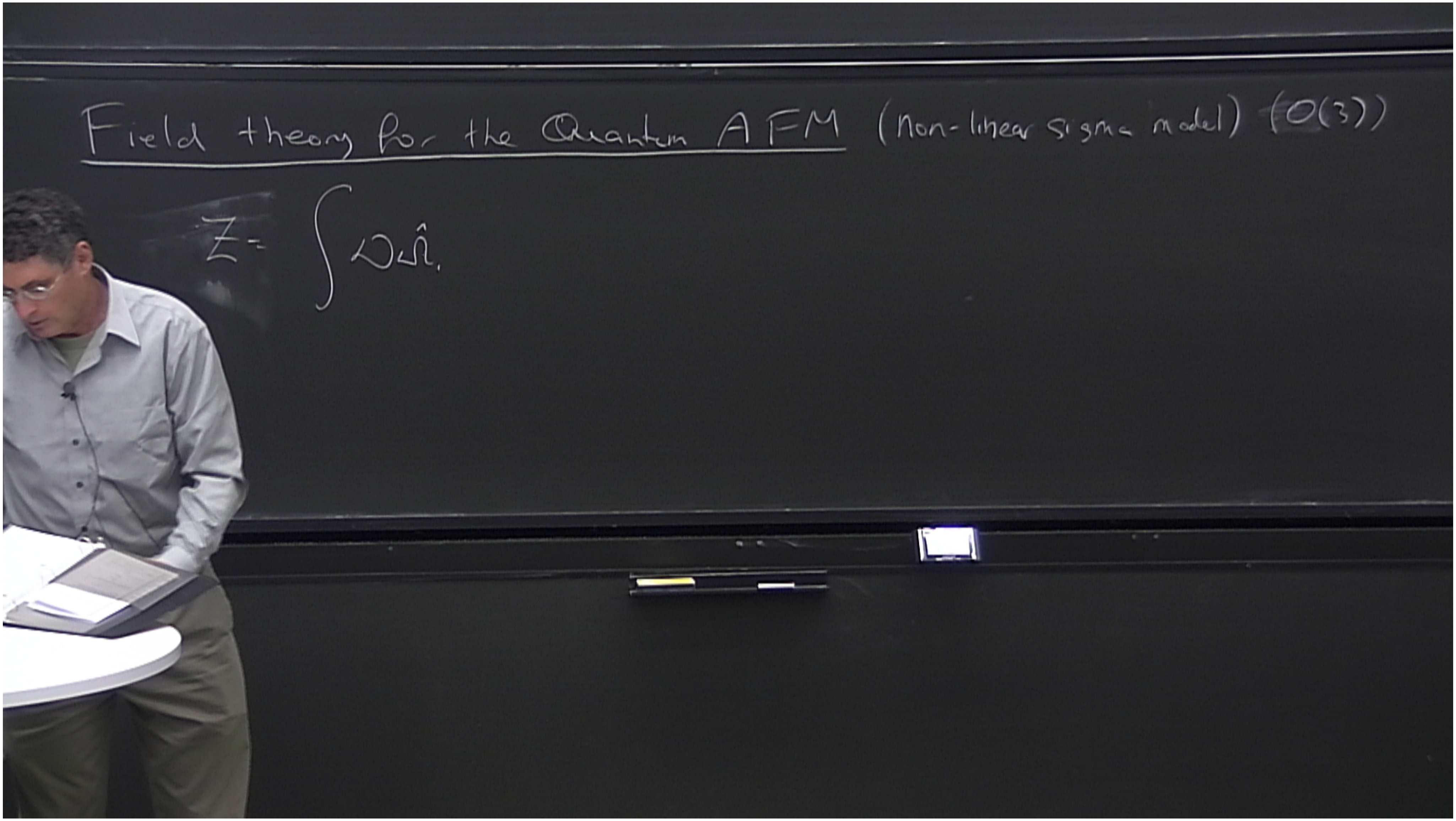
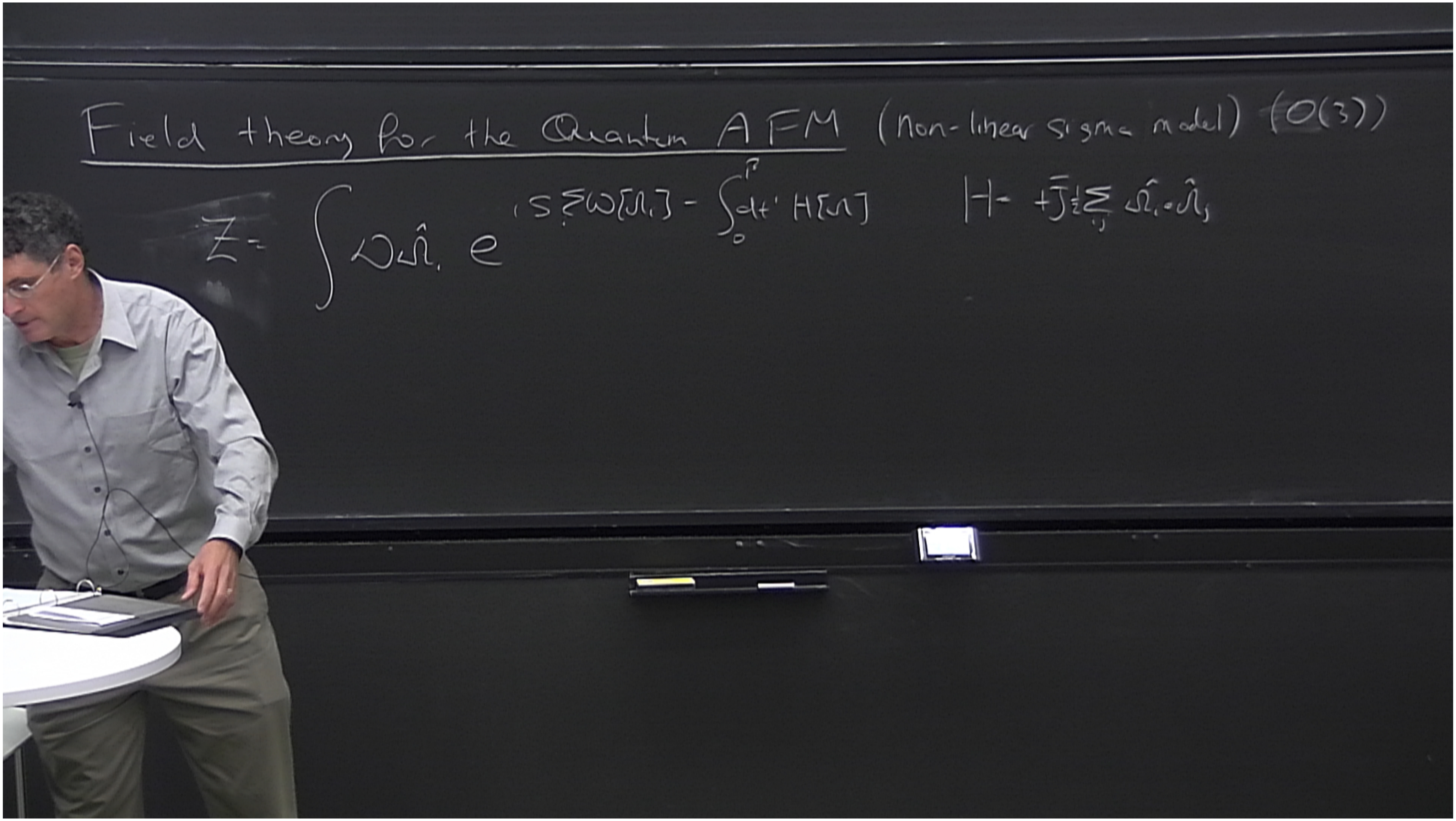
Title: Condensed Matter - Lecture 6

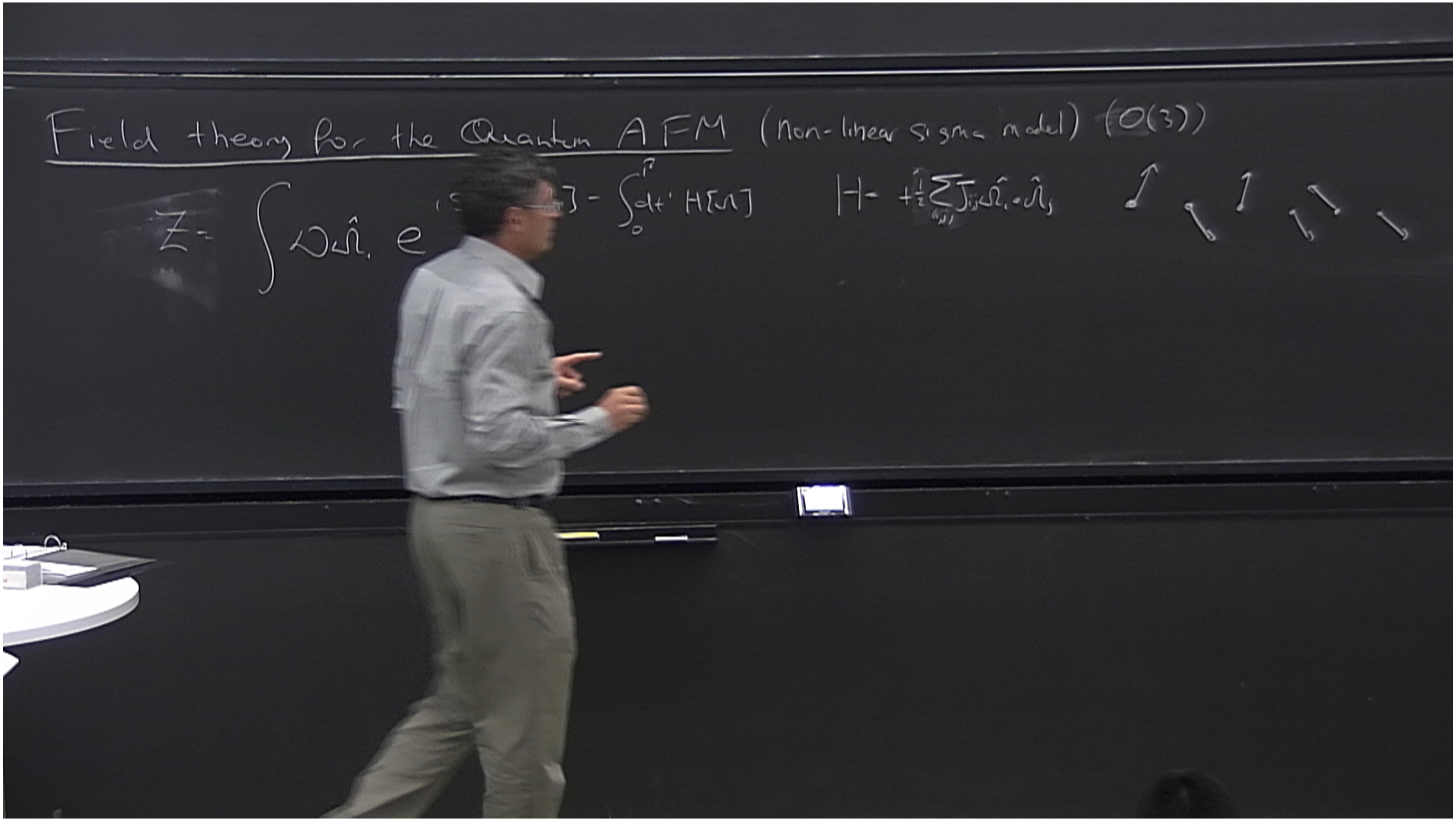
Date: Oct 16, 2012 10:30 AM

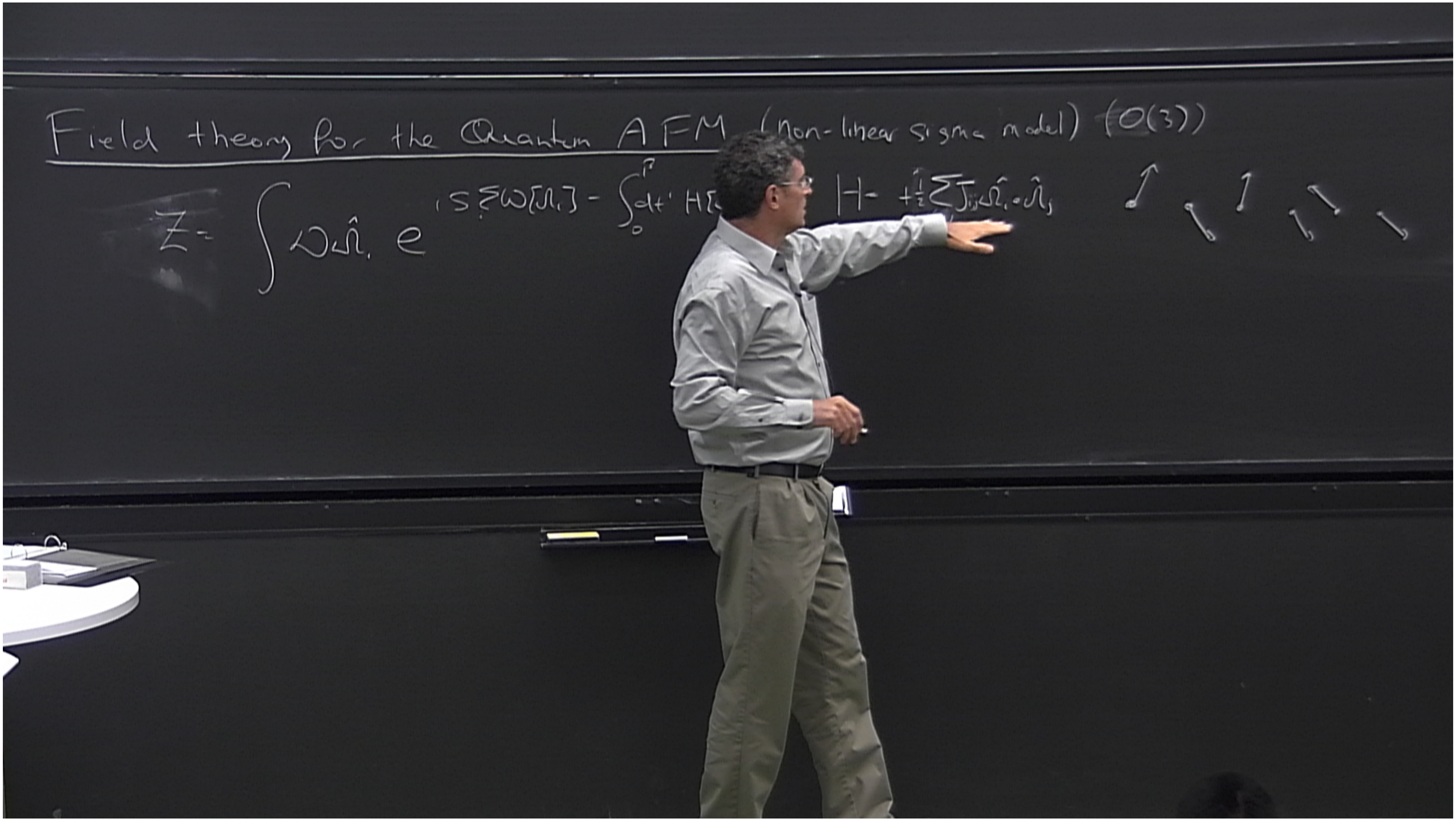
URL: http://pirsa.org/12100029

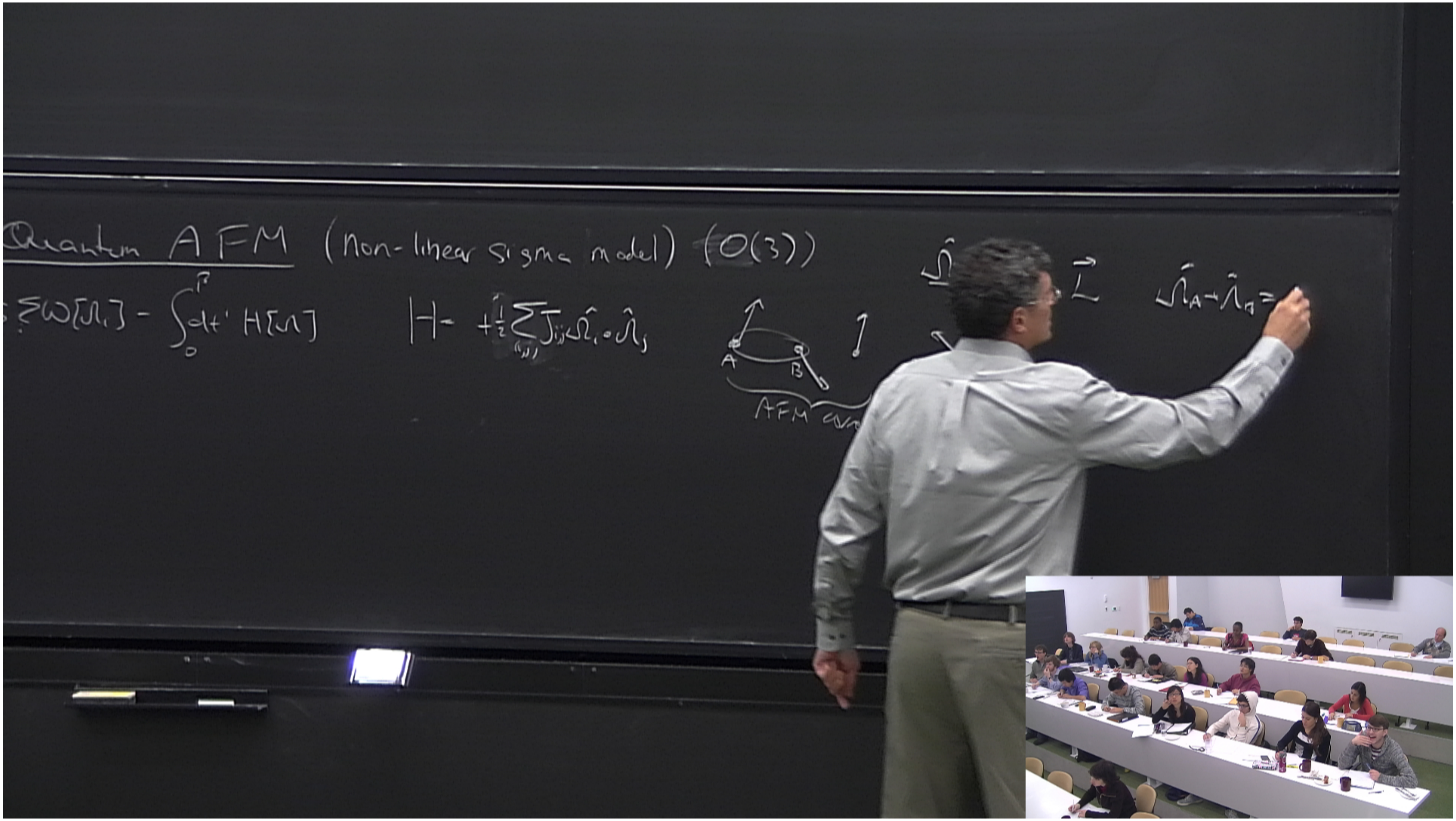
Abstract:

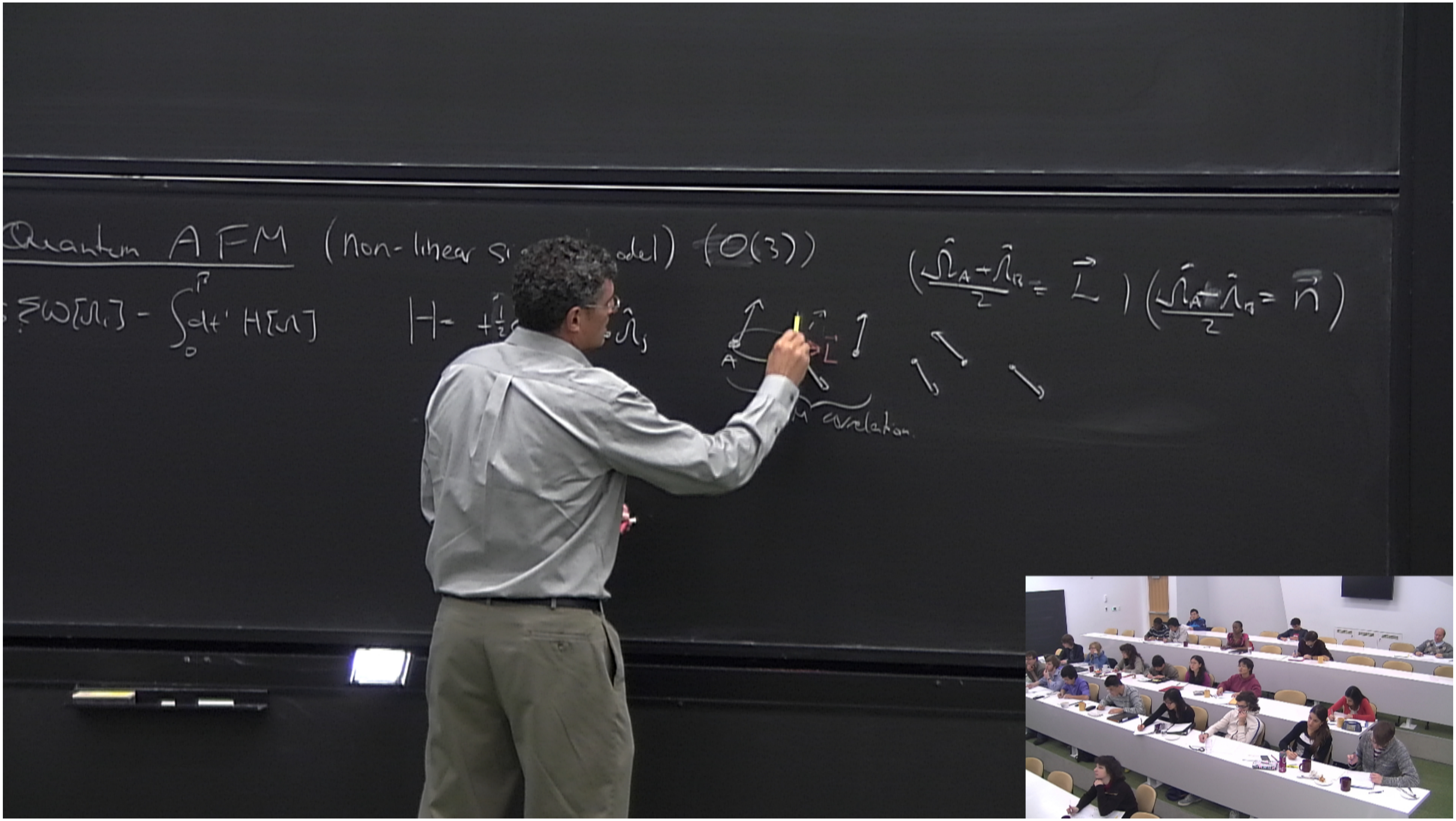

Field theory for the Quantum AFM (non-linear sigma model) (O(3))
Z = ∫ DΩ̂.

