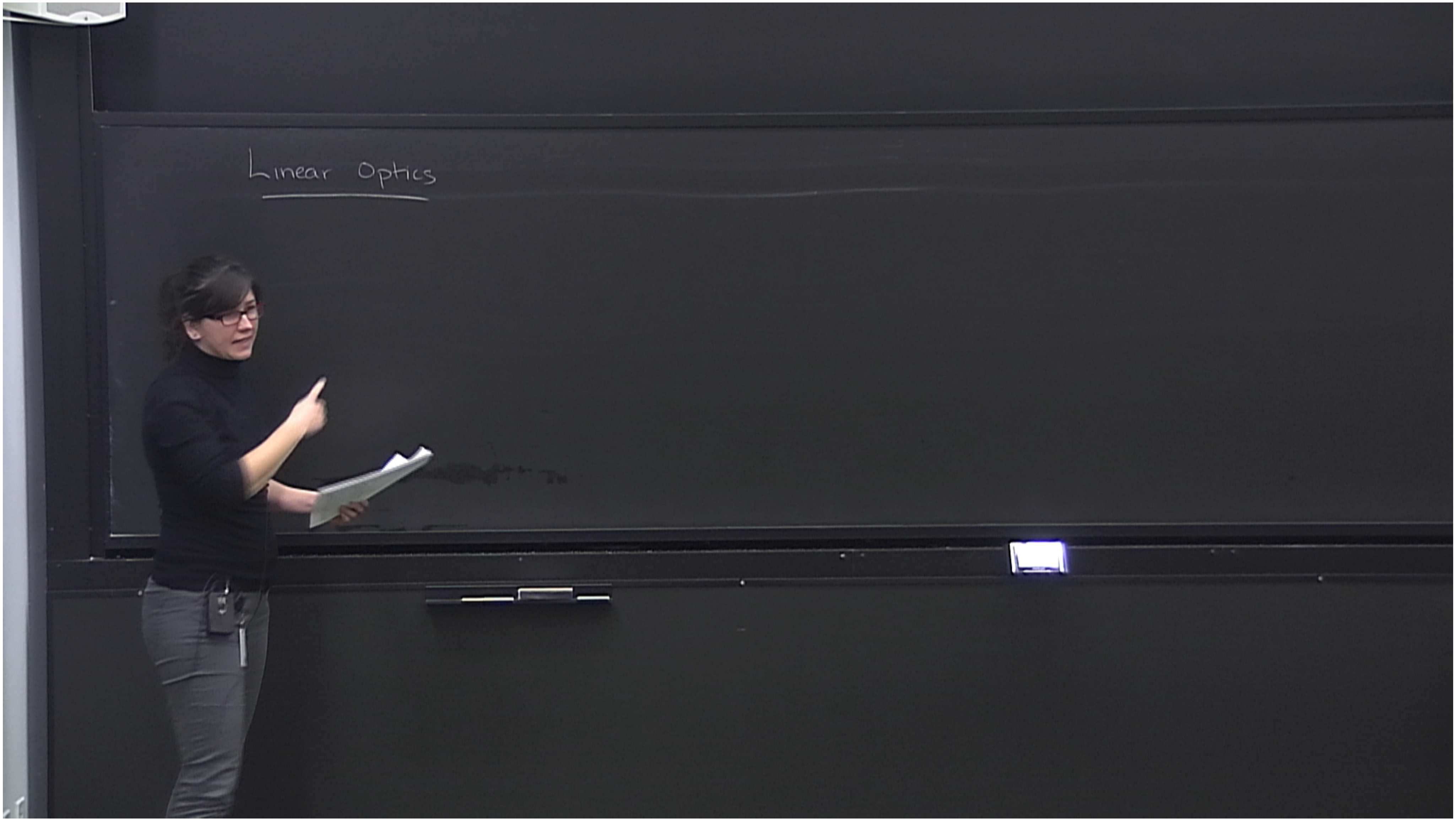
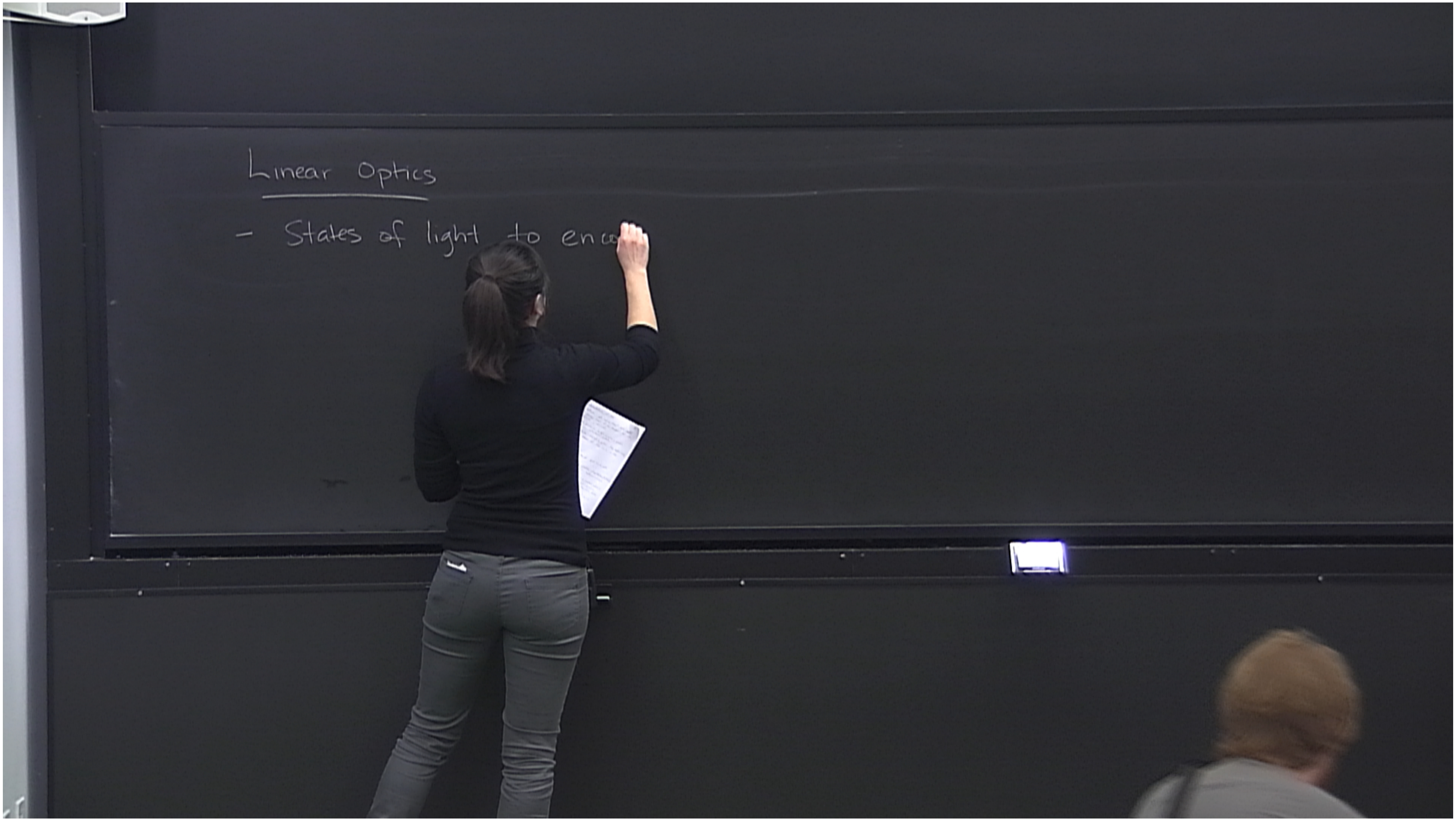
Title: Quantum Information Review-4

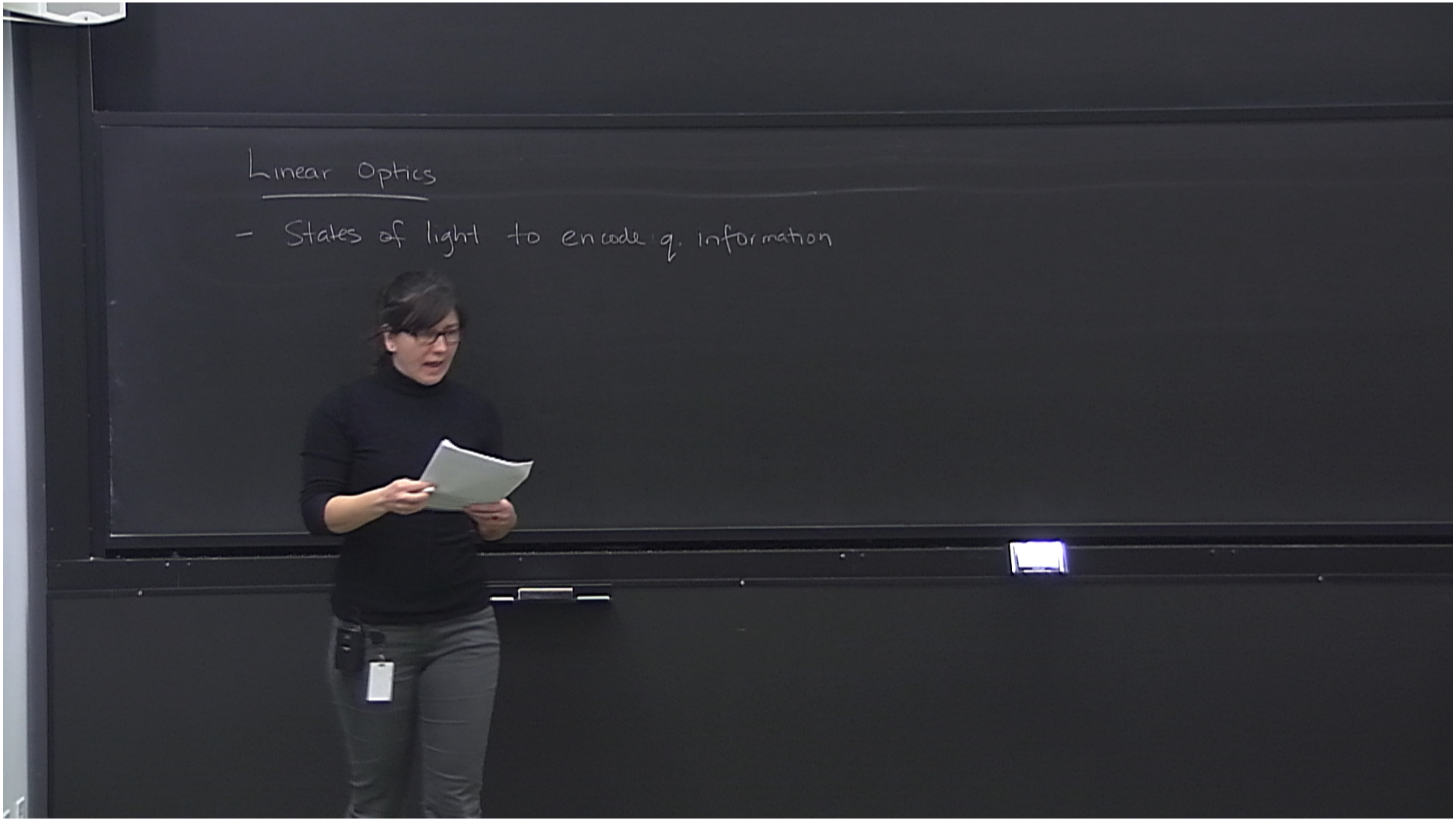
Date: Feb 20, 2015 11:30 AM

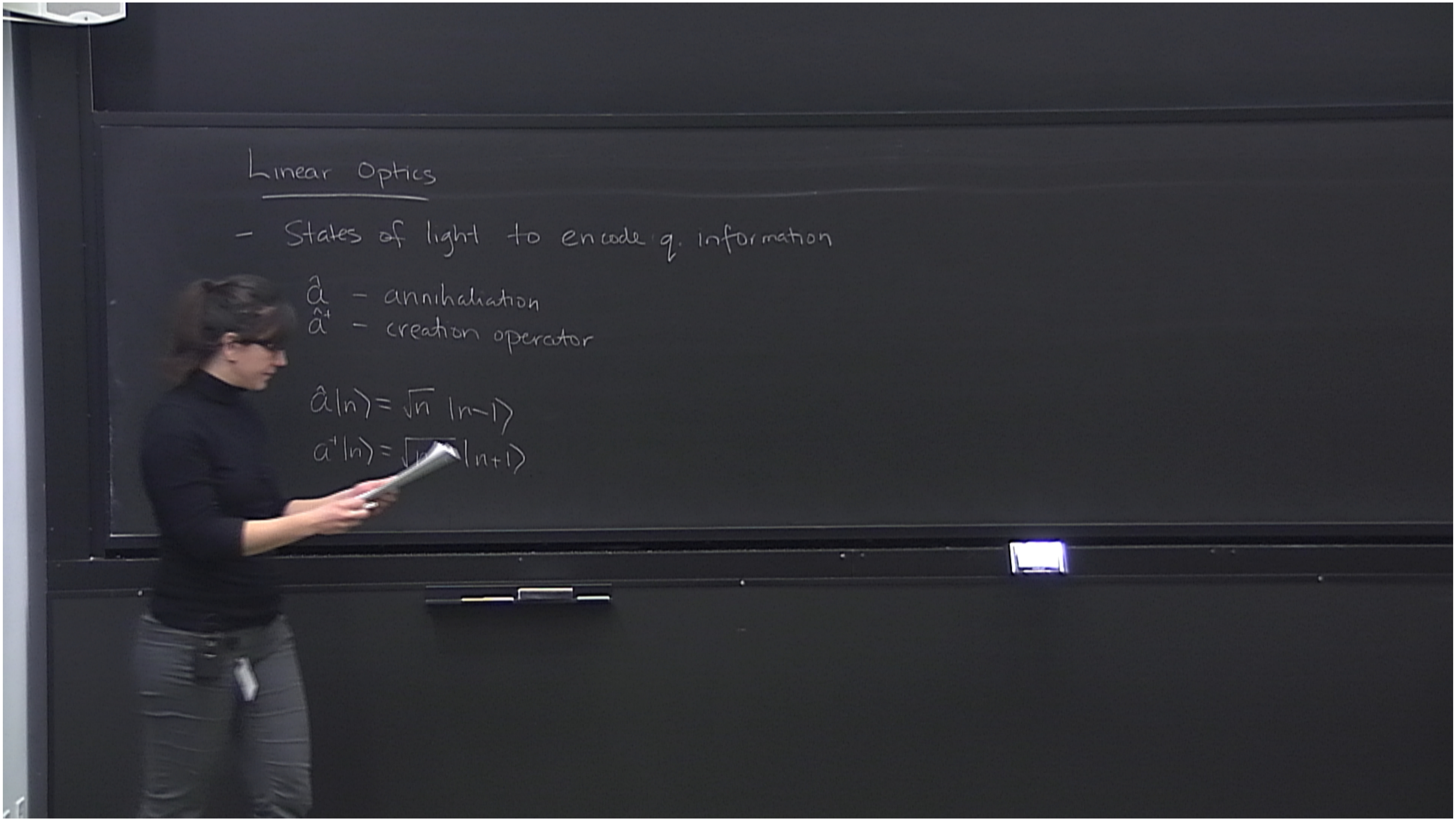
URL: http://pirsa.org/15020064

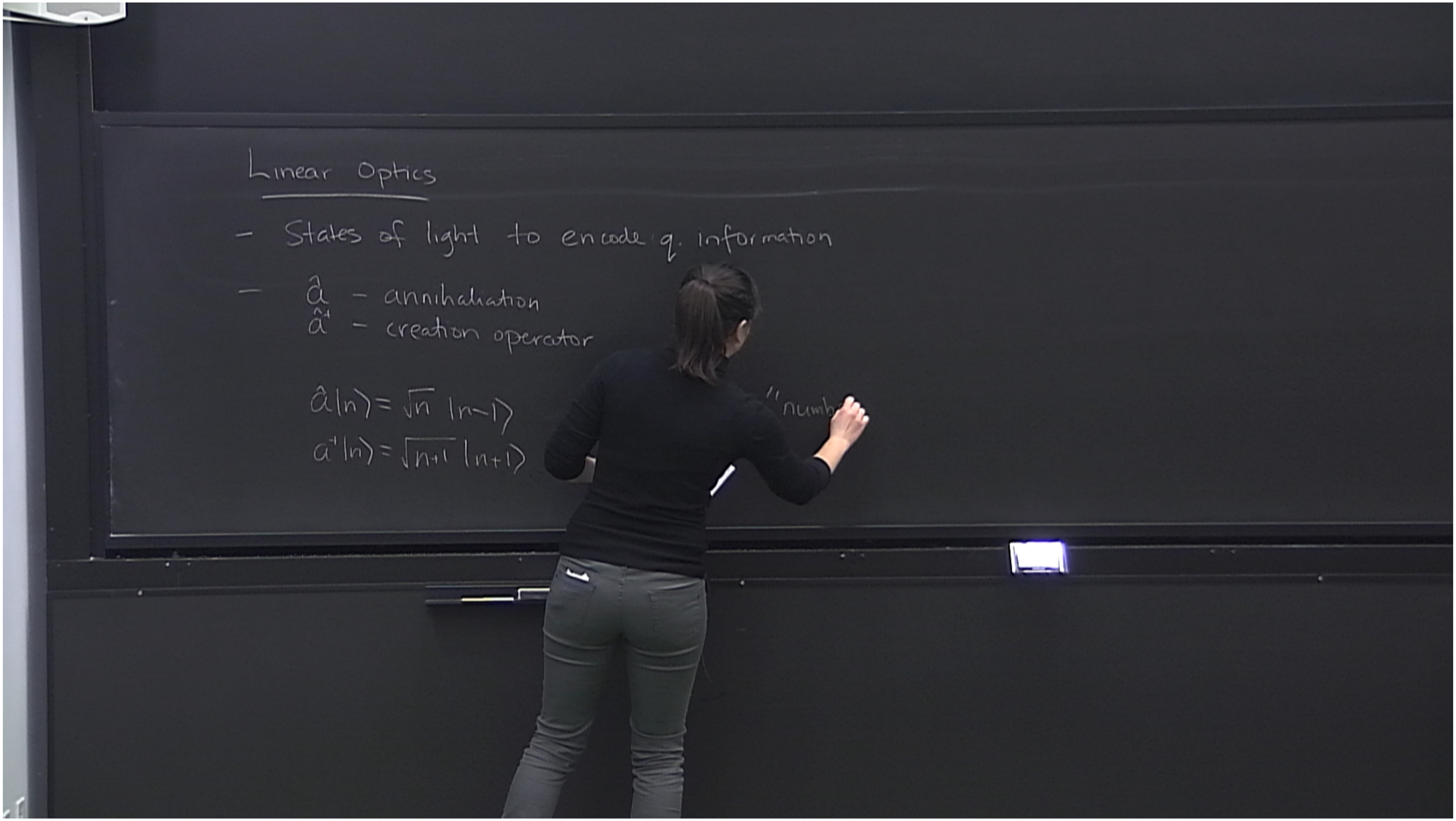
Abstract:


