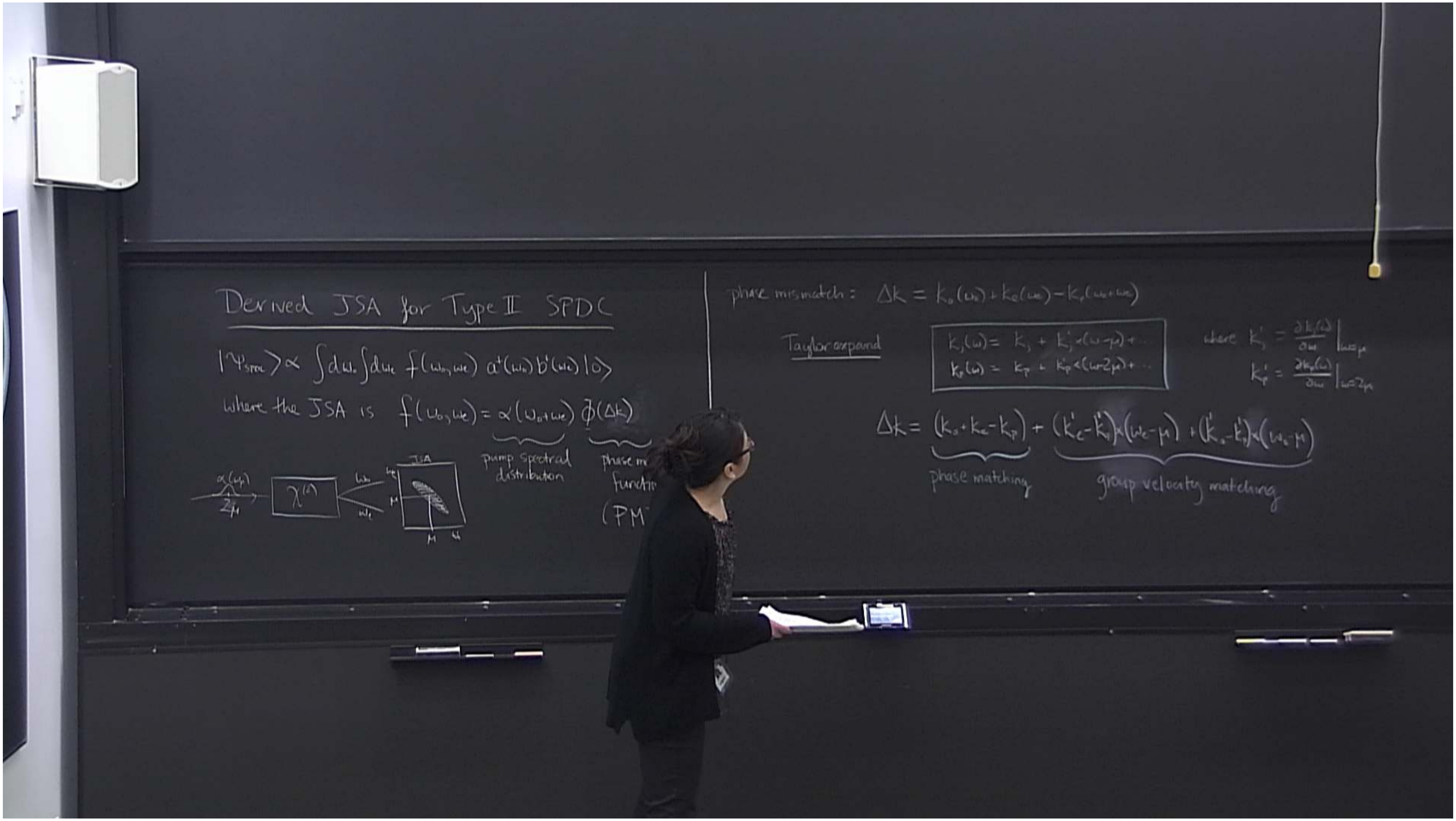
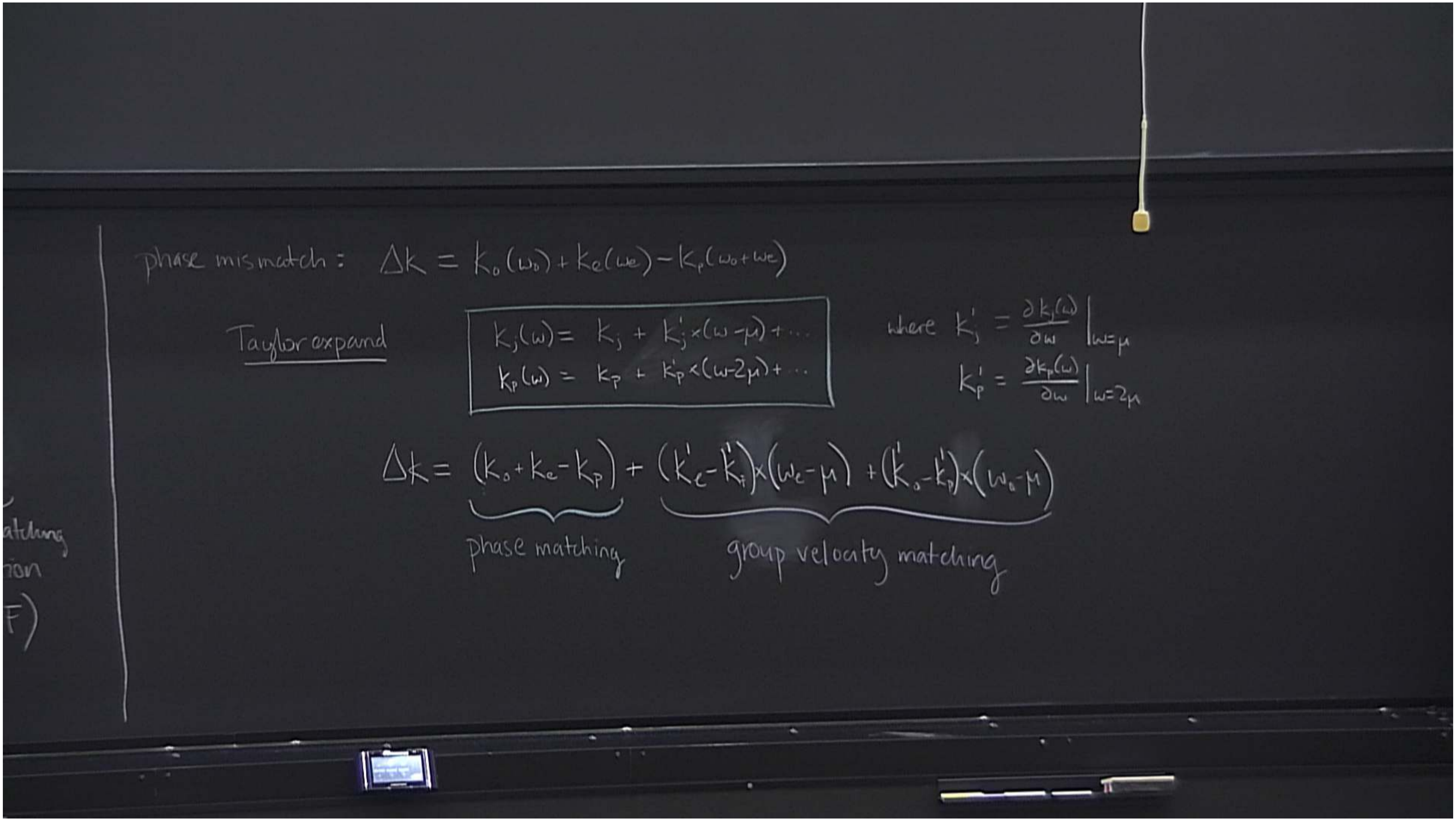
Title: PSI 2015/2016 Explorations in Quantum Information - Agata Branczyk - 13