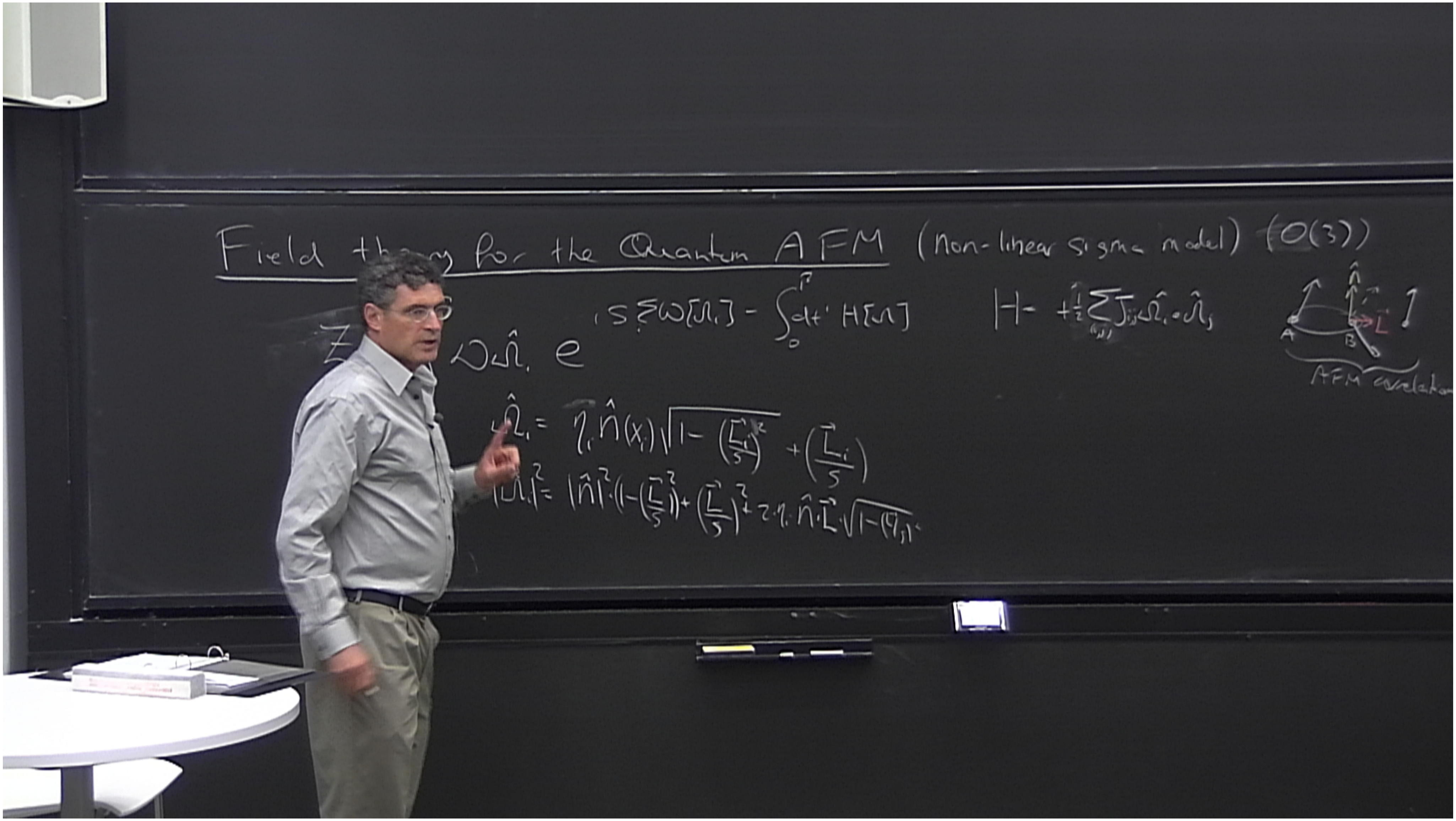

Field theory for the Quantum AFM (non-linear sigma model) (O(3))
$Z = \int \mathcal{D}\hat{\Omega}_i \, e^{iS\sum_i \omega[\Omega_i] - \int_0^\beta dt' \, H[\Omega]}$
$H = +J \frac{1}{2} \sum_{ij} \hat{\Omega}_i \cdot \hat{\Omega}_j$

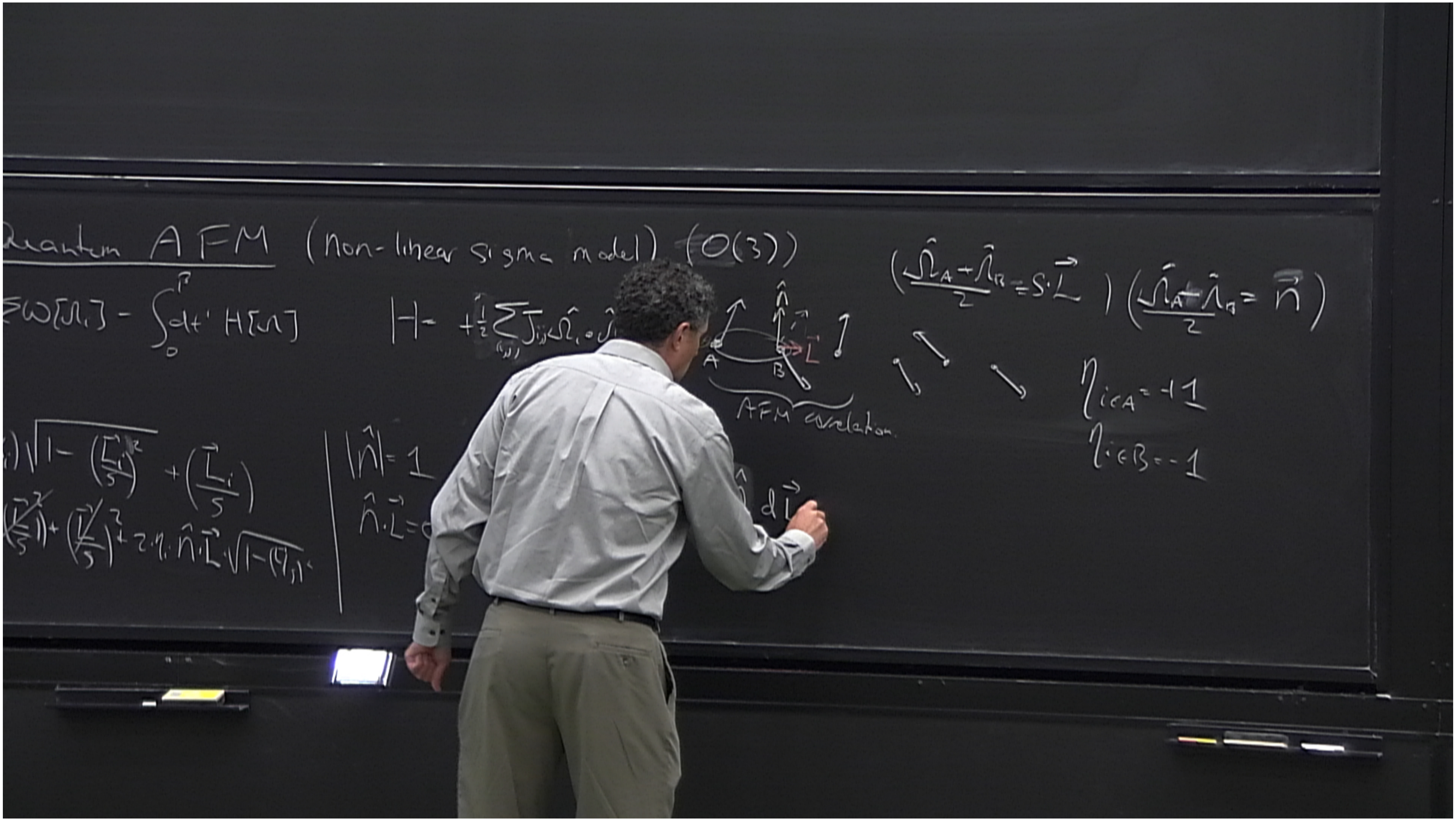

Field theory for the Quantum AFM (non-linear sigma model) (O(3))
H = +½ Σ J_ij Ω̂_i · Ω̂_j

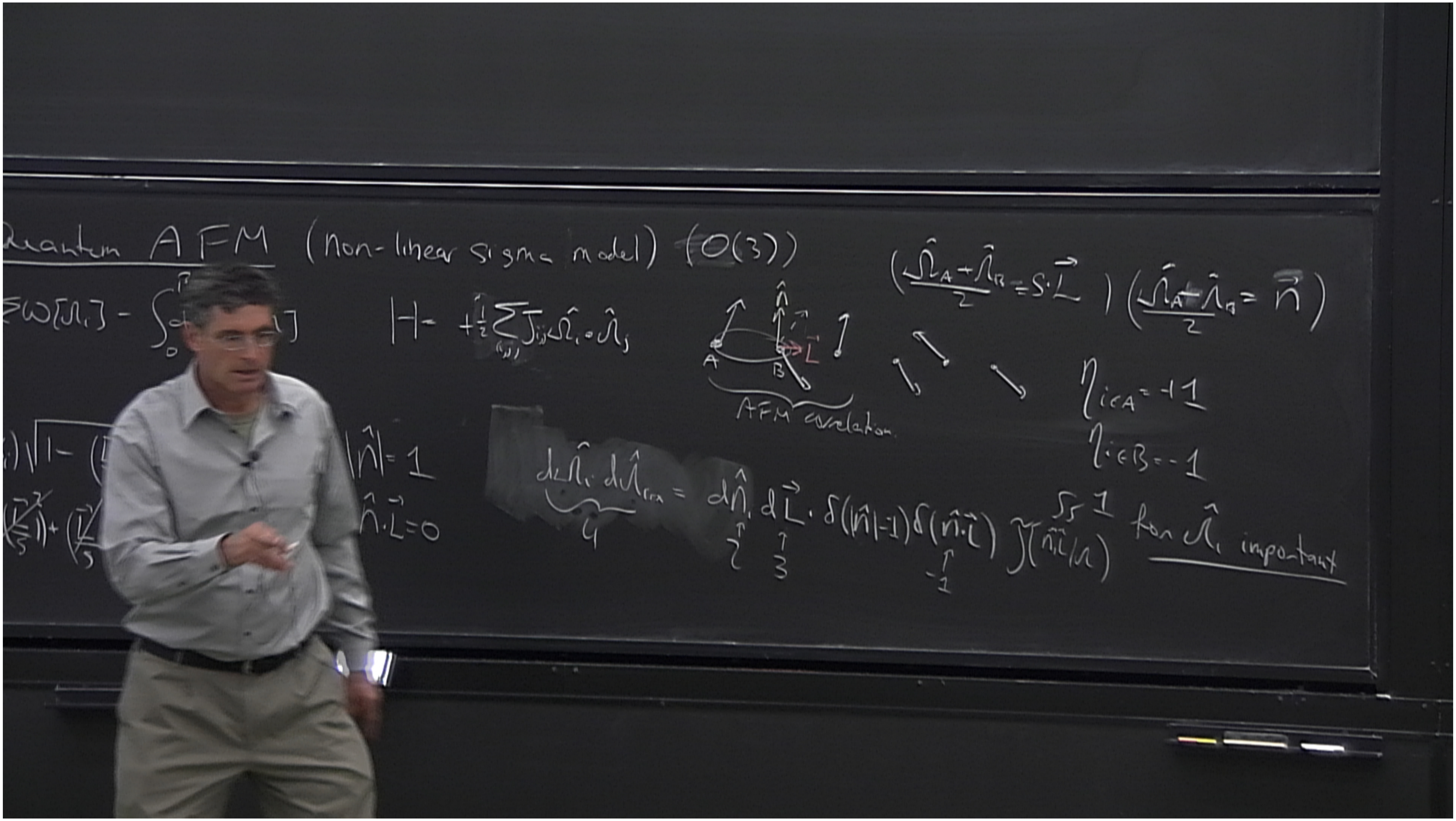

Field theory for the Quantum AFM (non-linear sigma model) (O(3))
Z = ∫ DΩ̂ᵢ e^(iS Σ ω[Ωᵢ] − ∫₀^β dt' H[
H = +½ Σ Jᵢⱼ Ω̂ᵢ · Ω̂ⱼ

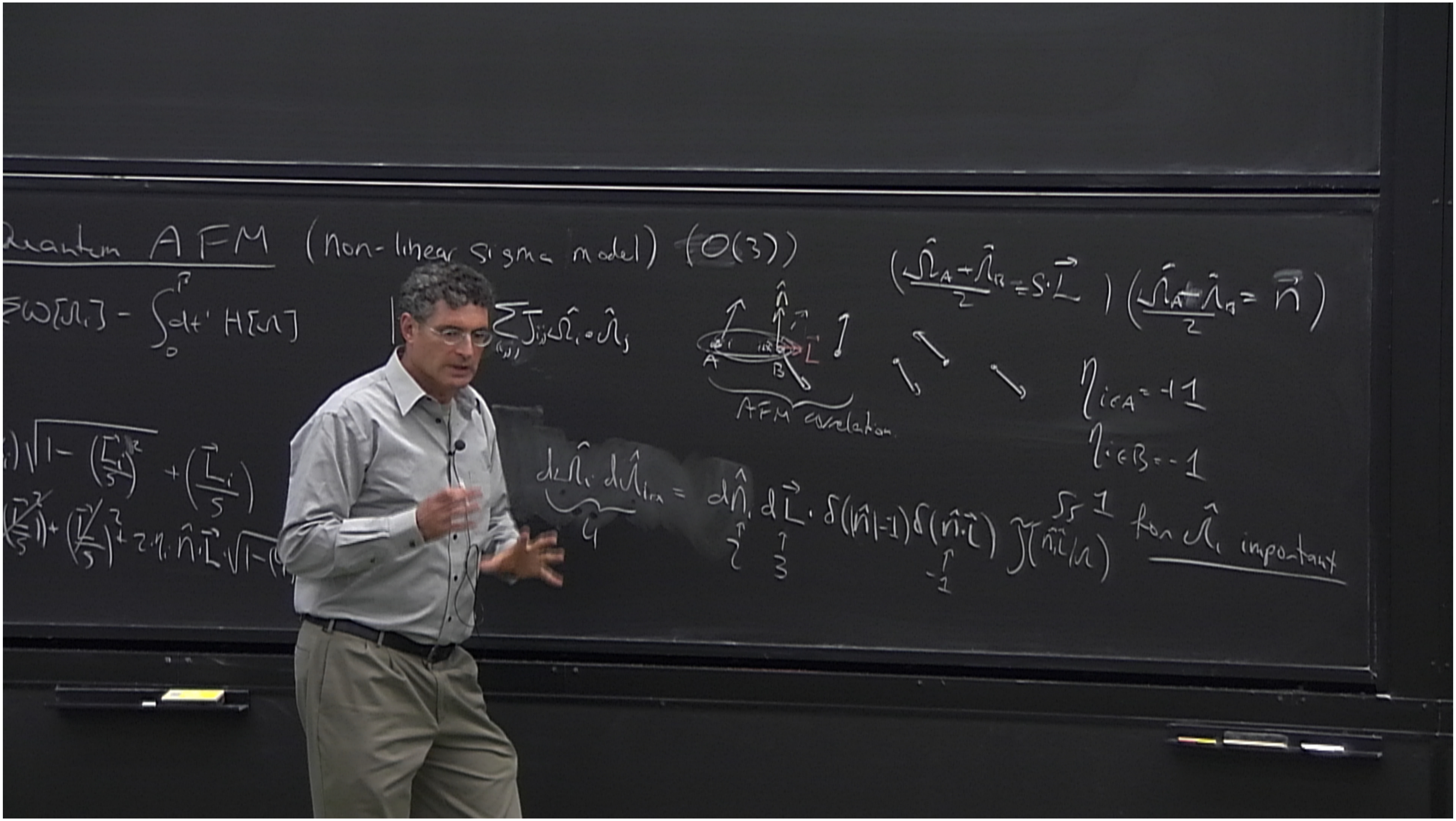

Quantum AFM (non-linear sigma model) (O(3))
A
B
AFM

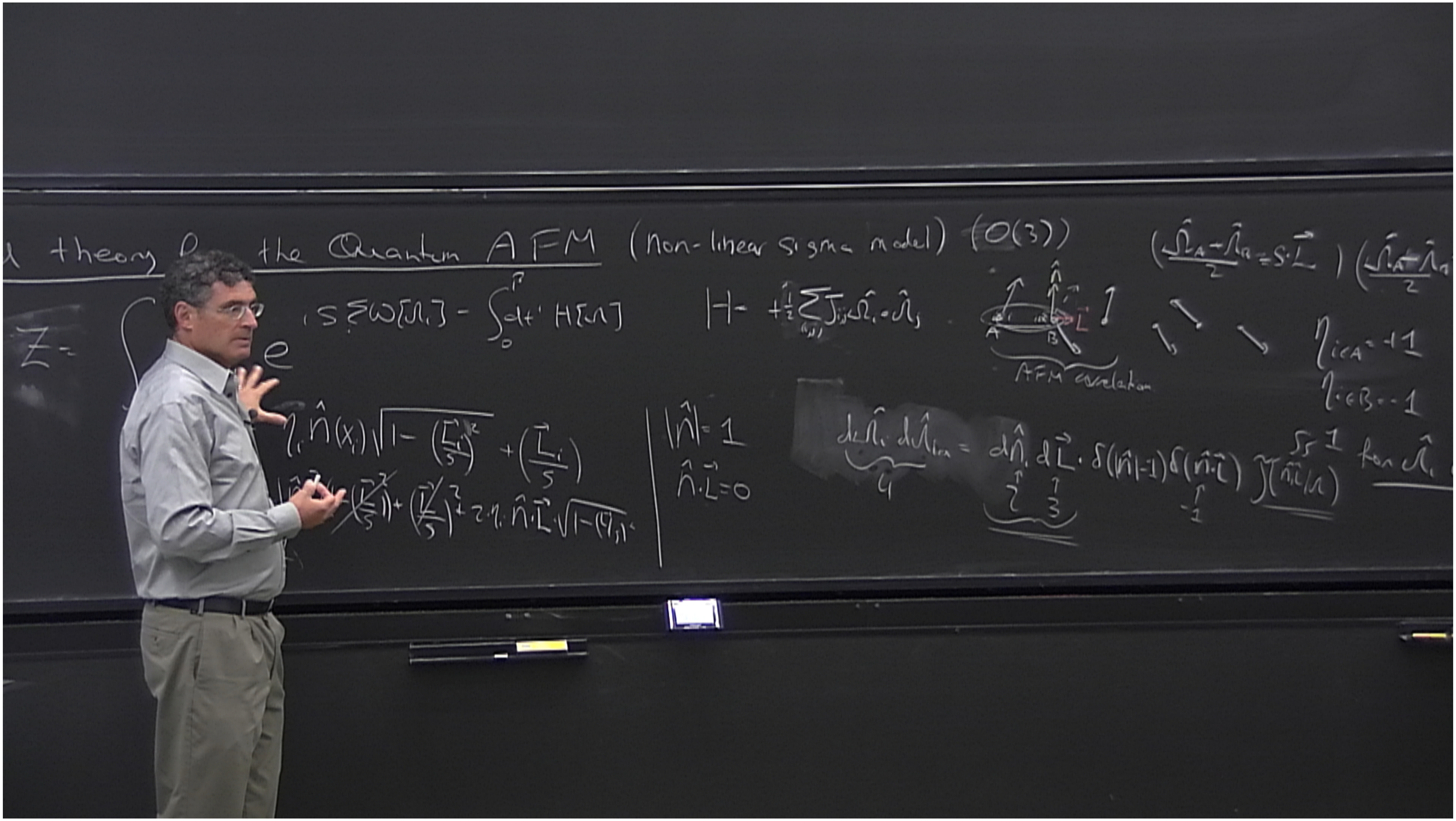

Quantum AFM (non-linear si... ...odel) (O(3))
$\left(\frac{\hat{\Omega}_A + \hat{\Omega}_B}{2} = \vec{L}\right)\left(\frac{\hat{\Omega}_A - \hat{\Omega}_B}{2} = \vec{n}\right)$
A
correlation