Linear Optics


Linear Optics
- States of light to en


Linear Optics
- States of light to encode q. information


Linear Optics
- States of light to encode q. information
â - annihaliation
â† - creation operator
â|n⟩ = √n |n−1⟩
a†|n⟩ = √ |n+1⟩

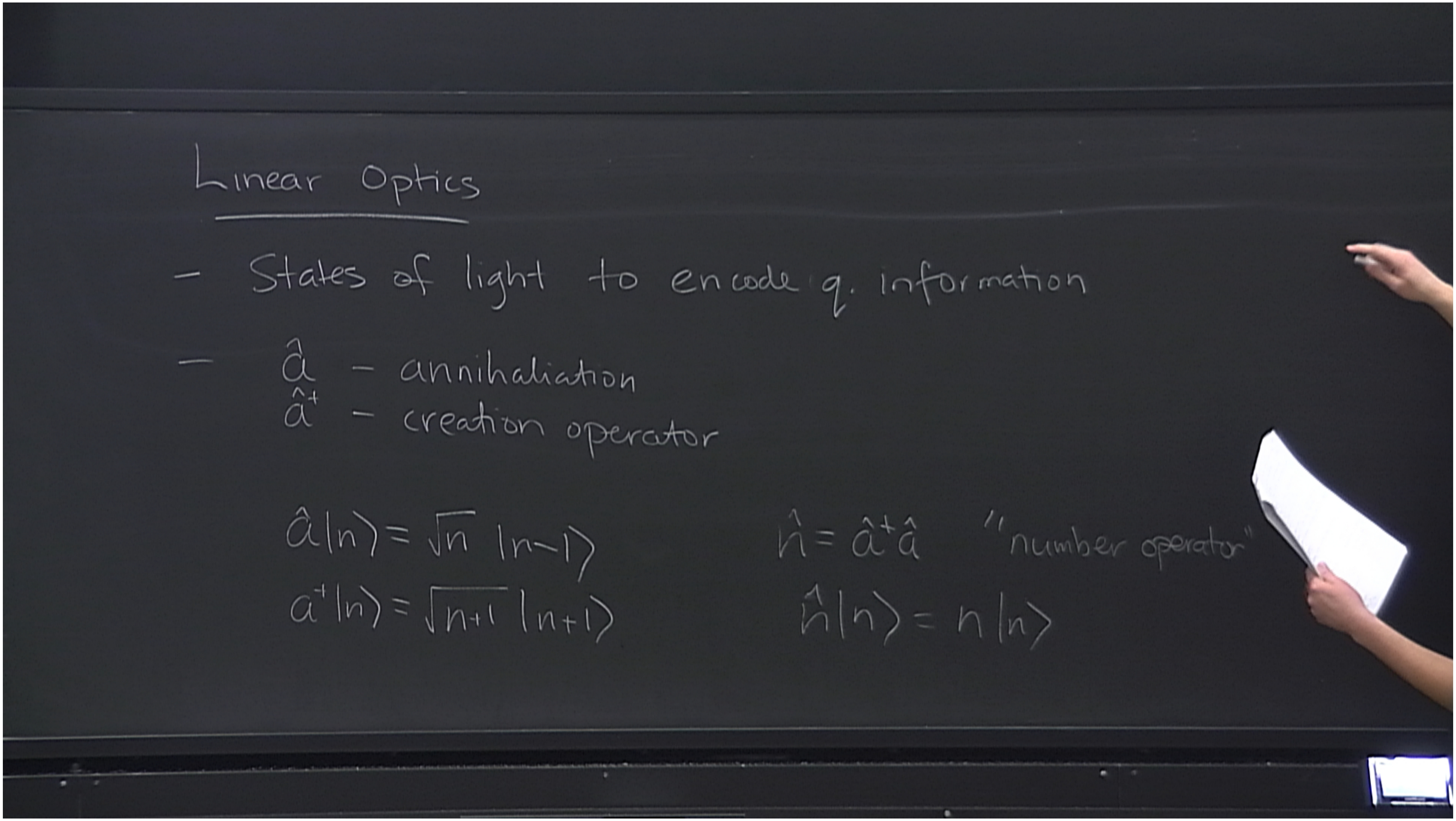

Linear Optics
- States of light to encode q. information
- $\hat{a}$ - annihalation
$\hat{a}^{\dagger}$ - creation operator
$\hat{a}|n\rangle = \sqrt{n}\,|n-1\rangle$
$a^{\dagger}|n\rangle = \sqrt{n+1}\,|n+1\rangle$

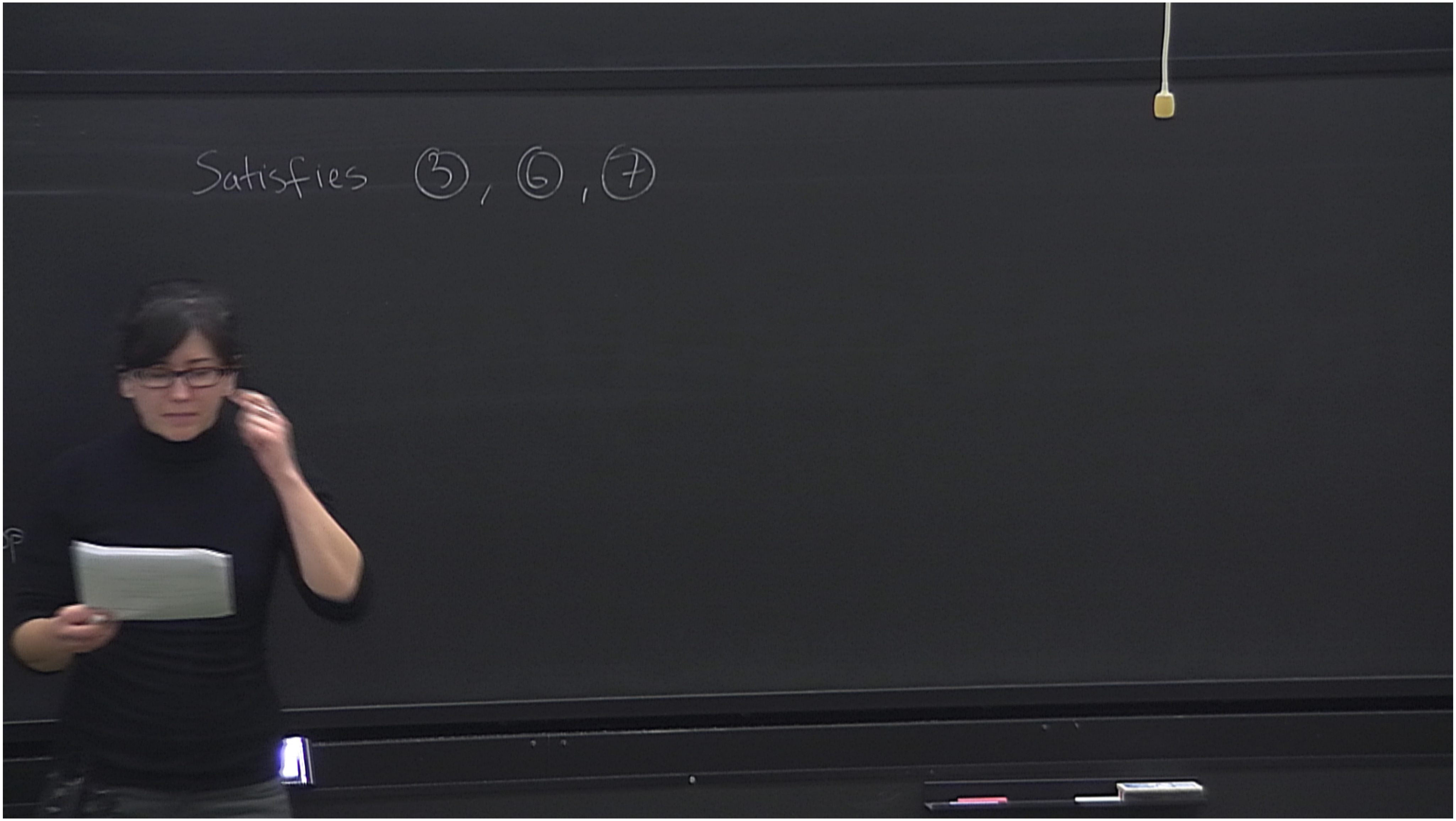
Linear Optics

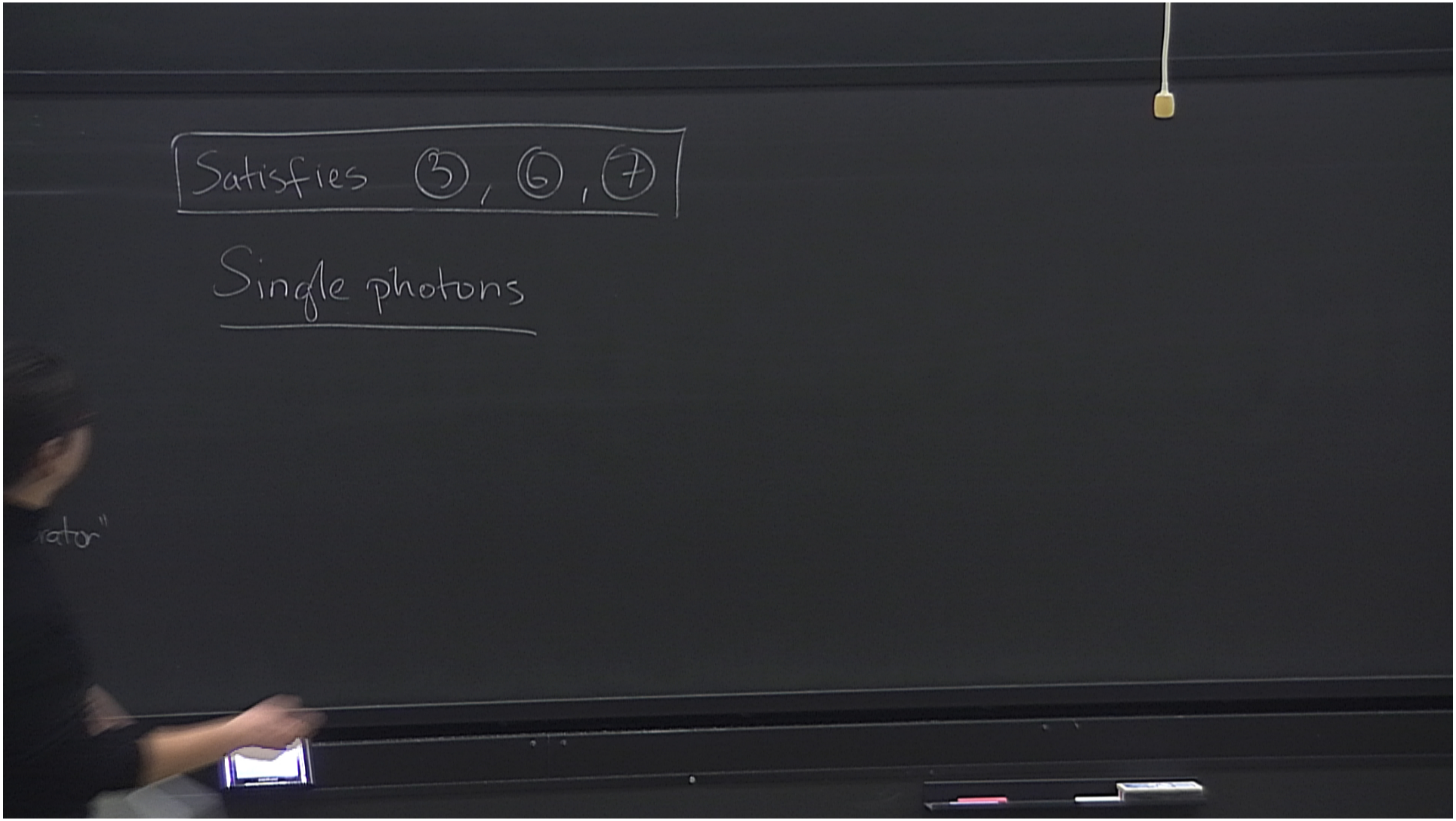
- States of light to encode q. information
- $\hat{a}$ – annihaliation
  $\hat{a}^{+}$ – creation operator

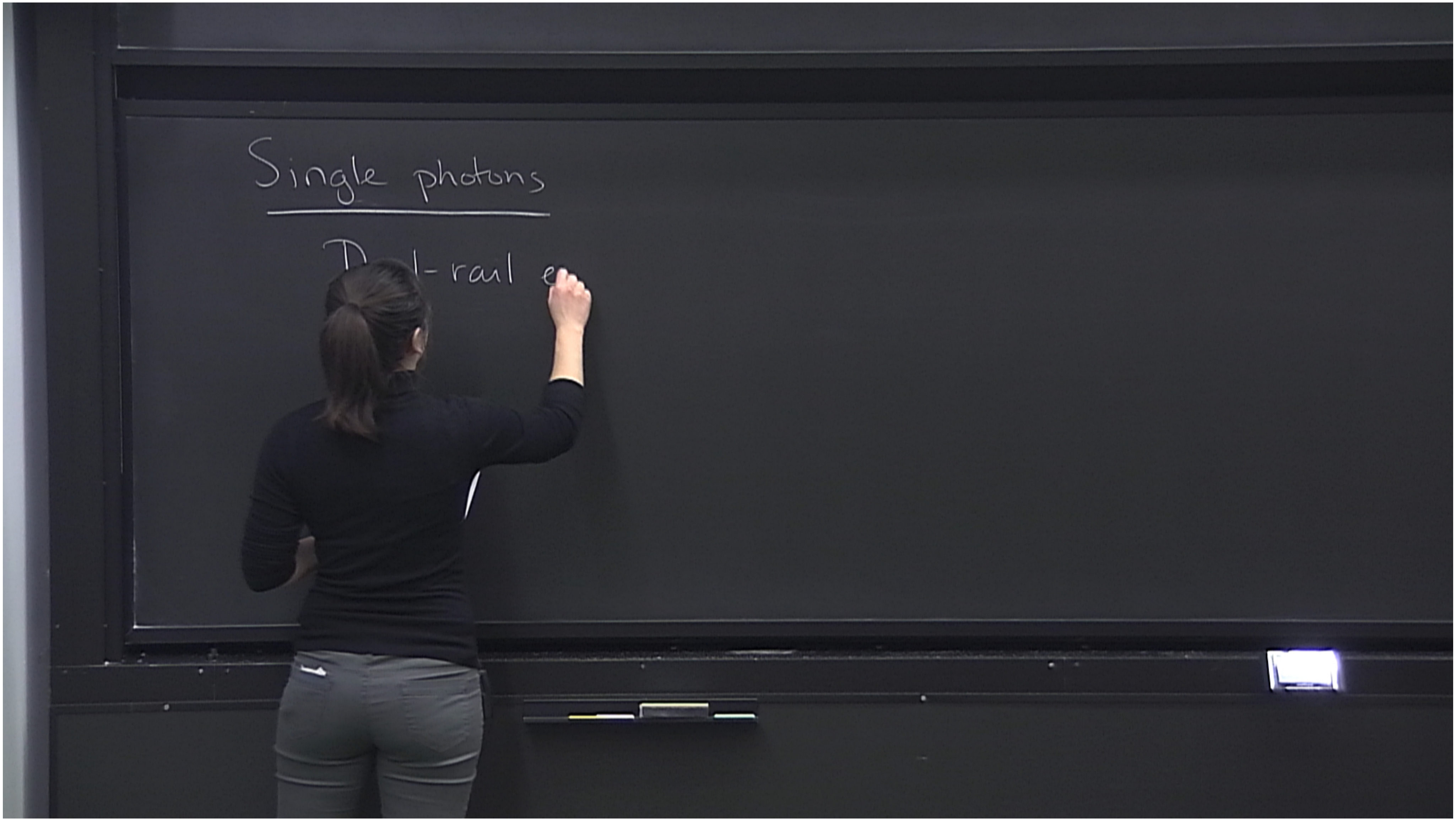
$$\hat{a}|n\rangle = \sqrt{n}\,|n-1\rangle \qquad \hat{n} = \hat{a}^{+}\hat{a} \quad \text{"number operator"}$$