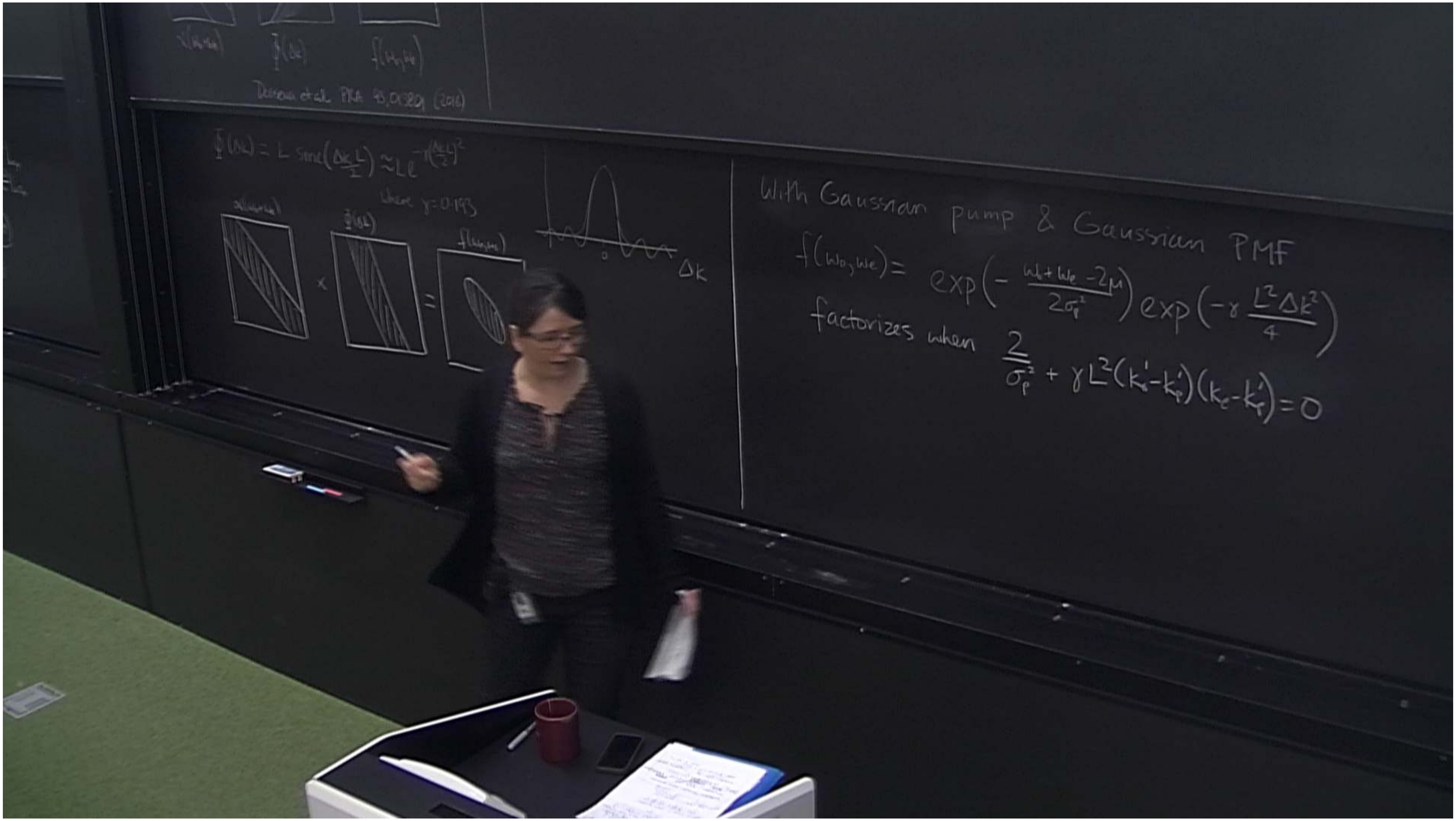
Date: Apr 07, 2016 09:00 AM

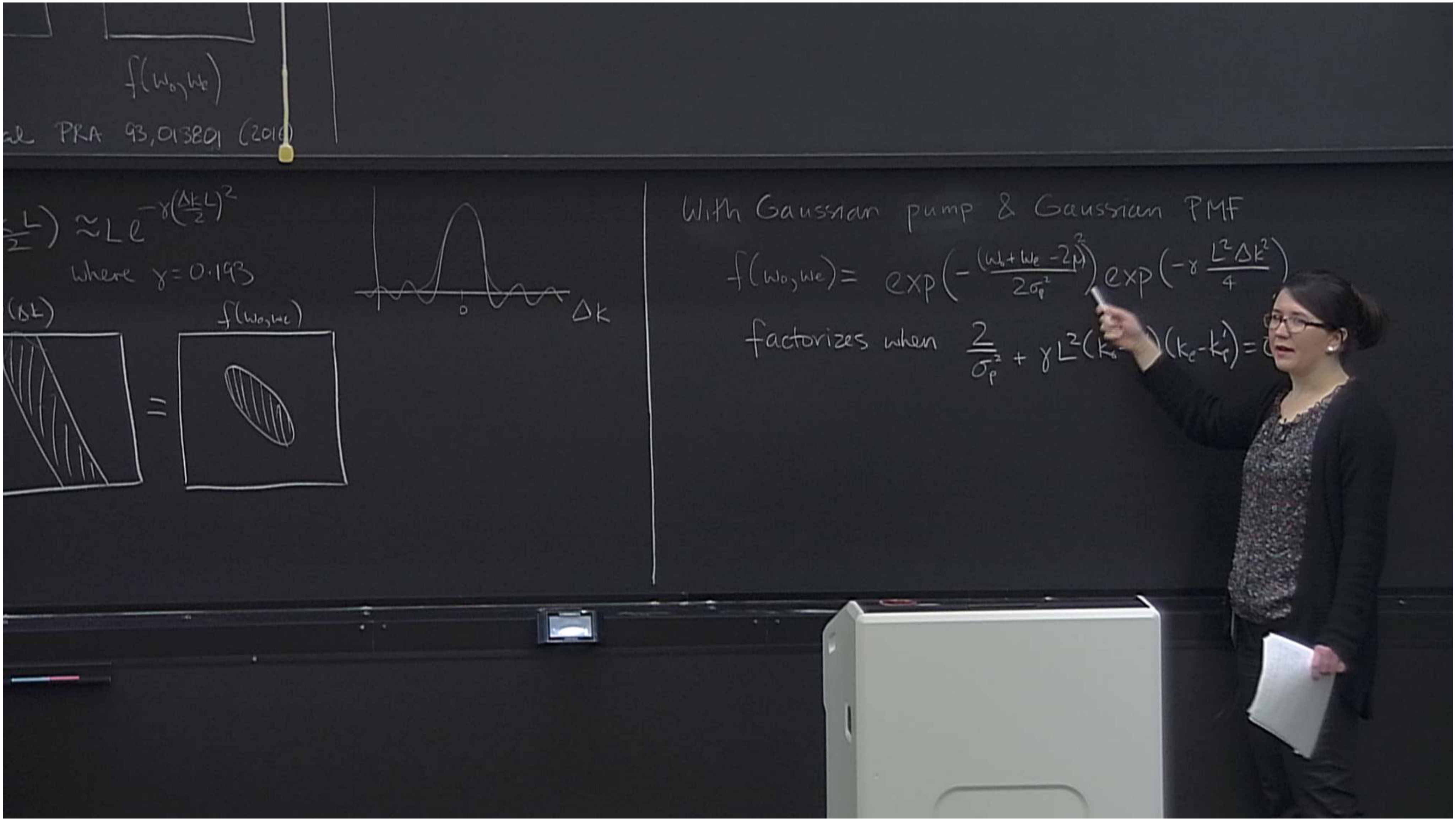