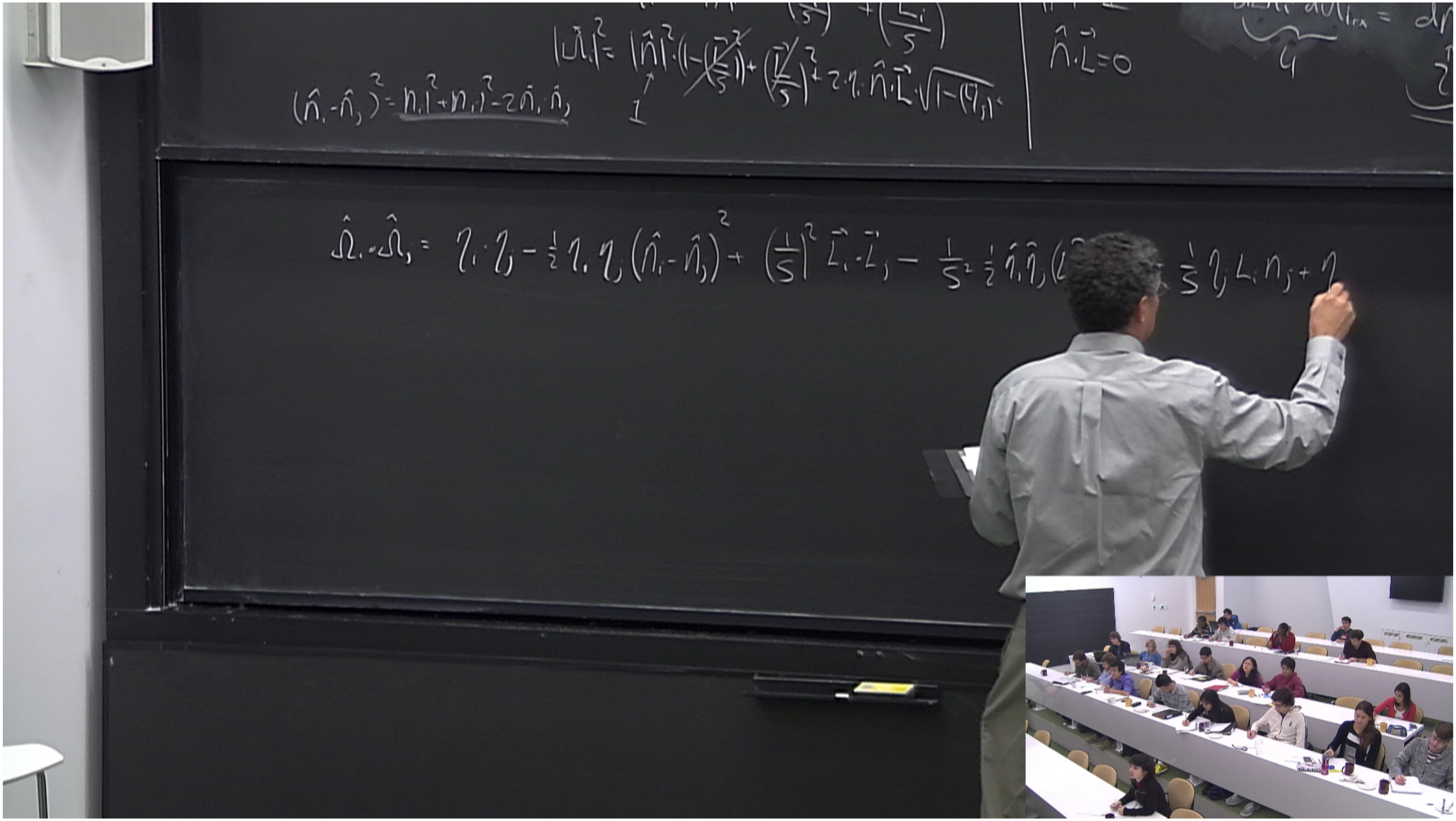

Field theory for the Quantum AFM
(non-linear sigma model)
(O(3))
A
B
L

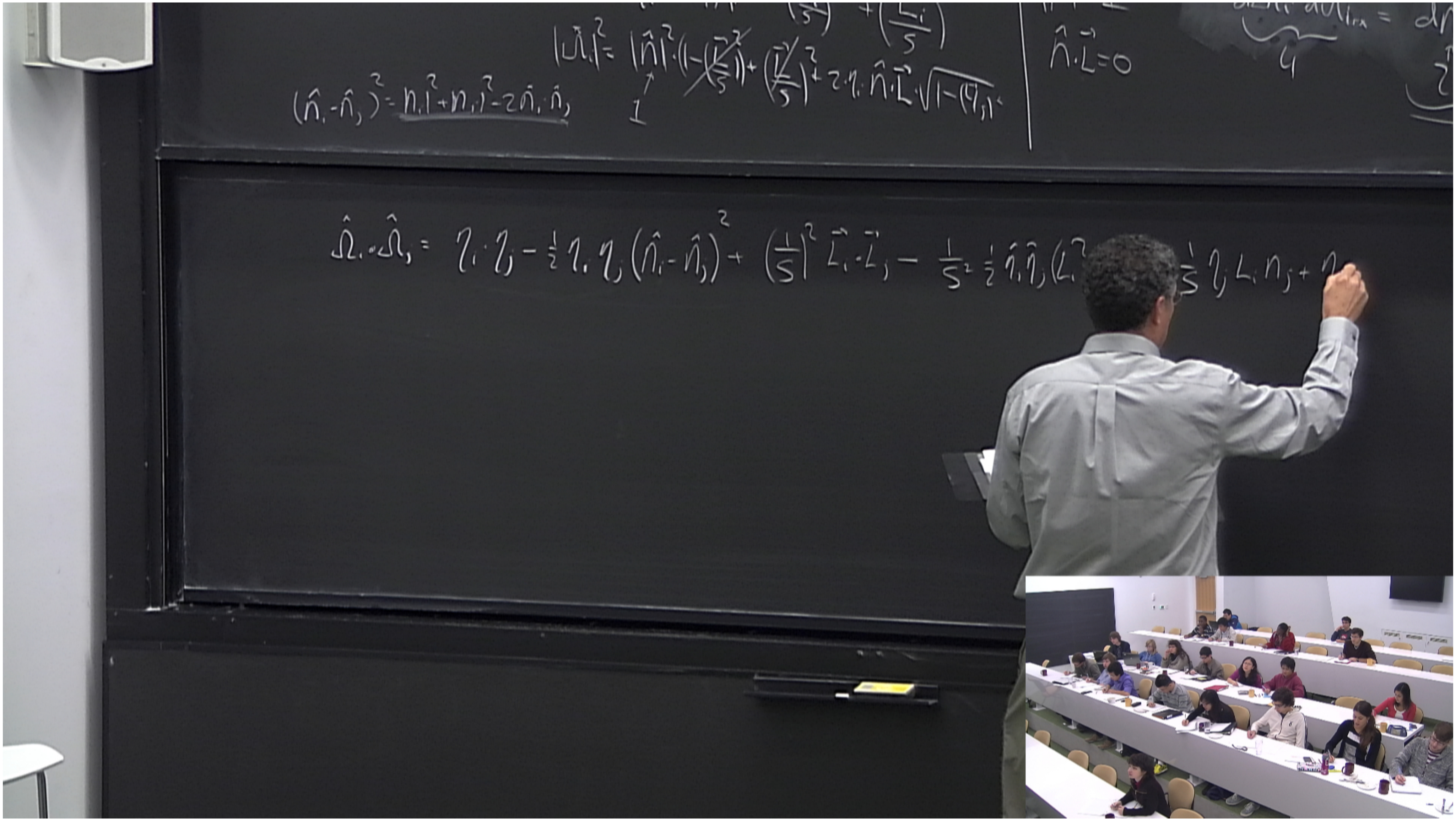

Quantum AFM (non-linear sigma model) (O(3))
AFM correlation

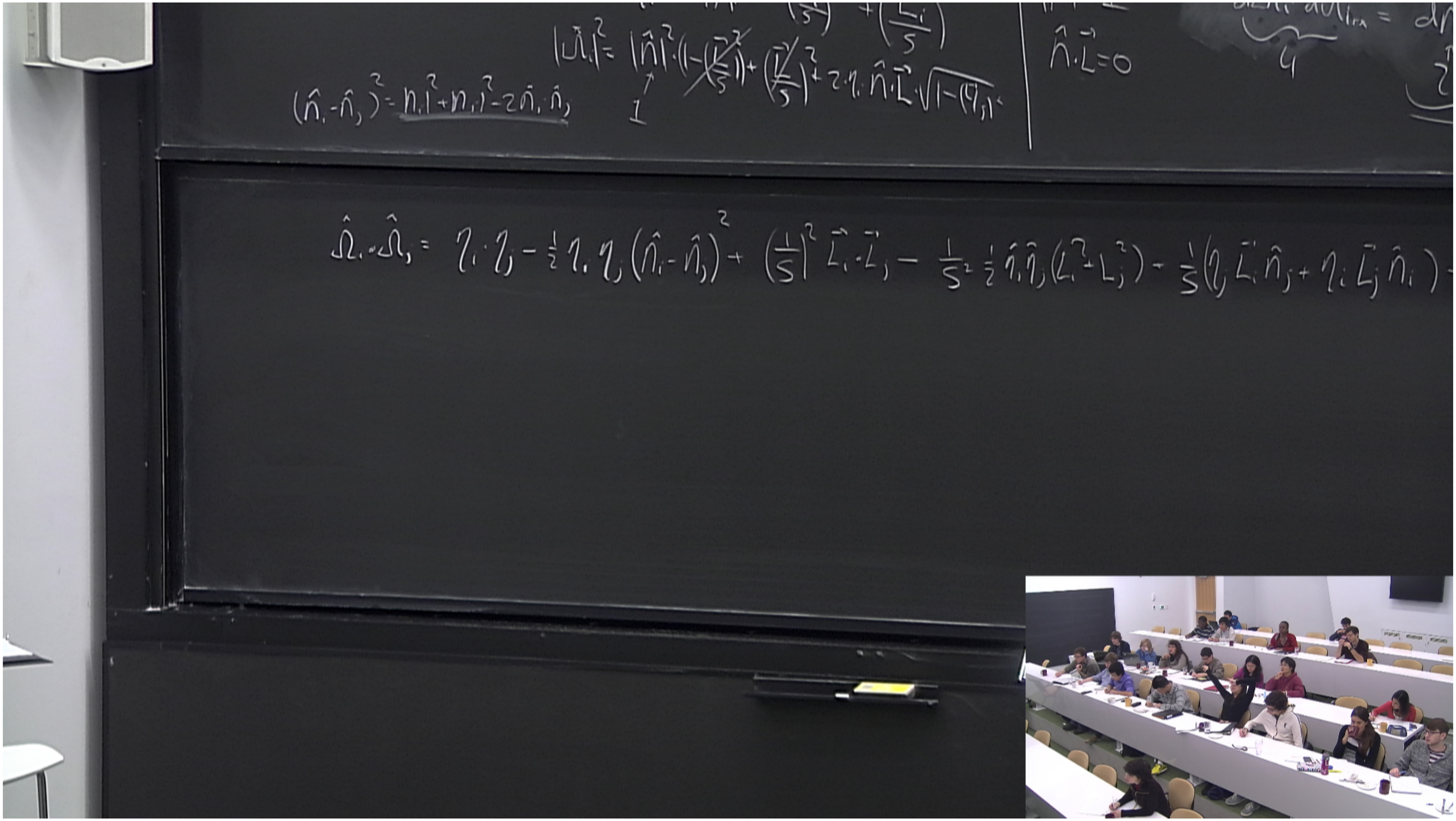

(non-linear sigma model) (O(3))
AFM correlation
|n| = 1

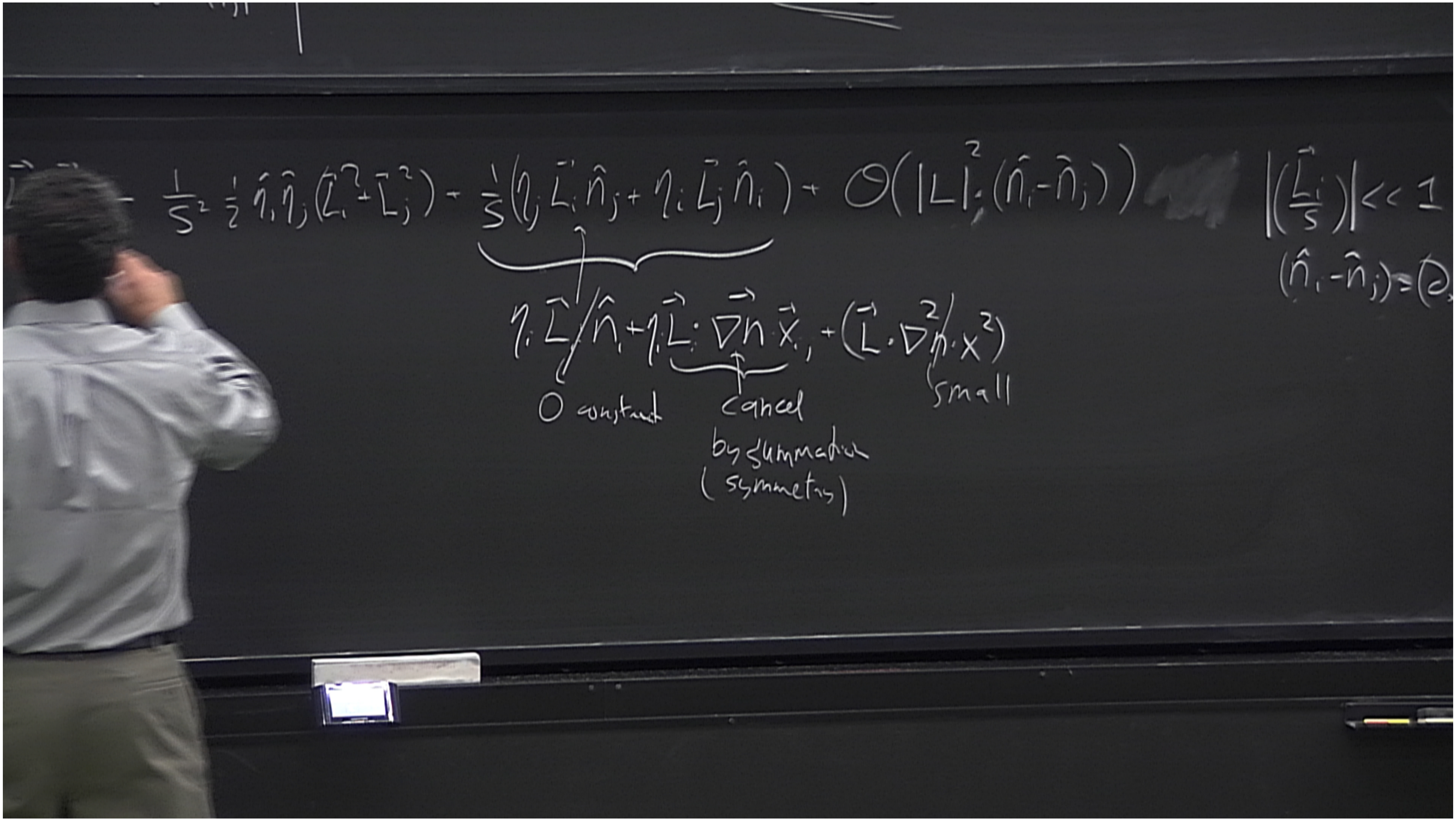

Quantum AFM (non-linear sigma model) (O(3))
AFM correlation
important

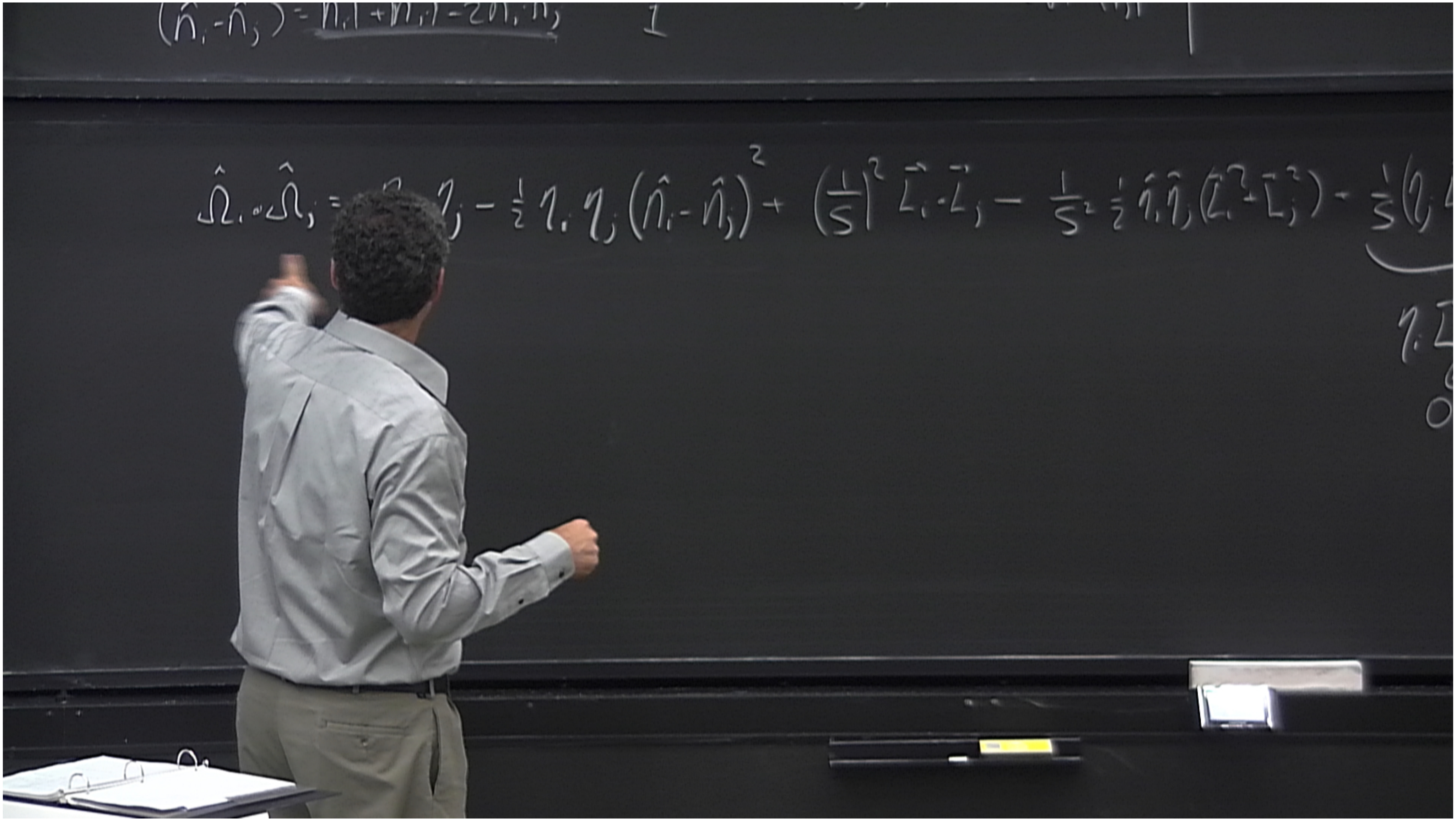

theory the Quantum AFM (non-linear sigma model) (O(3))
AFM correlation

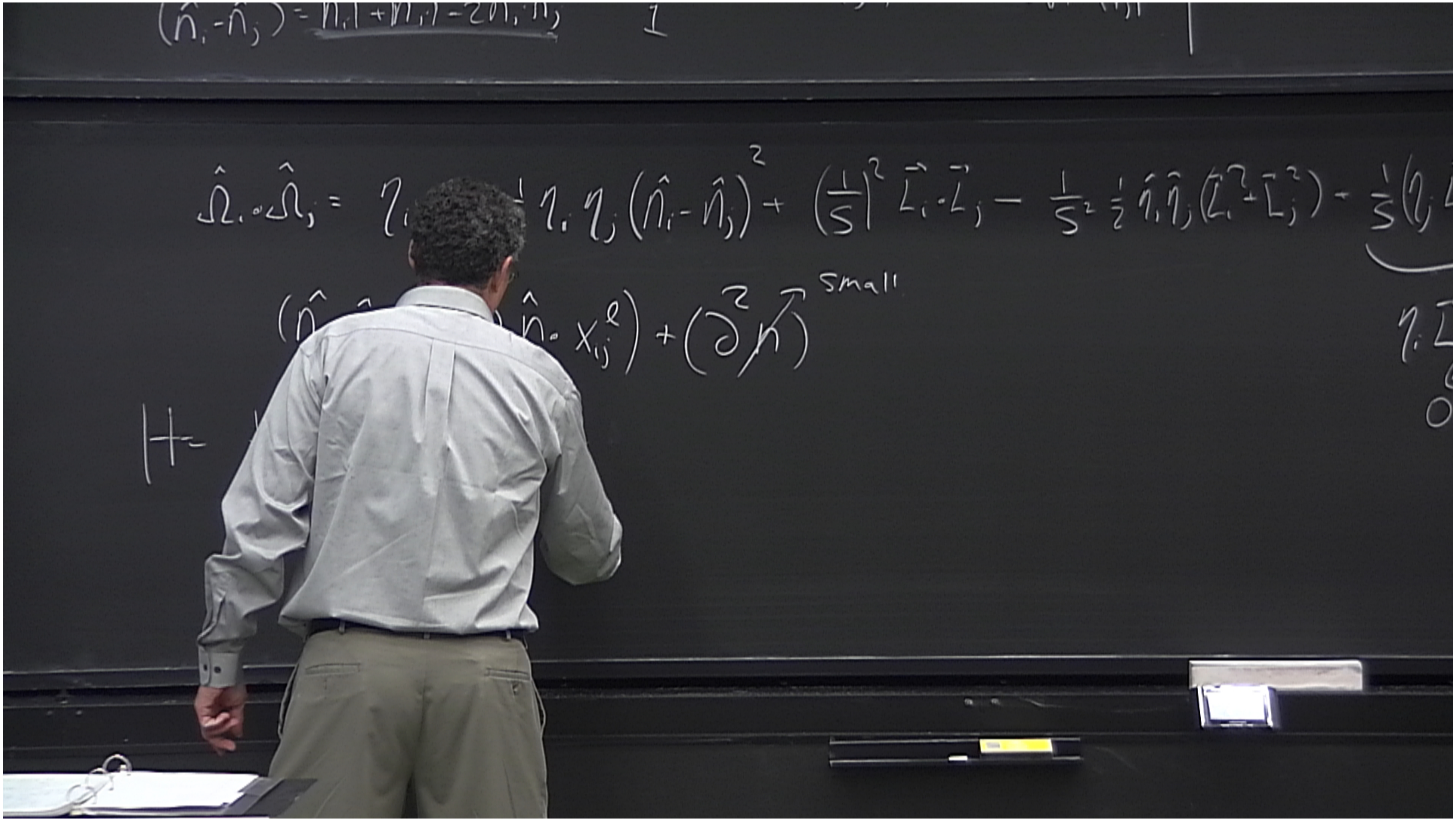