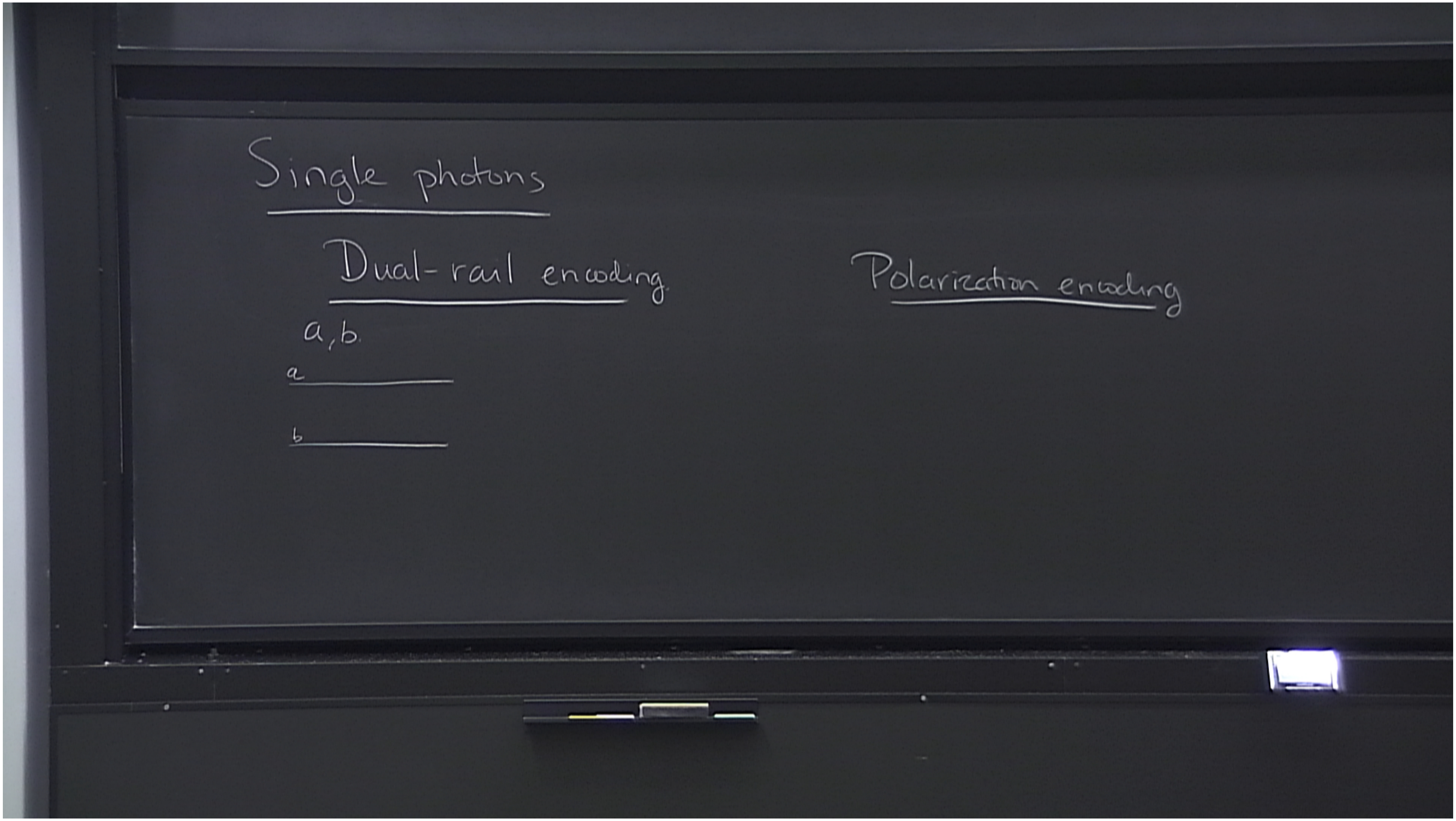
$$a^{+}|n\rangle = \sqrt{n+1}\,|n+1\rangle \qquad \hat{n}|n\rangle = n|n\rangle$$

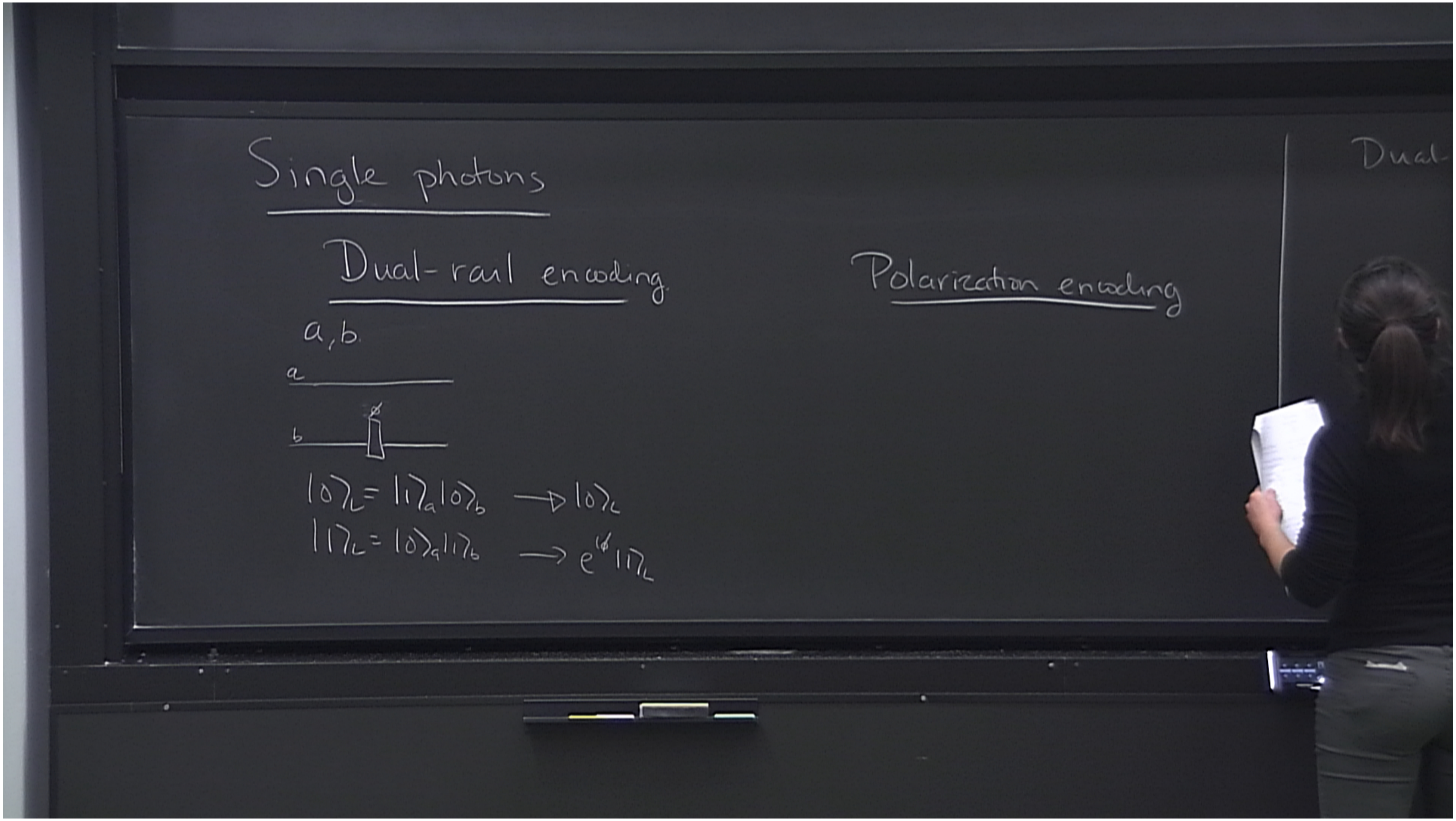

Linear Optics
- States of light to encode q. information
- â - annihaliation
â† - creation operator
â|n⟩ = √n |n−1⟩
a†|n⟩ = √(n+1) |n+1⟩
n̂ = â†â "number operator"
n̂|n⟩ = n|n⟩

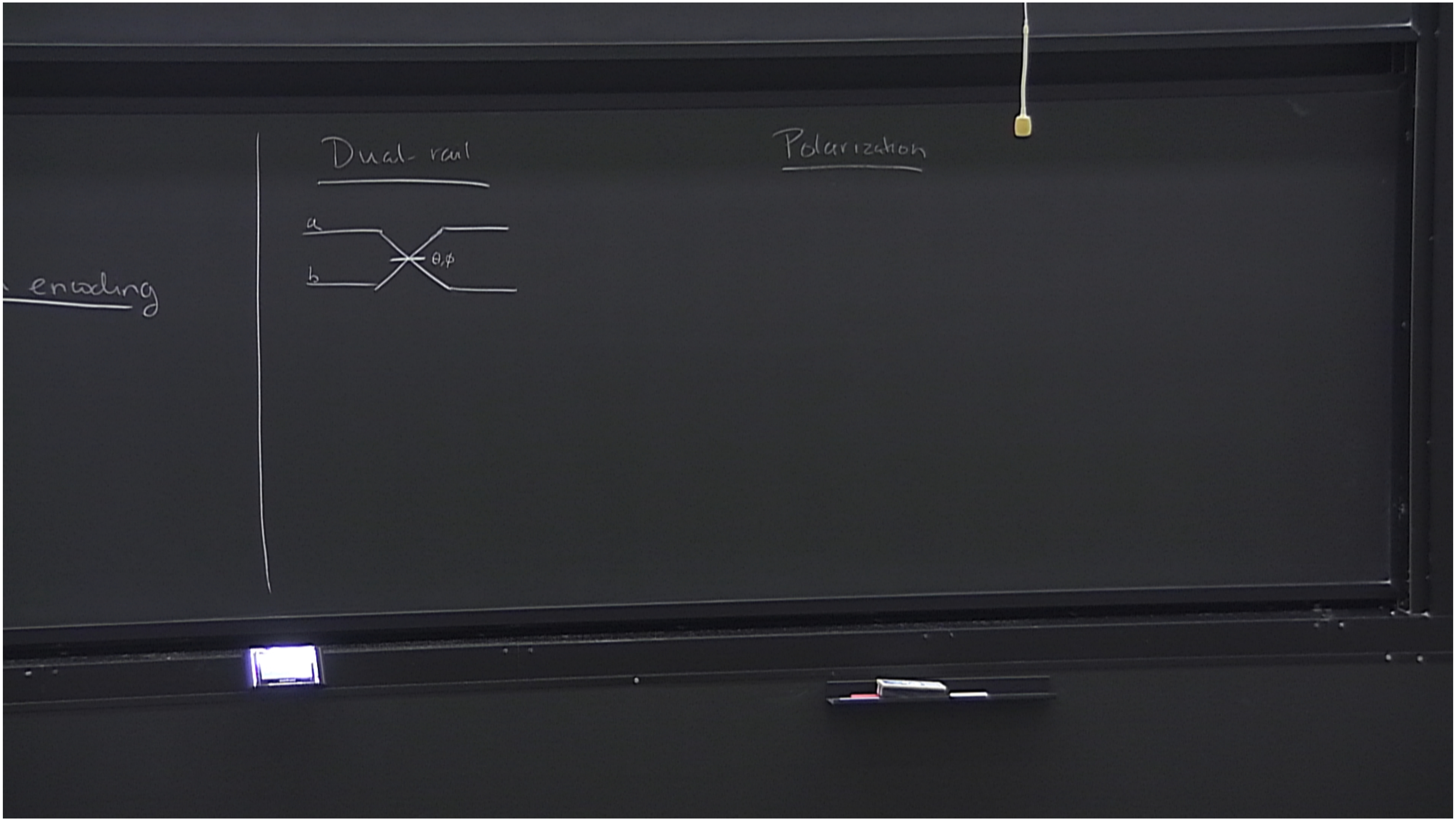

Satisfies ③, ⑥, ⑦

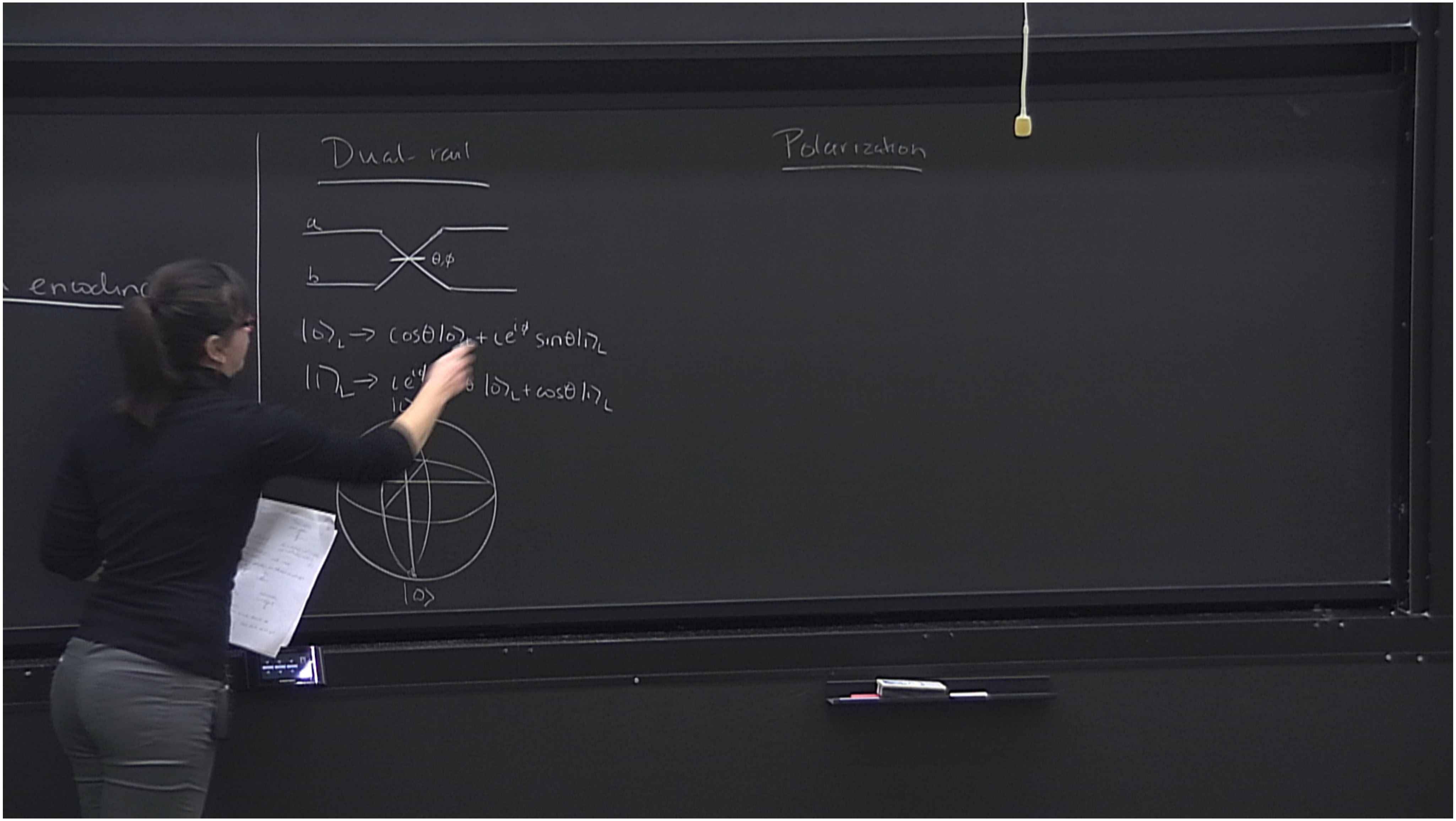

Satisfies ③, ⑥, ⑦
Single photons
rator"