URL: http://pirsa.org/16040004

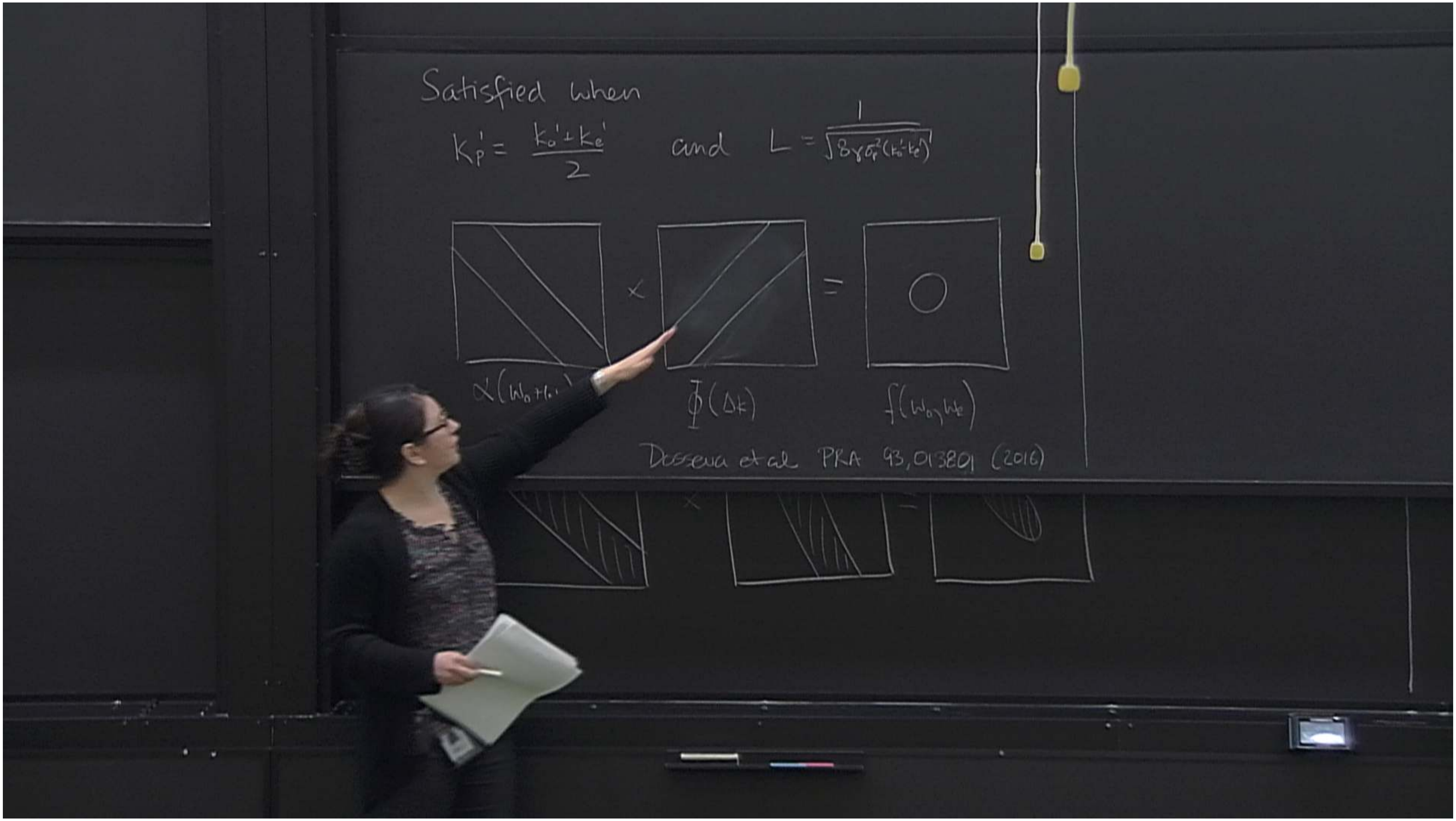
Abstract:

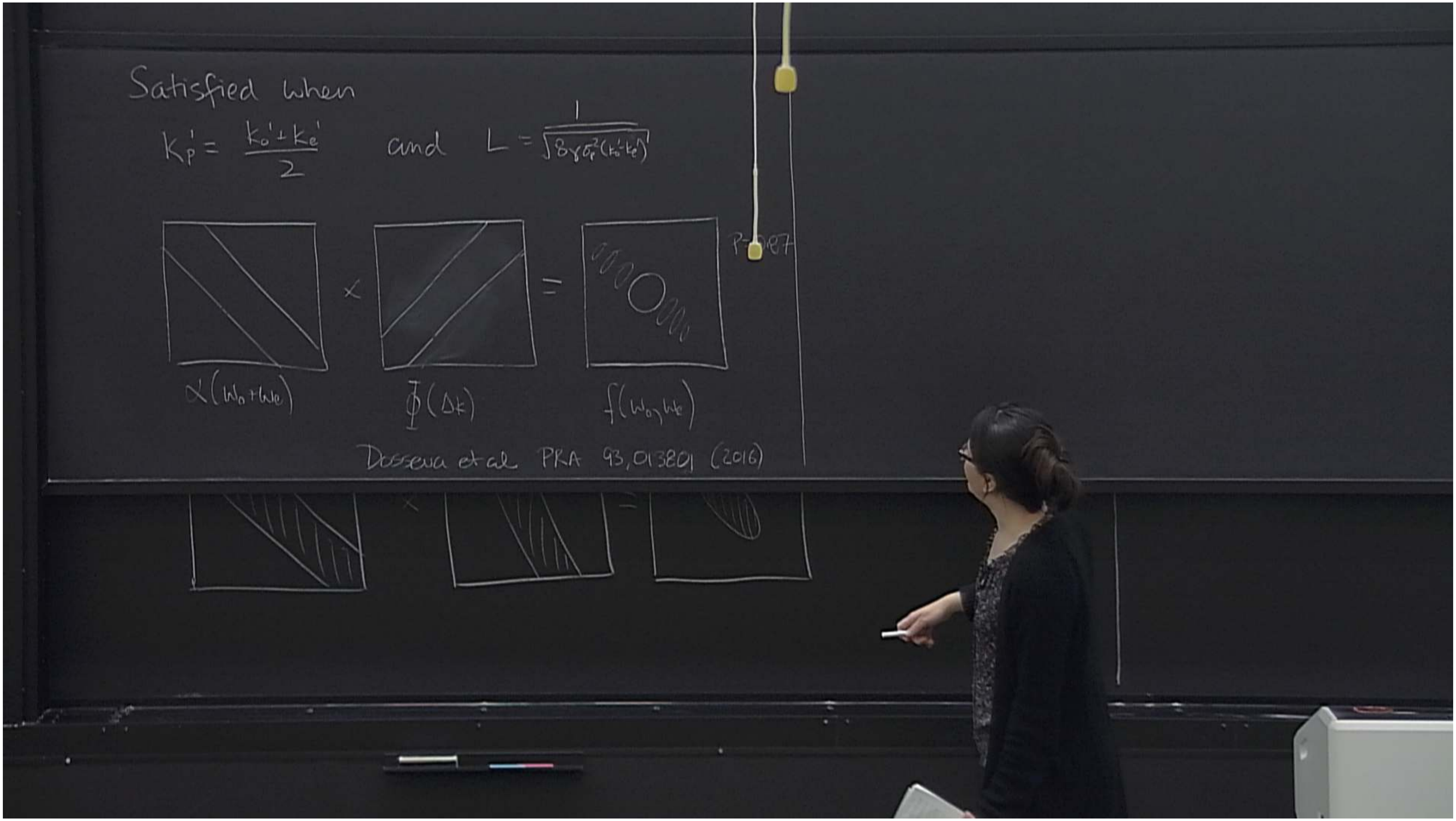

Derived JSA for Type II SPDC
where the JSA is
pump spectral distribution
phase matching
group velocity matching
phase mismatch:
Taylor expand
JSA