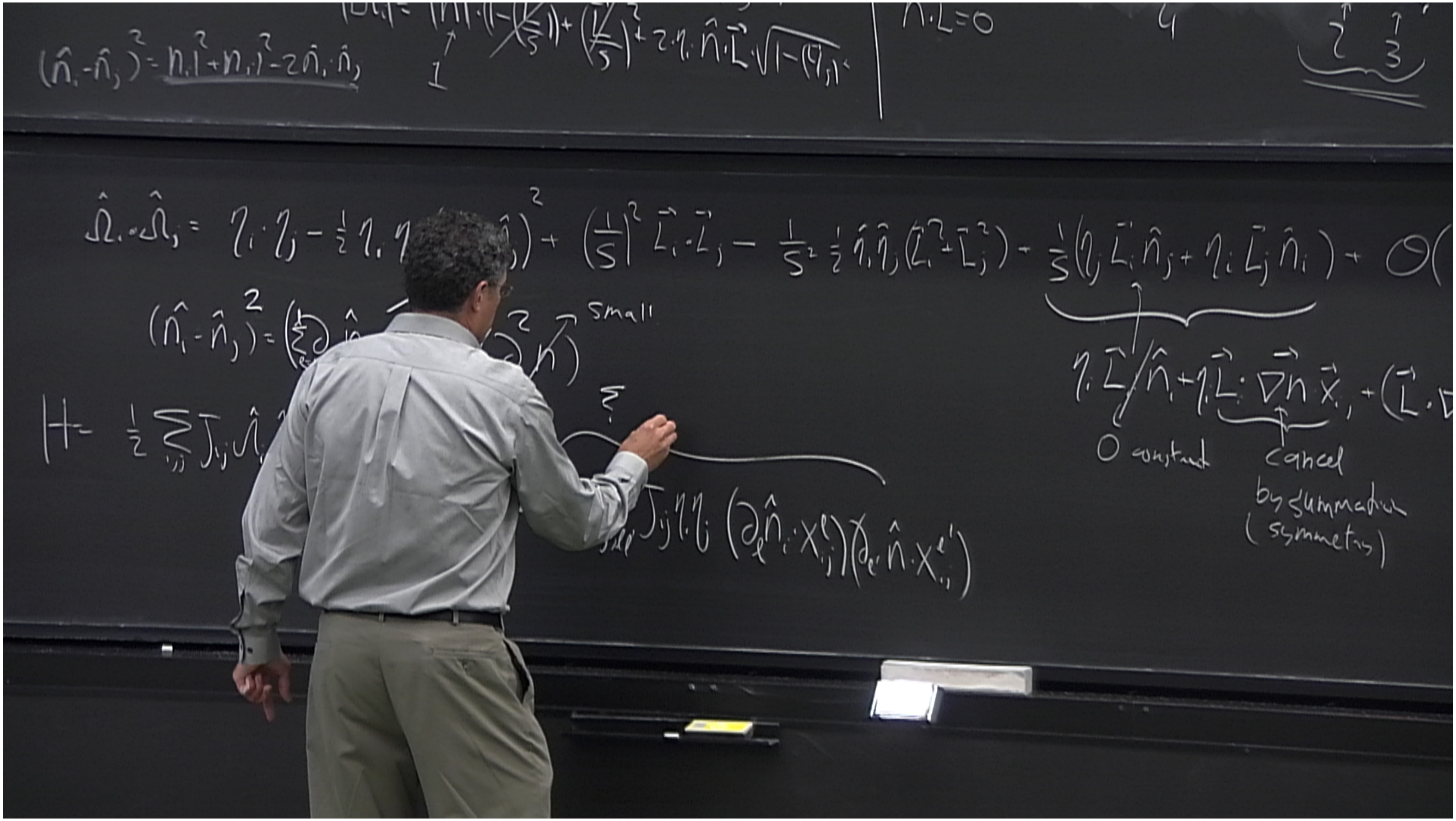


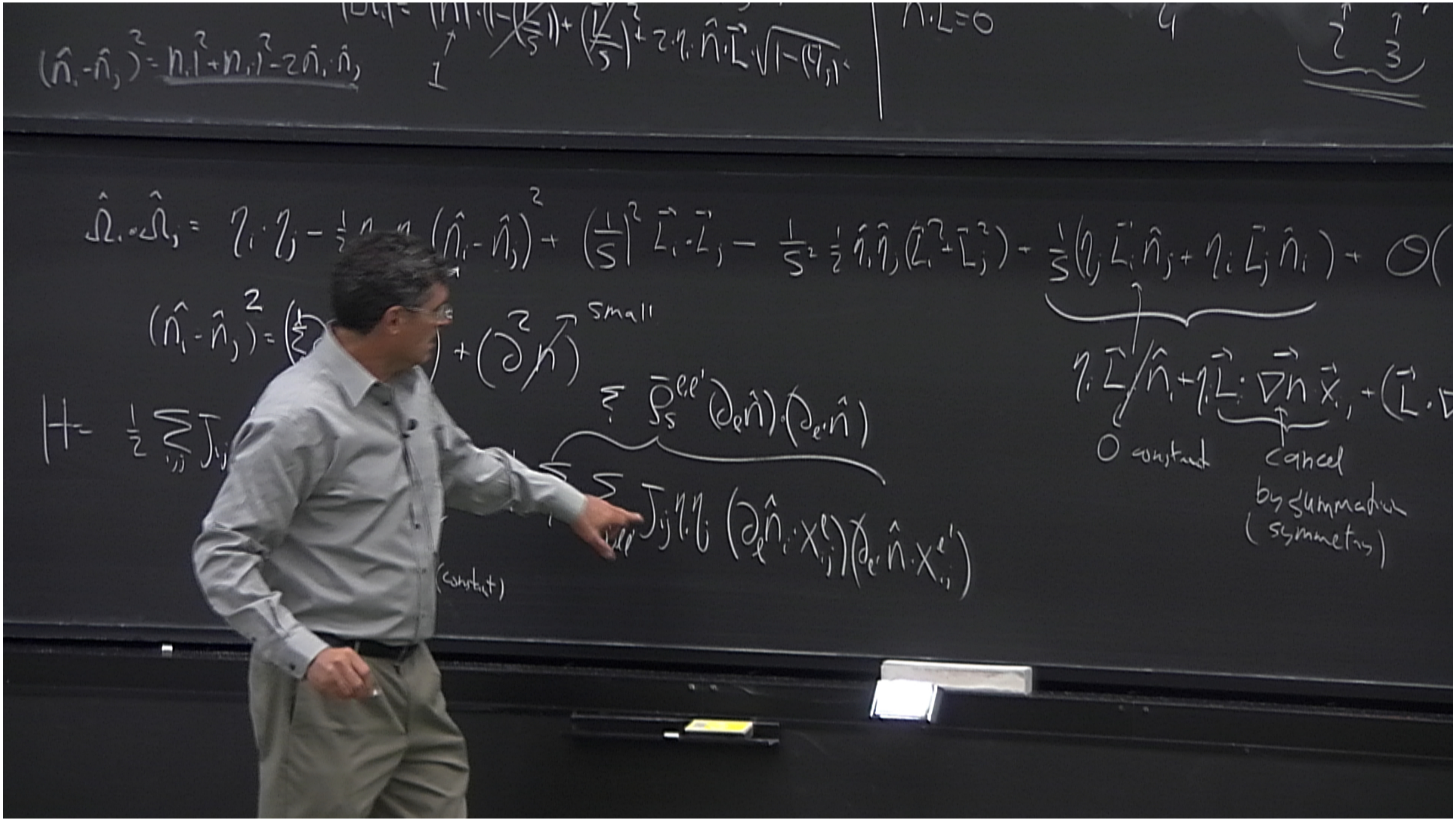

n̂·L⃗=0

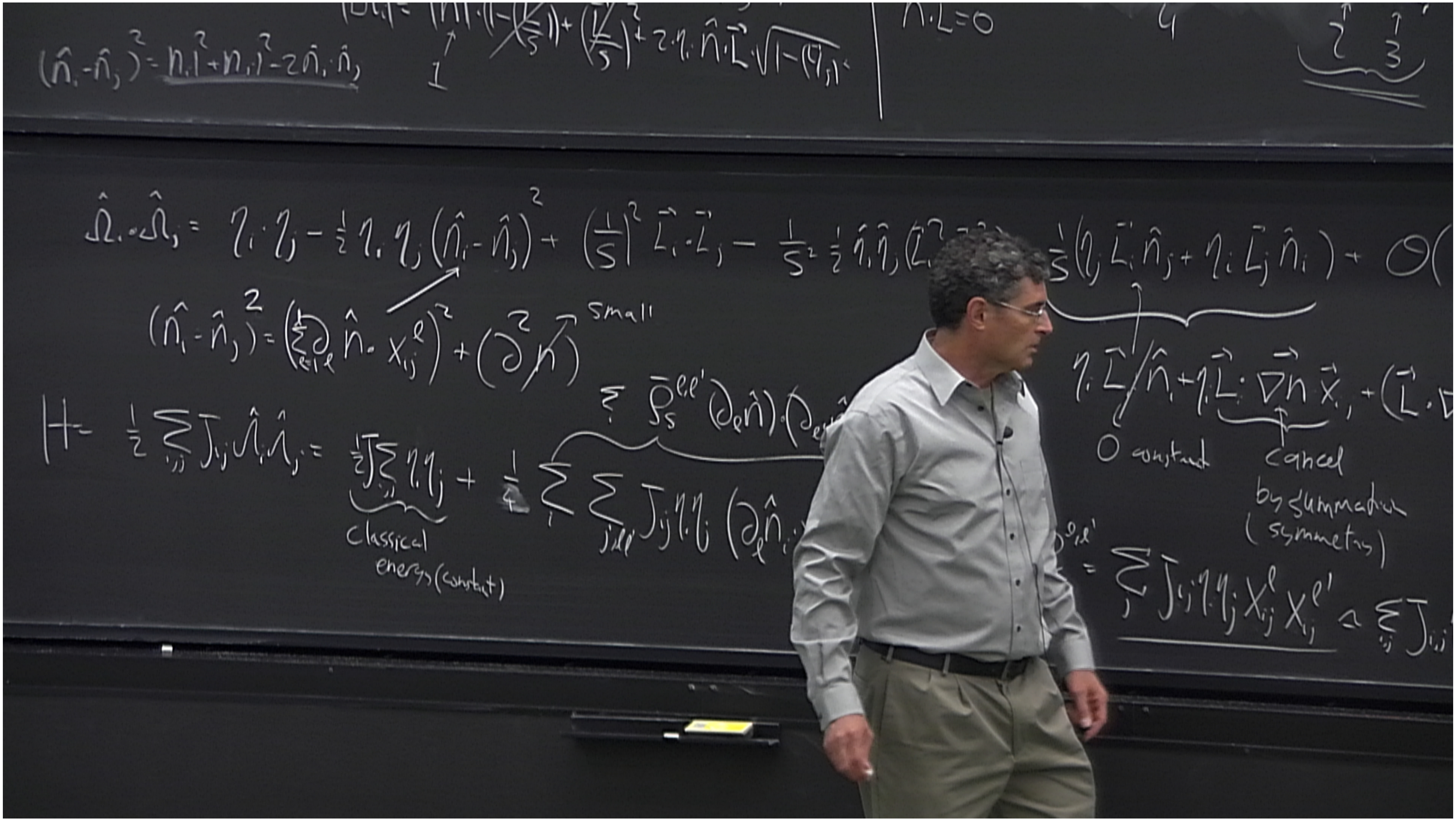

constant
cancel
by summation
(symmetry)
small

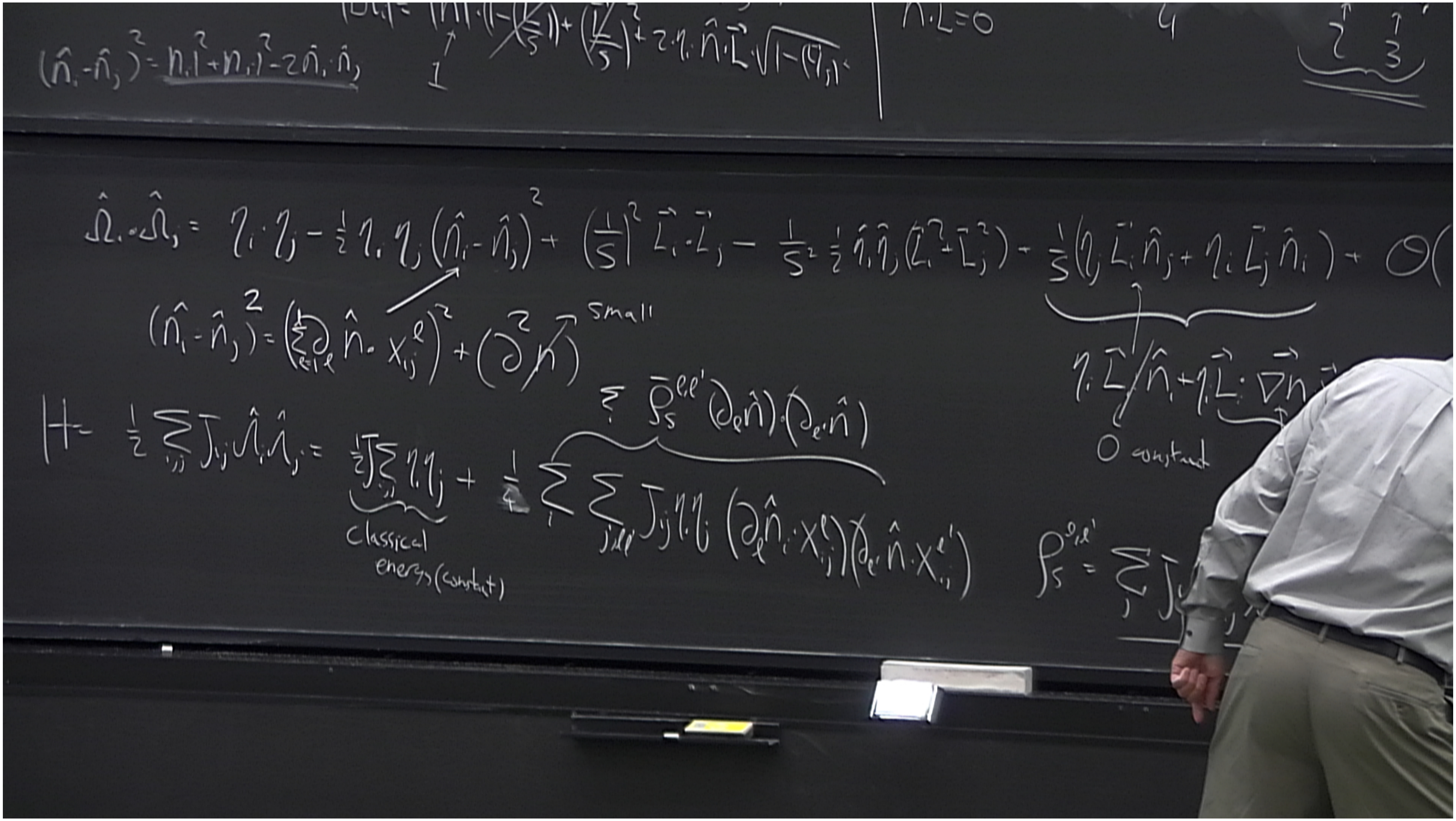


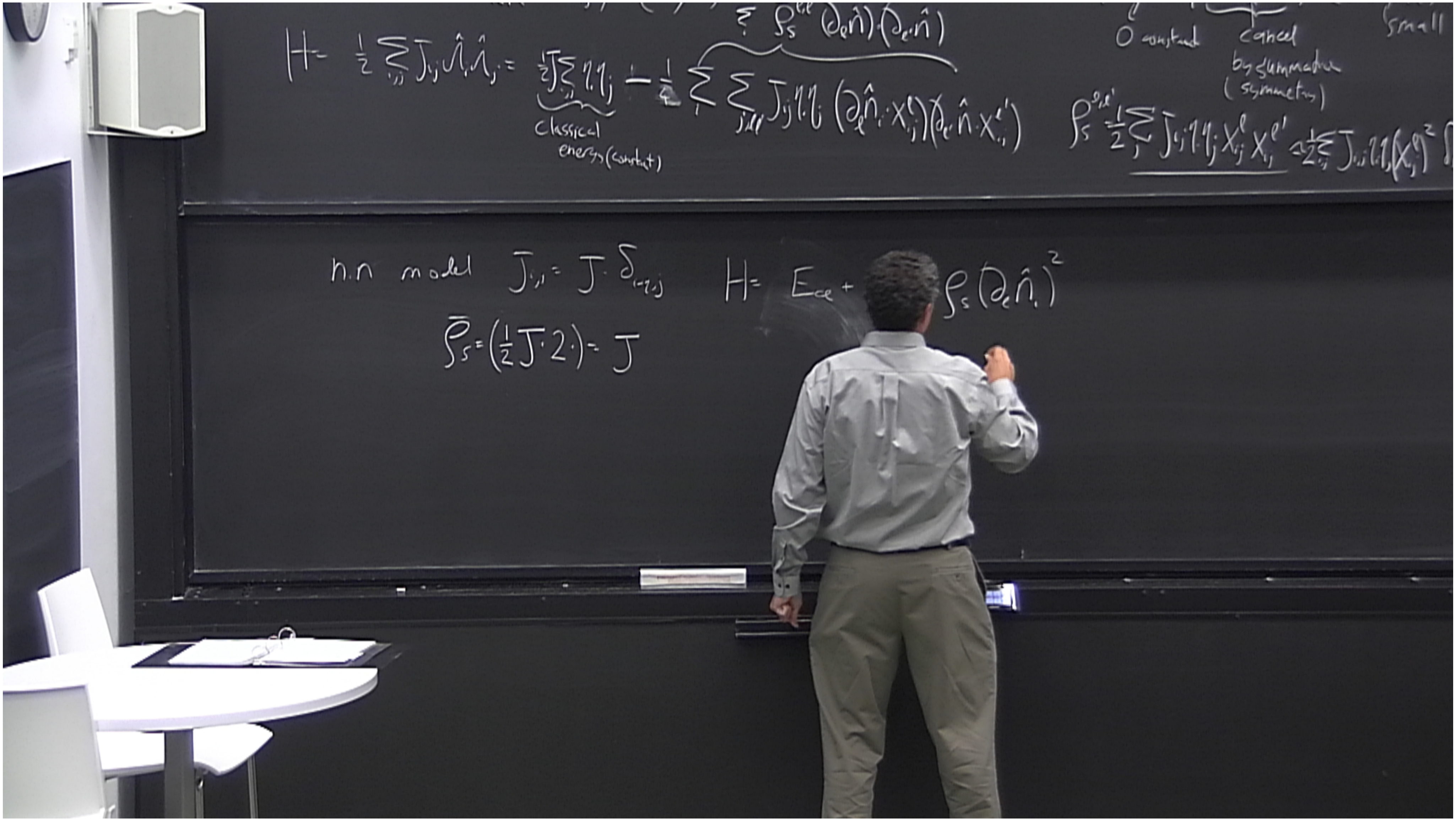

small


small
O constant
cancel
by summation
(symmetry)

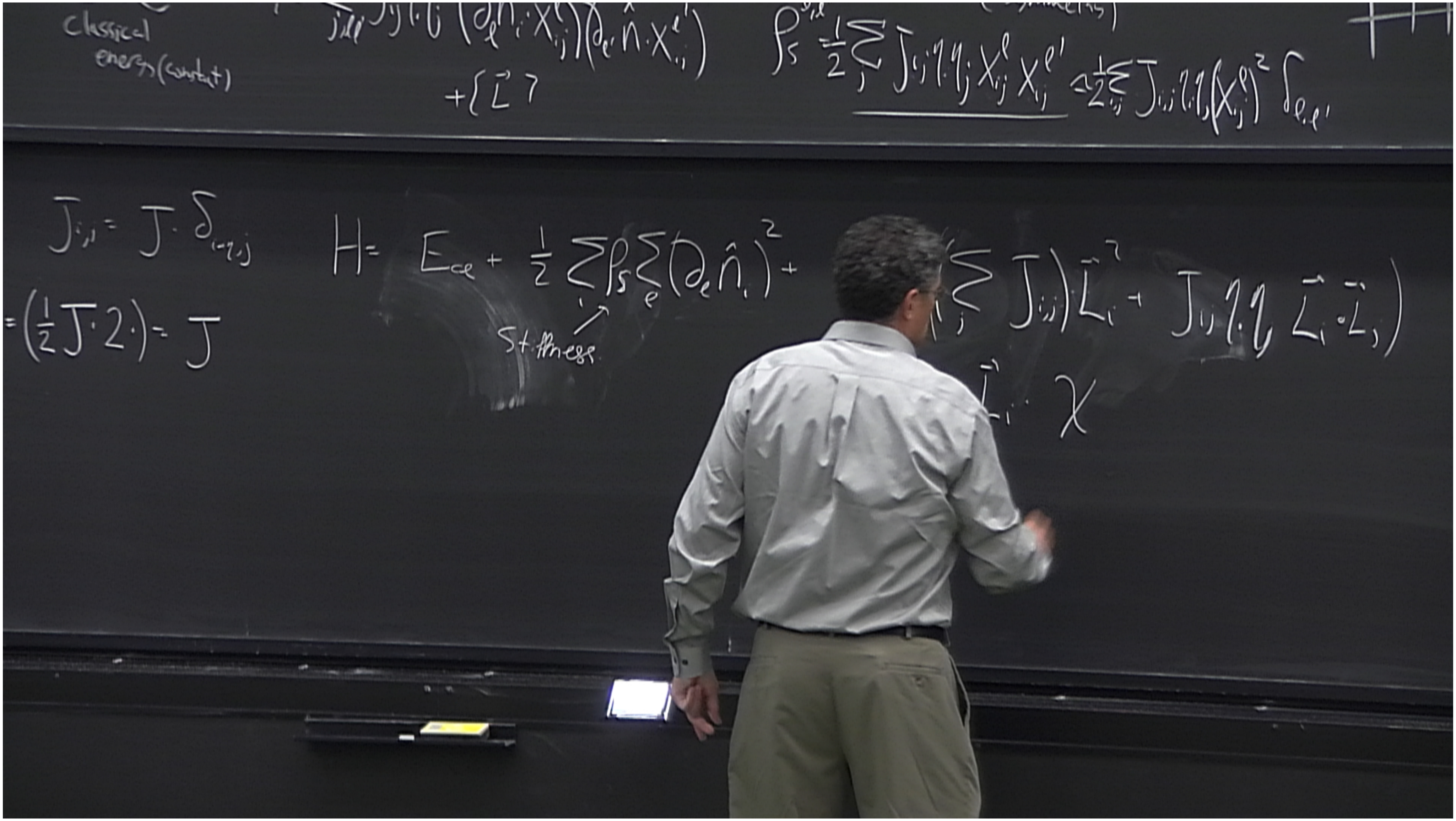

small
0 constant
cancel
by summation
(symmetry)
(constant)

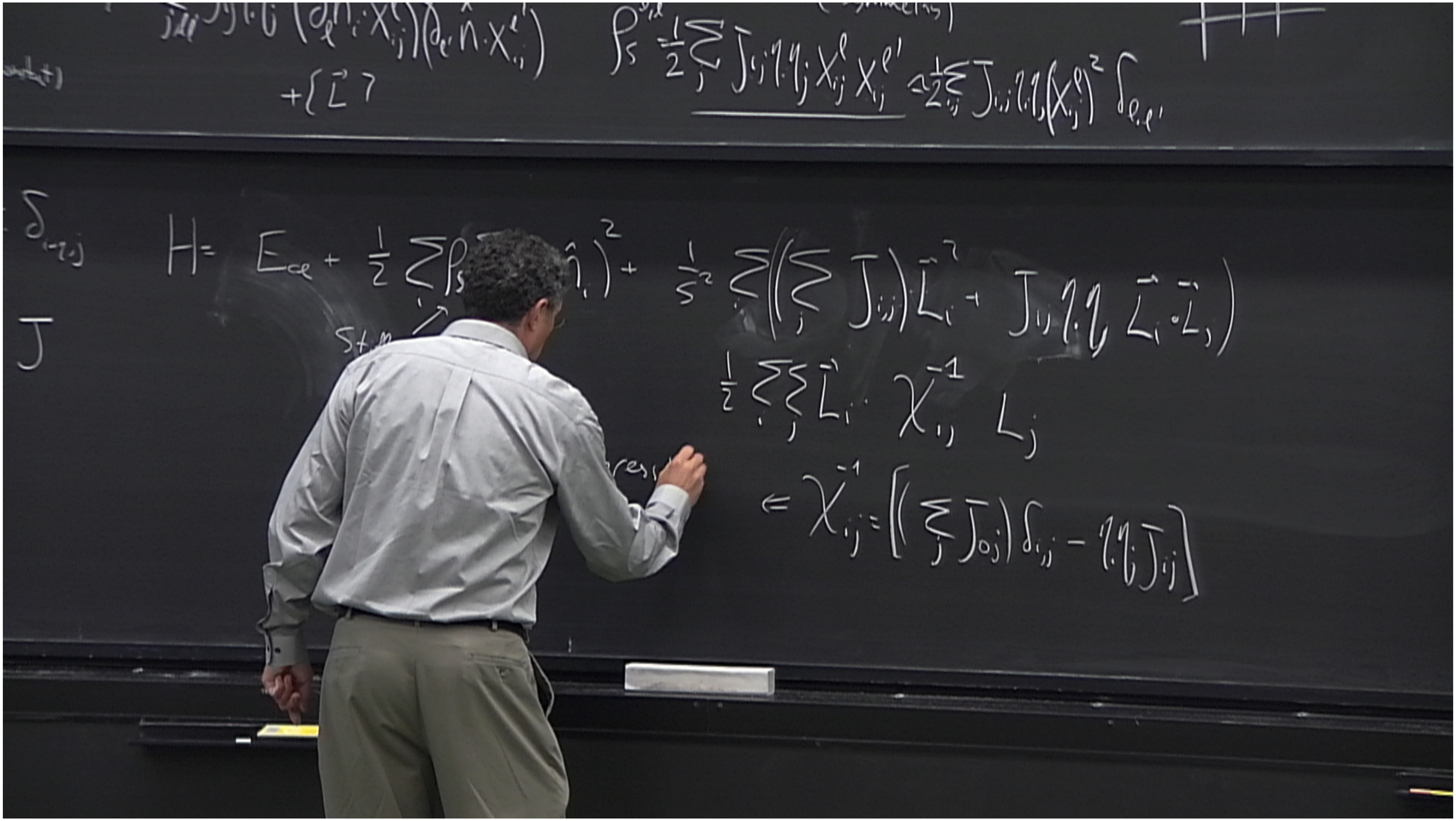

small
Classical
energy (constant)
0 constant
cancel
by summation
(symmetry)