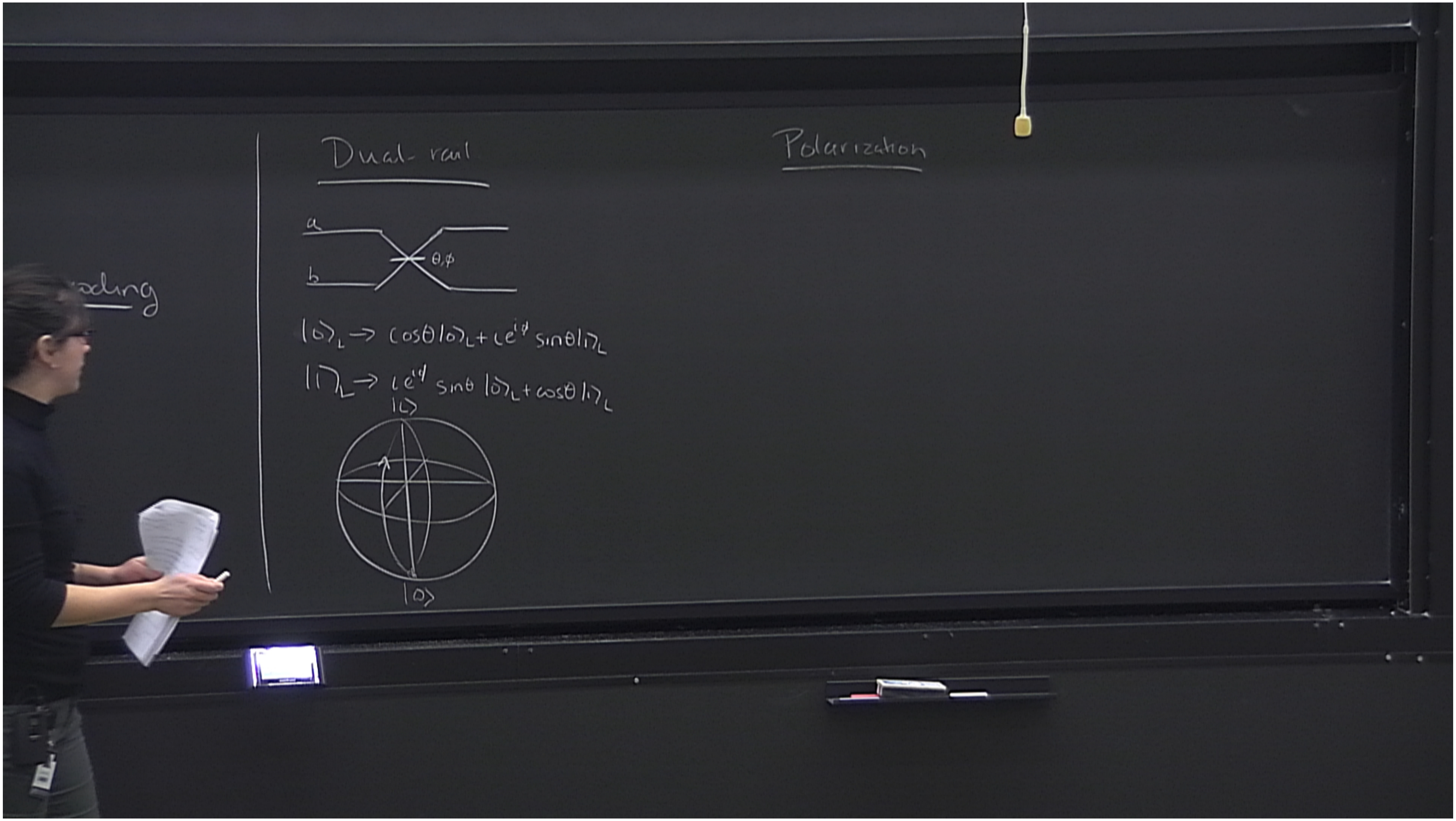

Single photons

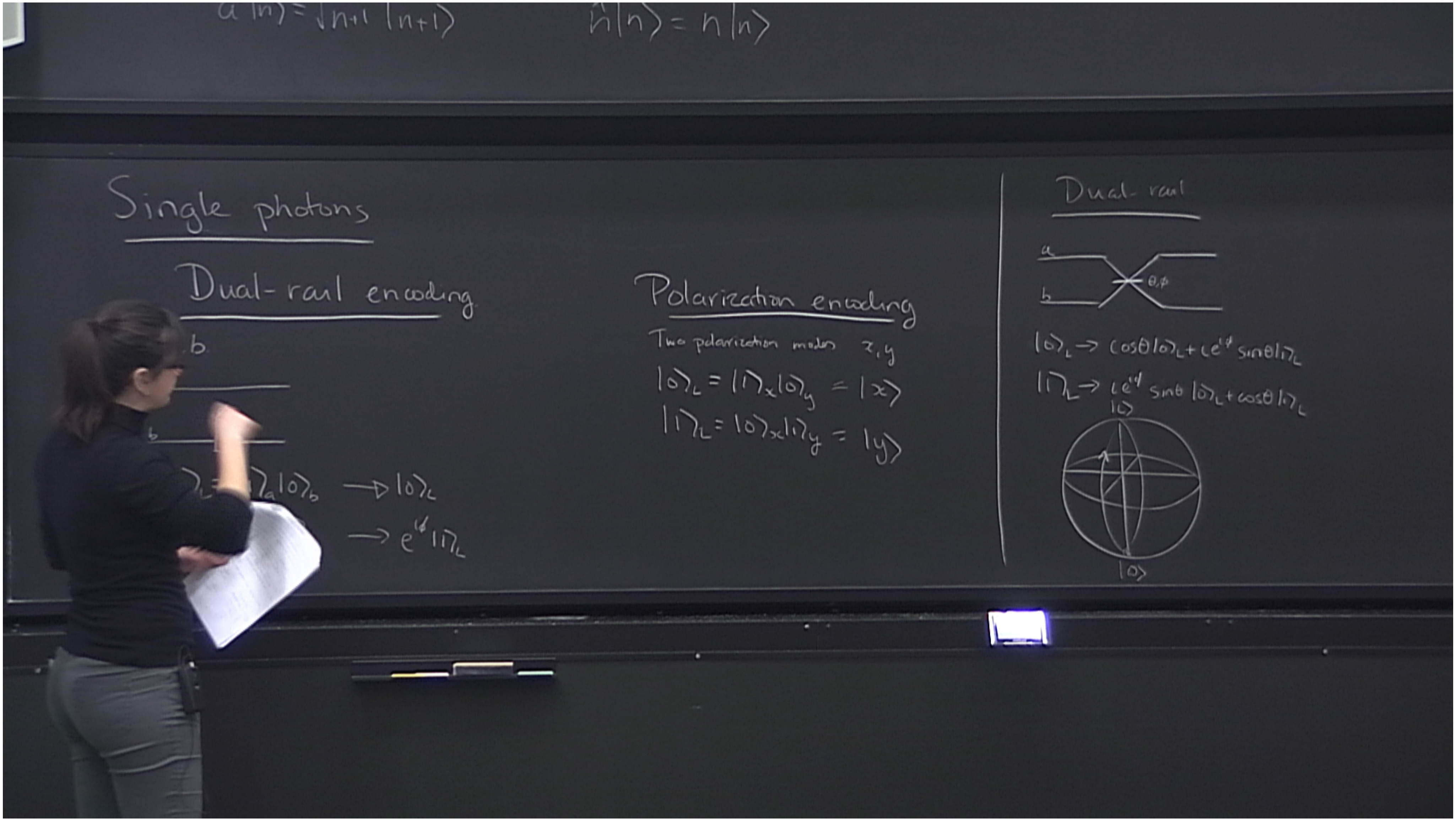

Single photons
Dual-rail encoding
Polarization encoding
a, b
a
b


Single photons
Dual-rail encoding
a, b
a
b
φ
$|0\rangle_L = |1\rangle_a |0\rangle_b \rightarrow |0\rangle_L$
$|1\rangle_L = |0\rangle_a |1\rangle_b \rightarrow e^{i\phi} |1\rangle_L$
Polarization encoding
Dual-

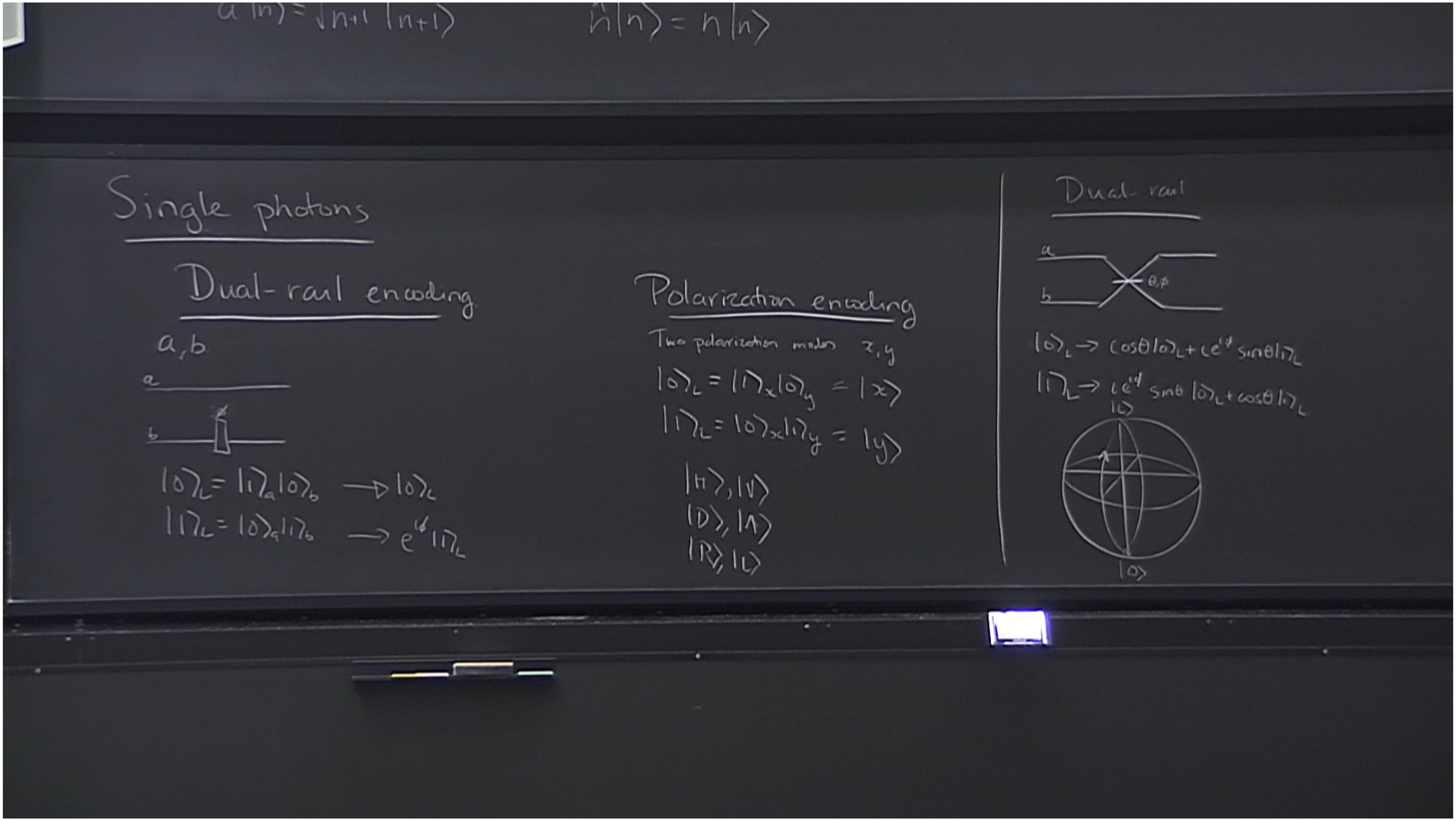

encoding
Dual-rail
a
b
θ,φ
Polarization

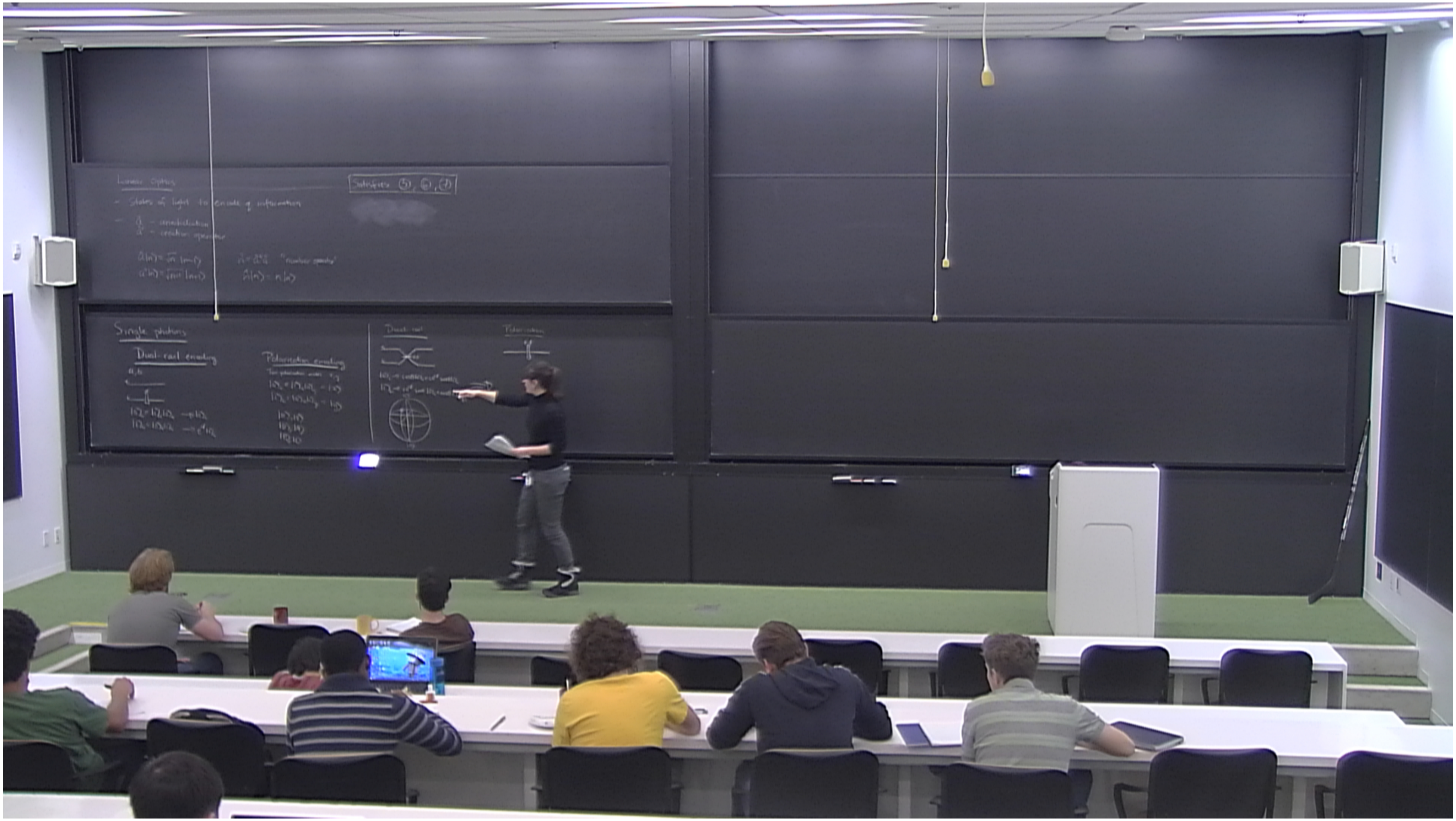

Dual-rail
Polarization
a
b
θ,φ
|0⟩L → cosθ|0⟩L + ie^iφ sinθ|1⟩L
|0⟩

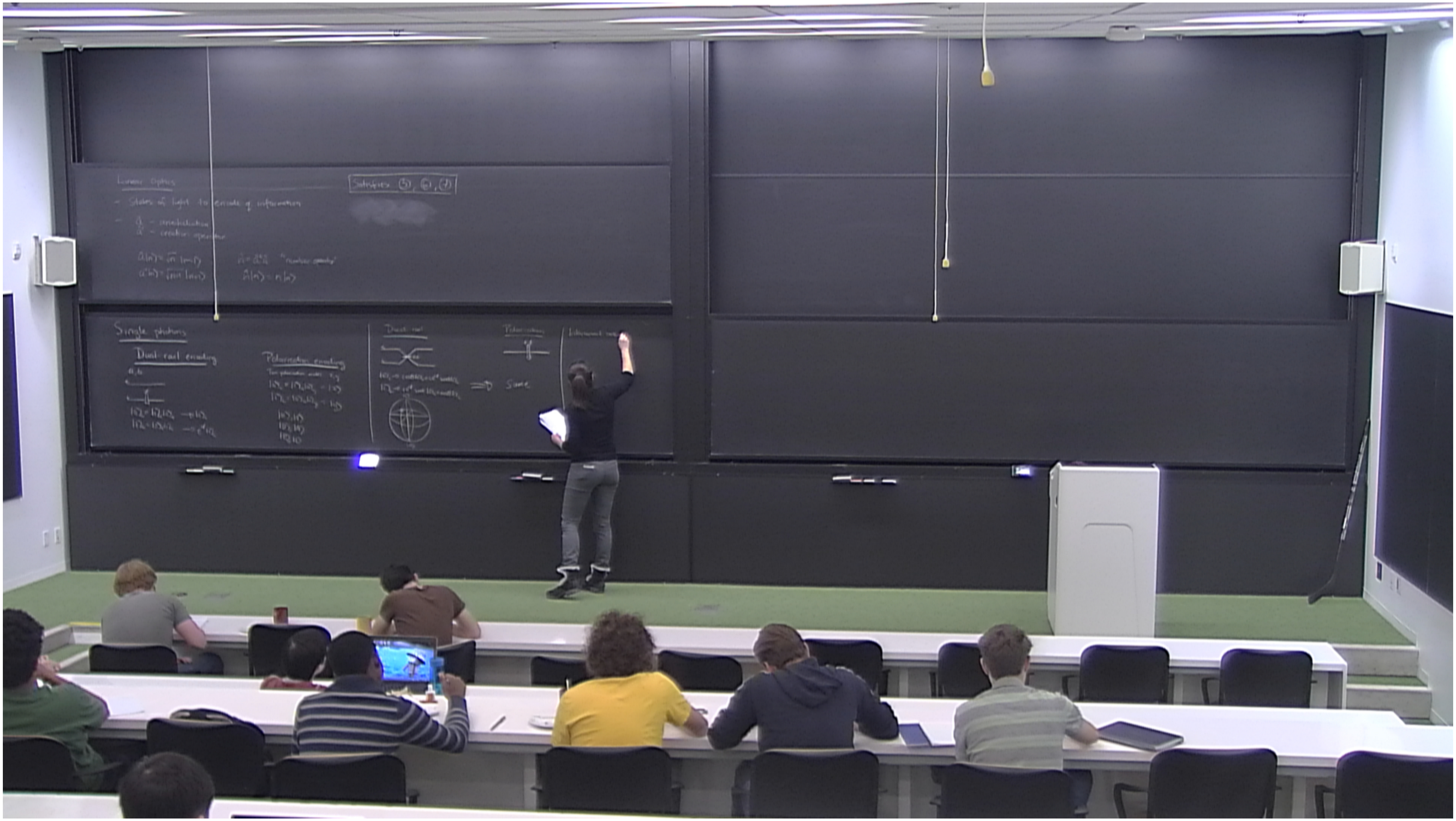

Dual-rail
a
b
θ,φ
|0⟩L → cosθ|0⟩L + ie^iφ sinθ|1⟩L
|1⟩L → ie^iφ sinθ |0⟩L + cosθ|1⟩L
|1⟩
|0⟩
Polarization

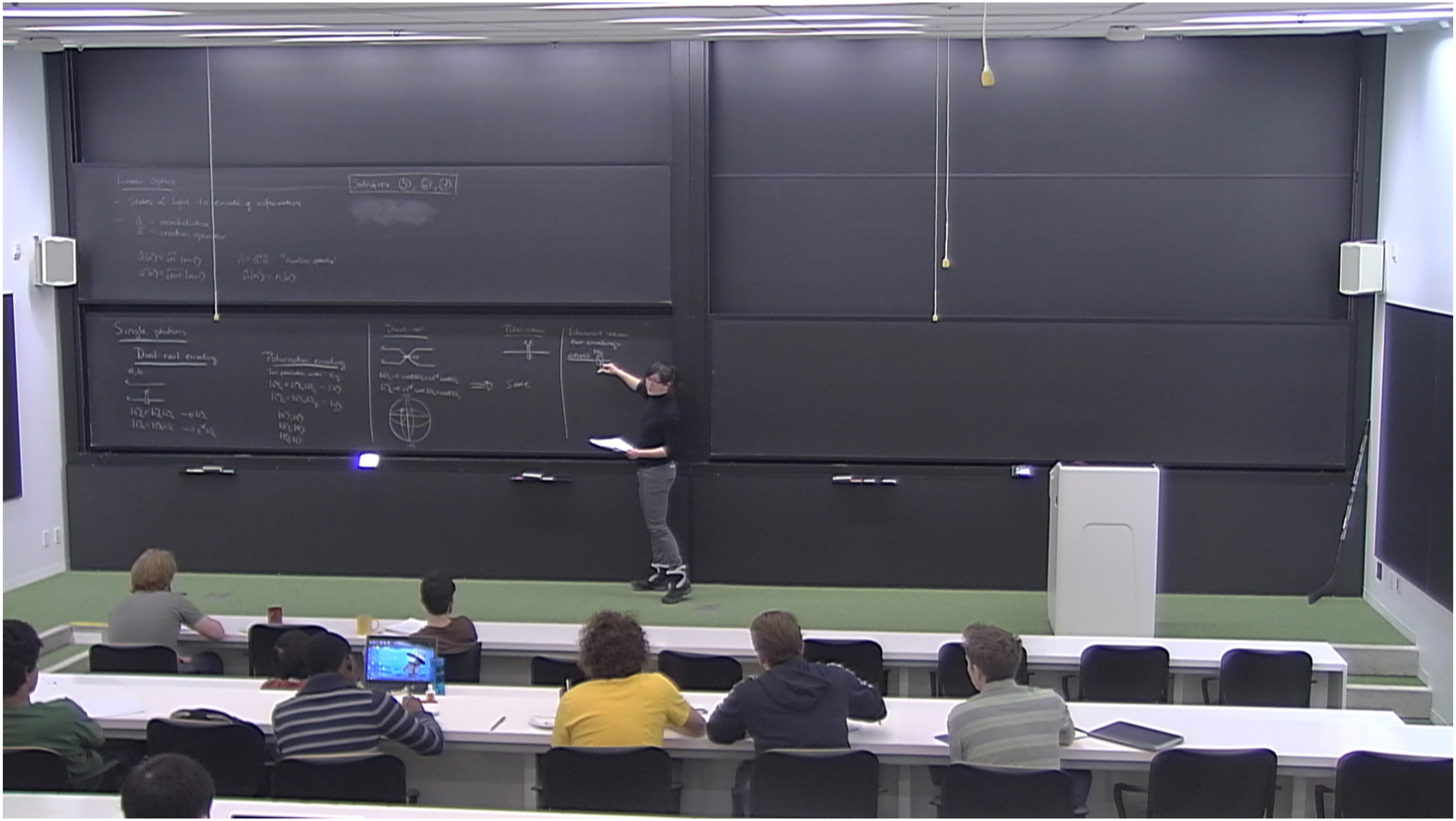


Single photons
Dual-rail encoding
Polarization encoding
Two polarization modes x, y
Dual-rail