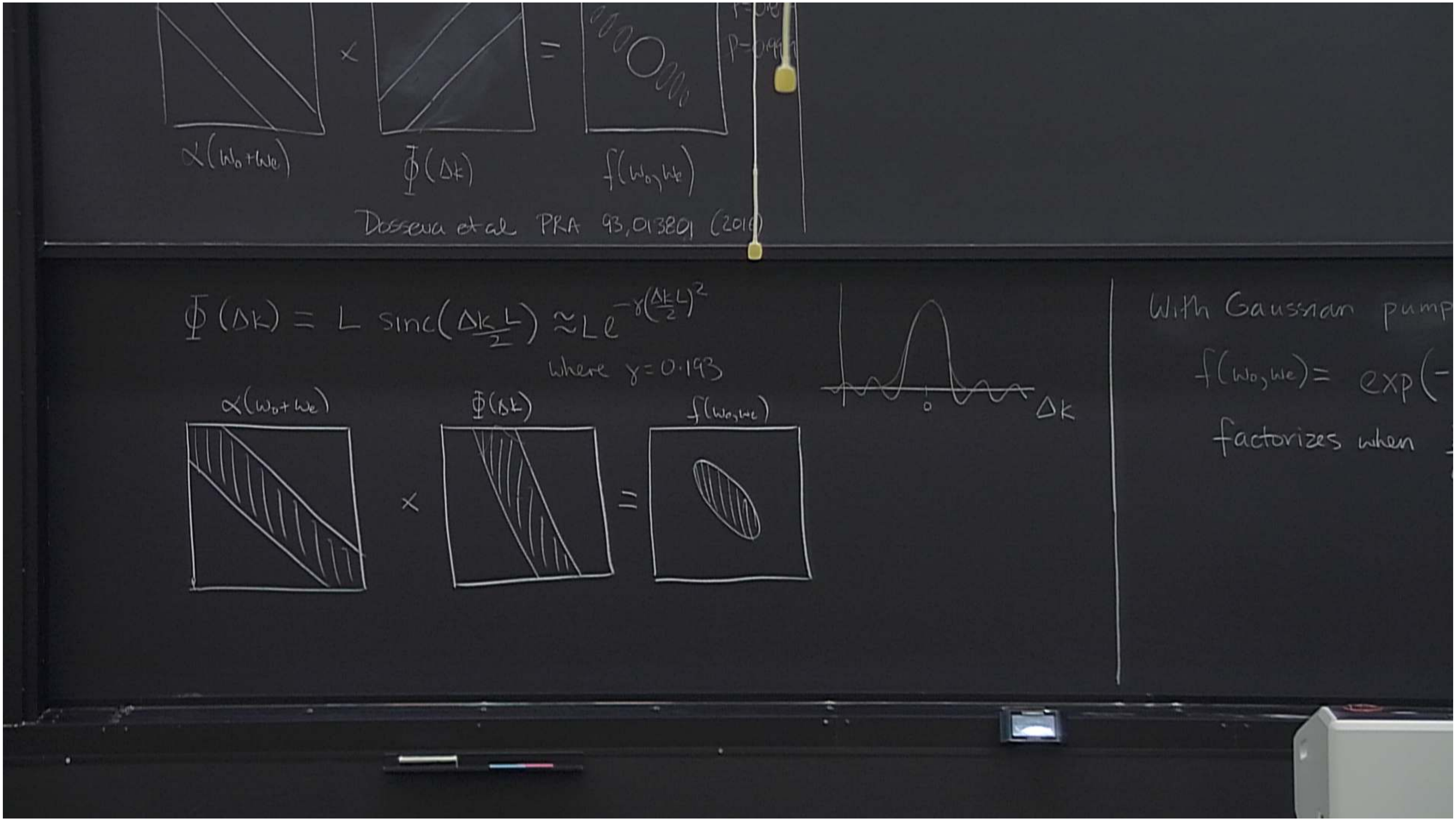

phase mismatch: $\Delta k = k_o(\omega_o) + k_e(\omega_e) - k_p(\omega_o + \omega_e)$
Taylor expand
$k_j(\omega) = k_j + k_j' \times (\omega - \mu) + \ldots$
$k_p(\omega) = k_p + k_p' \times (\omega - 2\mu) + \ldots$
where $k_j' = \frac{\partial k_j(\omega)}{\partial \omega}\Big|_{\omega=\mu}$
$k_p' = \frac{\partial k_p(\omega)}{\partial \omega}\Big|_{\omega=2\mu}$
$\Delta k = (k_o + k_e - k_p) + (k_e' - k_p') \times (\omega_e - \mu) + (k_o' - k_p') \times (\omega_o - \mu)$
phase matching
group velocity matching
atching
ion
F)

