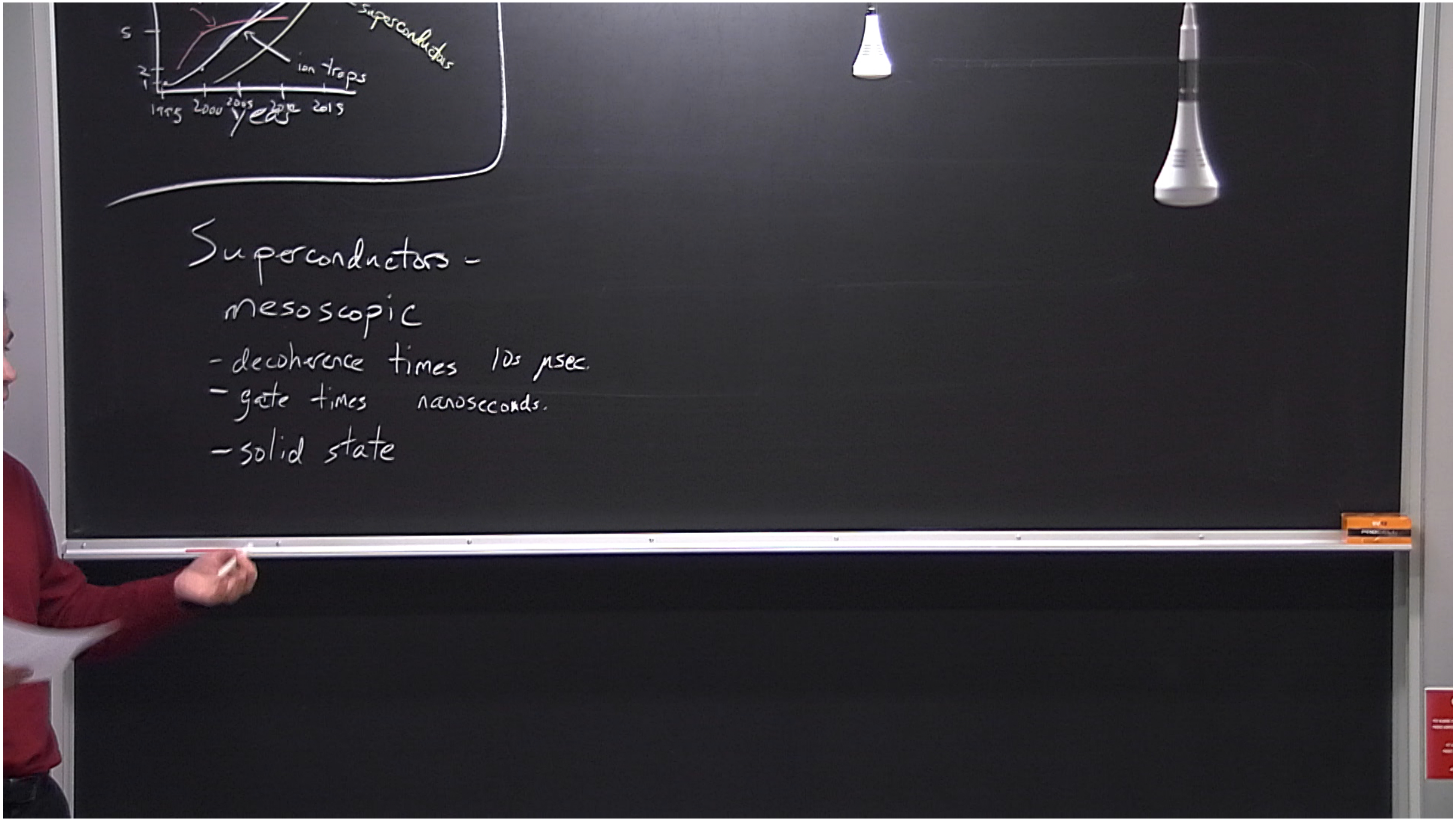
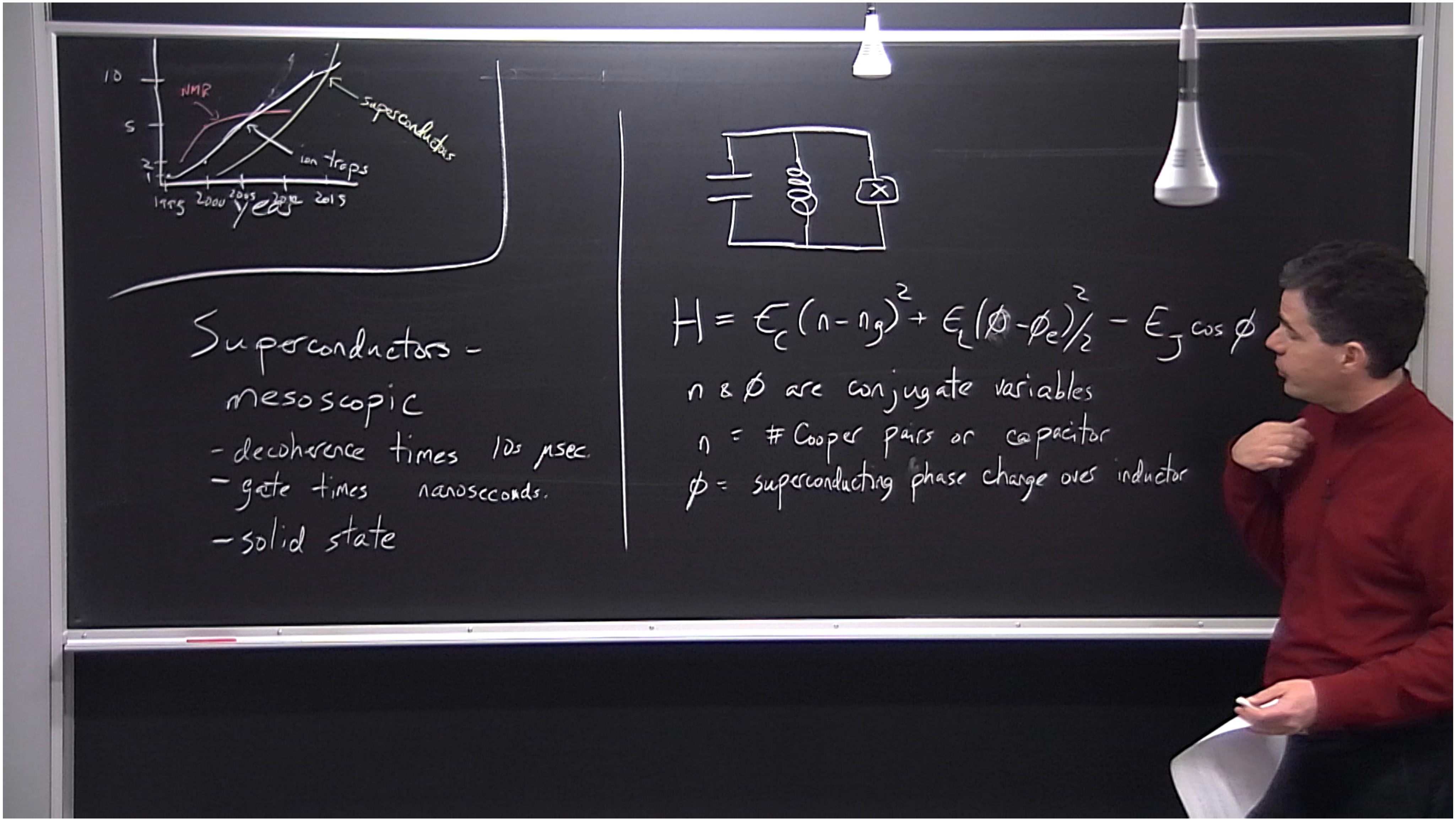
Title: PSI 17/18 - Quantum Information - Lecture 4

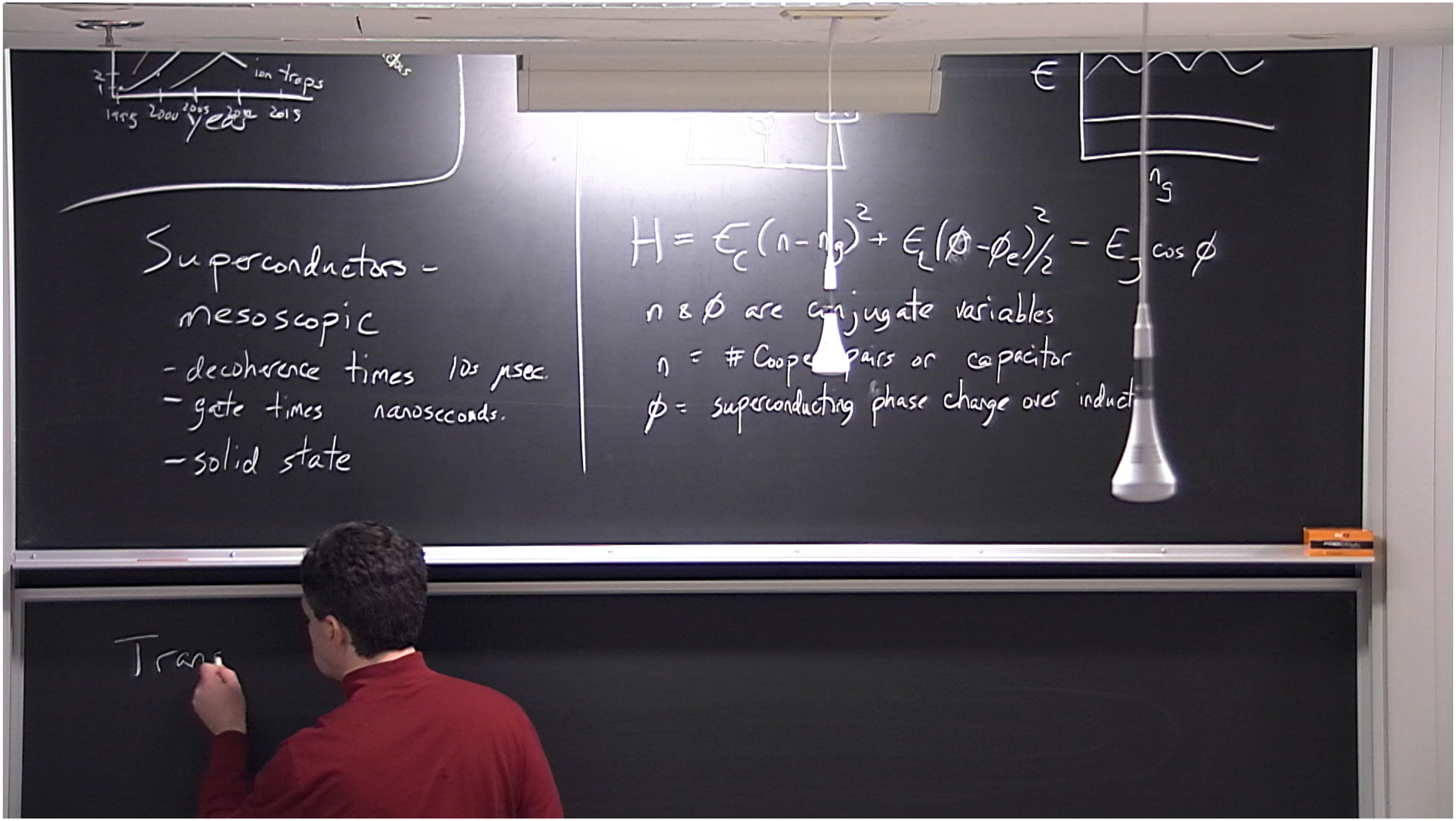
Date: Feb 23, 2018 11:30 AM

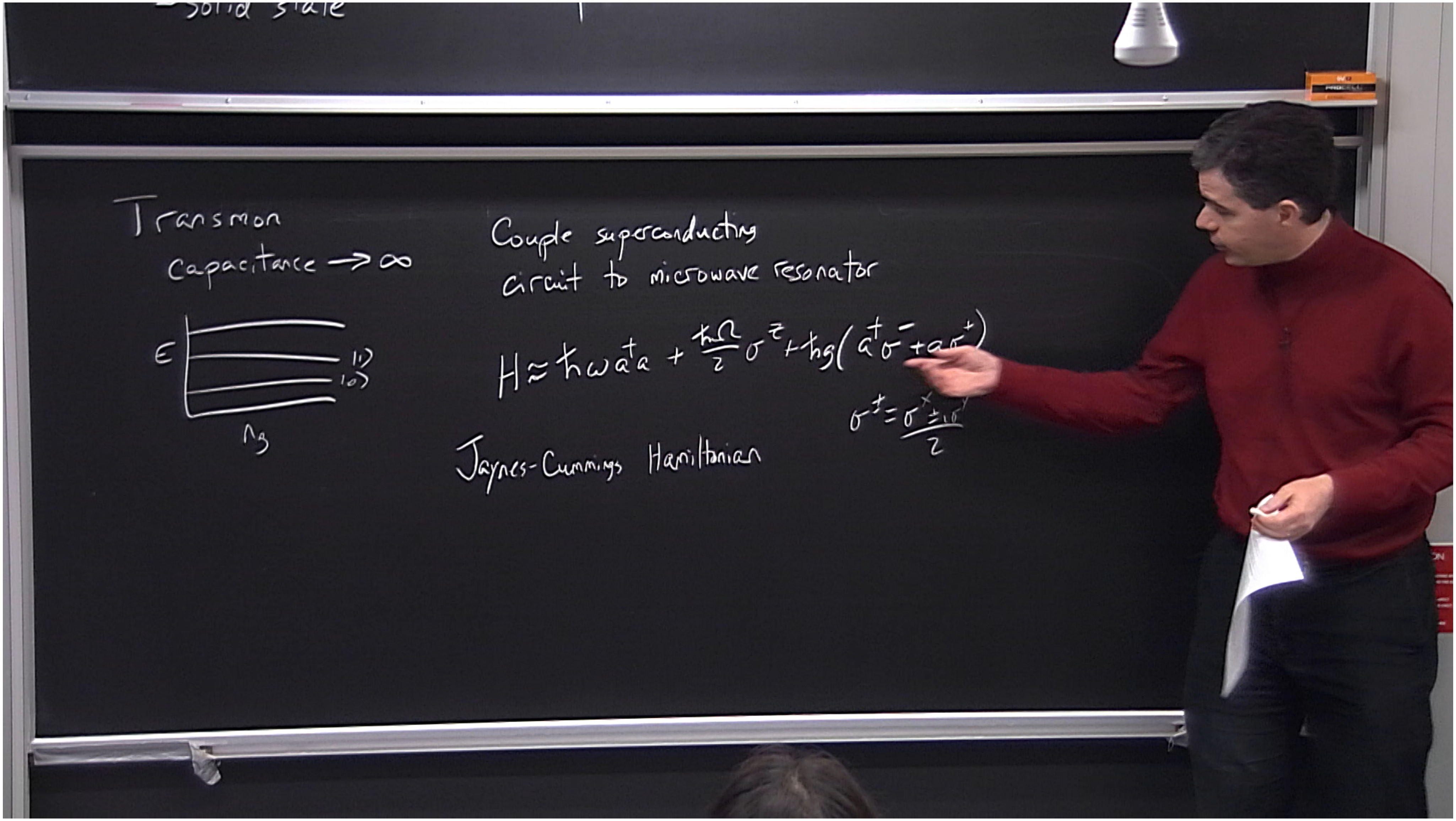