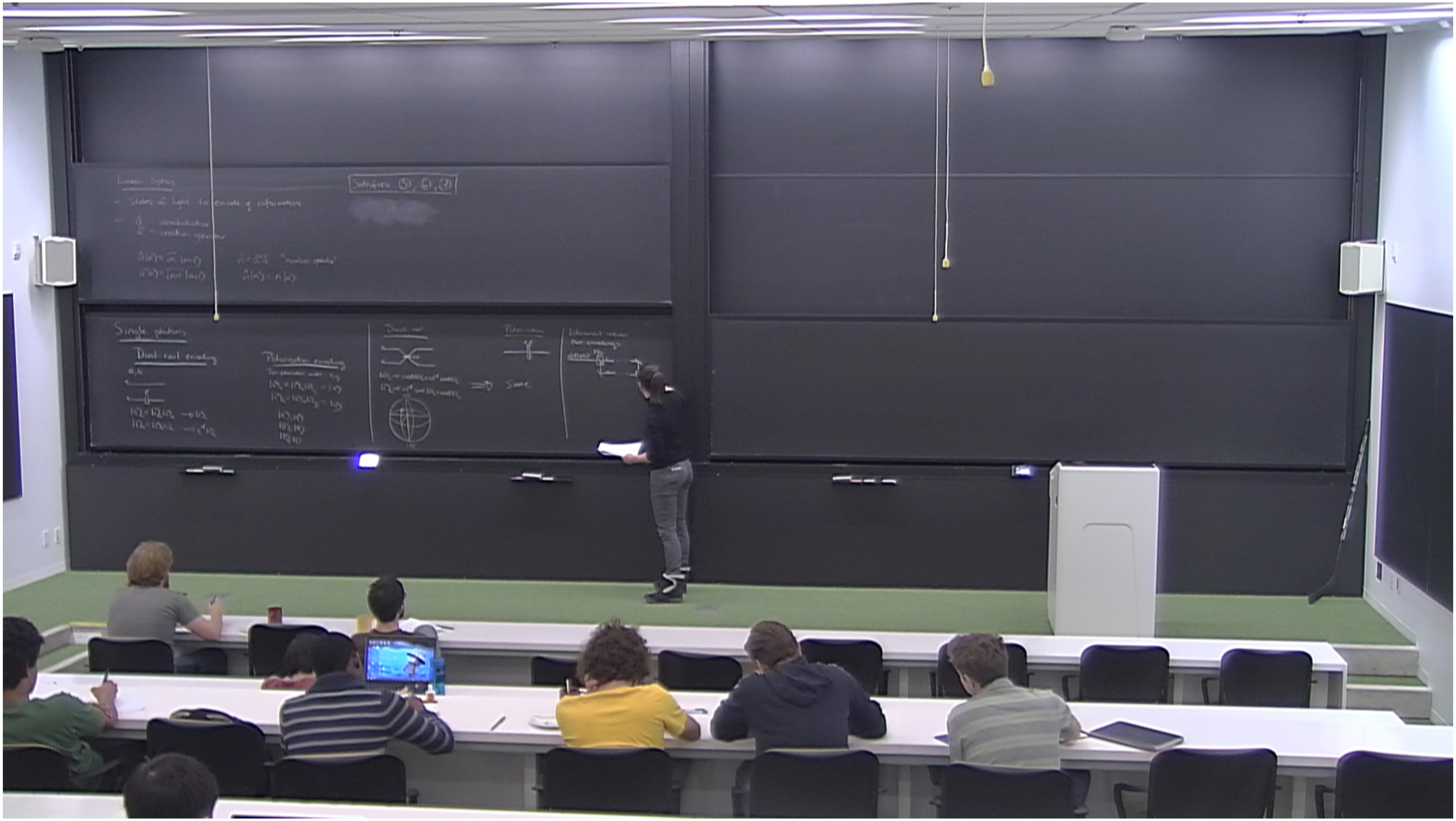

$a^\dagger|n\rangle = \sqrt{n+1}\,|n+1\rangle$
$\hat{n}|n\rangle = n|n\rangle$
Single photons
Dual-rail encoding
a, b
a
b
$|0\rangle_L = |1\rangle_a|0\rangle_b \rightarrow |0\rangle_L$
$|1\rangle_L = |0\rangle_a|1\rangle_b \rightarrow e^{i\phi}|1\rangle_L$
Polarization encoding
Two polarization modes x, y
$|0\rangle_L = |1\rangle_x|0\rangle_y = |x\rangle$
$|1\rangle_L = |0\rangle_x|1\rangle_y = |y\rangle$
$|H\rangle, |V\rangle$
$|D\rangle, |A\rangle$
$|R\rangle, |L\rangle$
Dual-rail
a
b
θ, ϕ
$|0\rangle_L \rightarrow \cos\theta|0\rangle_L + ie^{i\phi}\sin\theta|1\rangle_L$
$|1\rangle_L \rightarrow ie^{i\phi}\sin\theta|0\rangle_L + \cos\theta|1\rangle_L$
$|1\rangle$
$|0\rangle$

