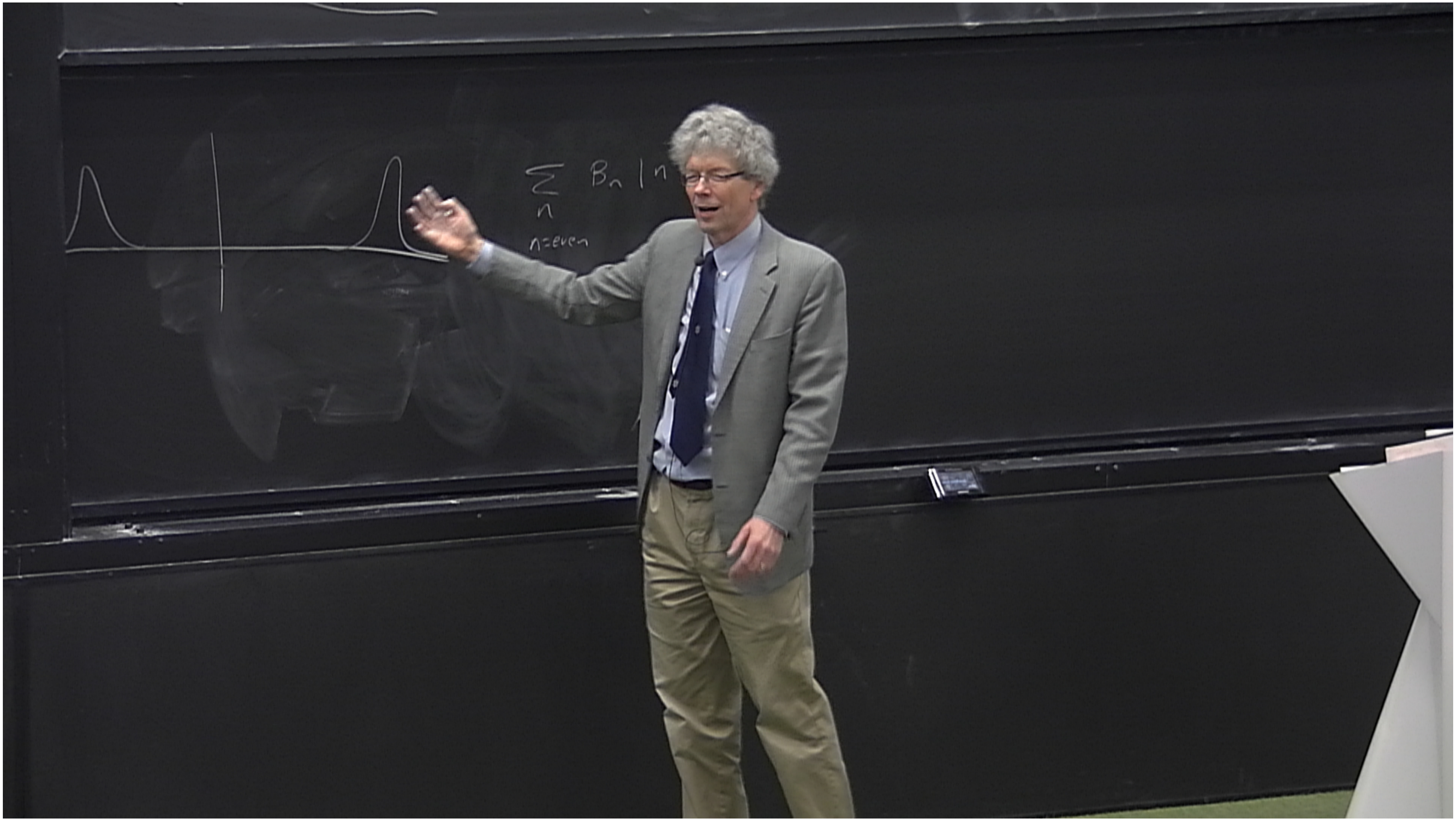
$$|\alpha\rangle = e^{-\frac{1}{2}|\alpha|^2} e^{\alpha a^\dagger}|0\rangle$$

$$\left(1+\alpha a^\dagger + \frac{1}{2}\alpha^2 a^\dagger a^\dagger + \frac{1}{3!}(a^\dagger)^3\right)|0\rangle$$