URL: http://pirsa.org/18020047

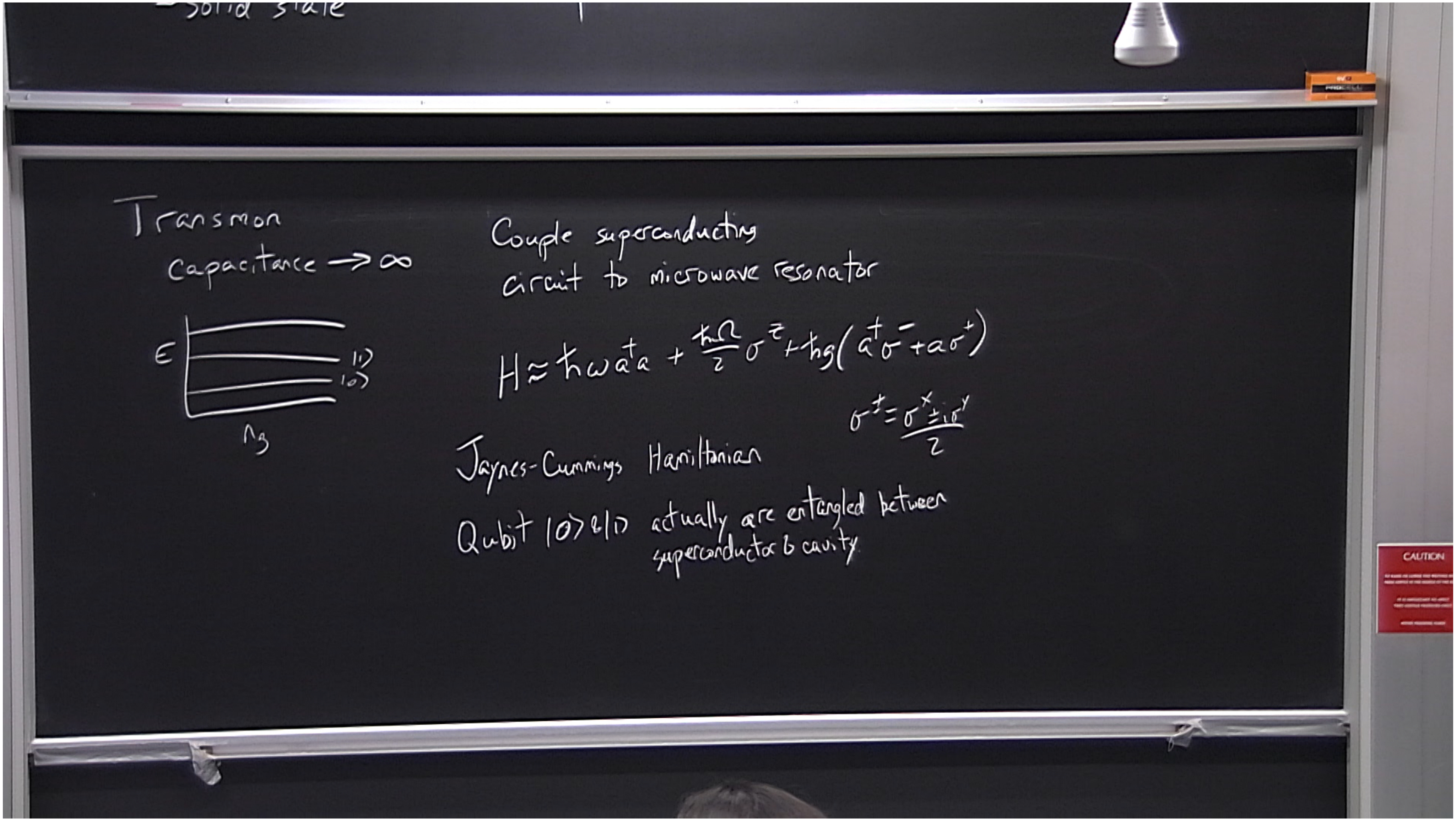
Abstract:


Superconductors
ion traps
1995 2000 2005 2015
years
Superconductors -
mesoscopic
- decoherence times 10s μsec.
- gate times nanoseconds.
- solid state


10
NMR
5
2
1
1995
2000
2005
2010
2015
years
superconductors
ion traps
Superconductors -
mesoscopic
- decoherence times 10s μsec.
- gate times nanoseconds.
- solid state
H = E_C (n - n_g)^2 + E_L (φ - φ_e)^2/2 - E_J cos φ
n & φ are conjugate variables
n = # Cooper pairs on capacitor
φ = superconducting phase change over inductor


ion traps
1995 2000 2005 2010 2015
years
Superconductors -
mesoscopic
- decoherence times 10s μsec
- gate times nanoseconds.