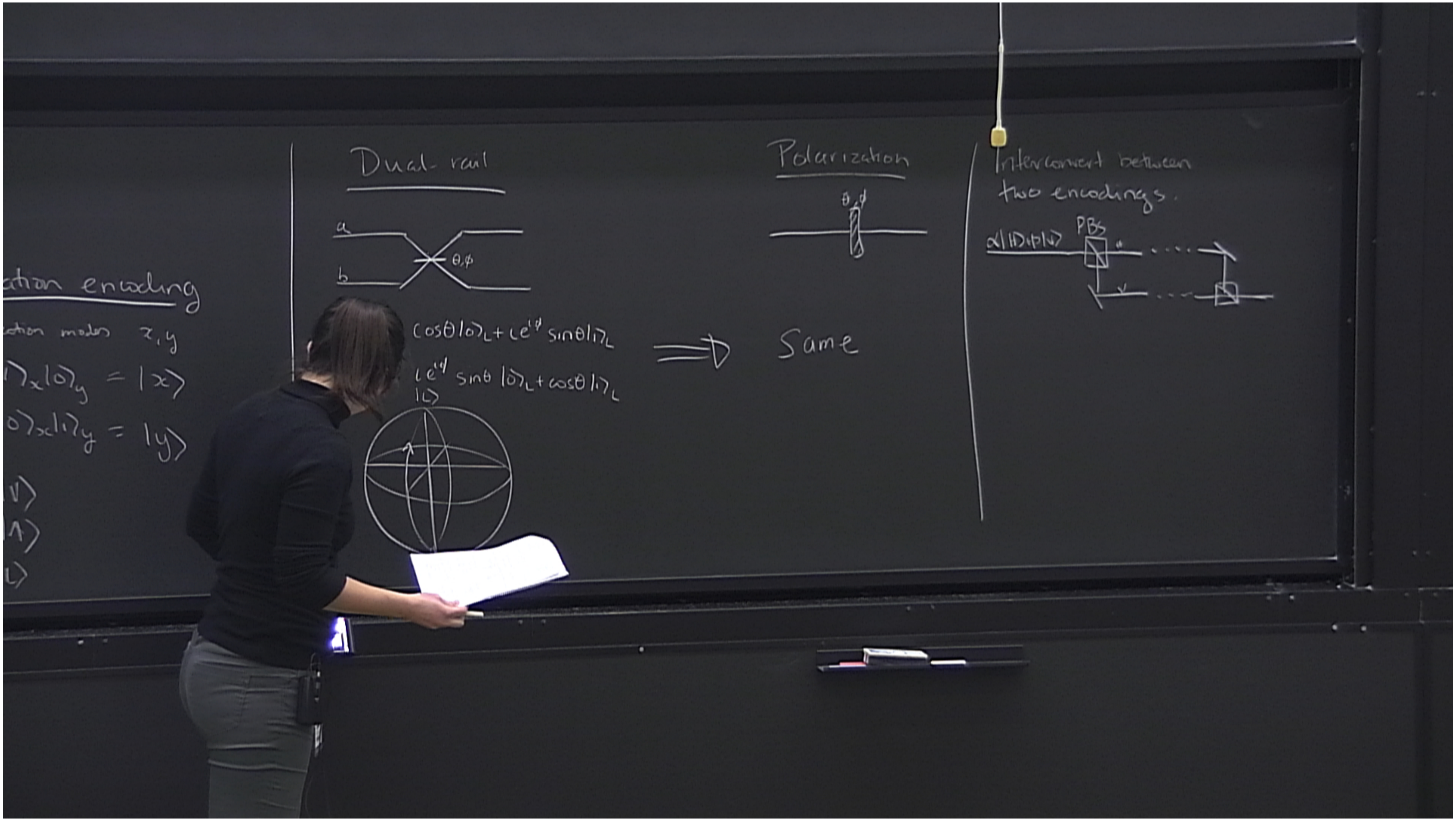

Linear optics
Single photons
Dual-rail encoding
Polarization encoding

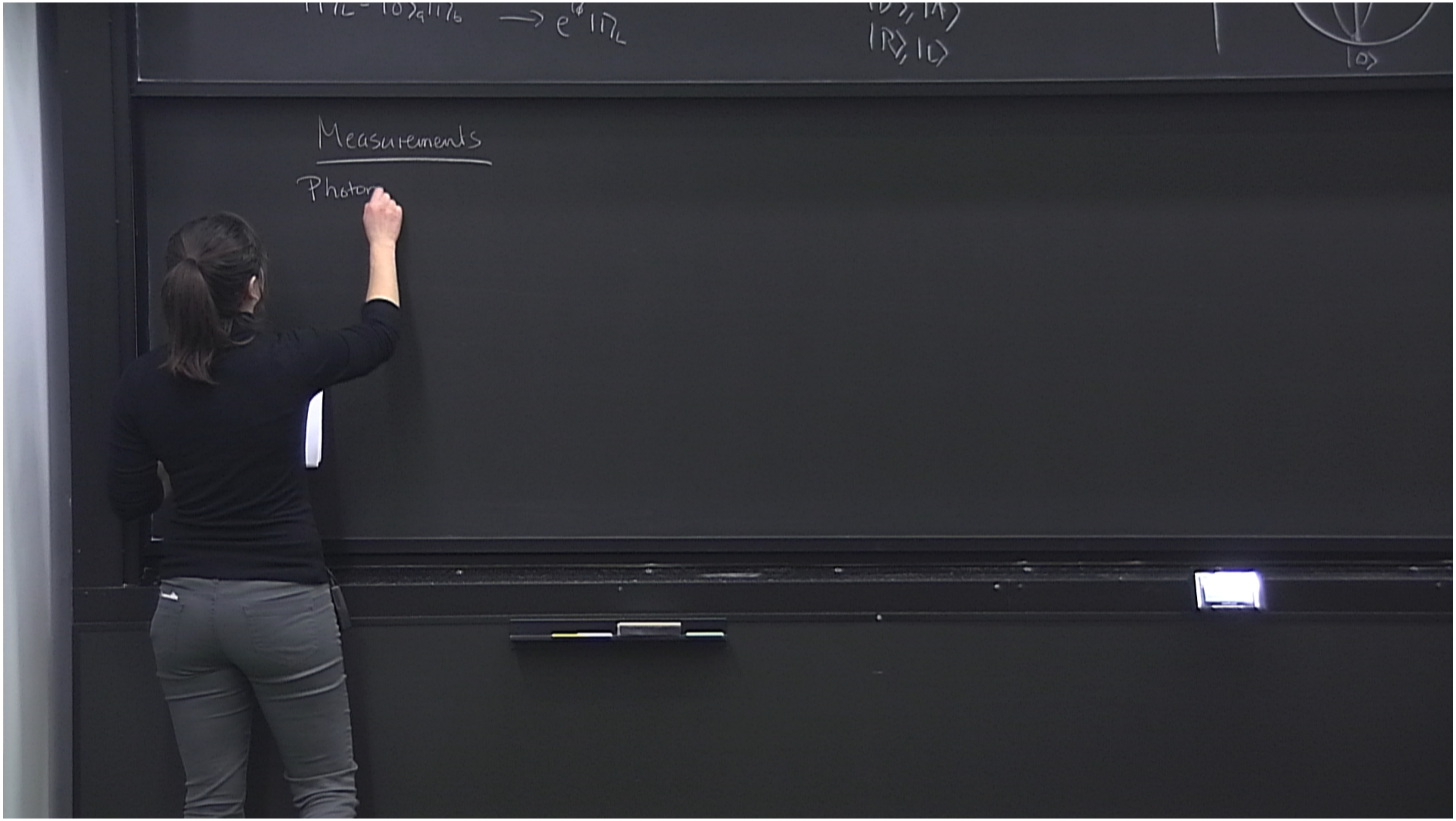

Linear optics
Single photons
Dual-rail encoding
Polarization encoding
Same

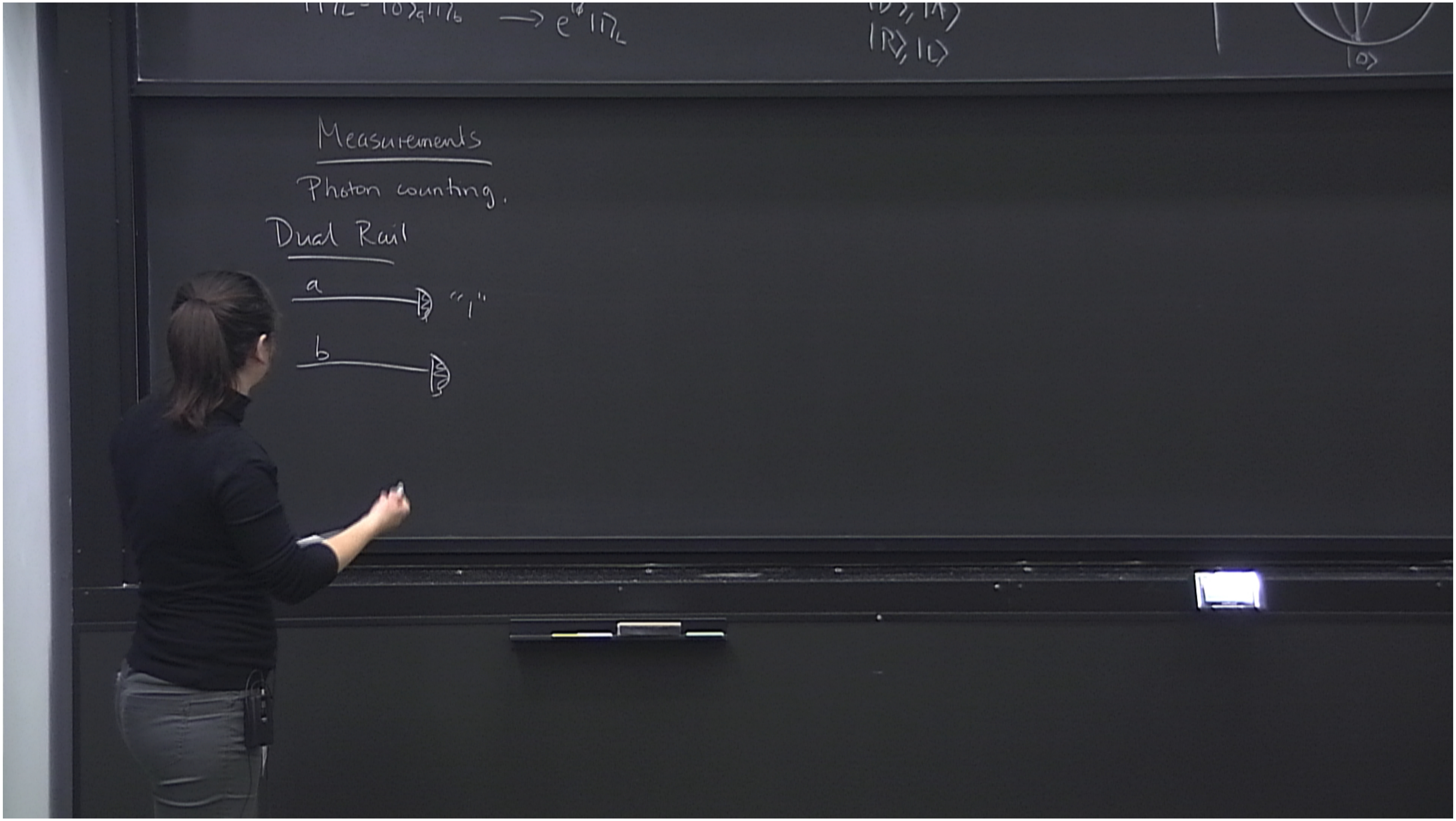


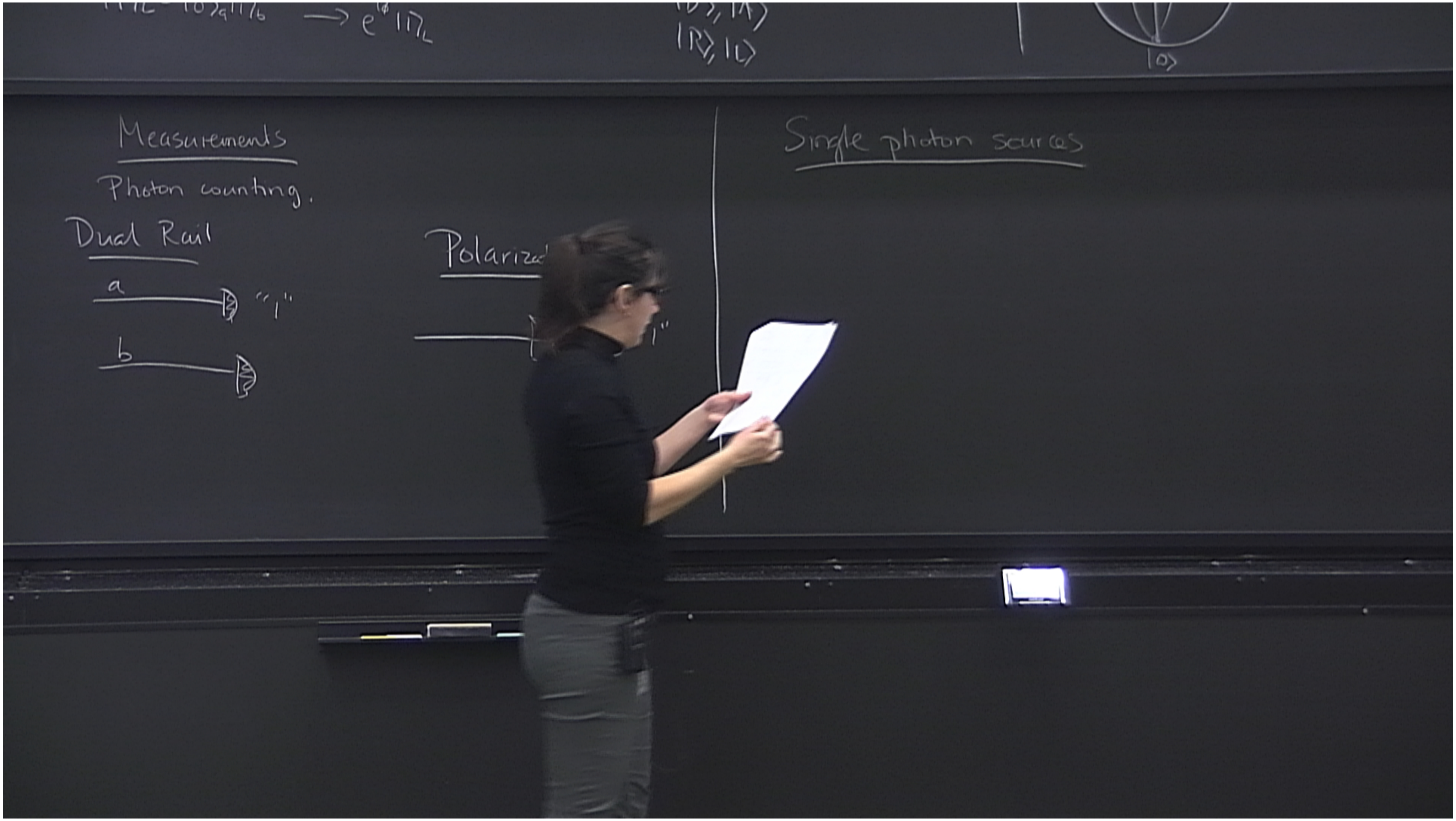
Linear optics
Single photons
Dual-rail encoding
Polarization encoding
Same

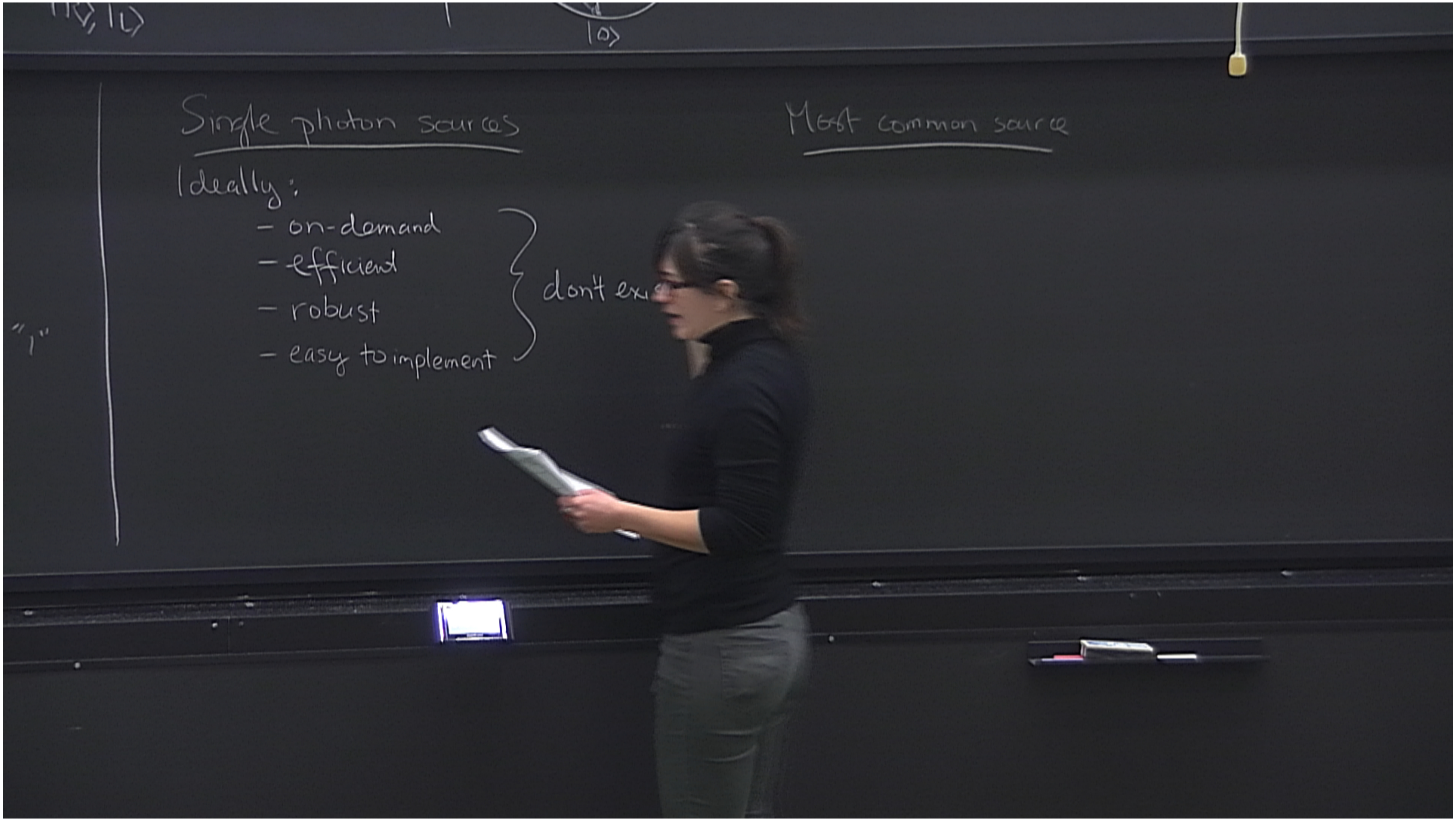


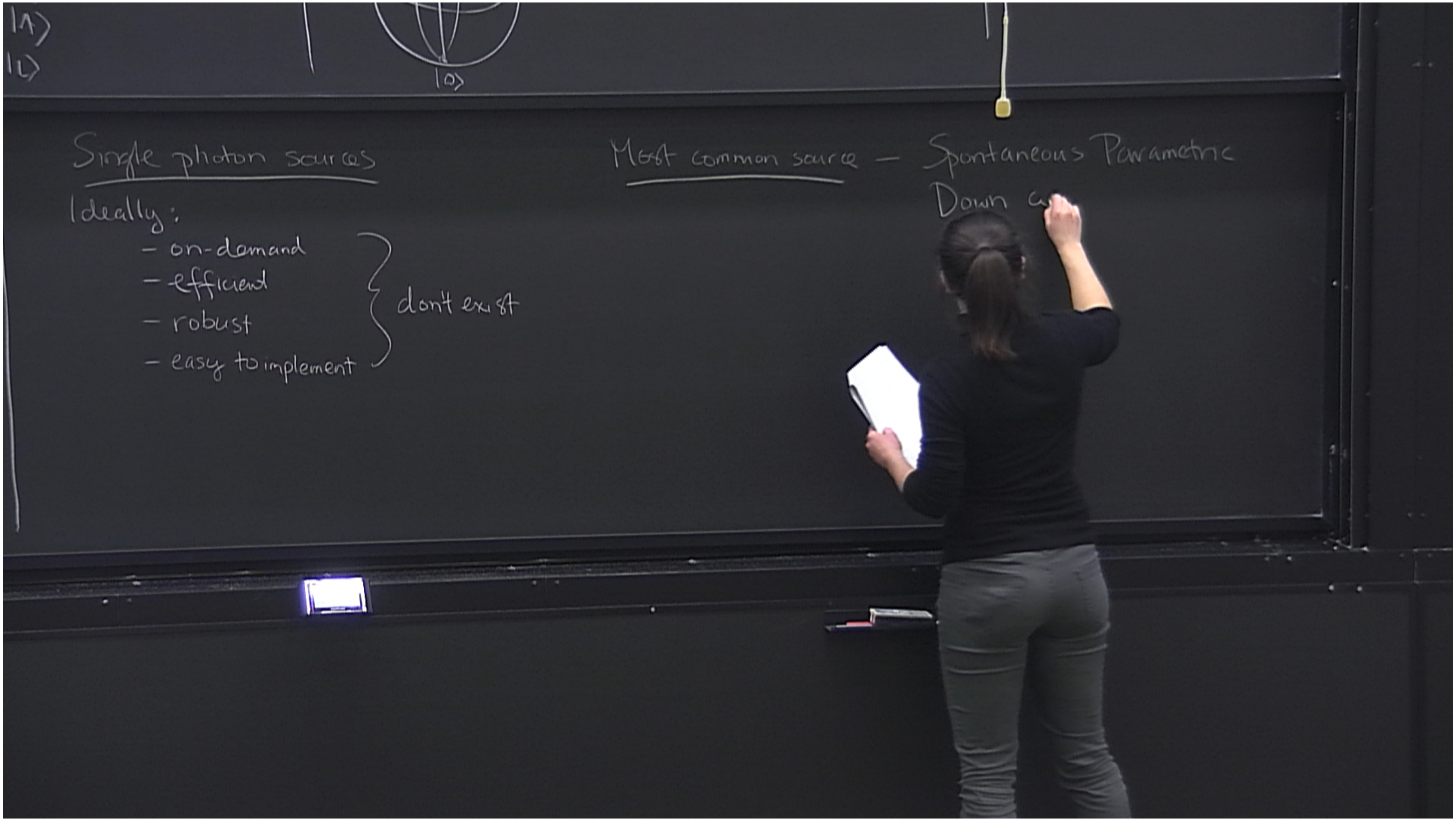

Dual-rail
a
b
θ,φ
Polarization
θ,φ
Same
Interconvert between
two encodings.
PBS
...ation encoding
...ation modes x, y