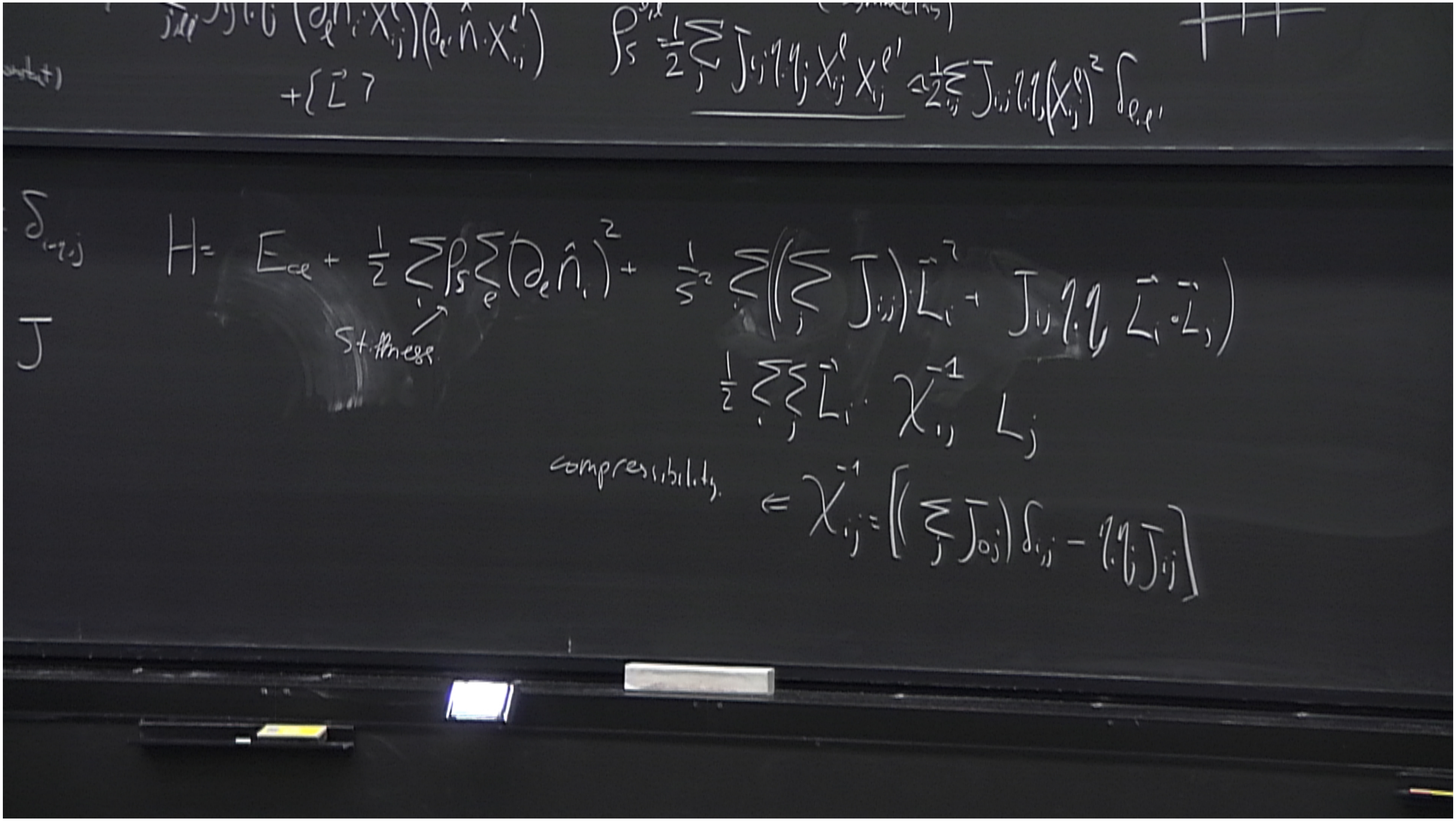

small
Classical
energy (constant)
0 constant

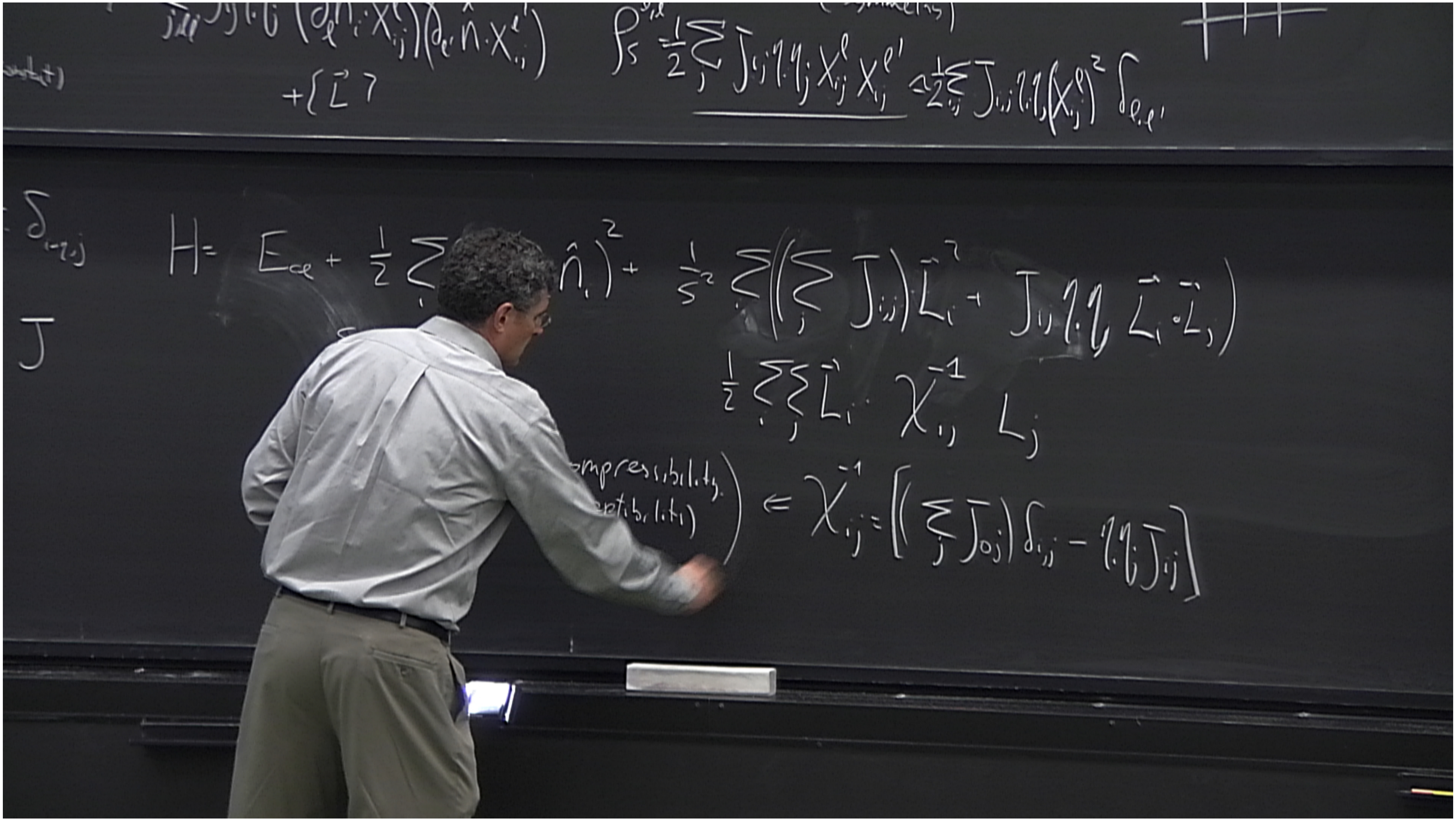


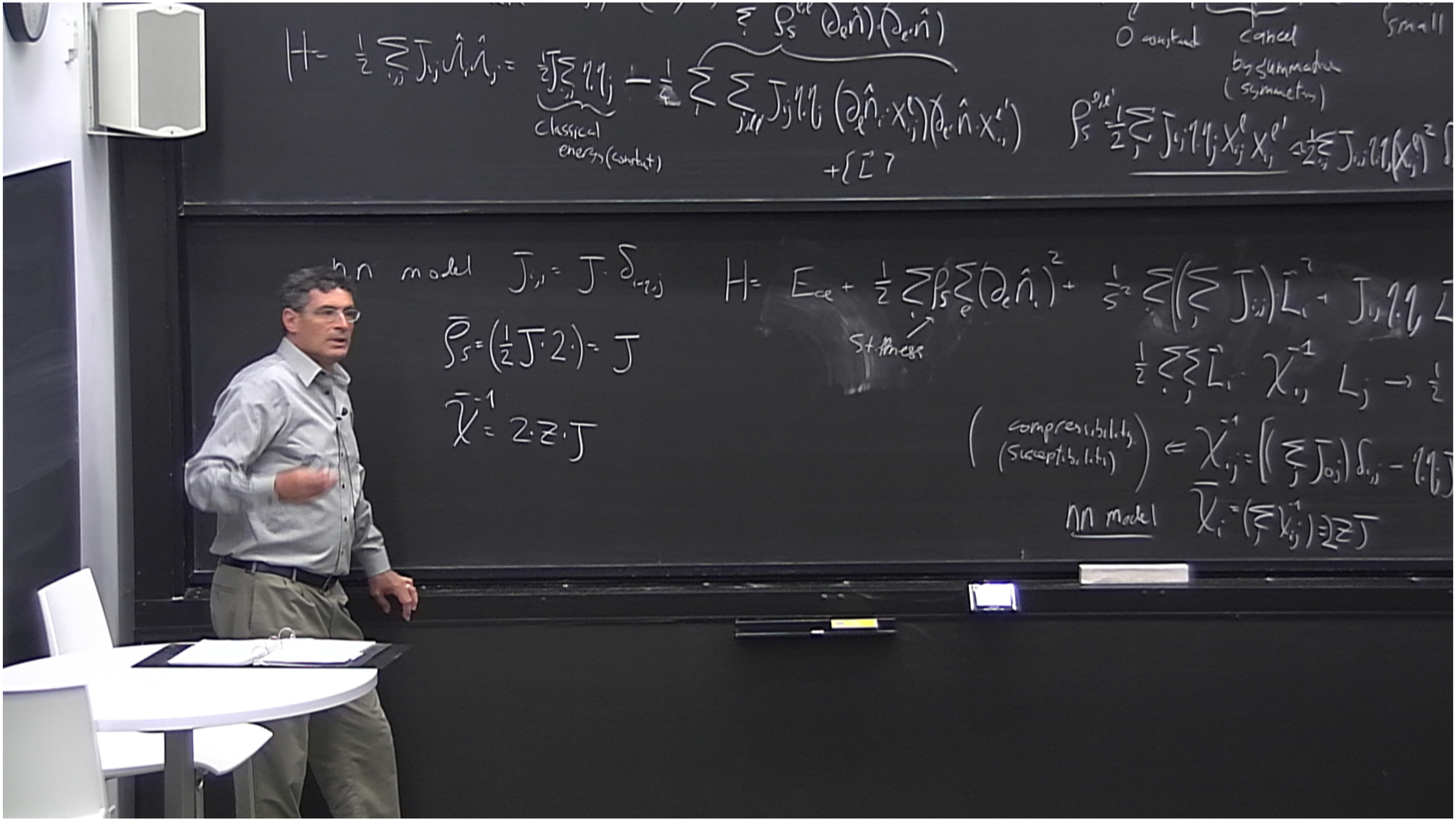
classical energy (constant)
0 constant
cancel by summation (symmetry)
small
n.n model

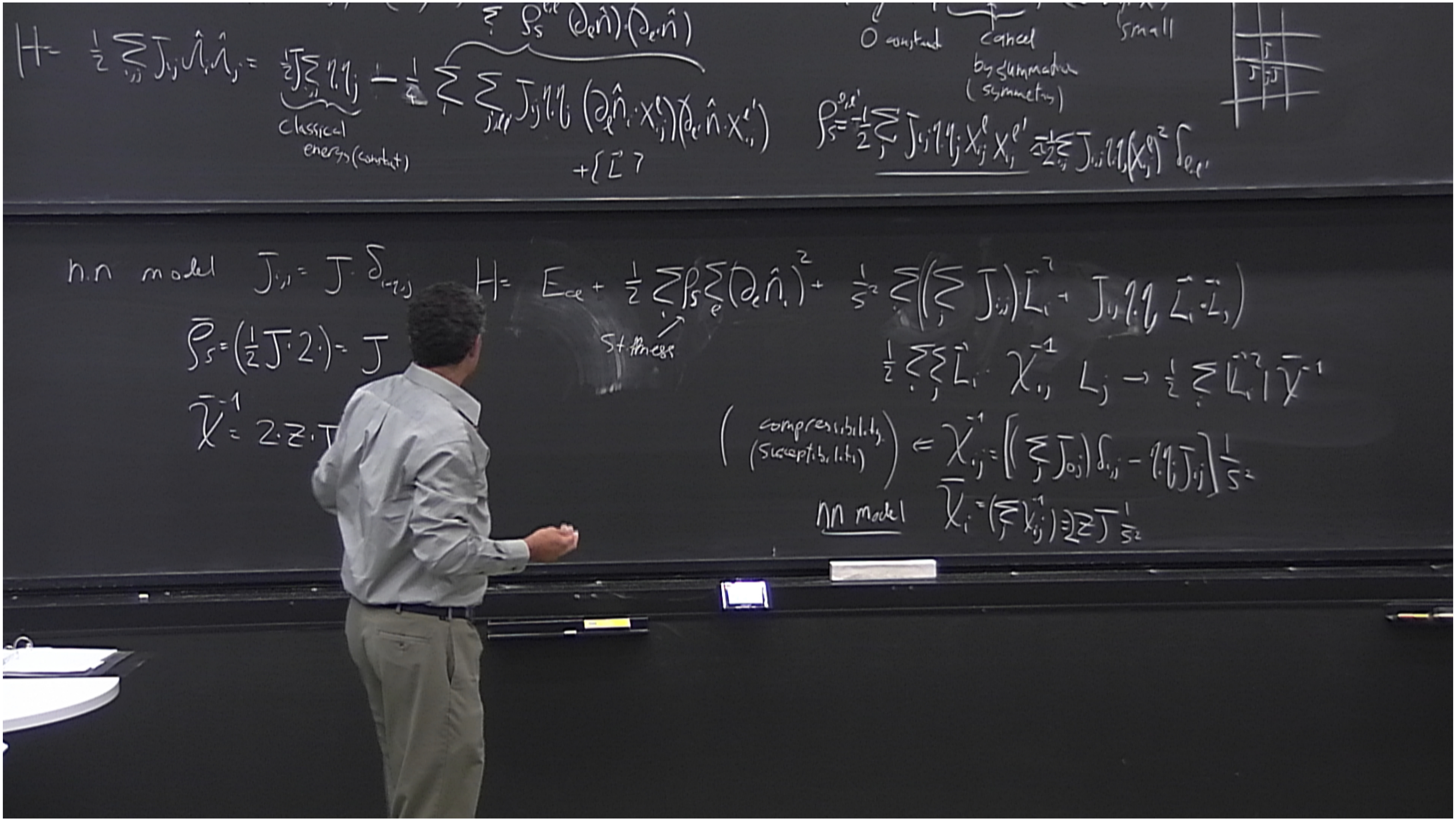

Classical energy (constant)
stiffness



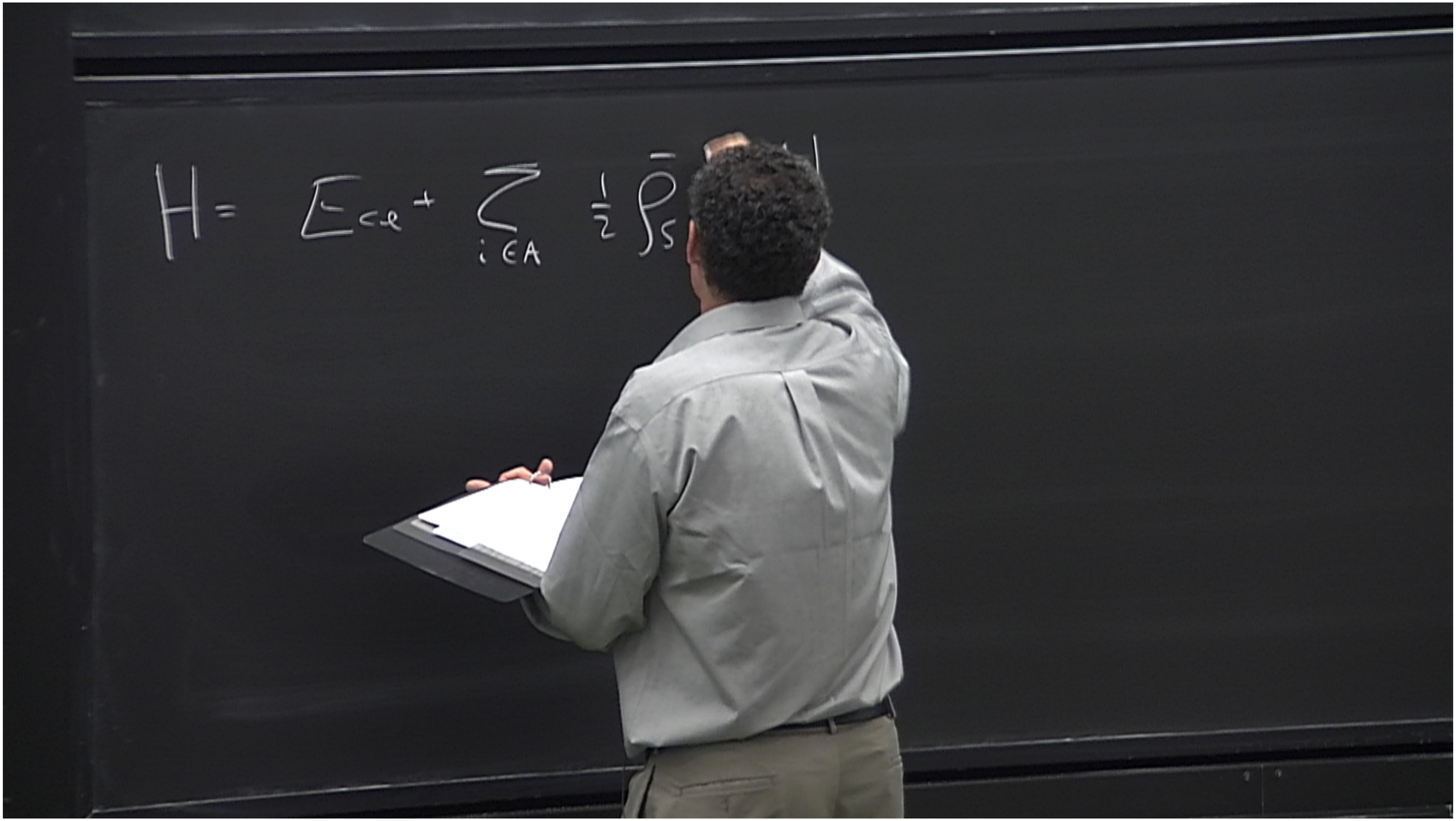

stiffness
compressibility

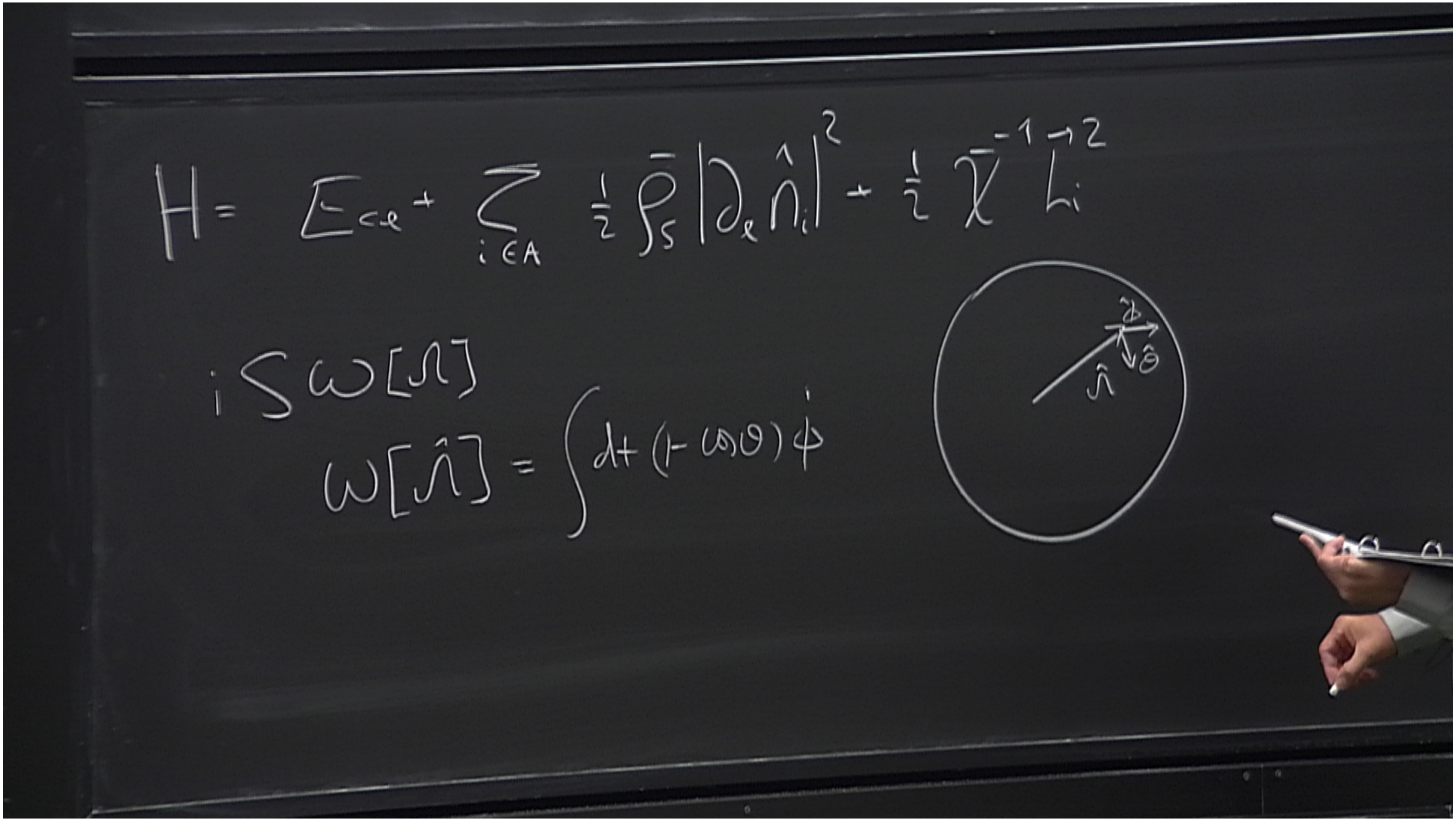


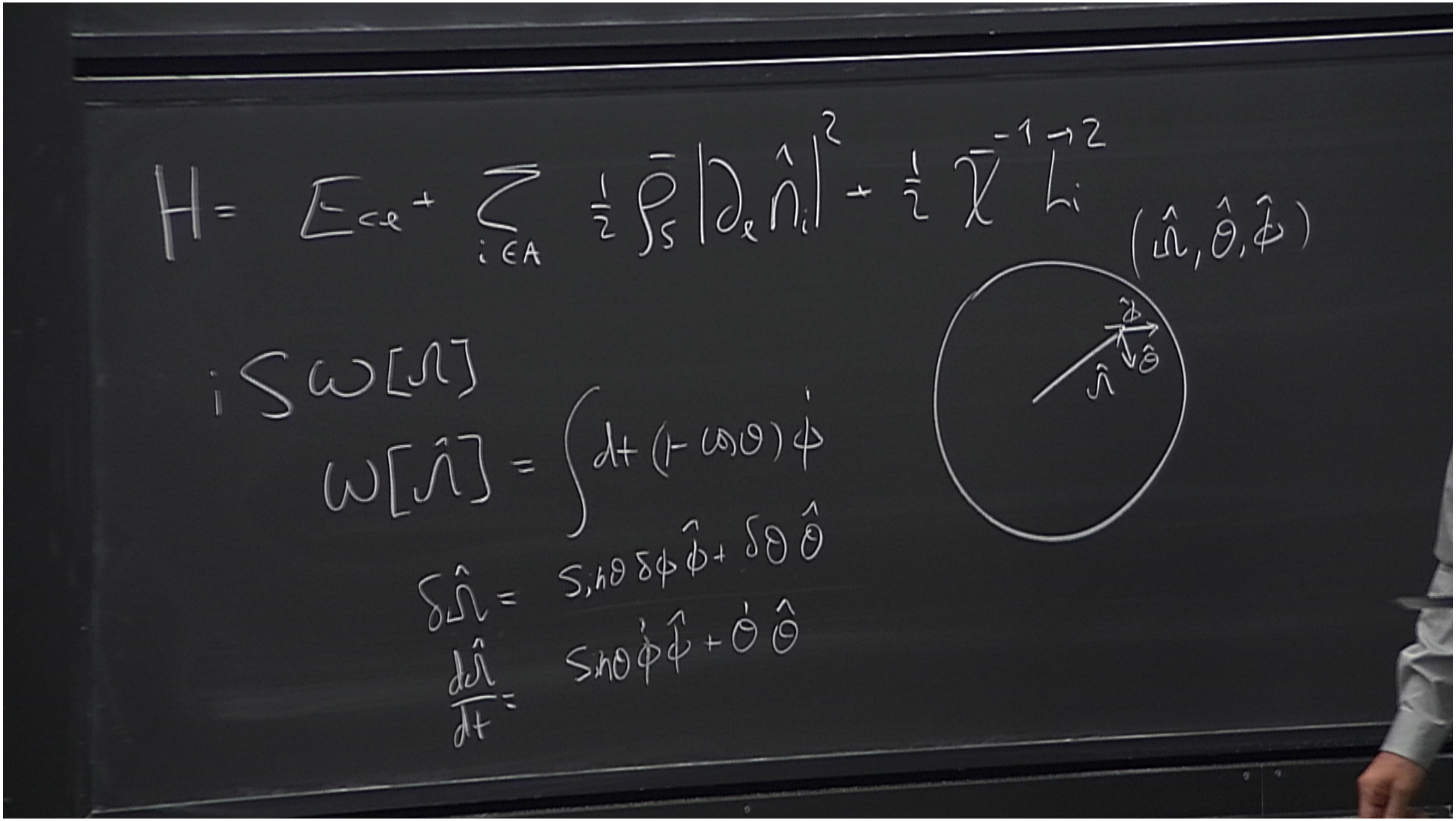

small
cancel
by summation
(symmetry)
classical
energy (constant)
nn model
Stiffness
compressibility
(susceptibility)
nn model