- solid state
ε
n_g
$H = E_C (n - n_g)^2 + E_L (\phi - \phi_e)^2/2 - E_J \cos\phi$
n & φ are conjugate variables
n = # Cooper pairs on capacitor
φ = superconducting phase change over induct
Tran


solid state
Transmon
capacitance → ∞
E
|1⟩
|0⟩
n_g
Couple superconducting circuit to microwave resonator
H ≈ ħωa†a + (ħΩ/2)σ^z + ħg(a†σ⁻ + aσ⁺)
σ^± = (σ^x ± iσ^y)/2
Jaynes-Cummings Hamiltonian


Transmon
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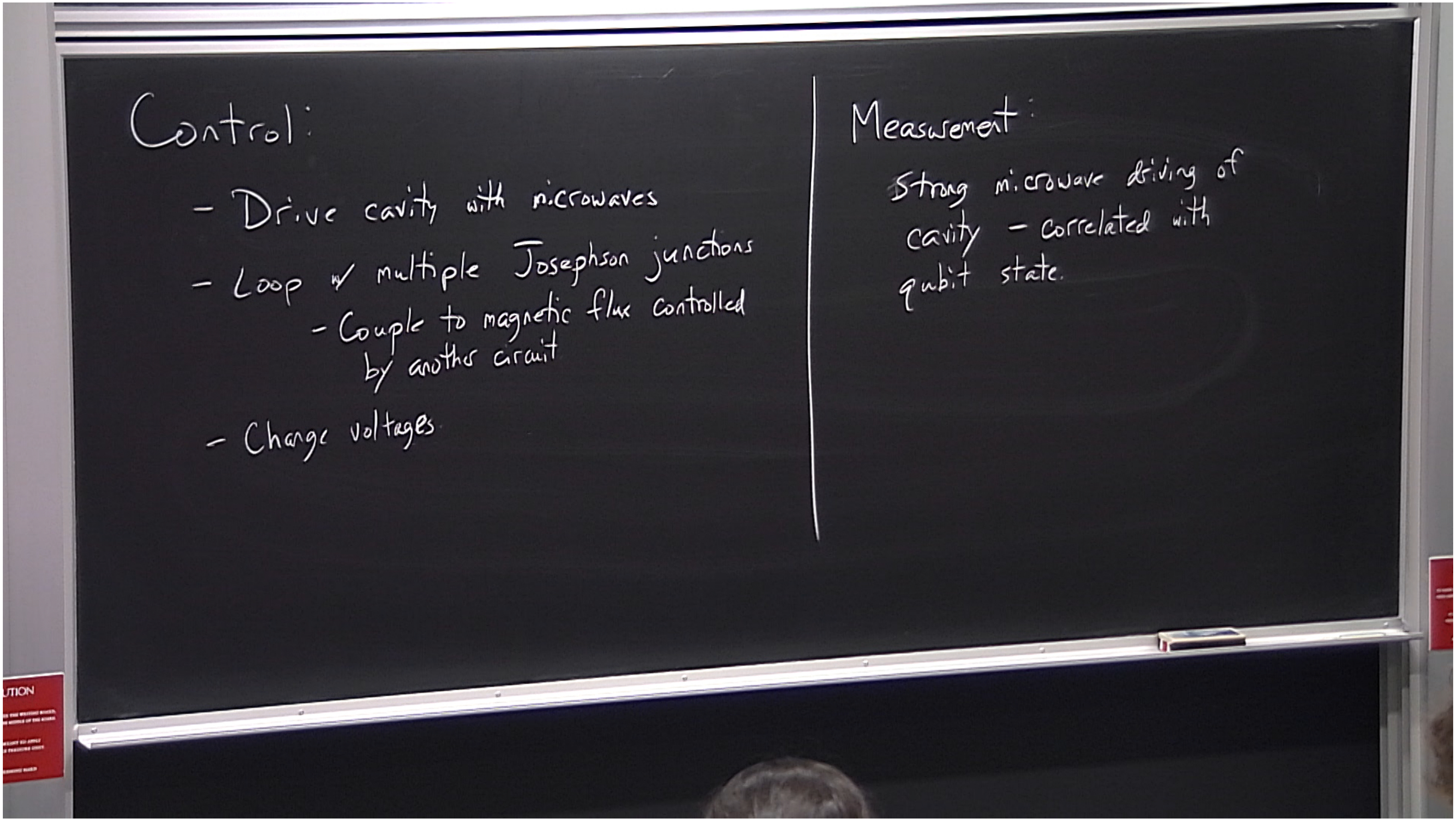