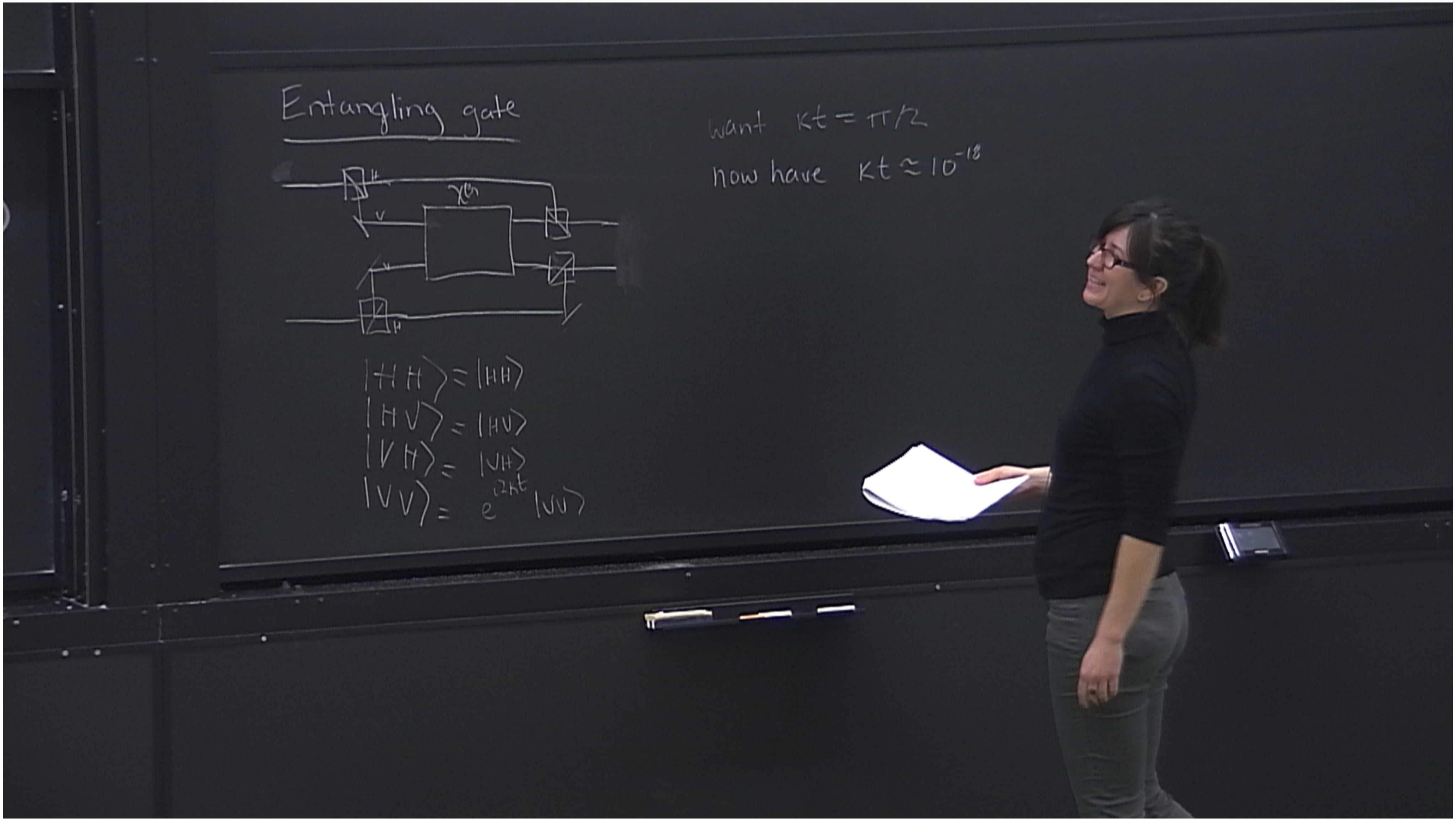

Measurements
Photon

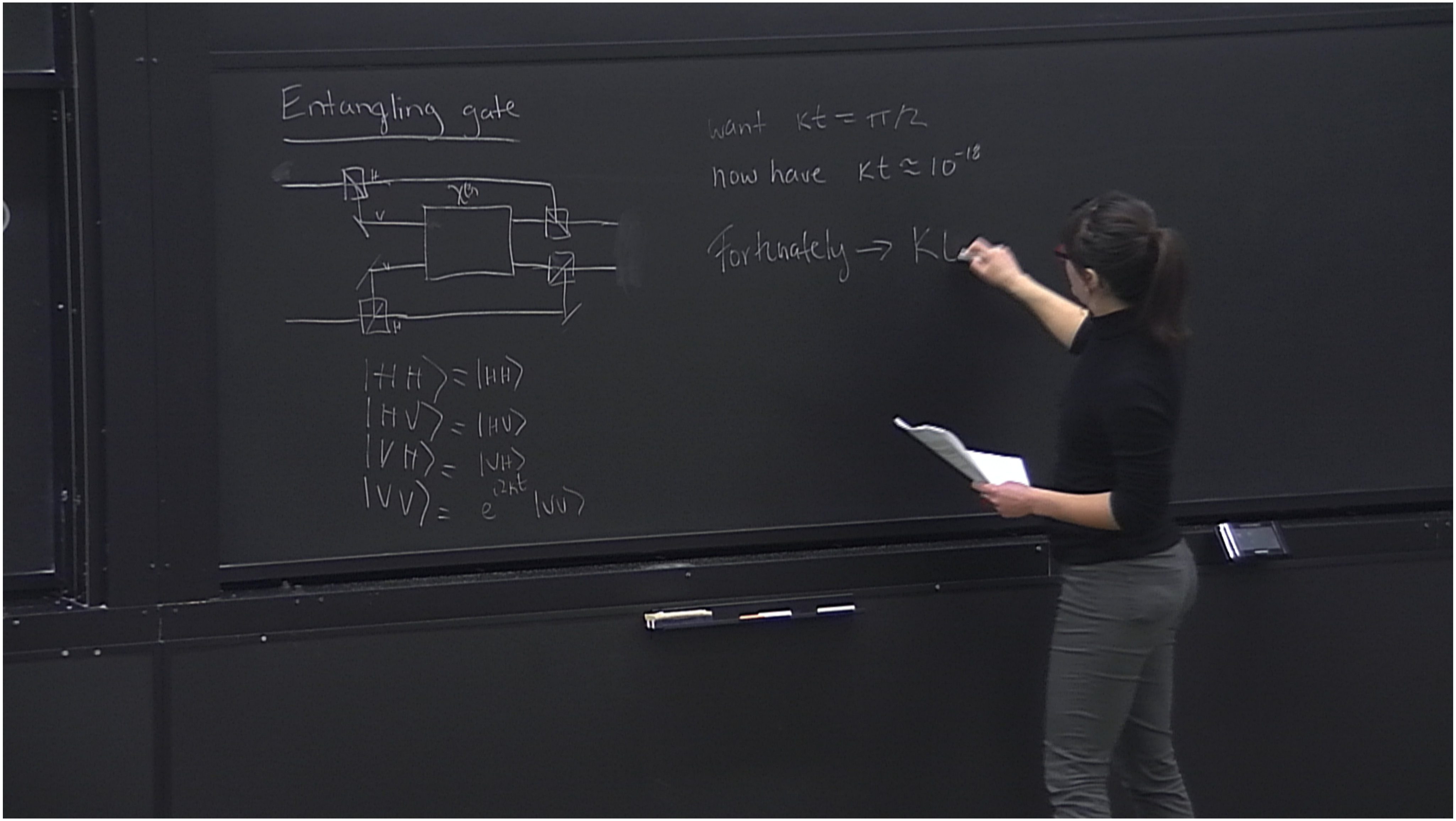

Measurements
Photon counting.
Dual Rail
a
"1"
b

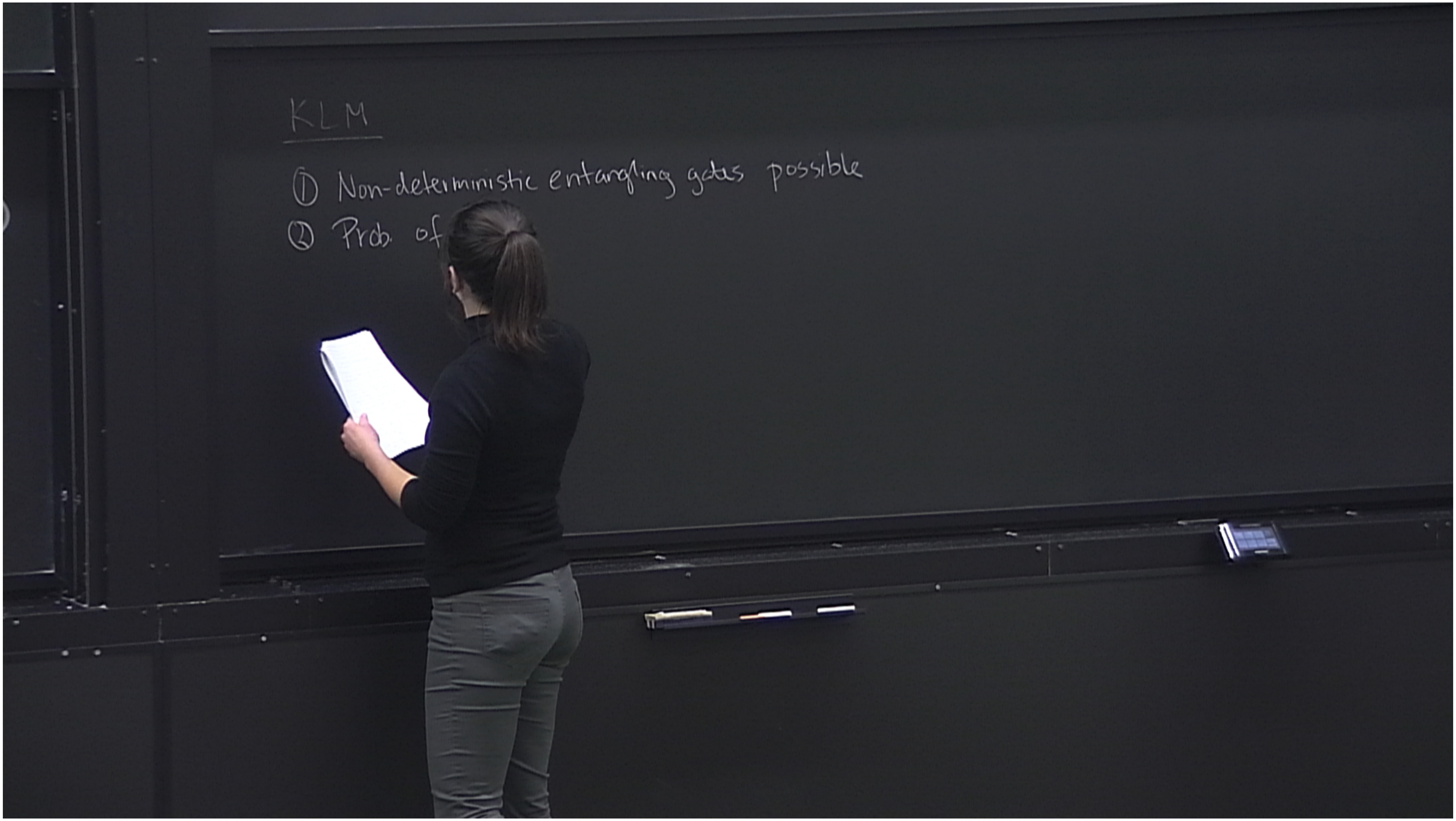

Measurements
Photon counting.
Dual Rail
a
"1"
b
Single photon sources

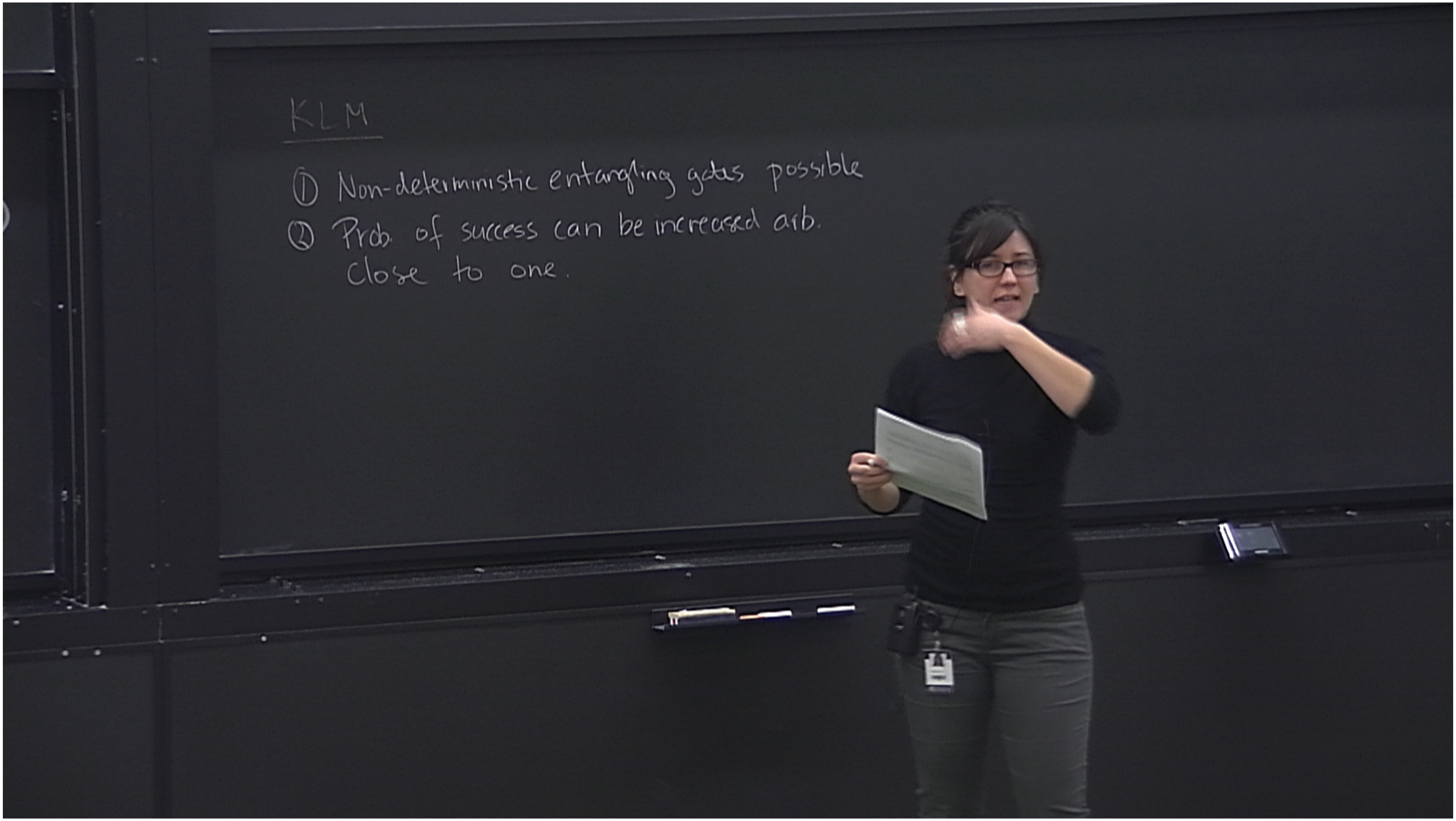

Single photon sources
Ideally:
- on-demand
- efficient
- robust
- easy to implement
don't ex
Most common source

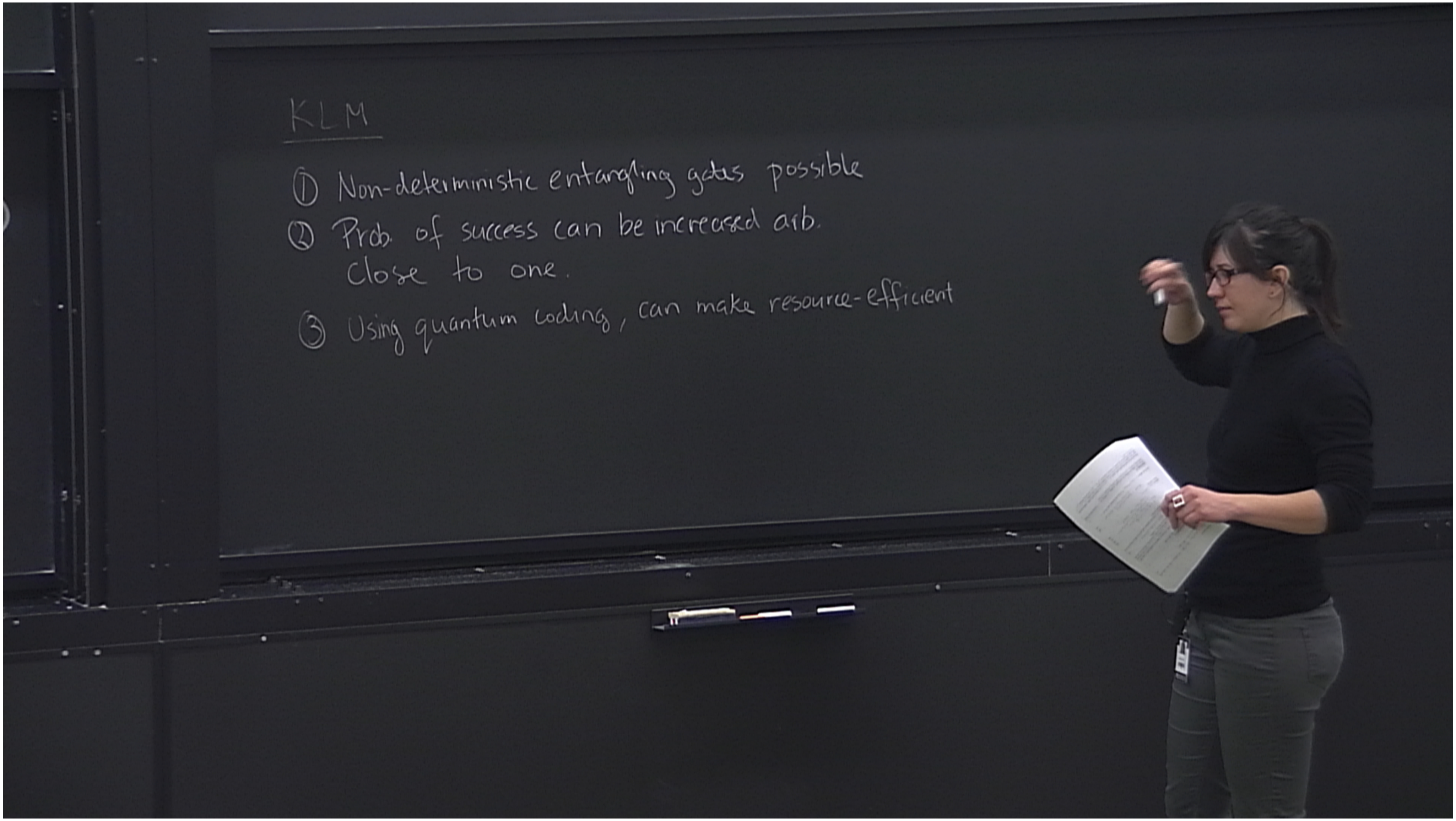

Single photon sources
Ideally:
- on-demand
- efficient
- robust
- easy to implement
don't exist
Most common source — Spontaneous Parametric
Down

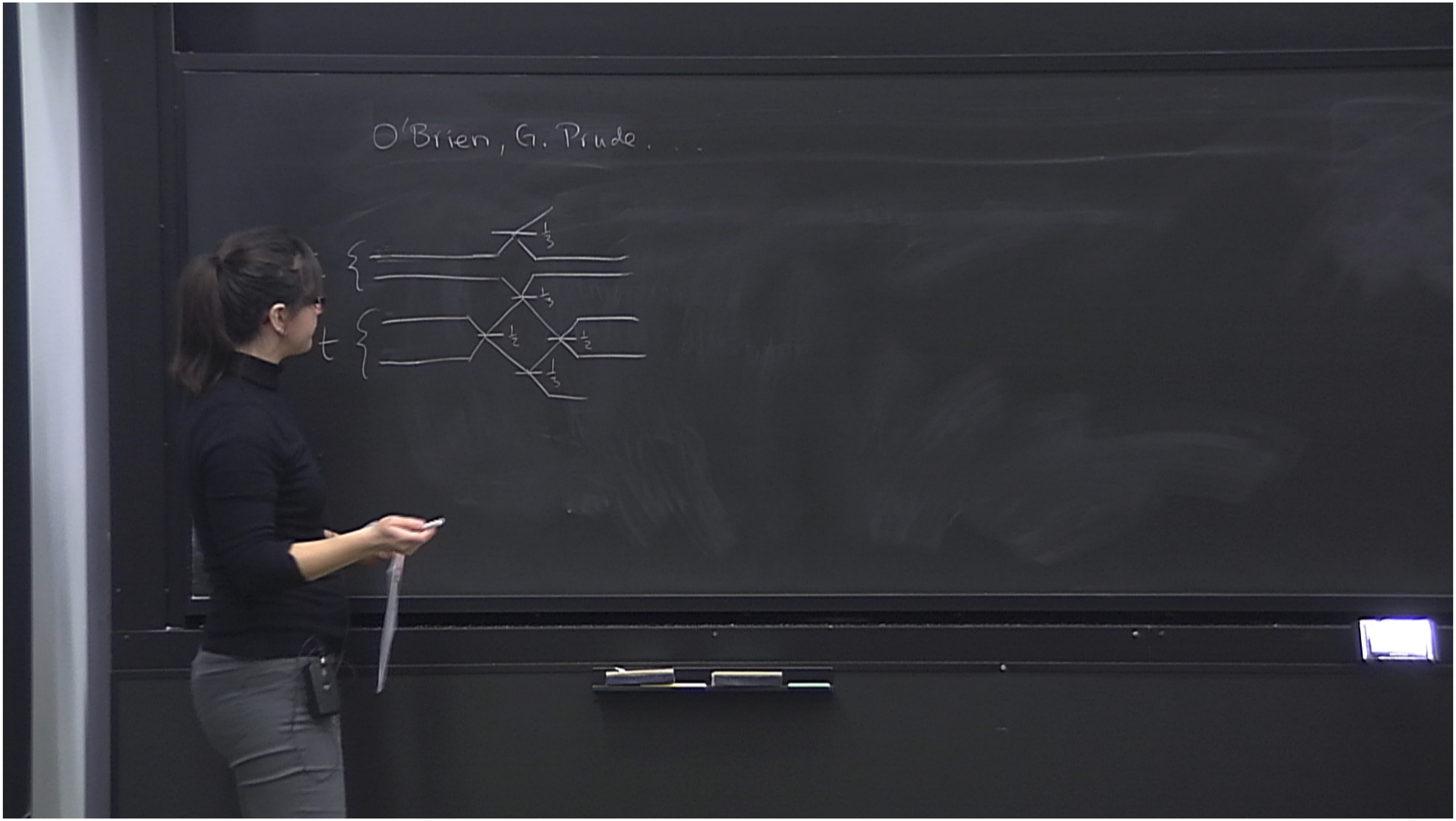

Entangling gate
want κt = π/2
now have κt ≈ 10^-18
|HH⟩ = |HH⟩
|HV⟩ = |HV⟩
|VH⟩ = |VH⟩
|VV⟩ = e^(i2κt) |VV⟩

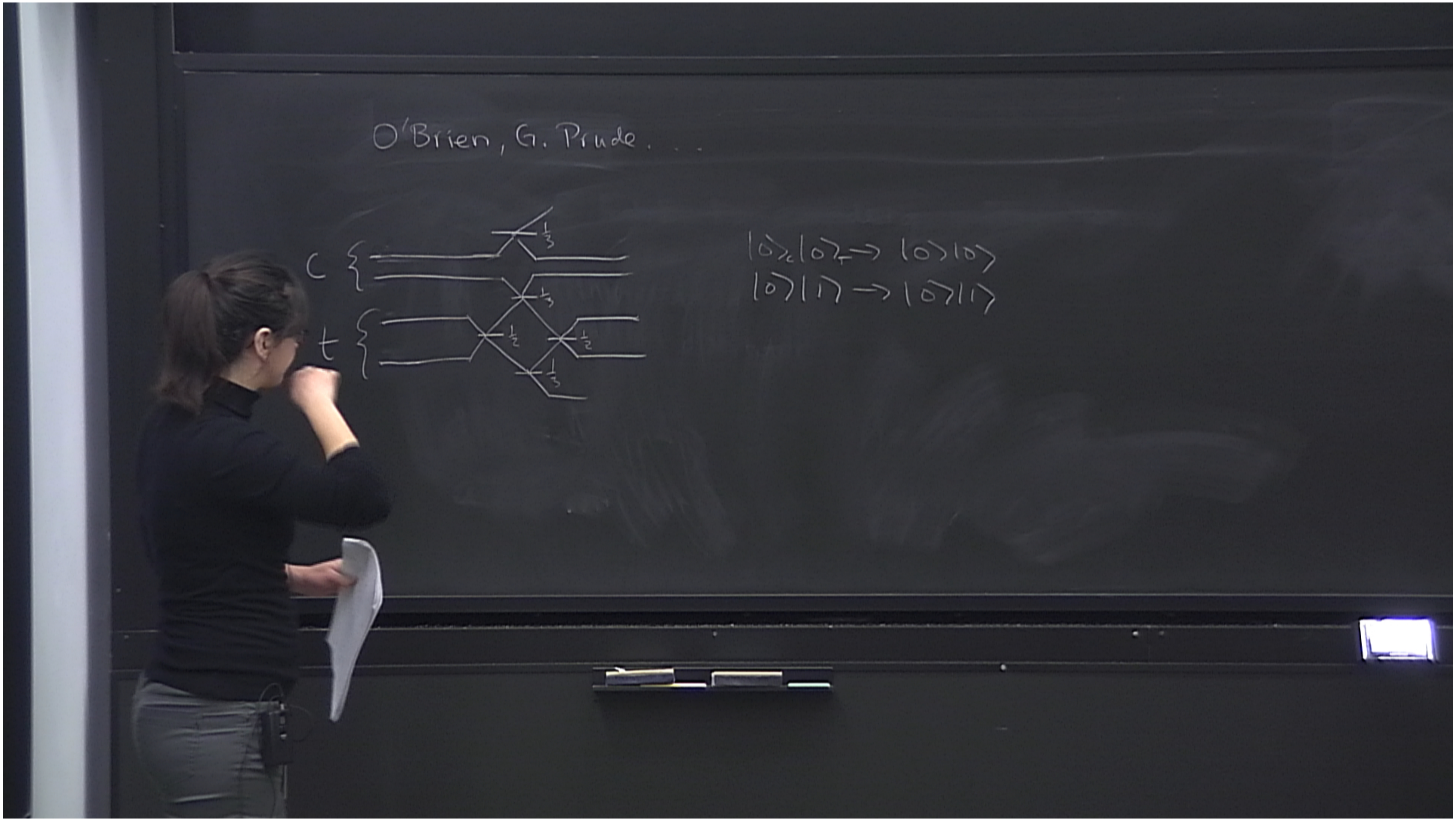

Entangling gate
want κt = π/2
now have κt ≃ 10^-18
Fortunately →
|HH⟩ = |HH⟩
|HV⟩ = |HV⟩
|VH⟩ = |VH⟩
|VV⟩ = e^{i2κt} |VV⟩