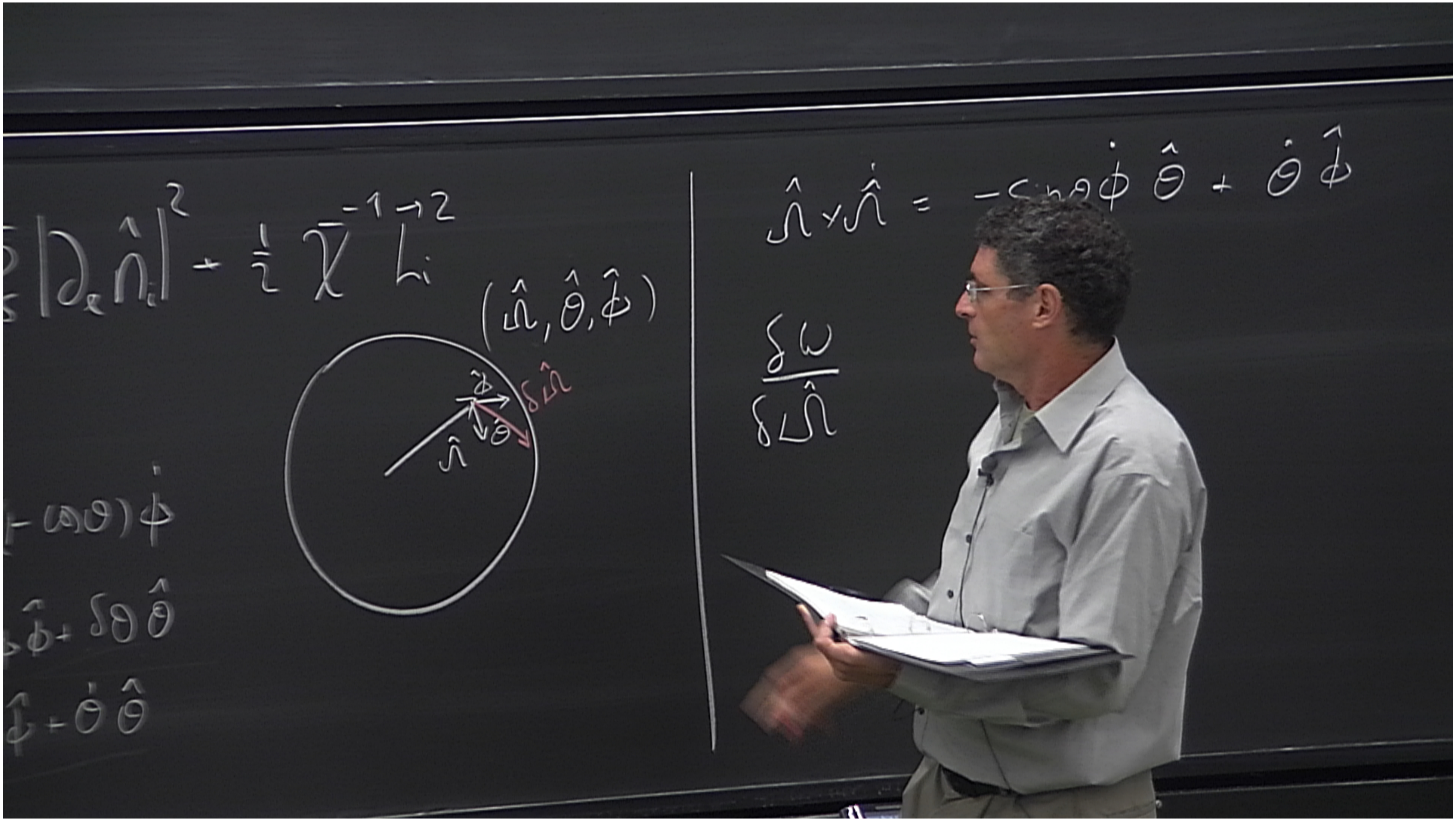


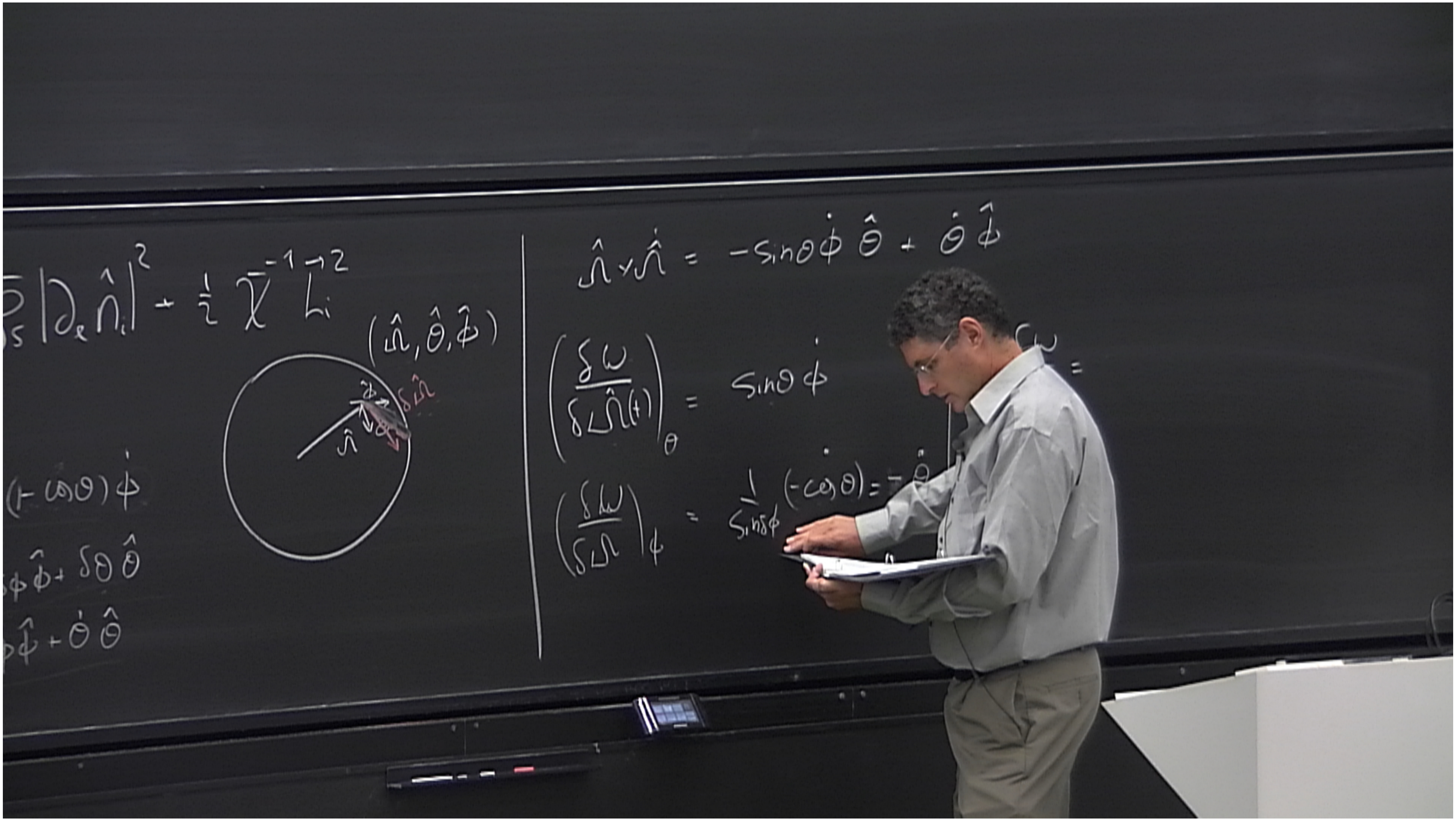
O constant
cancel by summation (symmetry)
small
Classical energy (constant)
n.n model
Stiffness
compressibility (susceptibility)
nn model

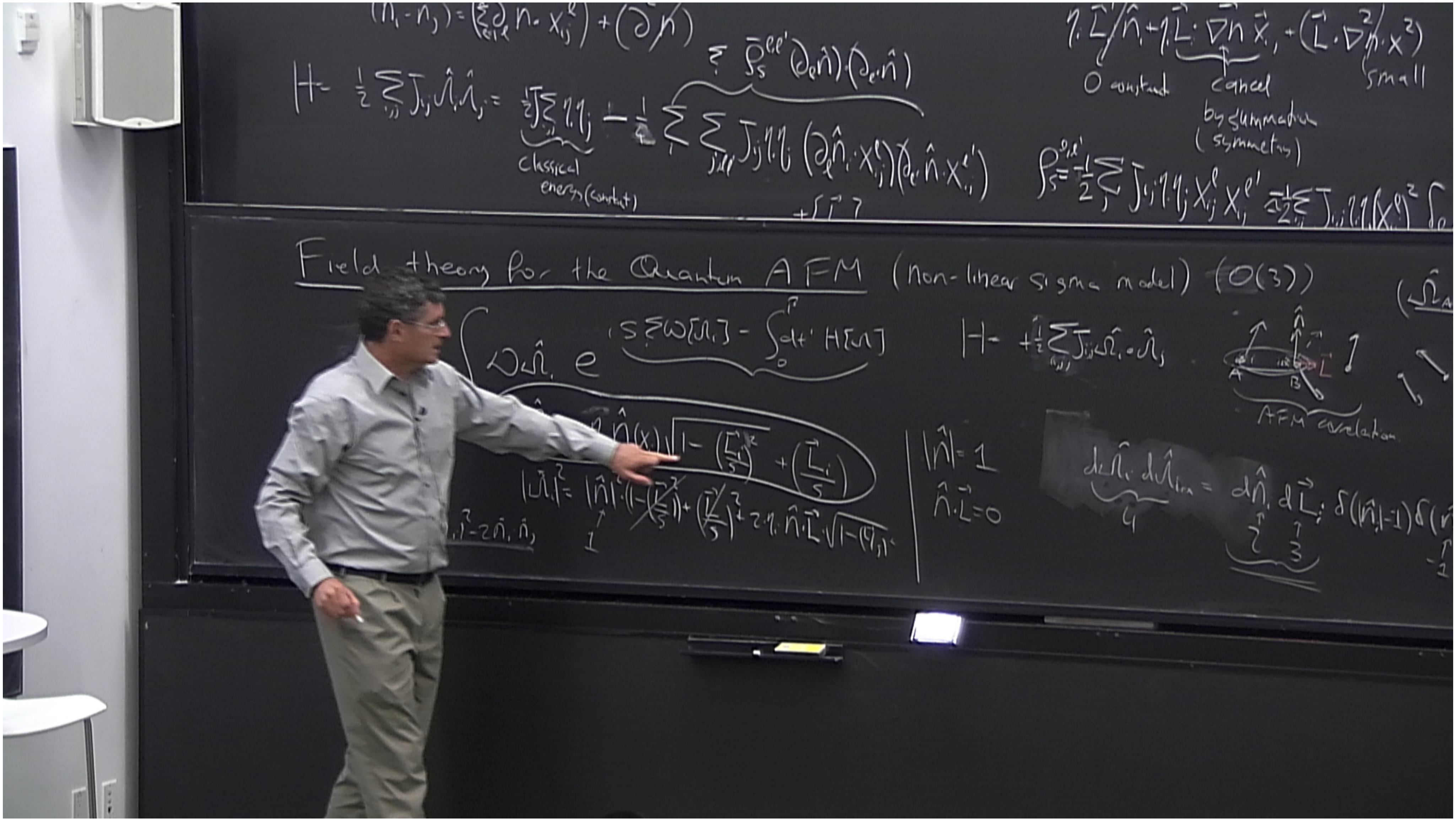

$H = E_{ce} + \sum_{i \in A} \frac{1}{2} \bar{\rho}_s$

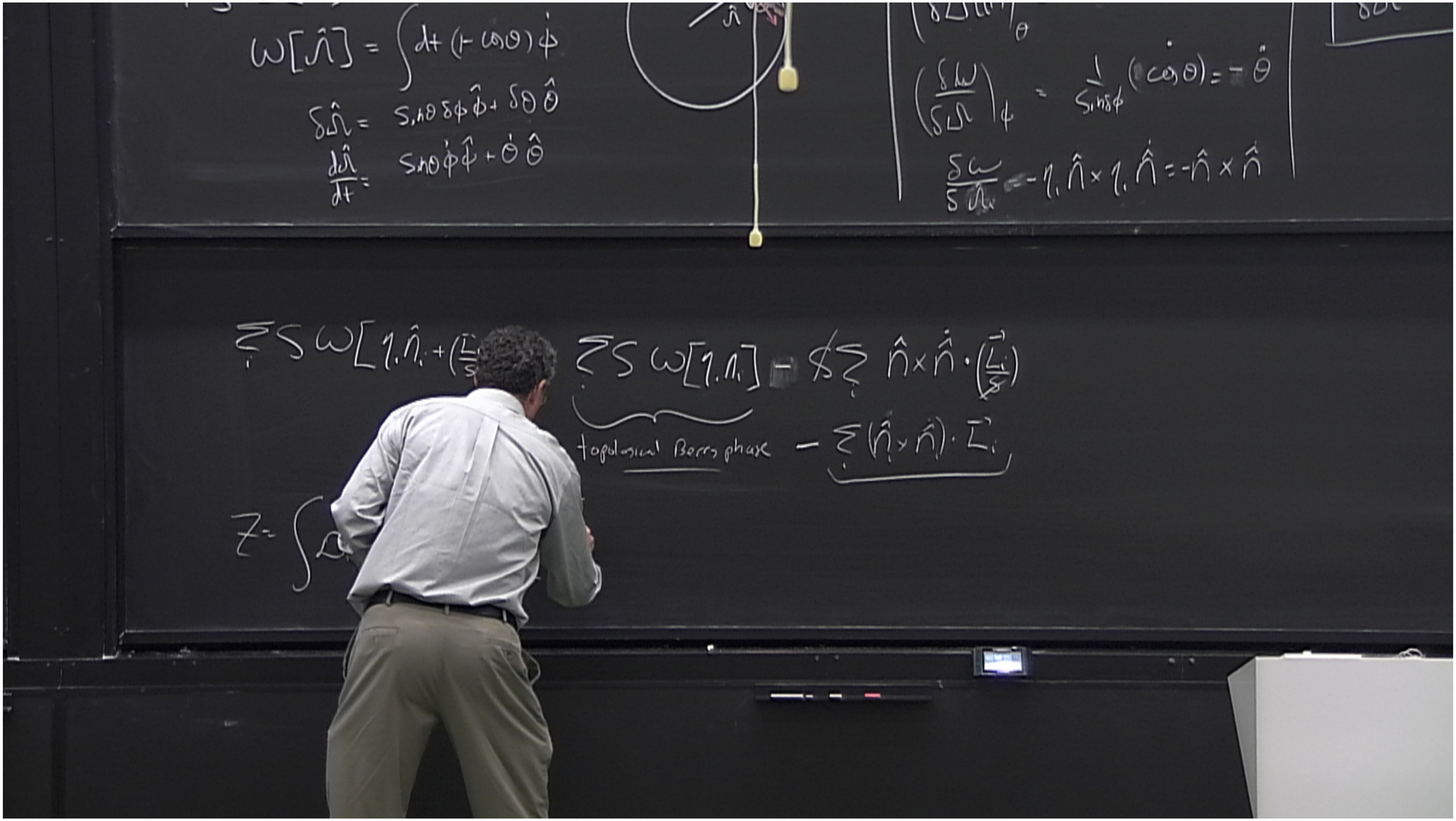

H = E_cl + Σ_{i∈A} ½ ρ̄_s |∂_ℓ n̂_i|² + ½ χ̄^{-1} L_i²
i S ω[n̂]
ω[n̂] = ∫ dt (1 - cos θ) φ̇
φ̂
θ̂
n̂

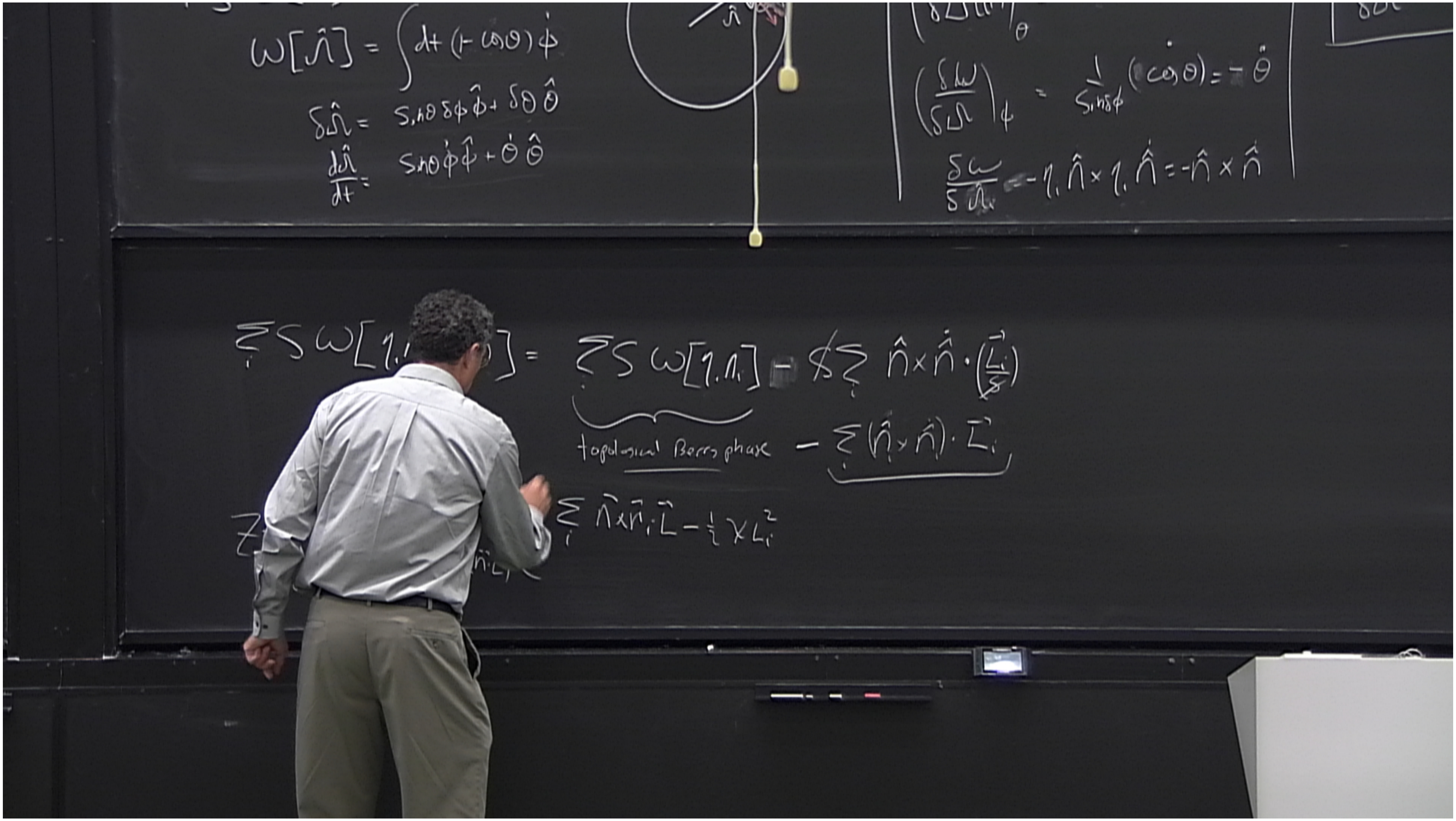

$H = E_{ce} + \sum_{i \in A} \frac{1}{2} \bar{\rho}_s |\partial_\ell \hat{n}_i|^2 + \frac{1}{2} \bar{\chi}^{-1} \vec{L}_i^2$
$(\hat{n}, \hat{\theta}, \hat{\phi})$
$\hat{\phi}$
$\hat{\theta}$
$\hat{n}$
$i S \omega[n]$
$\omega[\hat{n}] = \int dt \, (1 - \cos\theta) \dot{\phi}$
$\delta \hat{n} = \sin\theta \, \delta\phi \, \hat{\phi} + \delta\theta \, \hat{\theta}$
$\frac{d\hat{n}}{dt} = \sin\theta \, \dot{\phi} \, \hat{\phi} + \dot{\theta} \, \hat{\theta}$

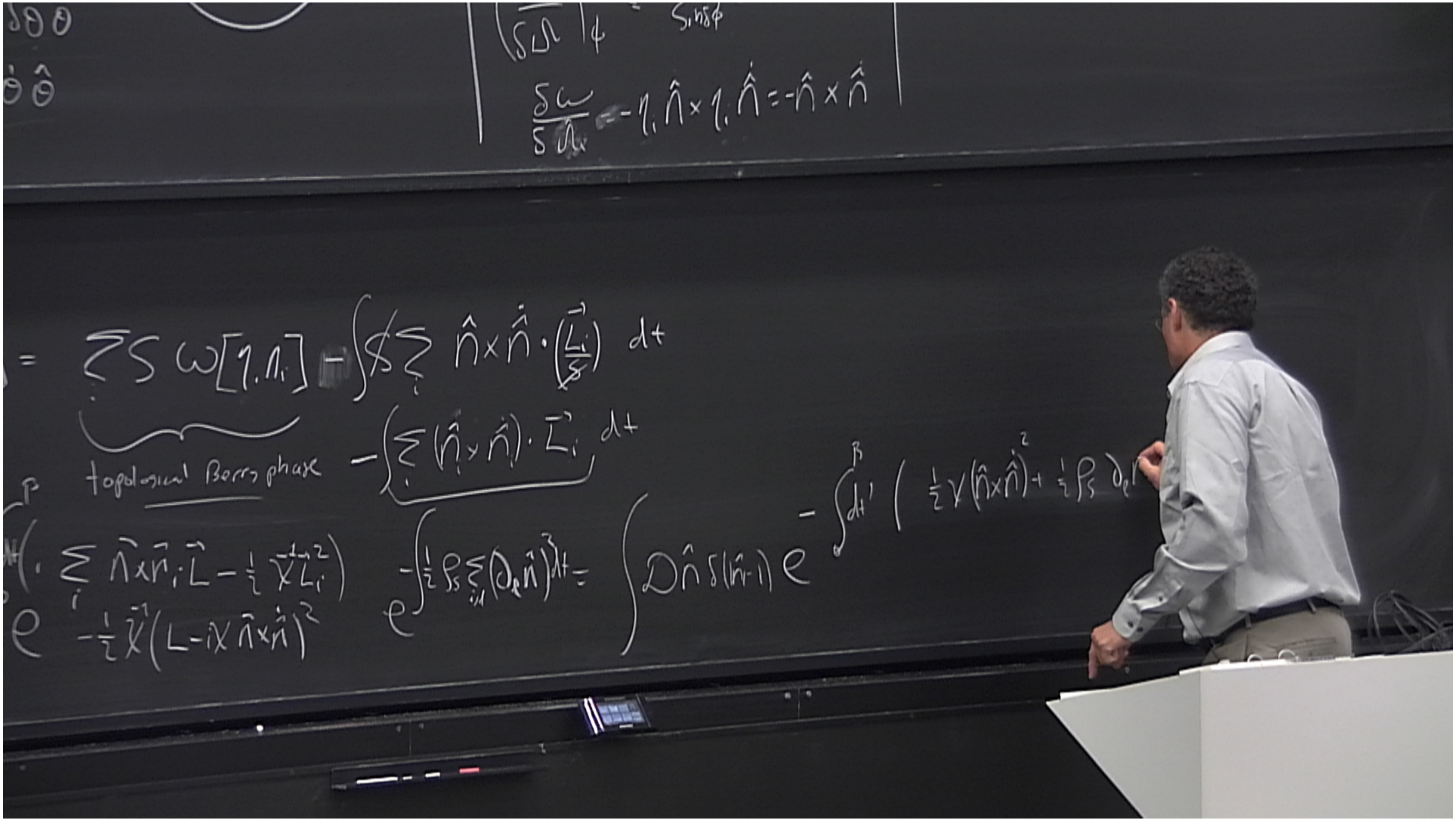


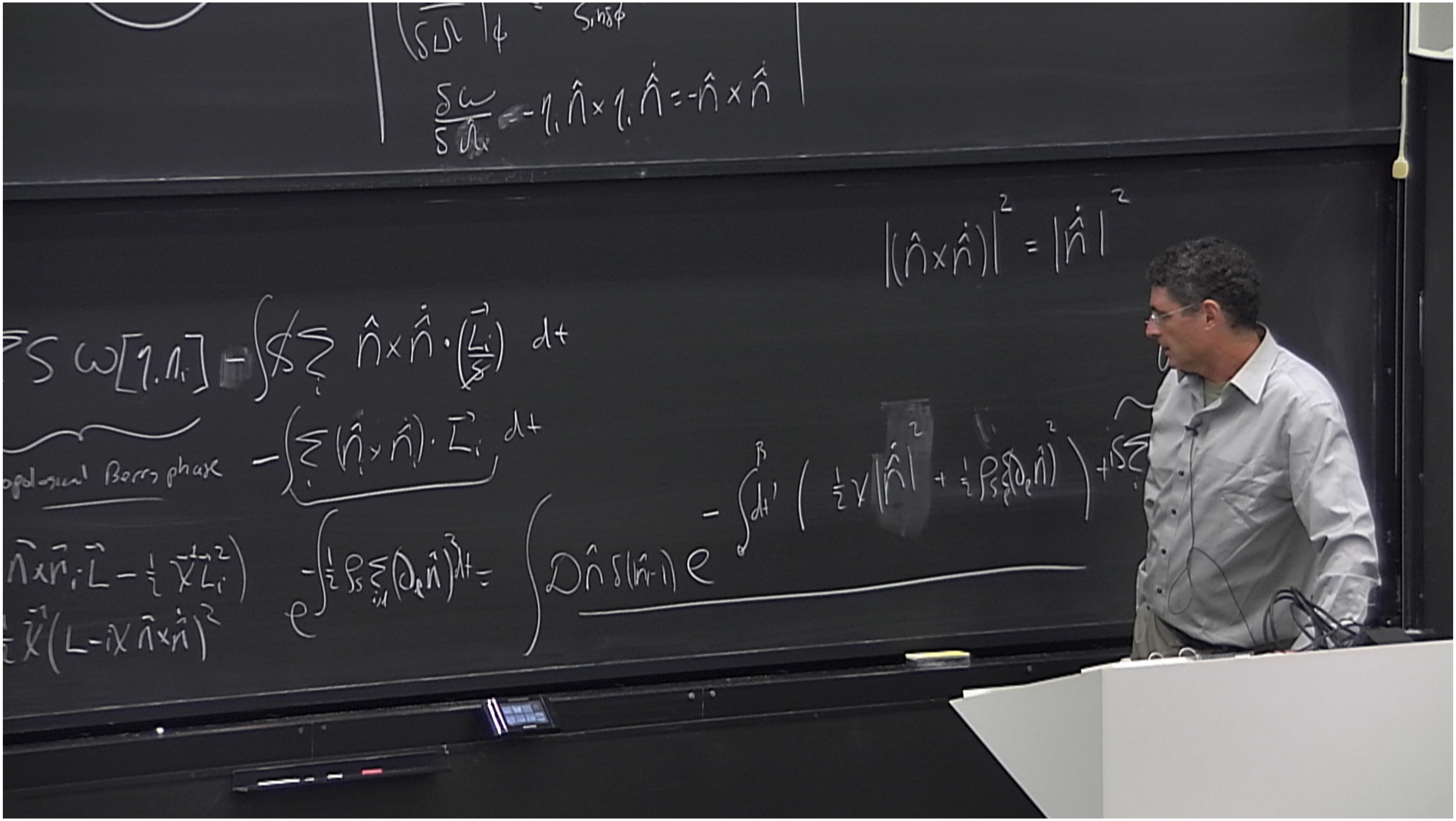


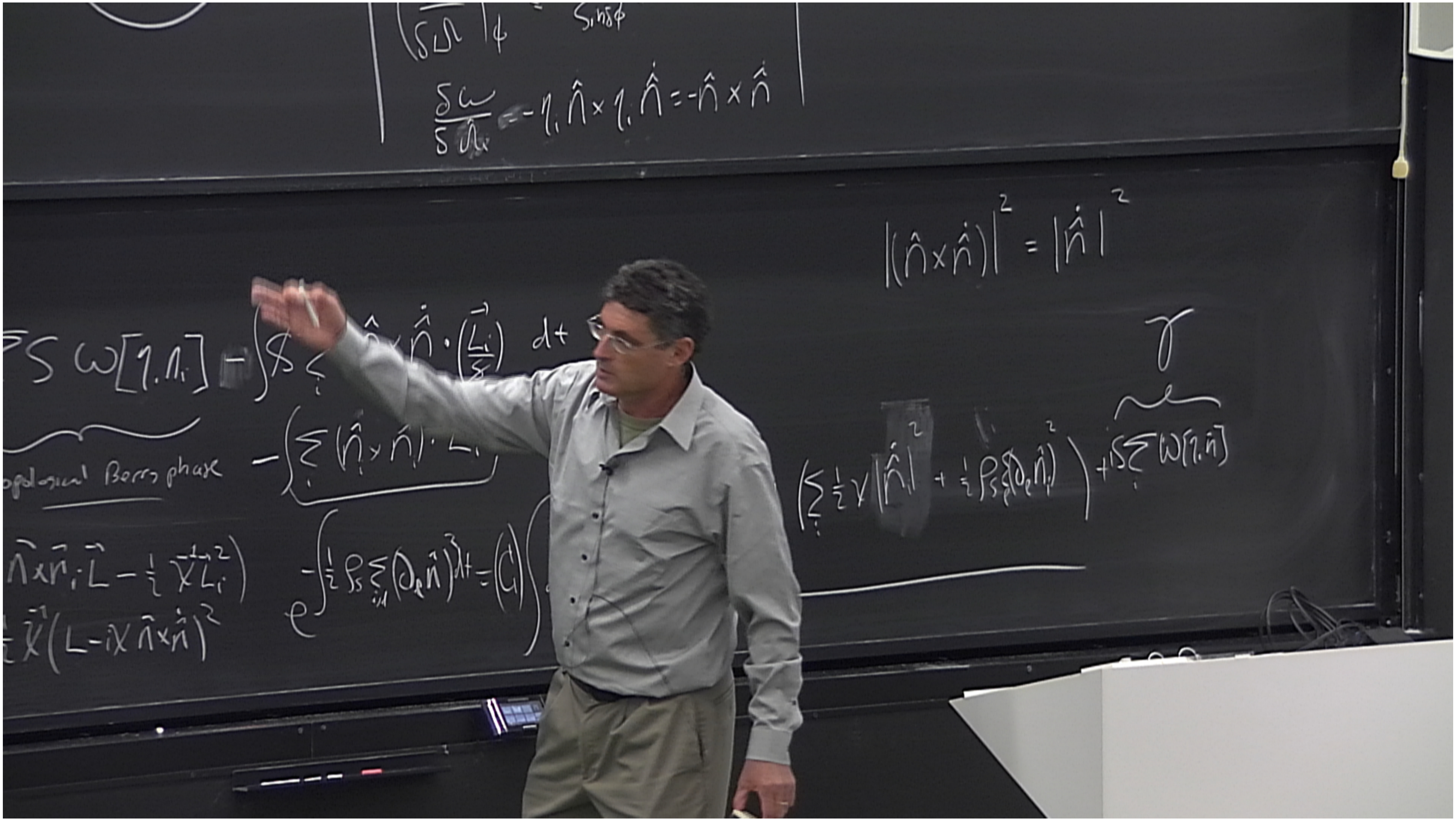

Field theory for the Quantum AFM (non-linear sigma model) (O(3))
classical energy (constant)
O constant
cancel by summation (symmetry)
small
AFM correlation