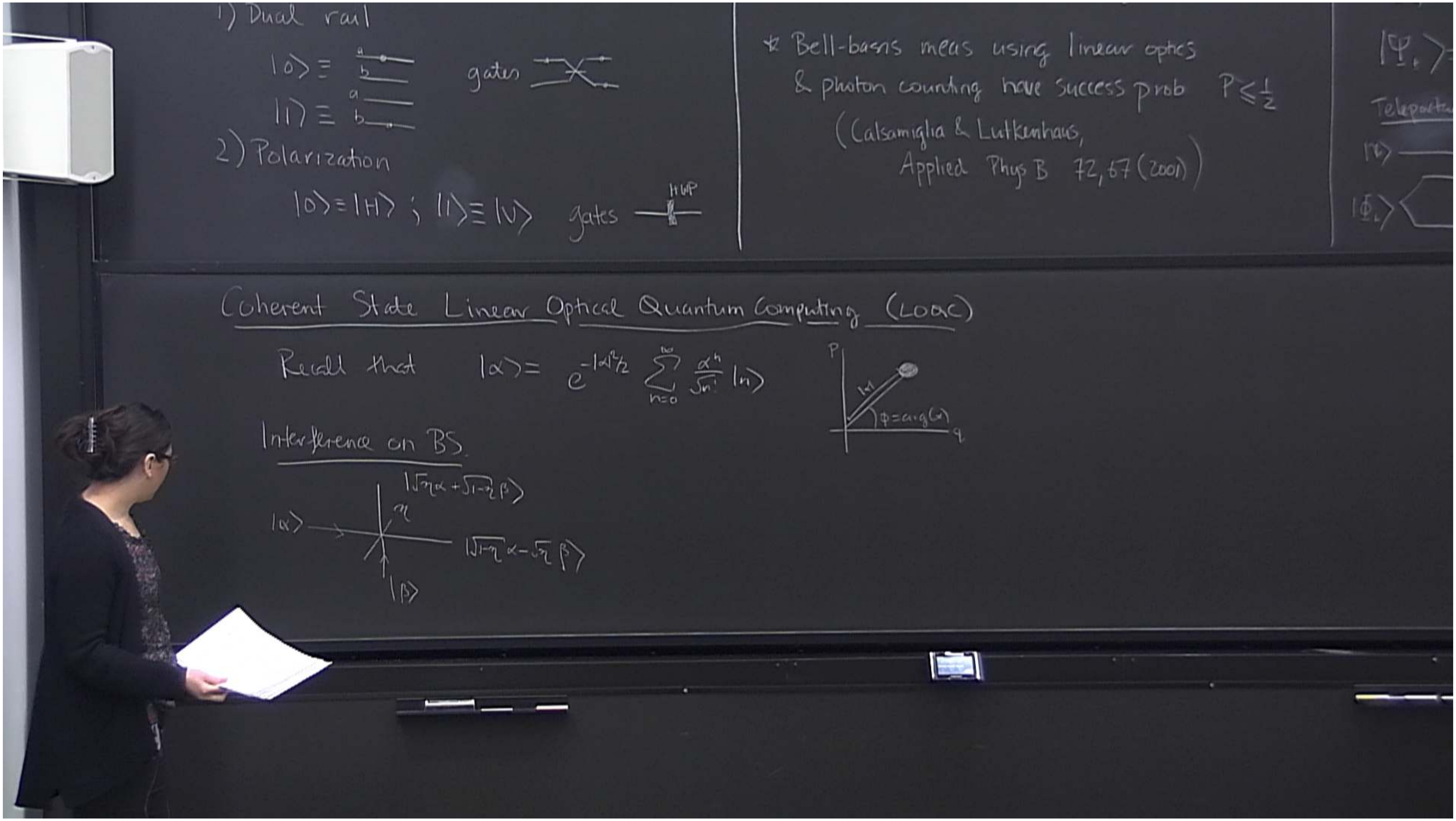

With Gaussian pump & Gaussian PMF
f(ωo, ωe) = exp(− (ωo + ωe − 2μ)/(2σp²)) exp(−γ L²Δk²/4)
factorizes when 2/σp² + γL²(ko′ − kp′)(ke − kp′) = 0
Φ(Δk) = L sinc(ΔkL/2) ≈ L e^(−γ(ΔkL/2)²)
where γ = 0.193
Δk

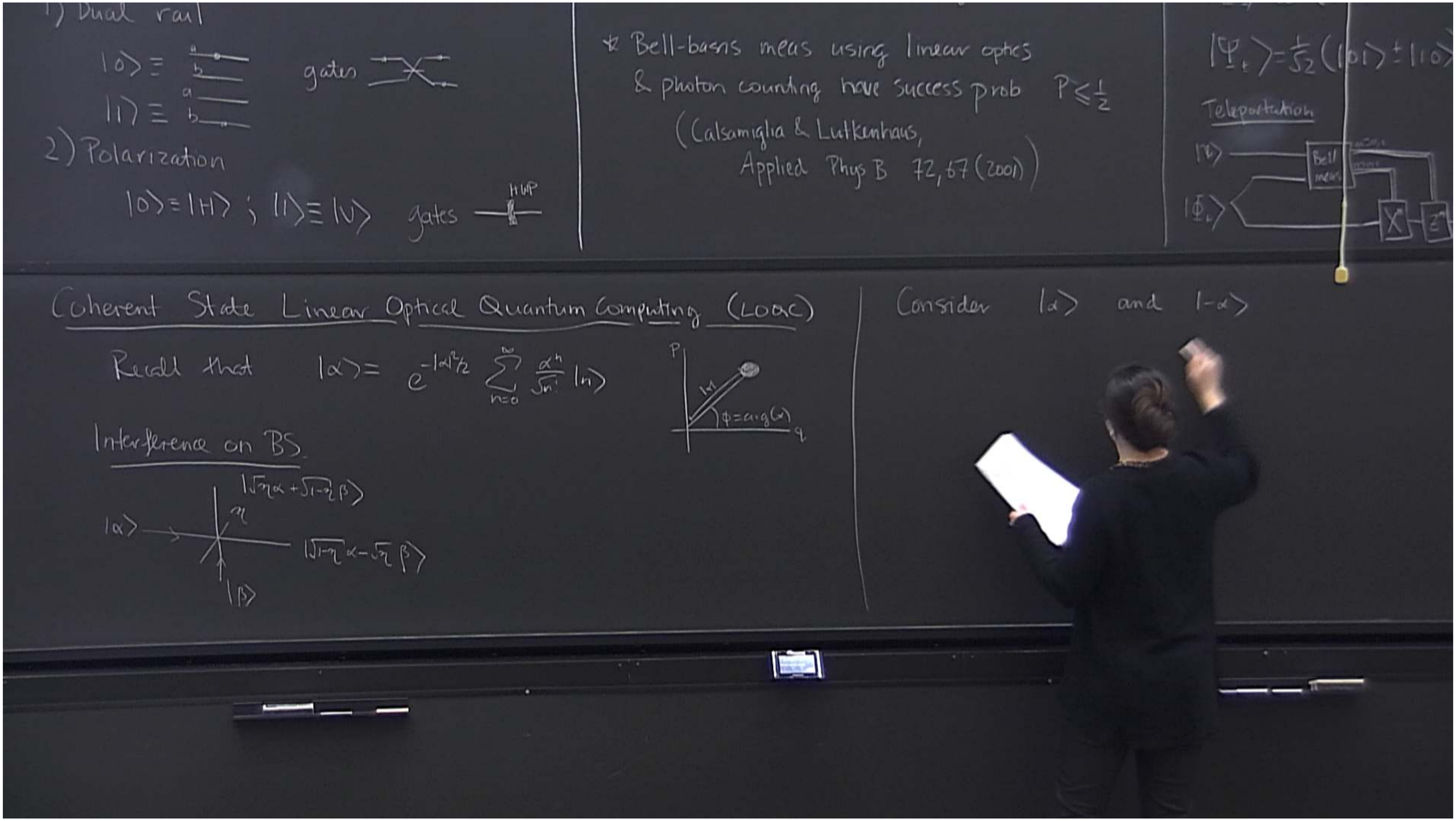

f(ωo, ωe)
PRA 93, 013801
where γ = 0.193
Δk
With Gaussian pump & Gaussian PMF
factorizes when