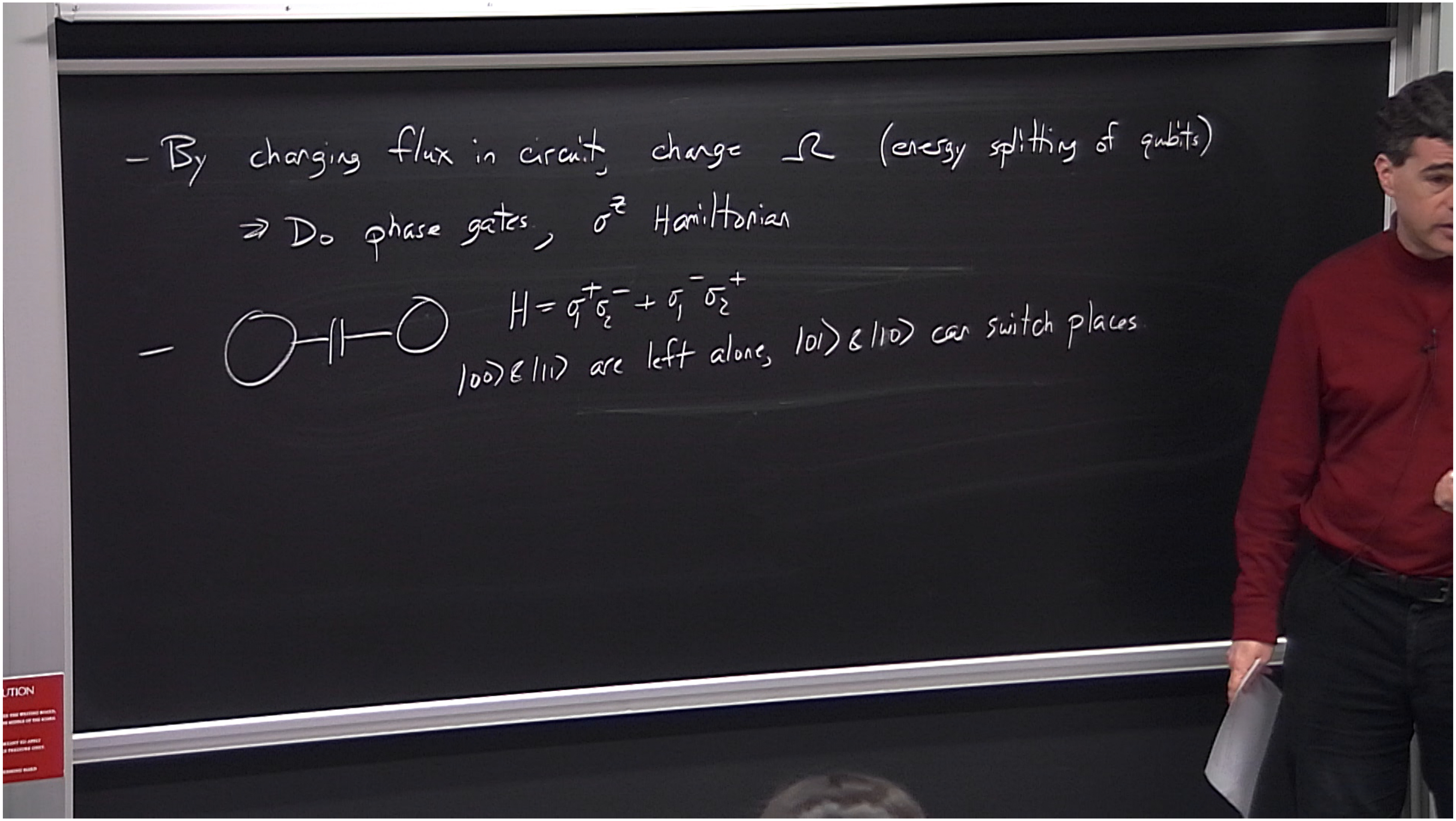
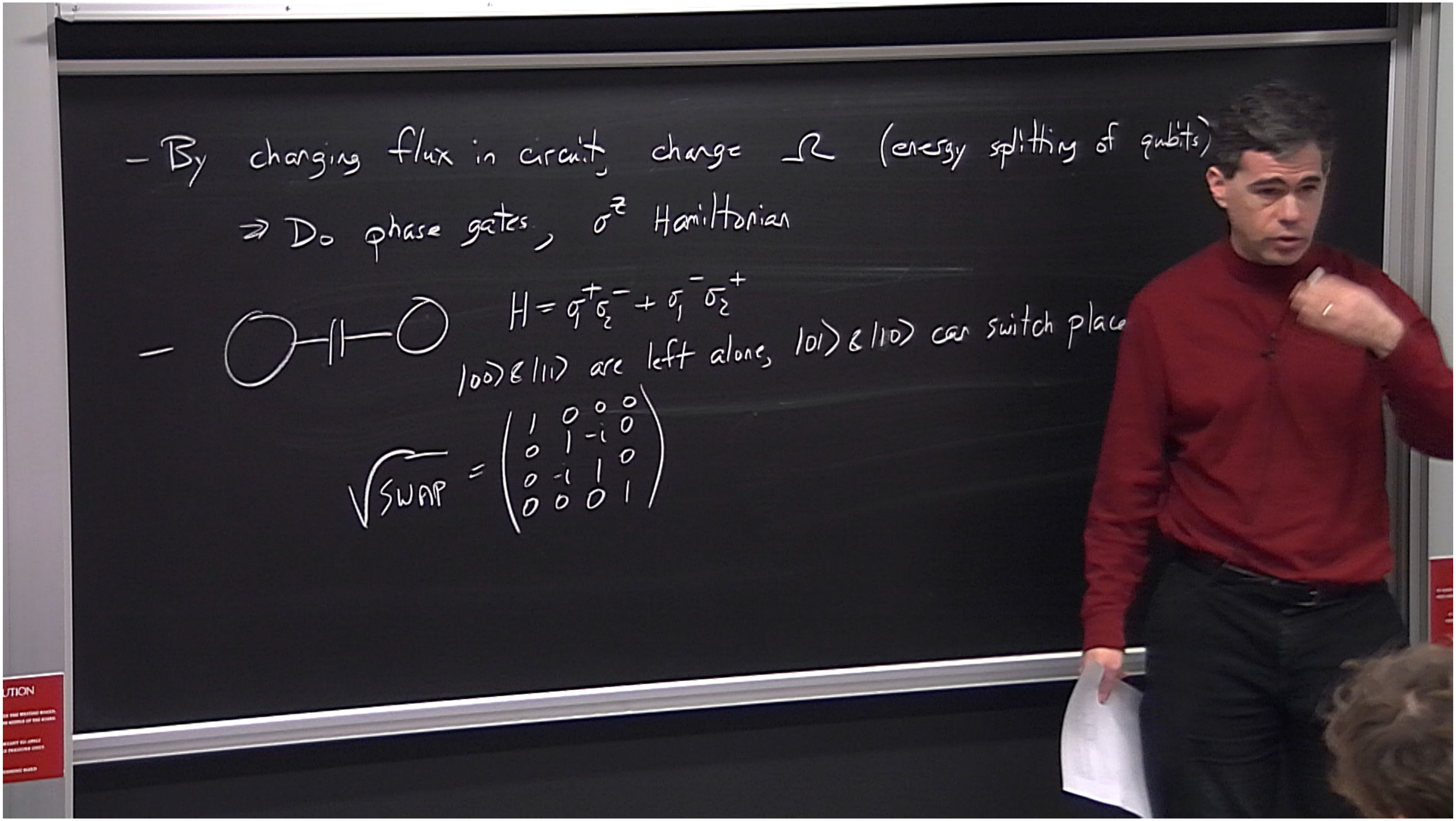
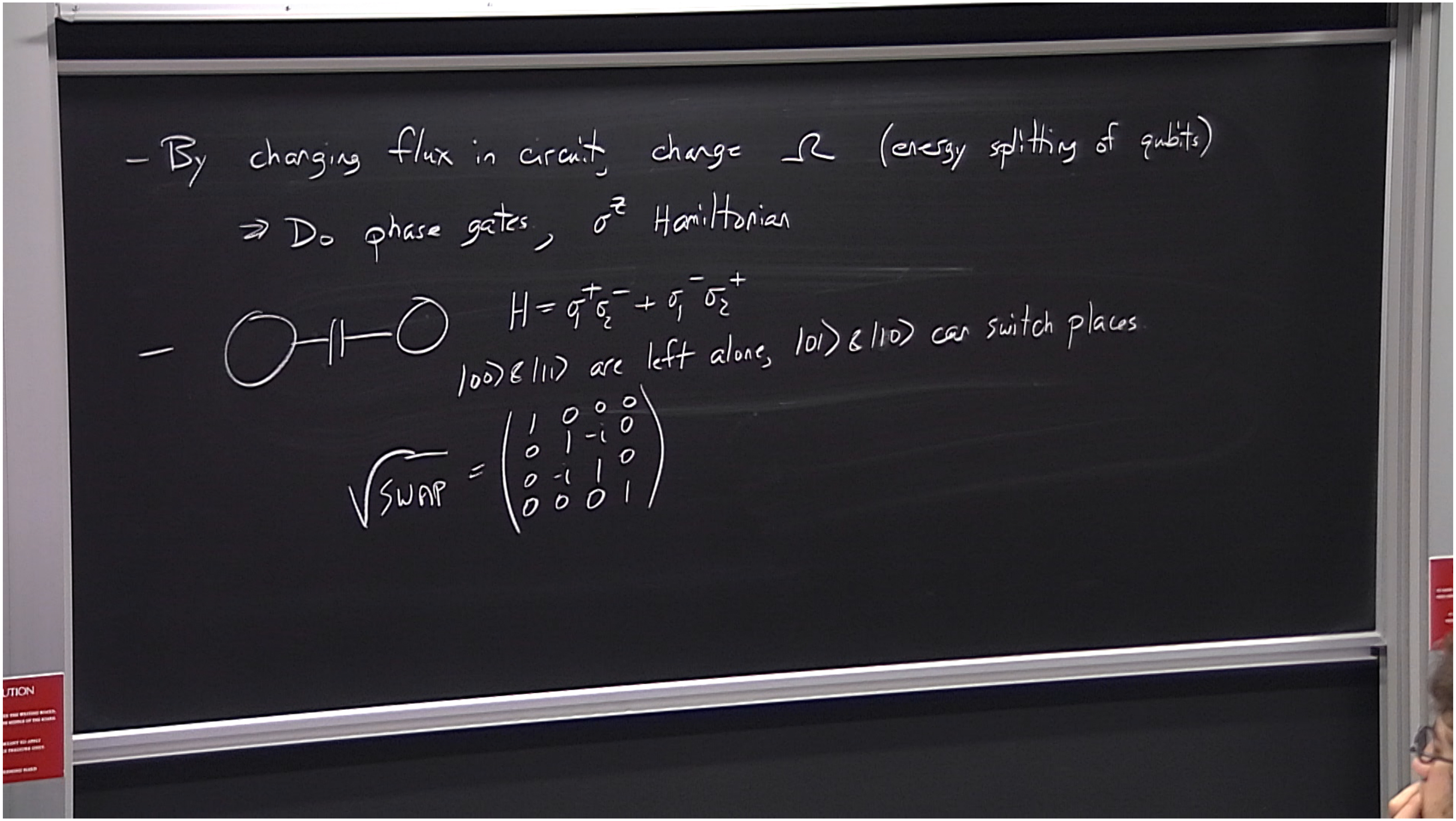
Jaynes-Cummings Hamiltonian
Qubit |0⟩ & |1⟩ actually are entangled between superconductor & cavity

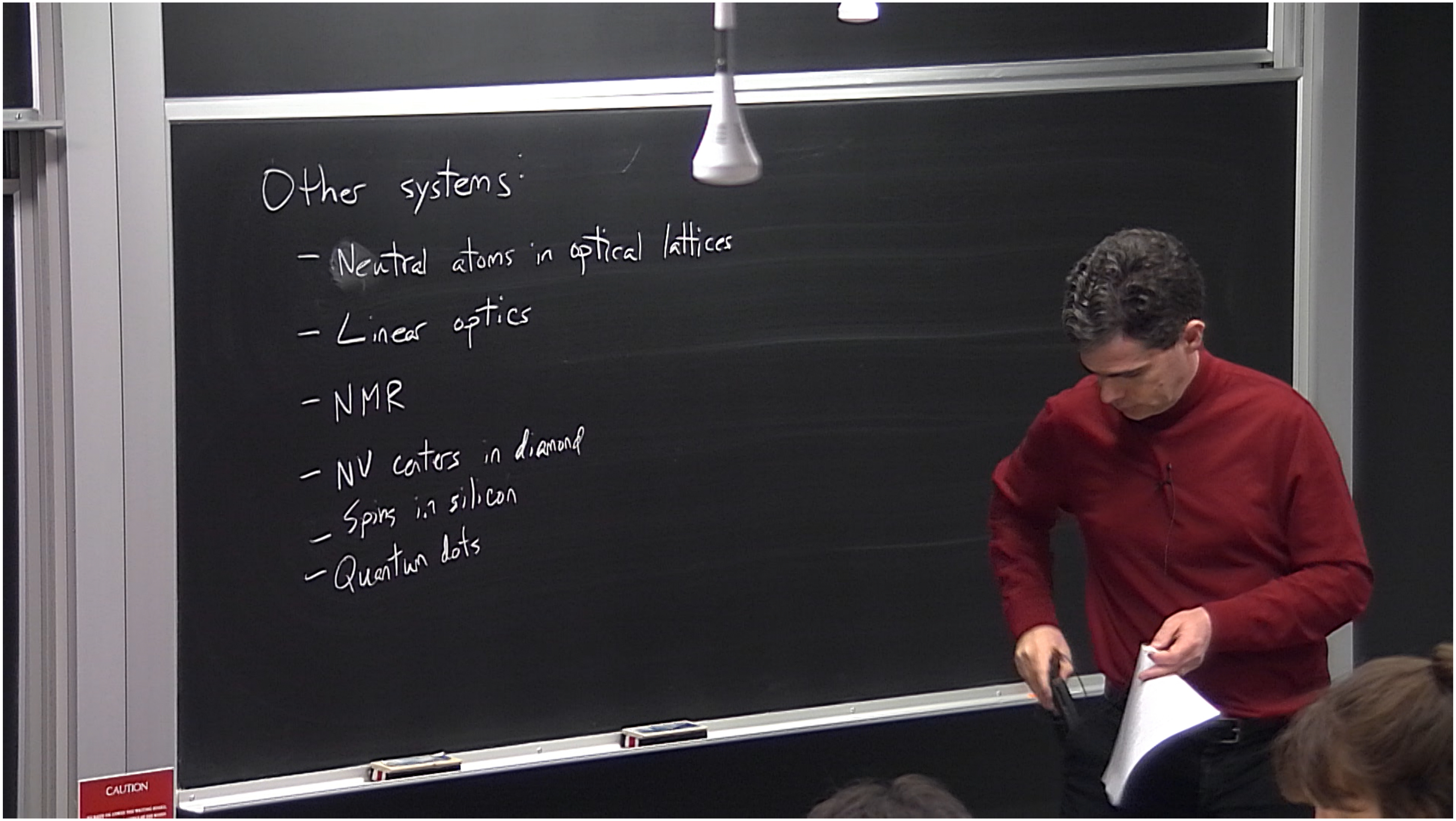

Control:
- Drive cavity with microwaves
- Loop w/ multiple Josephson junctions
- Couple to magnetic flux controlled by another circuit
- Charge voltages
Measurement:
Strong microwave driving of cavity - correlated with qubit state.


- By changing flux in circuit, change Ω (energy splitting of qubits)
⇒ Do phase gates, σ^z Hamiltonian
H = σ1^+ σ2^- + σ1^- σ2^+
|01⟩ & |10⟩ can switch places
|00⟩ & |11⟩ are left alone,


– By changing flux in circuit, change Ω (energy splitting of qubits)
⇒ Do phase gates, σ^z Hamiltonian
H = σ_1^+ σ_2^- + σ_1^- σ_2^+
|01⟩ & |10⟩ can switch place
|00⟩ & |11⟩ are left alone,
√SWAP = (1 0 0 0 / 0 1 -i 0 / 0 -i 1 0 / 0 0 0 1)
UTION



- By changing flux in circuit, change Ω (energy splitting of qubits)
⇒ Do phase gates, σ^z Hamiltonian
$H = \sigma_1^+ \sigma_2^- + \sigma_1^- \sigma_2^+$
|00⟩ & |11⟩ are left alone, |01⟩ & |10⟩ can switch places
$\sqrt{SWAP} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & -i & 0 \\ 0 & -i & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$


Other systems:
- Neutral atoms in optical lattices
- Linear optics
- NMR
- NV centers in diamond
- Spins in silicon
- Quantum dots
CAUTION