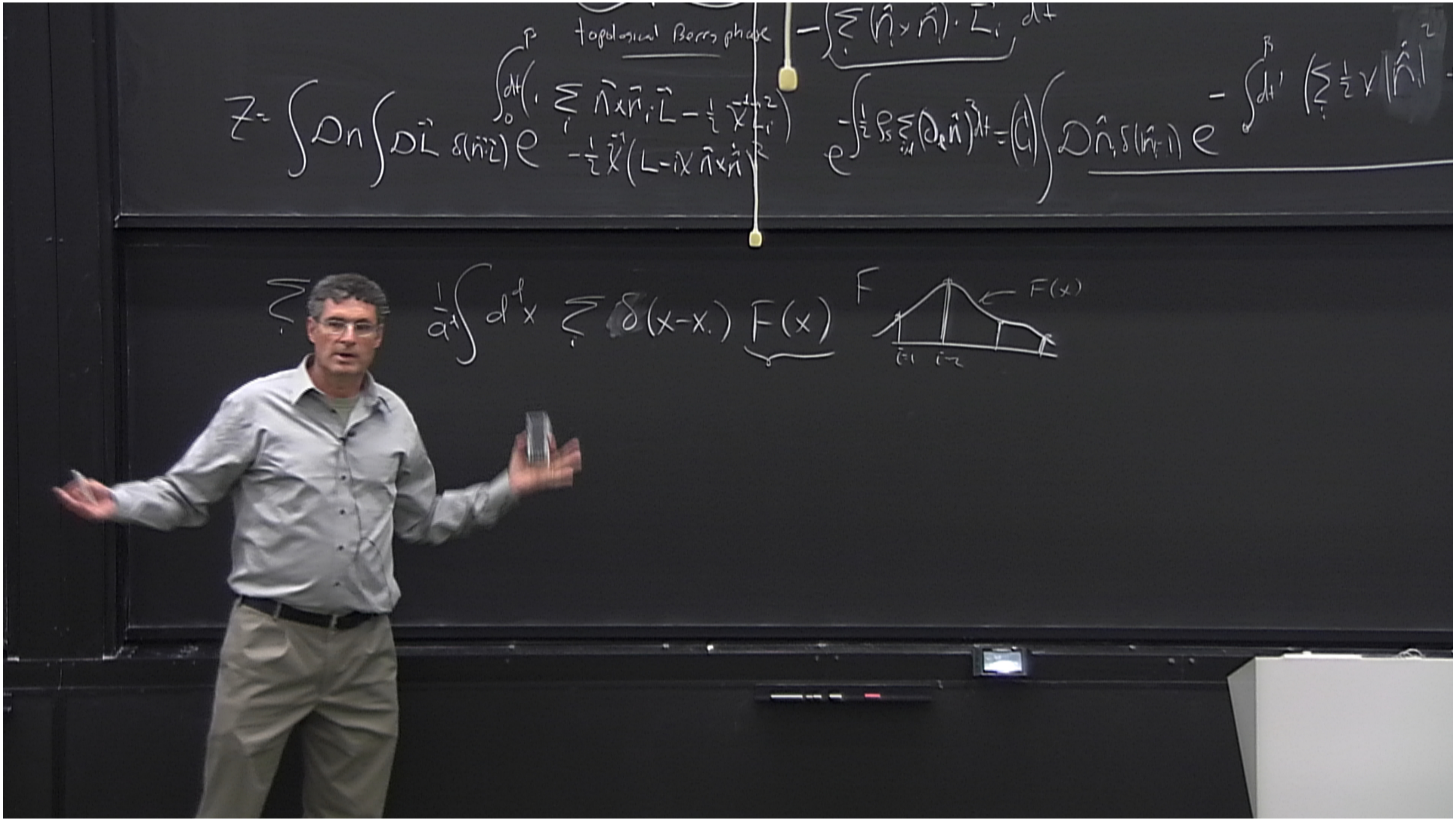

topological Berry phase

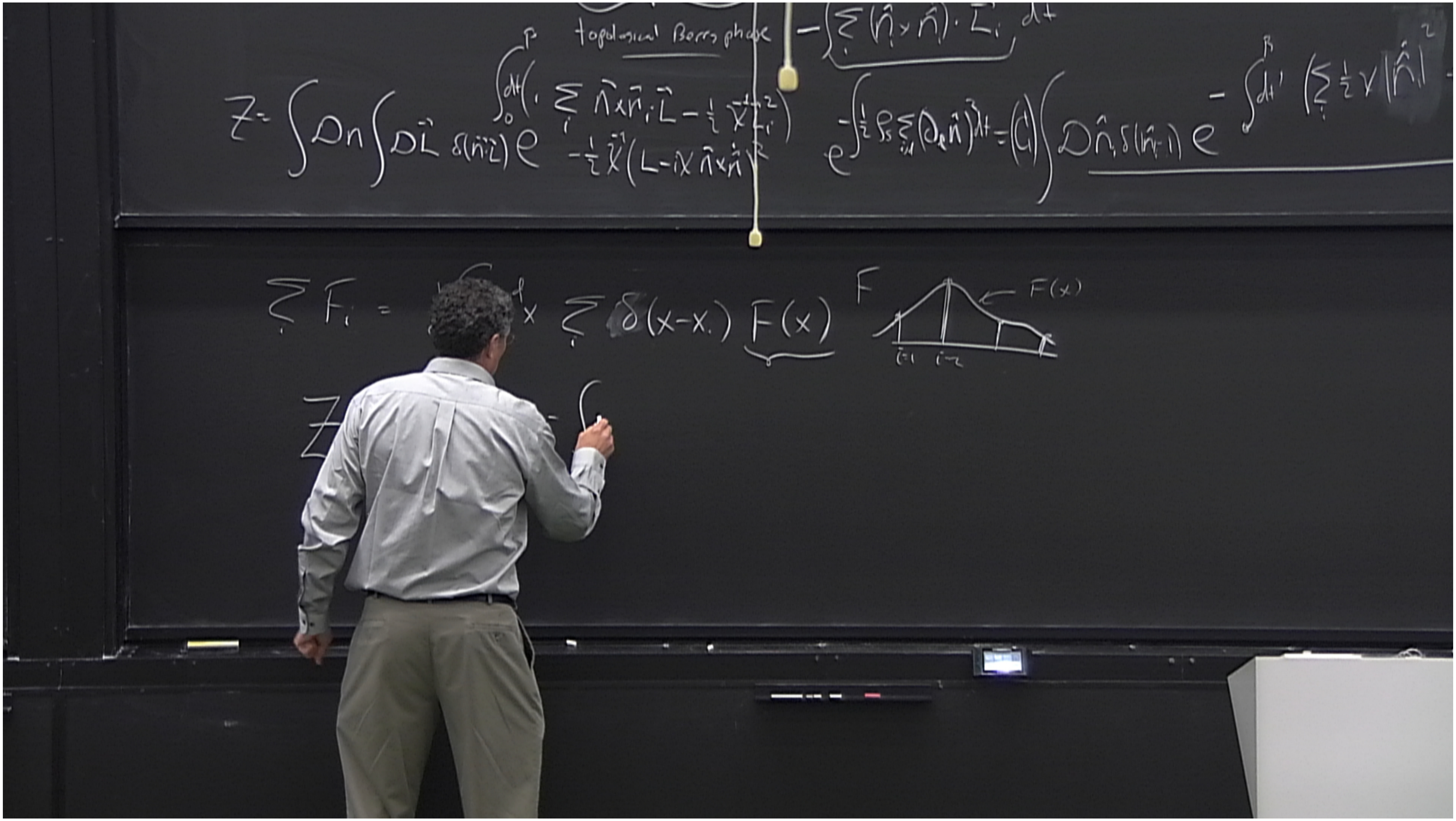

topological Berry phase

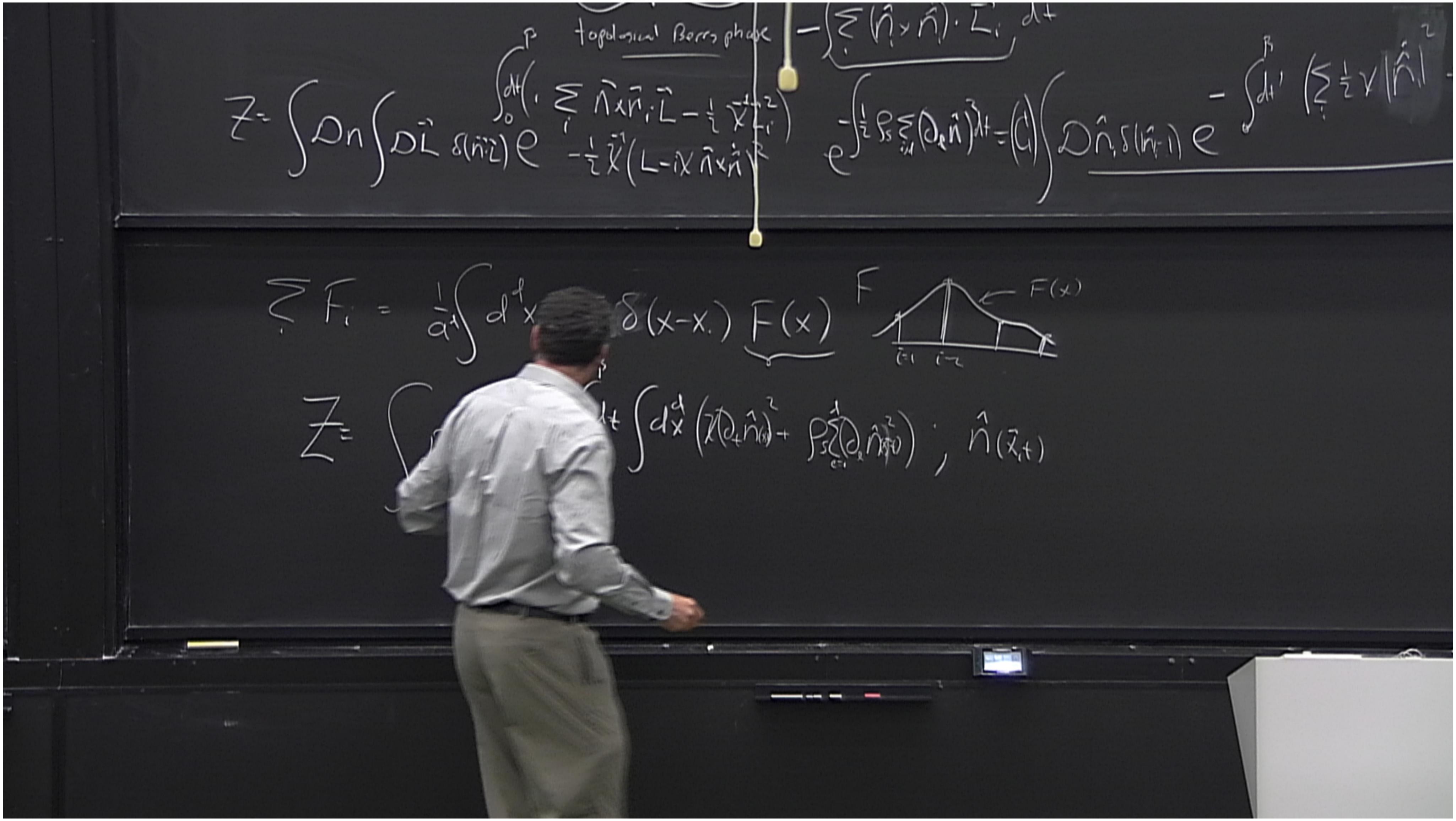

topological Berry phase

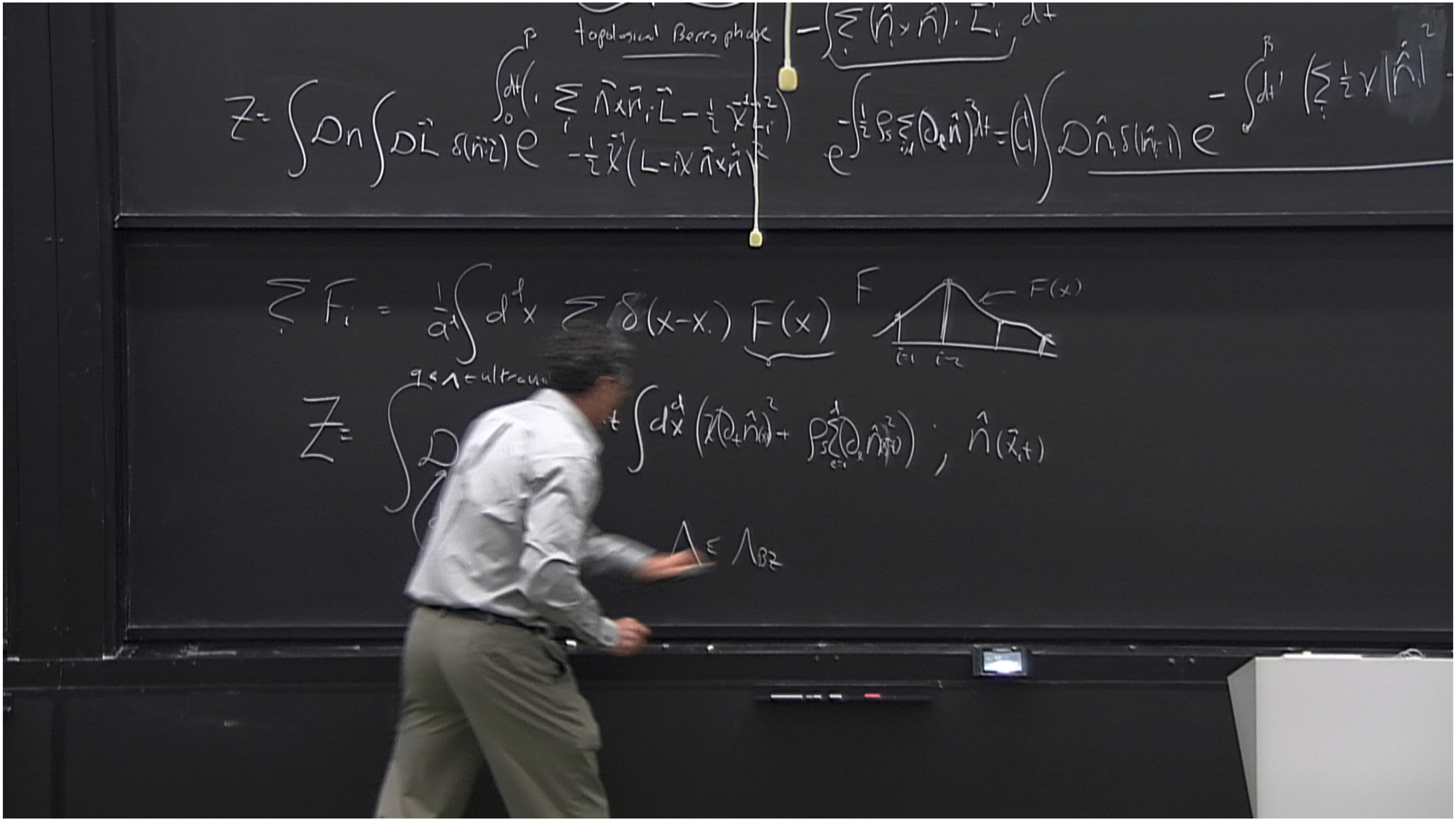

Berry phase

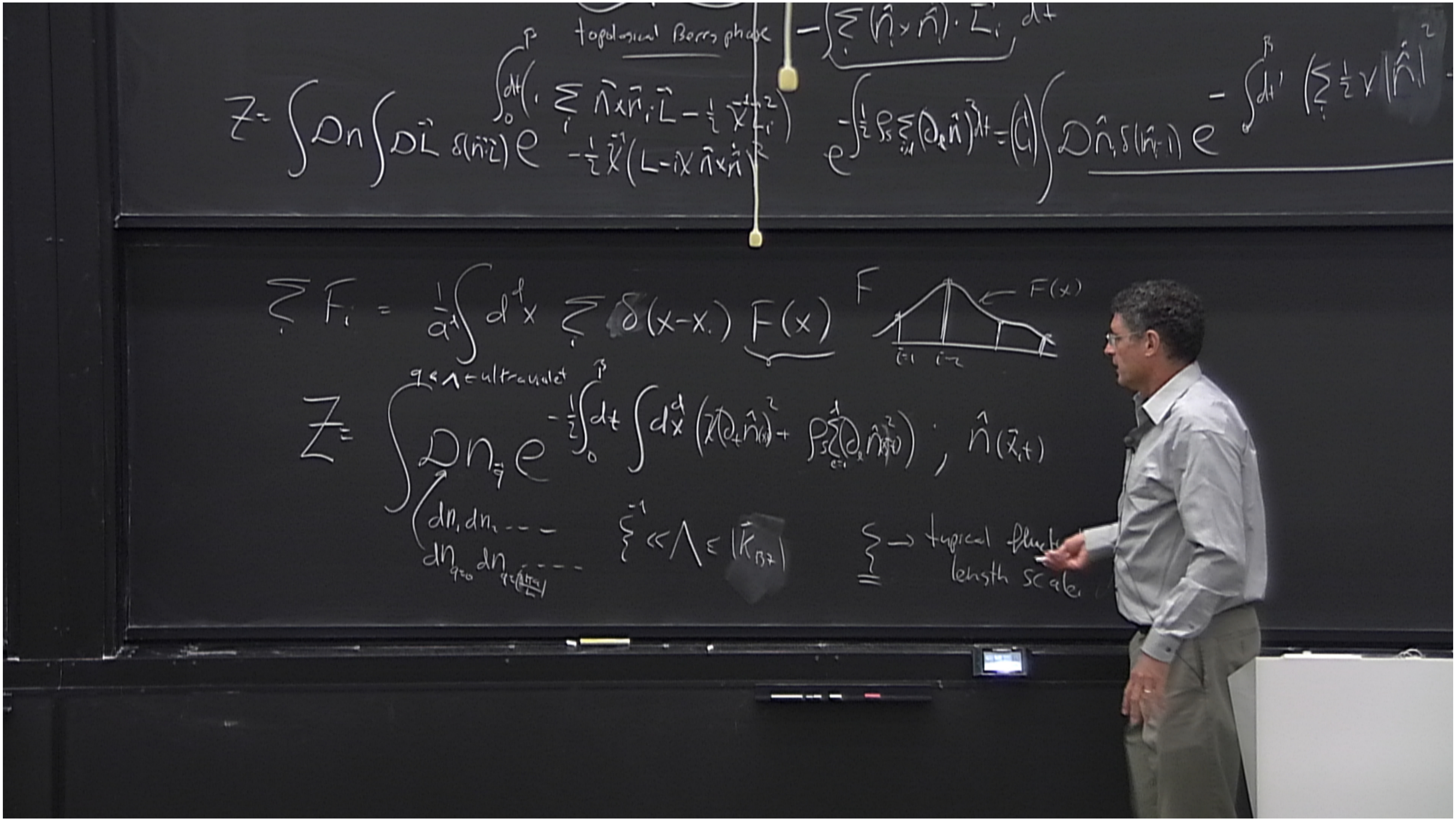

$\frac{\delta \omega}{\delta \hat{n}_i} = -\eta_i \hat{n} \times \eta_i \dot{\hat{n}} = -\hat{n} \times \dot{\hat{n}}$
$|(\hat{n} \times \dot{\hat{n}})|^2 = |\dot{\hat{n}}|^2$
Berry phase

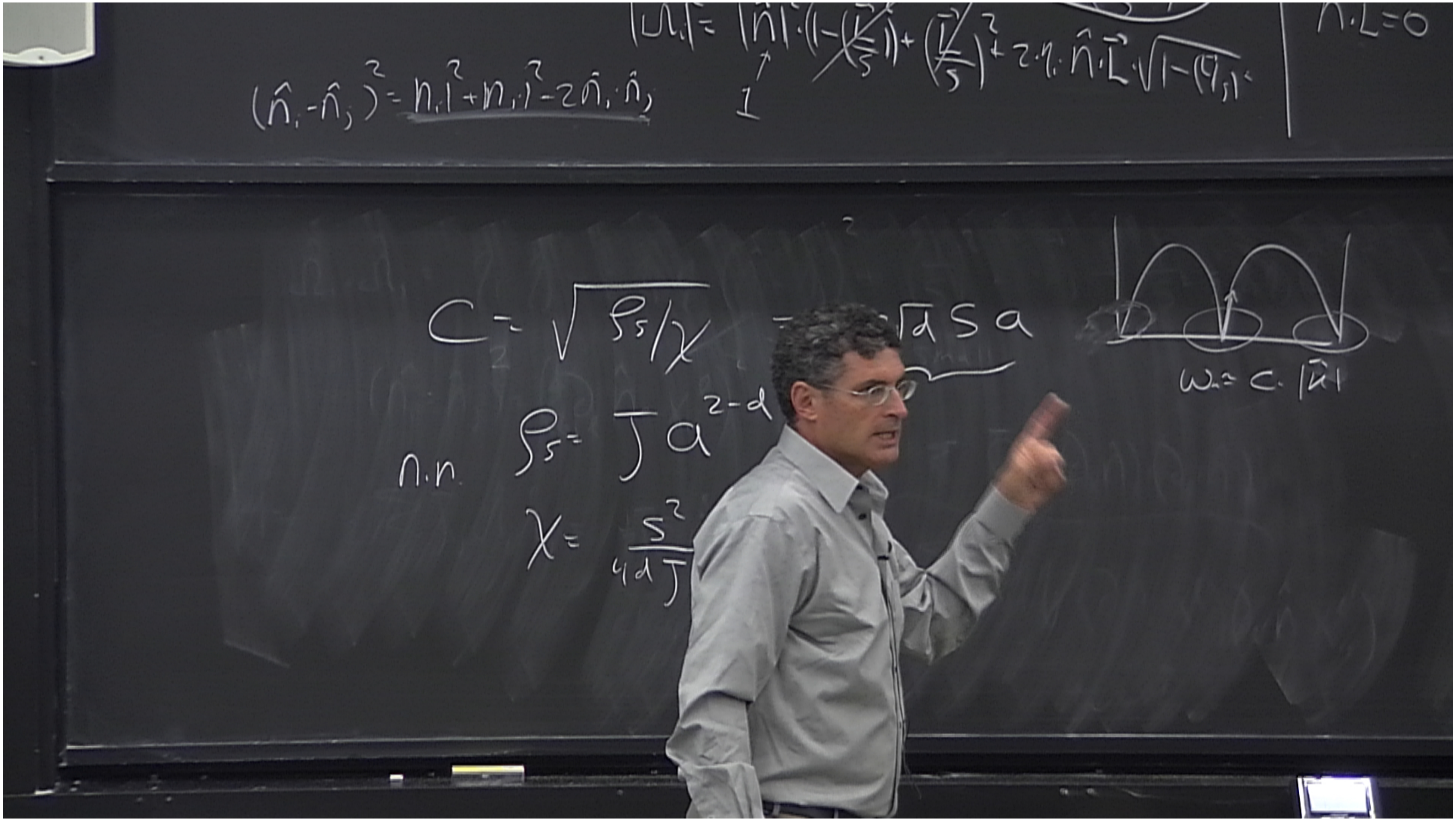

topological Berry phase
F(x)