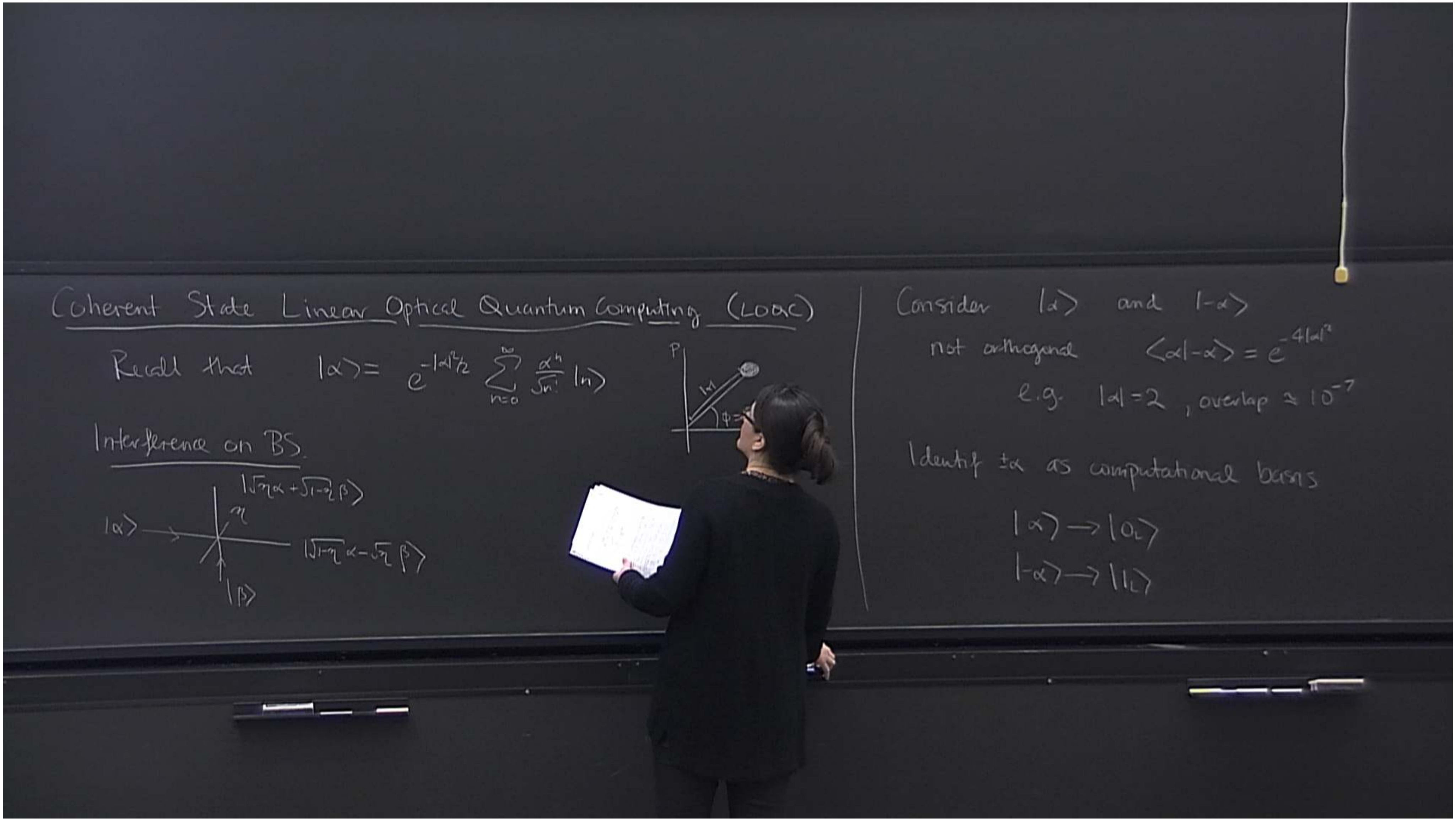

Satisfied when
and
Dosseva et al PRA 93, 013801 (2016)