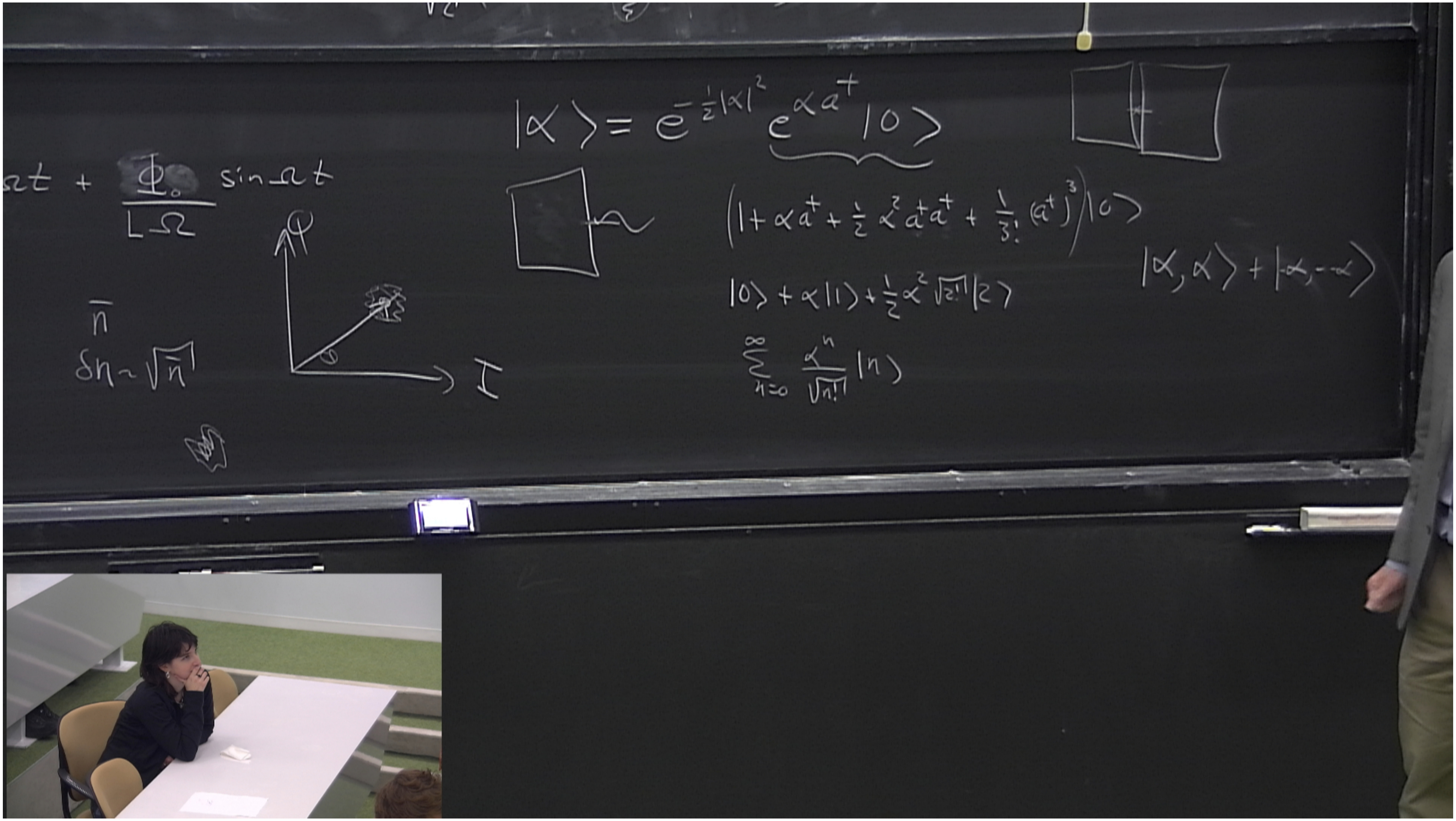
$$|0\rangle + \alpha|1\rangle + \frac{1}{2}\alpha^2\sqrt{2!}\,|2\rangle$$

$$\sum_{n=0}^{\infty} \frac{\alpha^n}{\sqrt{n!}}|n\rangle$$





$\sum_n B_n | n$
n=even


|α⟩ = e^{-½|α|²} e^{αa†} |0⟩
(1 + αa† + ½ α² a†a† + 1/3! (a†)³) |0⟩
|0⟩ + α|1⟩ + ½ α² √2! |2⟩
Σ_{n=0}^{∞} αⁿ/√n! |n⟩
|α, α⟩ + |-α, -α⟩
sin Ωt
Φ₀ / LΩ
n̄
δn ~ √n̄
φ
I