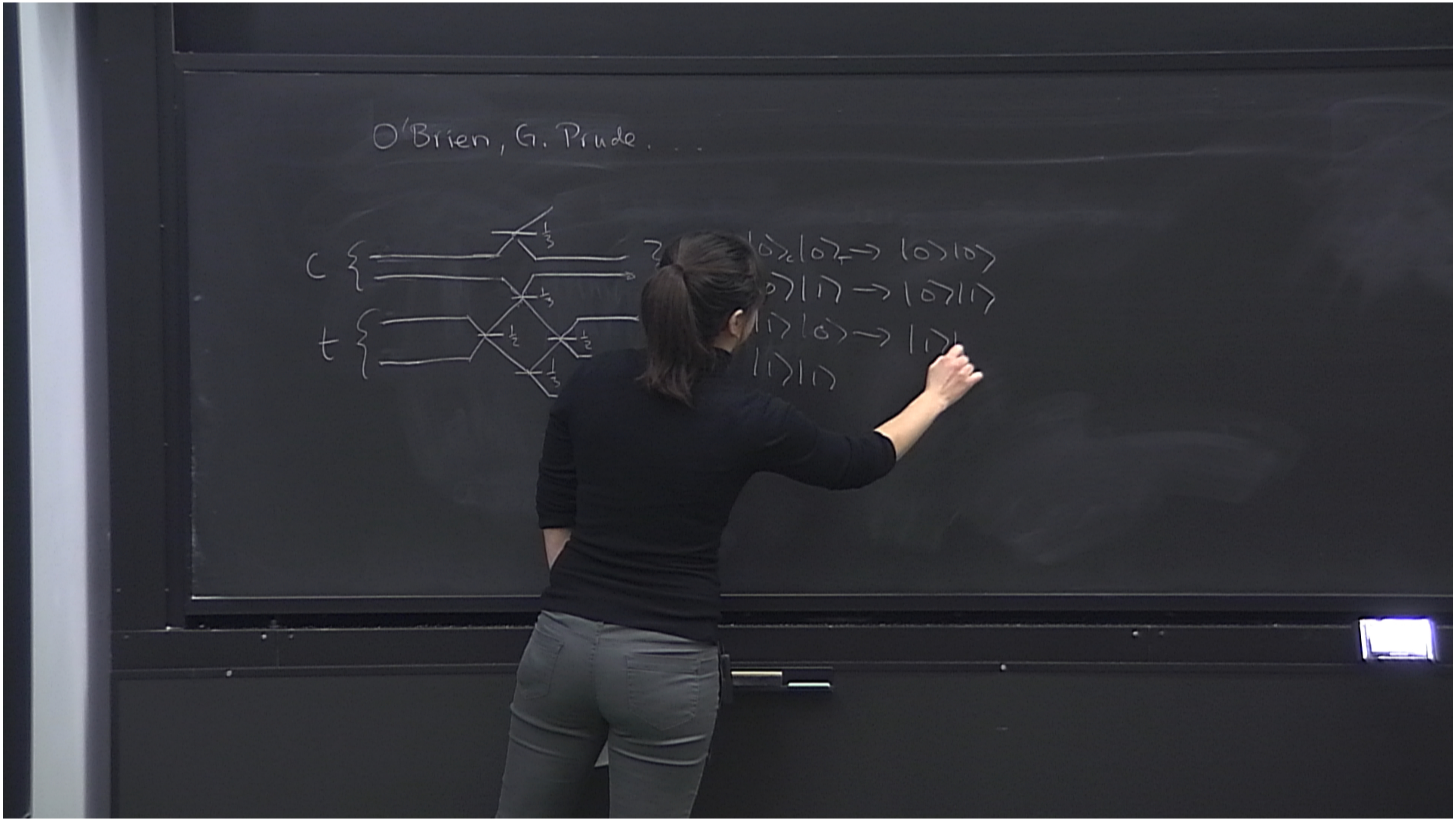

KLM
① Non-deterministic entangling gates possible
② Prob. of

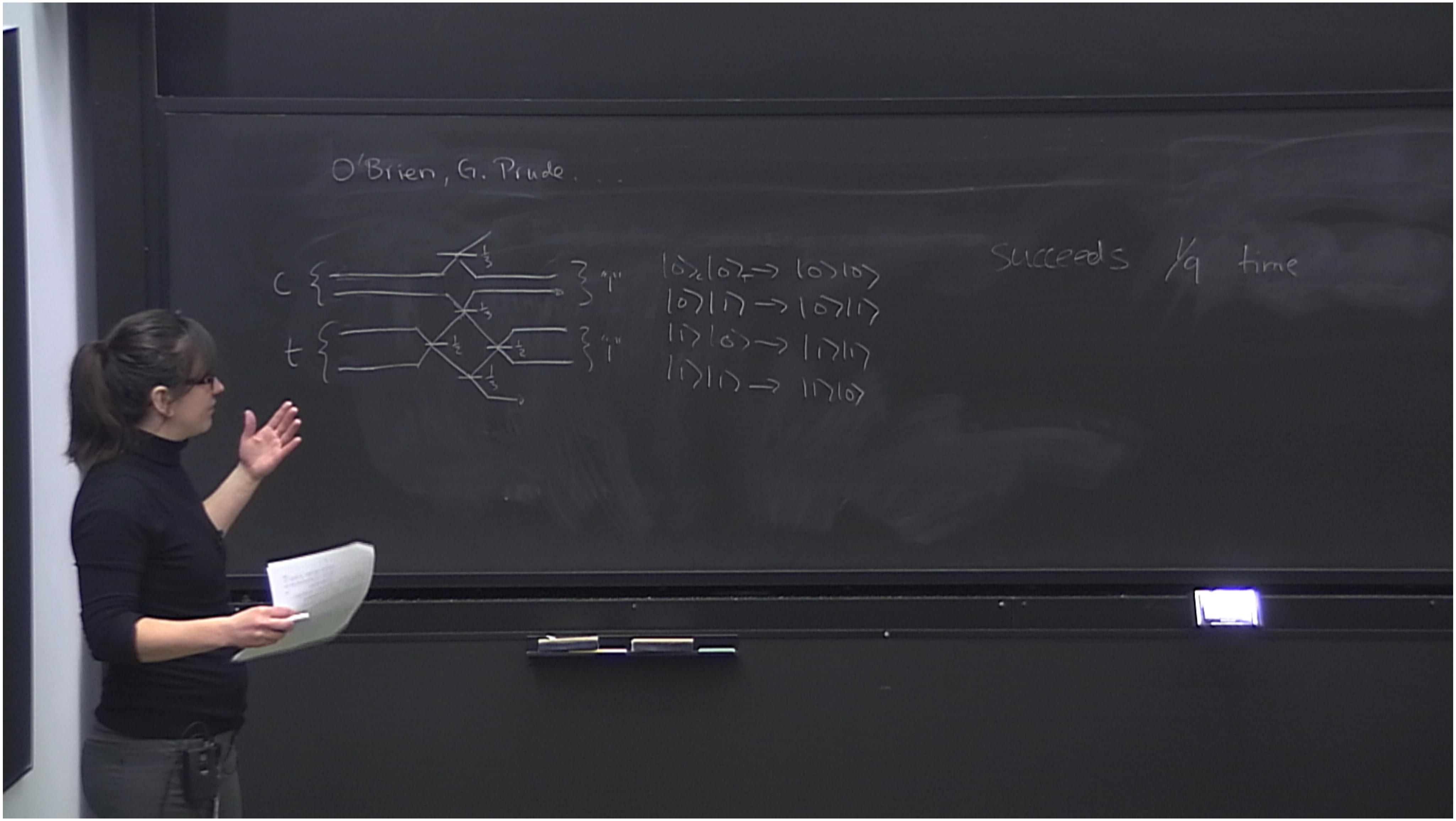

KLM
① Non-deterministic entangling gates possible
② Prob. of success can be increased arb.
close to one.

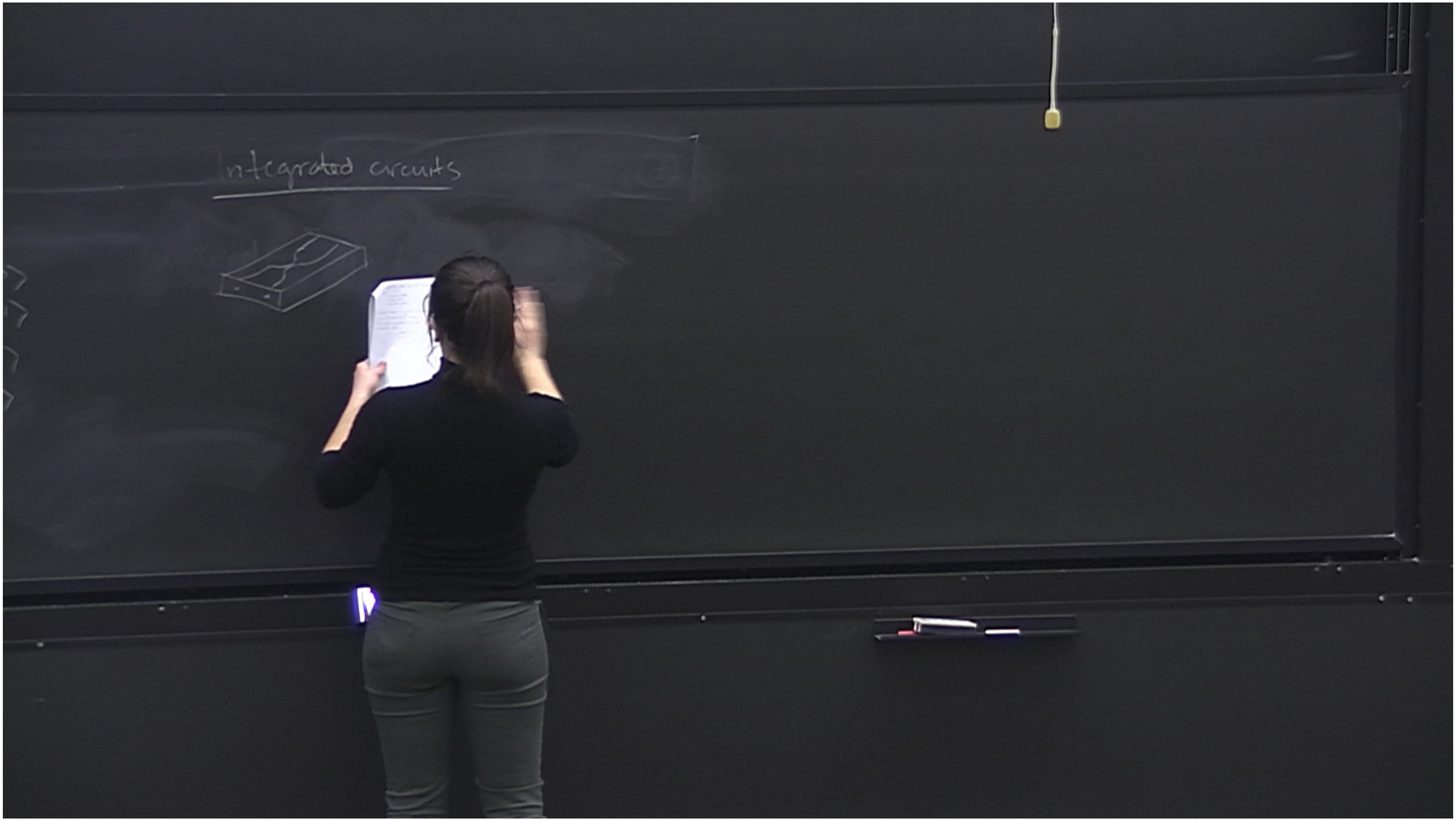

KLM
① Non-deterministic entangling gates possible
② Prob. of success can be increased arb.
close to one.
③ Using quantum coding, can make resource-efficient

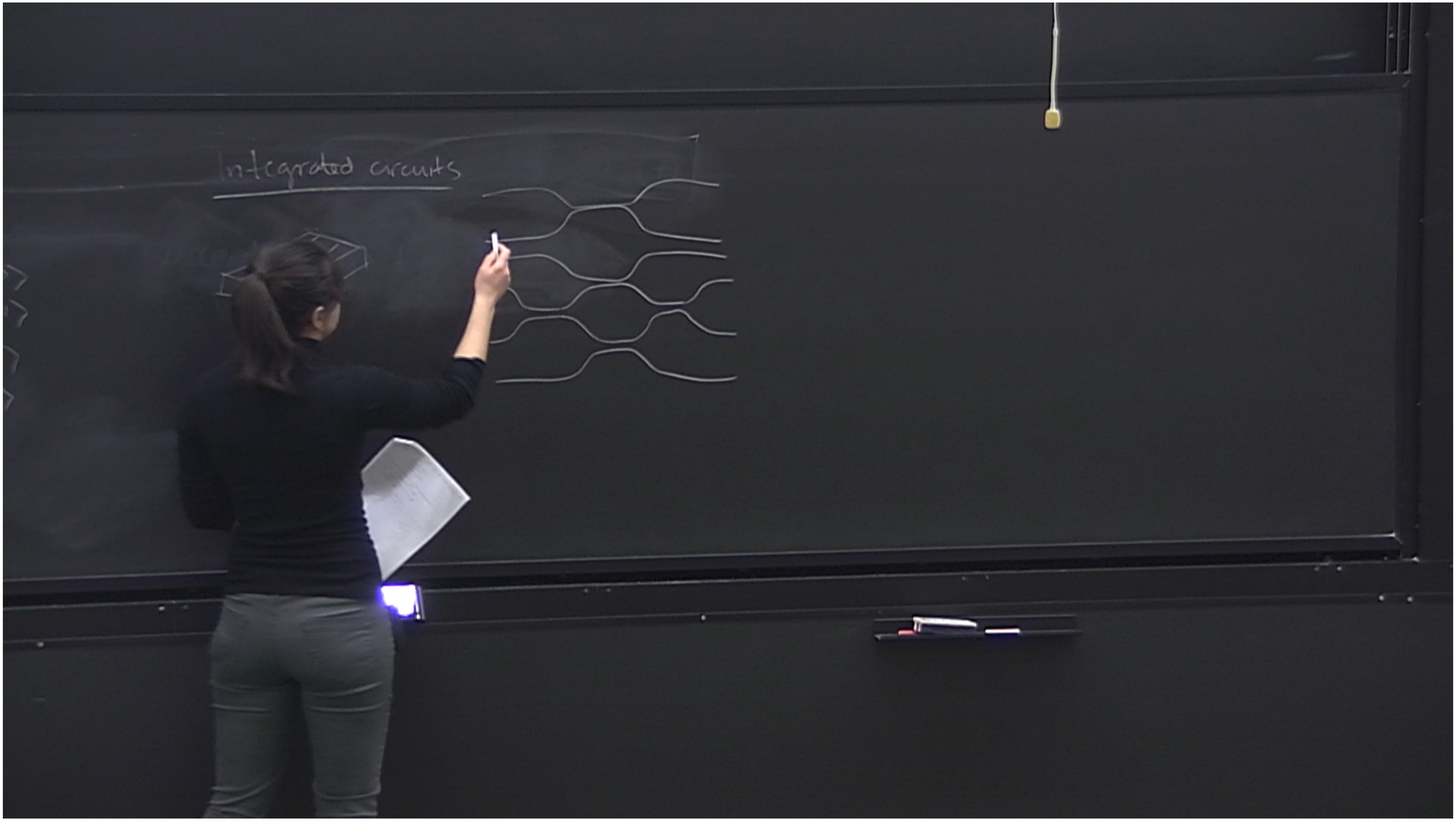

O'Brien, G. Prude . . .
t
1/3
1/3
1/2
1/2
1/3


O'Brien, G. Prude . . .
c
t
1/3
1/3
1/2
1/2
1/3
|0⟩c|0⟩t → |0⟩|0⟩
|0⟩|1⟩ → |0⟩|1⟩


O'Brien, G. Prude . . .
c
t
$\frac{1}{3}$
$\frac{1}{2}$
|0⟩|0⟩ → |0⟩|0⟩
|1⟩|0⟩ →


O'Brien, G. Pryde . . .
c
t
"1"
"1"
1/3
1/2
|0⟩|0⟩ → |0⟩|0⟩
|0⟩|1⟩ → |0⟩|1⟩
|1⟩|0⟩ → |1⟩|1⟩
|1⟩|1⟩ → |1⟩|0⟩
succeeds 1/9 time


Integrated circuits


Integrated circuits