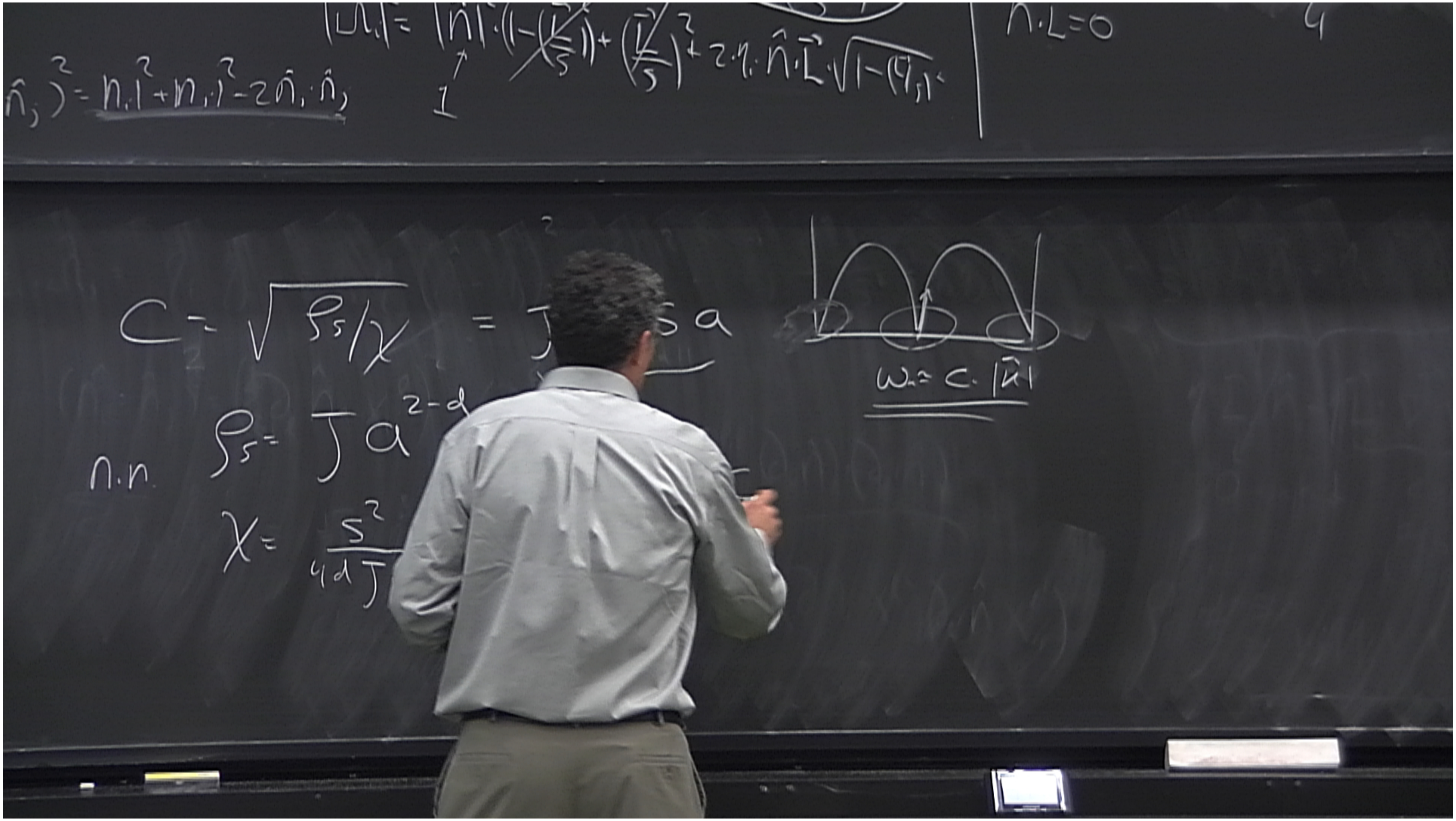



topological Berry phase
F(x)

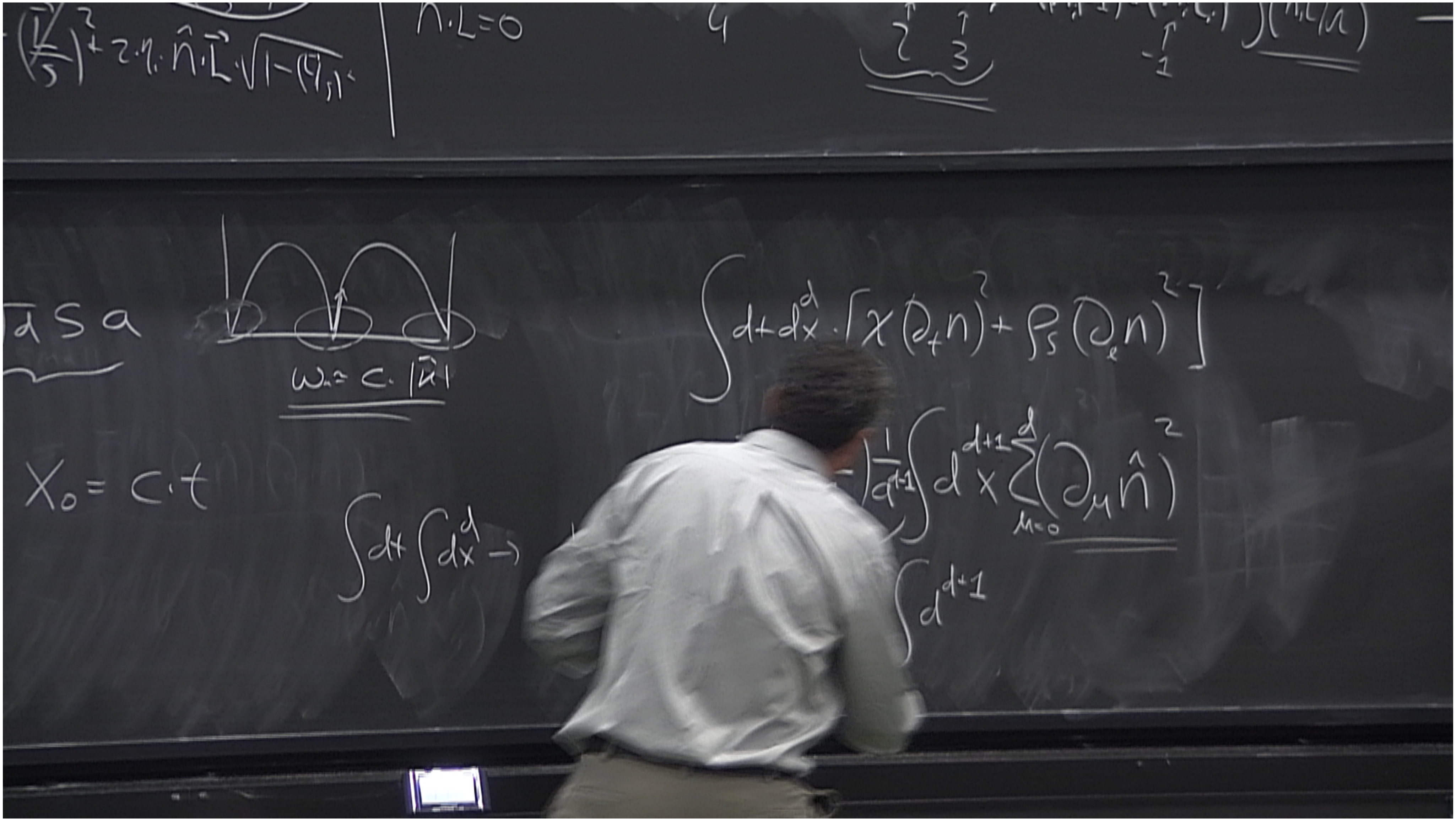

topological Berry phase
F(x)

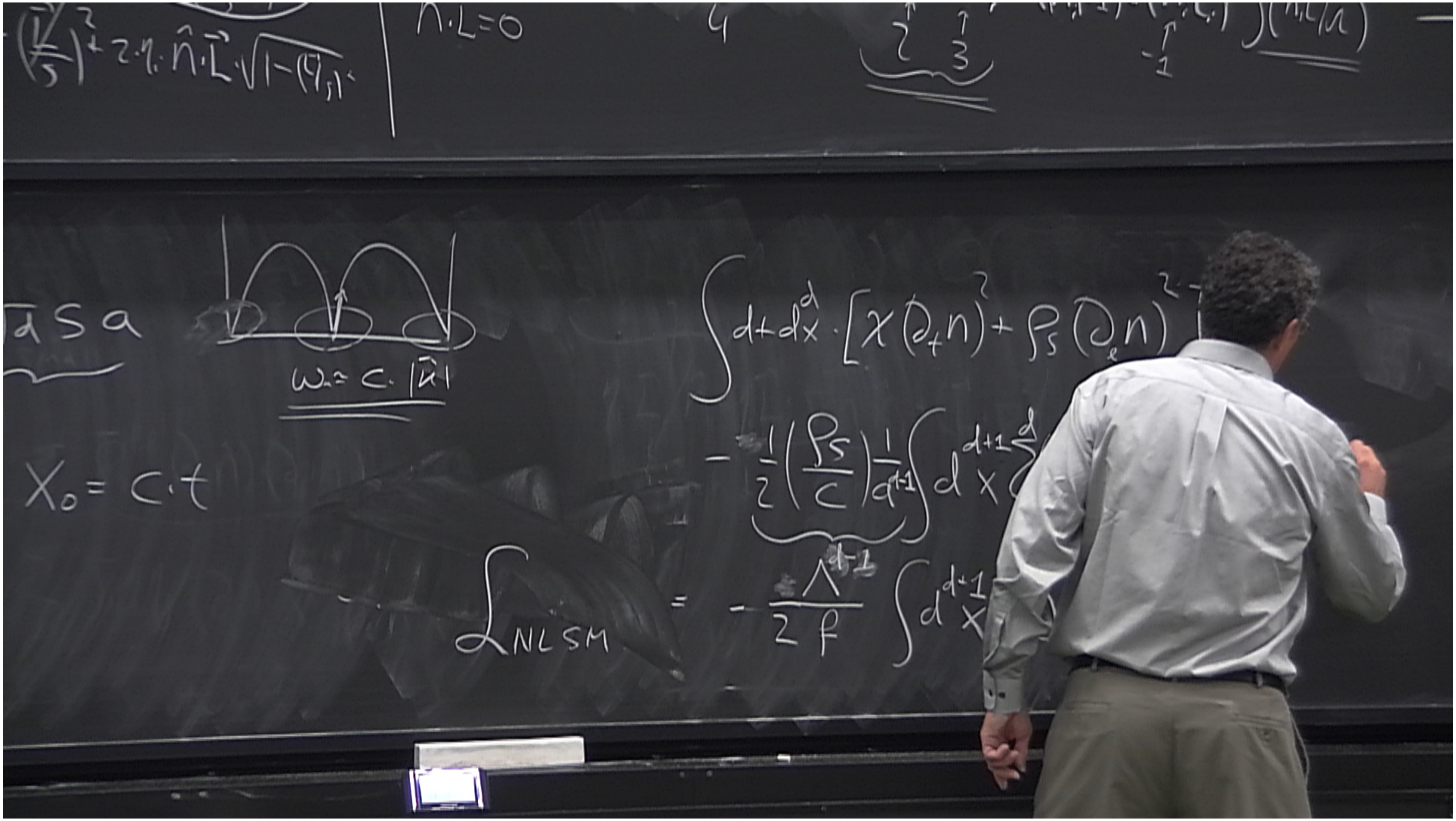

topological Berry phase
ultraviolet
F(x)
typical
length scale

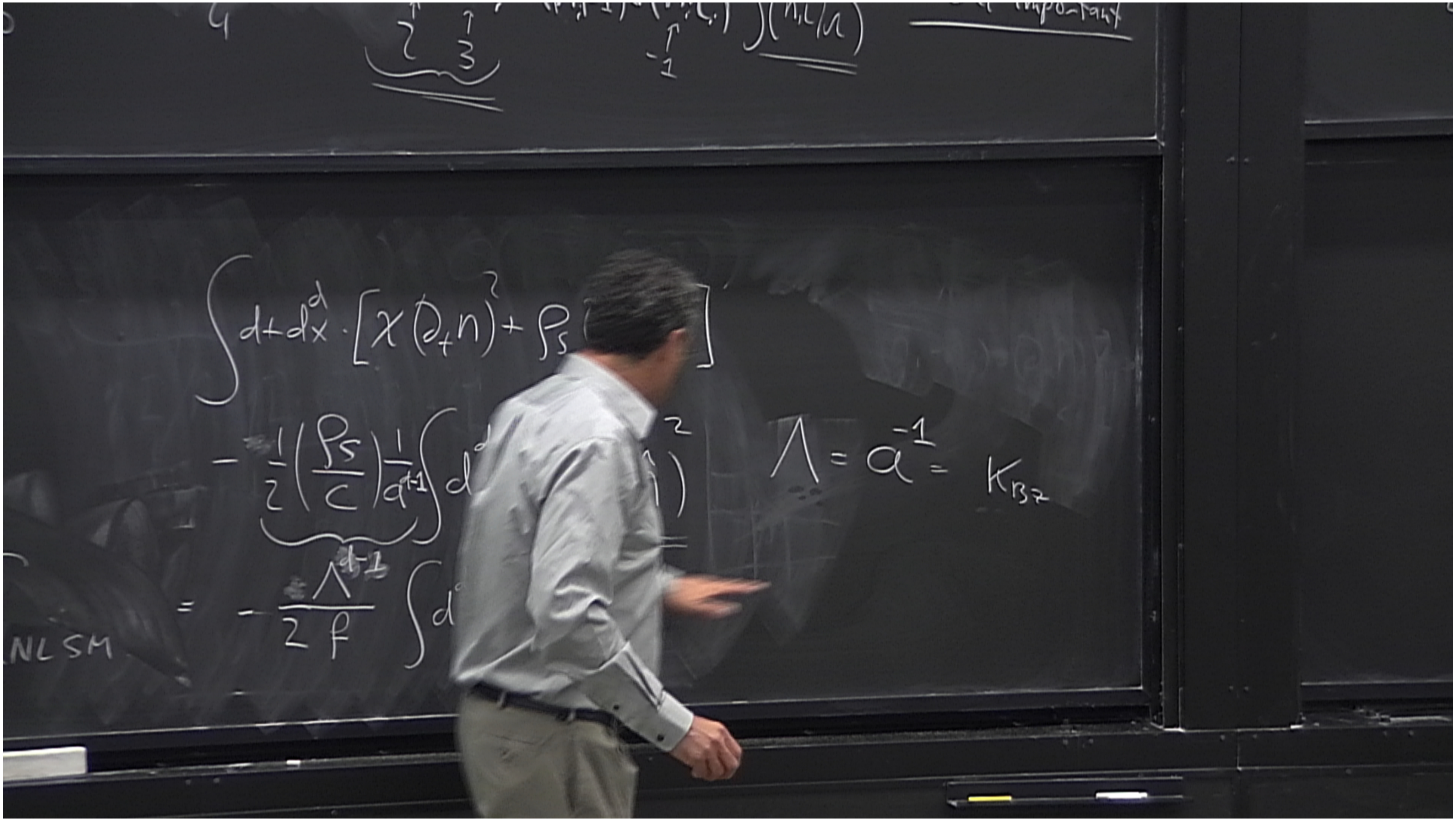

n·L=0
n·n
ω = c·|k|

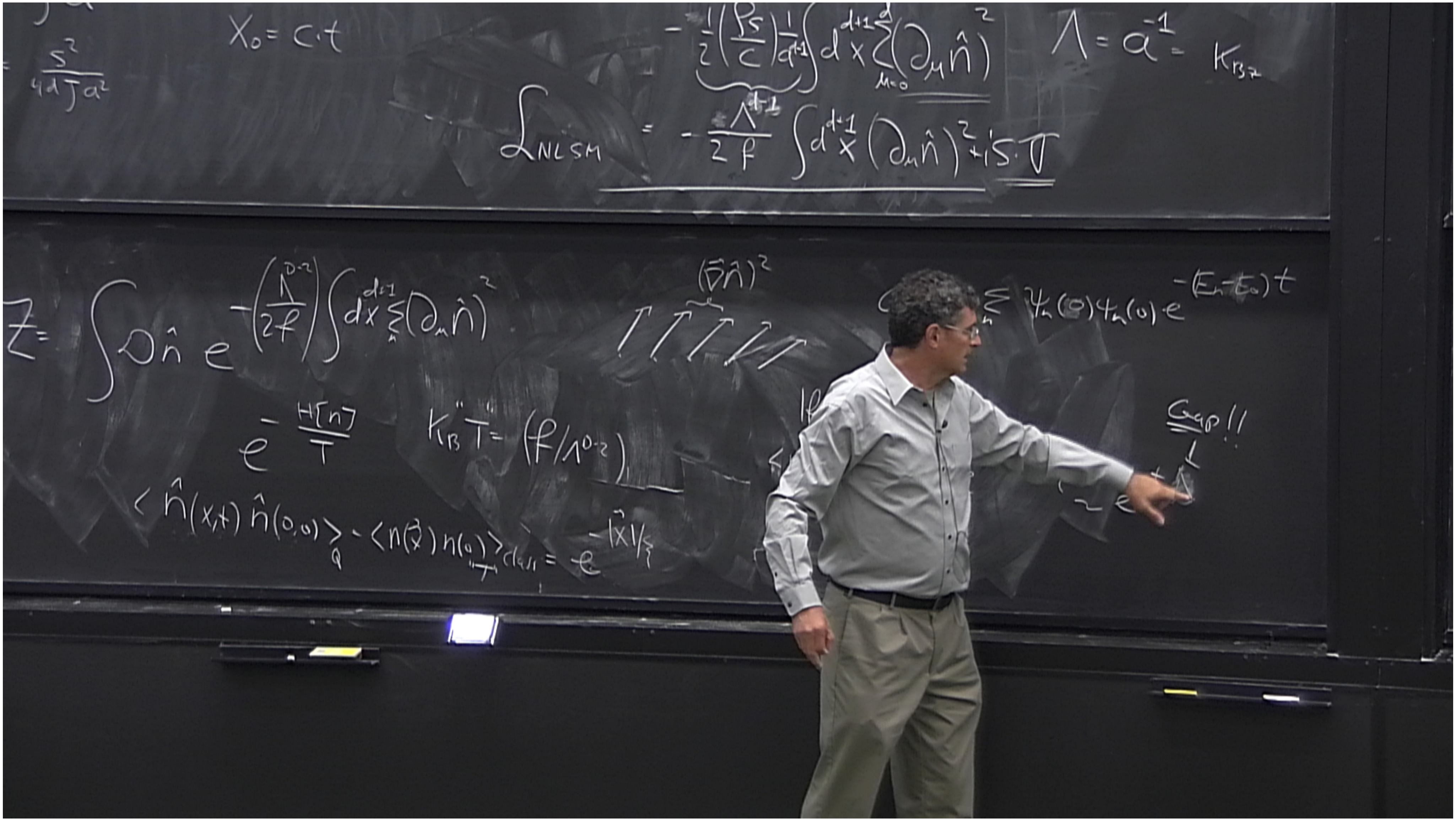

n·L=0
ω = c·|k|
n.n.
ρs = J a^(2-d)
χ = s² / 4dJ

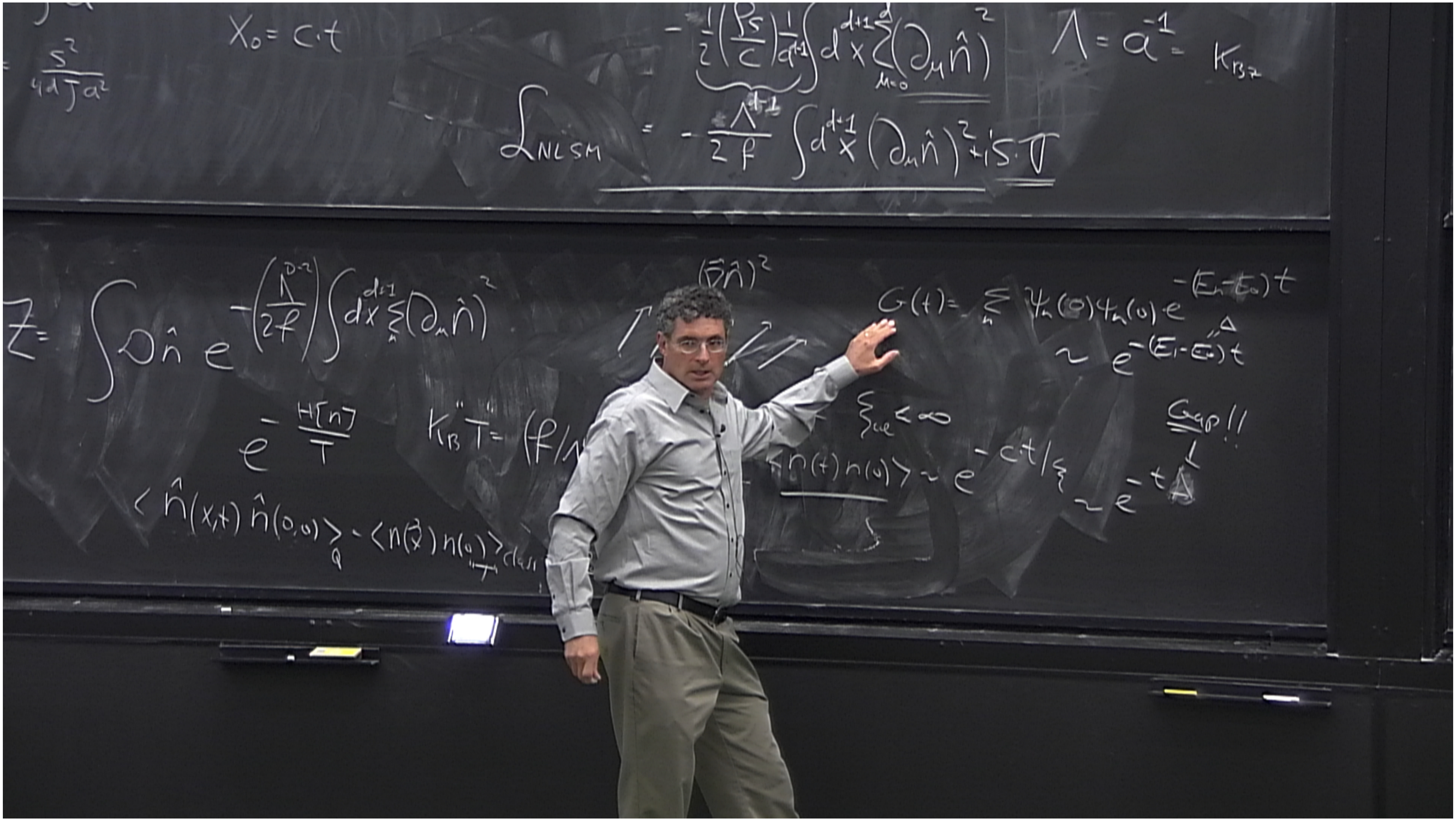

n·L=0
J 2√d S a
X₀ = c·t


n·L=0
X0 = c·t


n·L=0
X0 = c·t
LNLSM


NLSM
Λ = a⁻¹ = K


X₀ = c·t
Gap!!


X₀ = c·t
Λ = a⁻¹
L NLSM
G(t) =
Gap!!