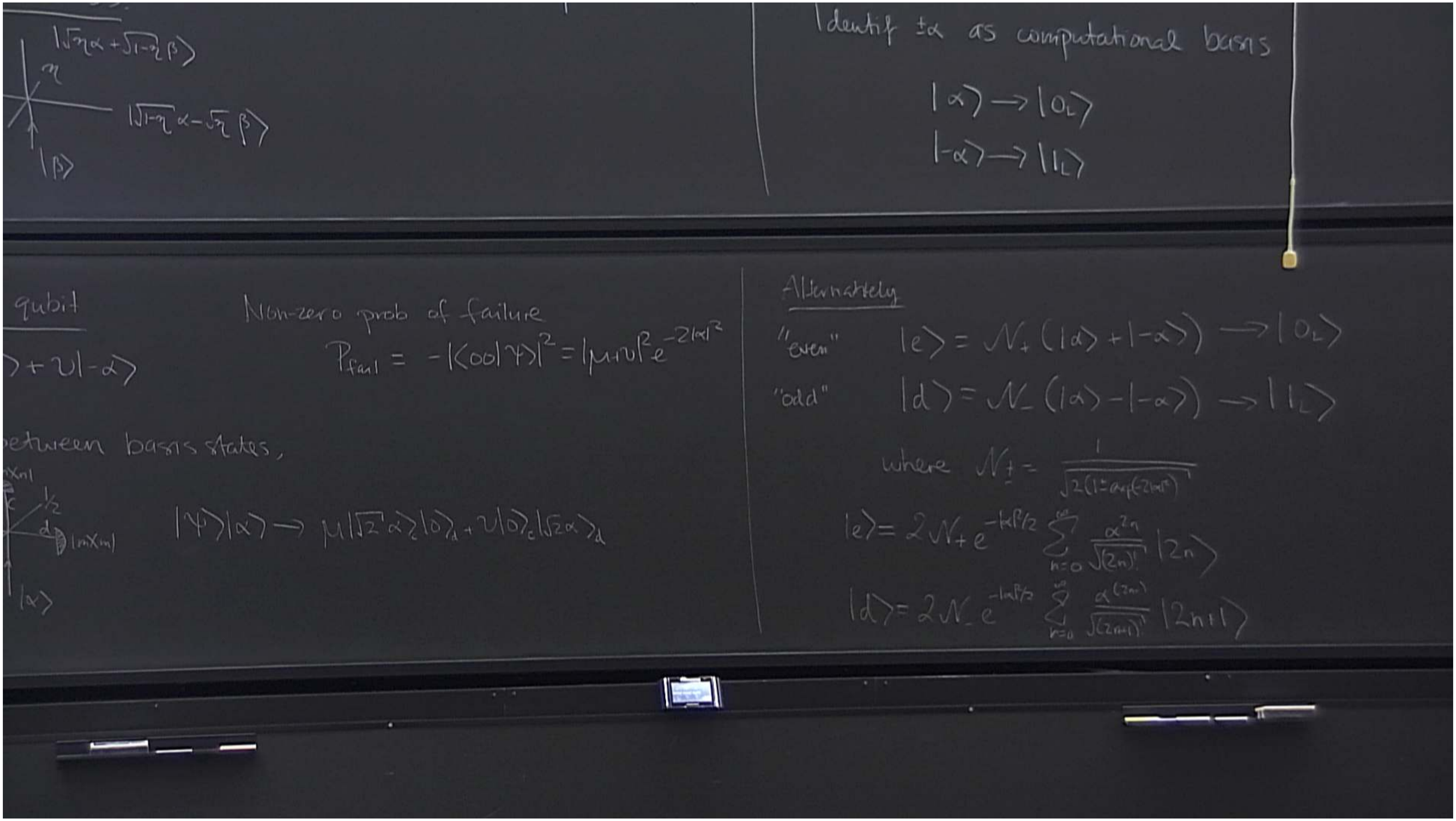

Satisfied when
$k_p' = \frac{k_o' + k_e'}{2}$ and $L = \frac{1}{\sqrt{8\gamma\sigma_p^2(k_o' - k_e')}}$
$\alpha(\omega_o + \omega_e)$
$\Phi(\Delta k)$
$f(\omega_o, \omega_e)$
Dosseva et al PRA 93, 013801 (2016)

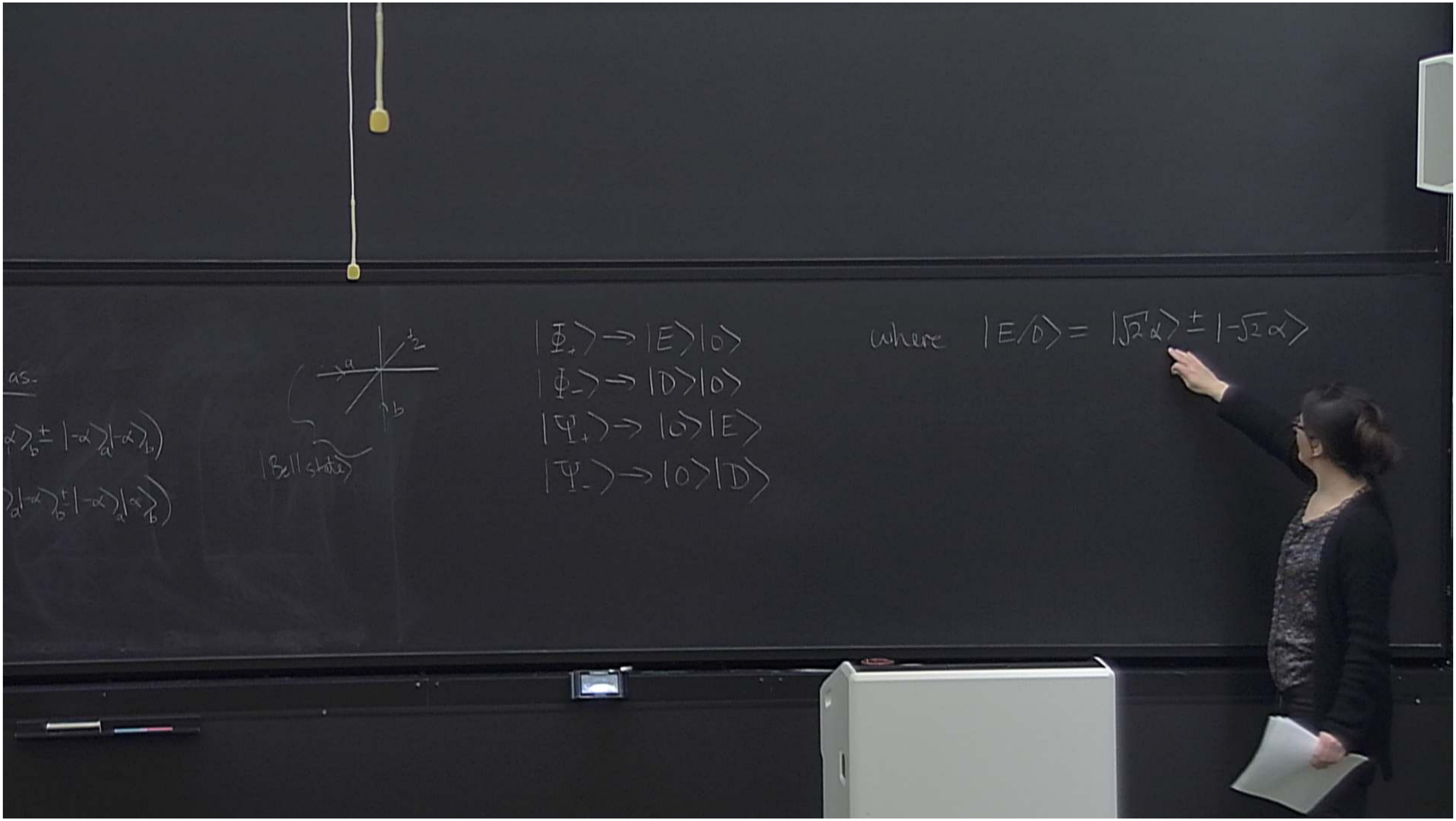

α(ω₀+ωₑ)
Φ(Δk)
f(ω₀,ωₑ)
Dosseva et al PRA 93, 013801 (2016)
Φ(Δk) = L sinc(ΔkL/2) ≈ L e^{-γ(ΔkL/2)²}
where γ = 0.193
α(ω₀+ωₑ)
Φ(Δk)
f(ω₀,ωₑ)
Δk
With Gaussian pump
f(ω₀,ωₑ) = exp(
factorizes when


1) Dual rail
|0> ≡
|1> ≡
gates
2) Polarization
|0> ≡ |H> ; |1> ≡ |V> gates
HWP
* Bell-basis meas using linear optics
& photon counting have success prob P ≤ 1/2
(Calsamiglia & Lutkenhaus,
Applied Phys B 72, 67 (2001))
Teleportation
Coherent State Linear Optical Quantum Computing (LOQC)
Recall that |α> = e^{-|α|²/2} Σ_{n=0}^∞ α^n/√n! |n>
φ = arg(α)
Interference on BS
|√η α + √(1-η) β>
|α>
|√(1-η) α - √η β>
|β>

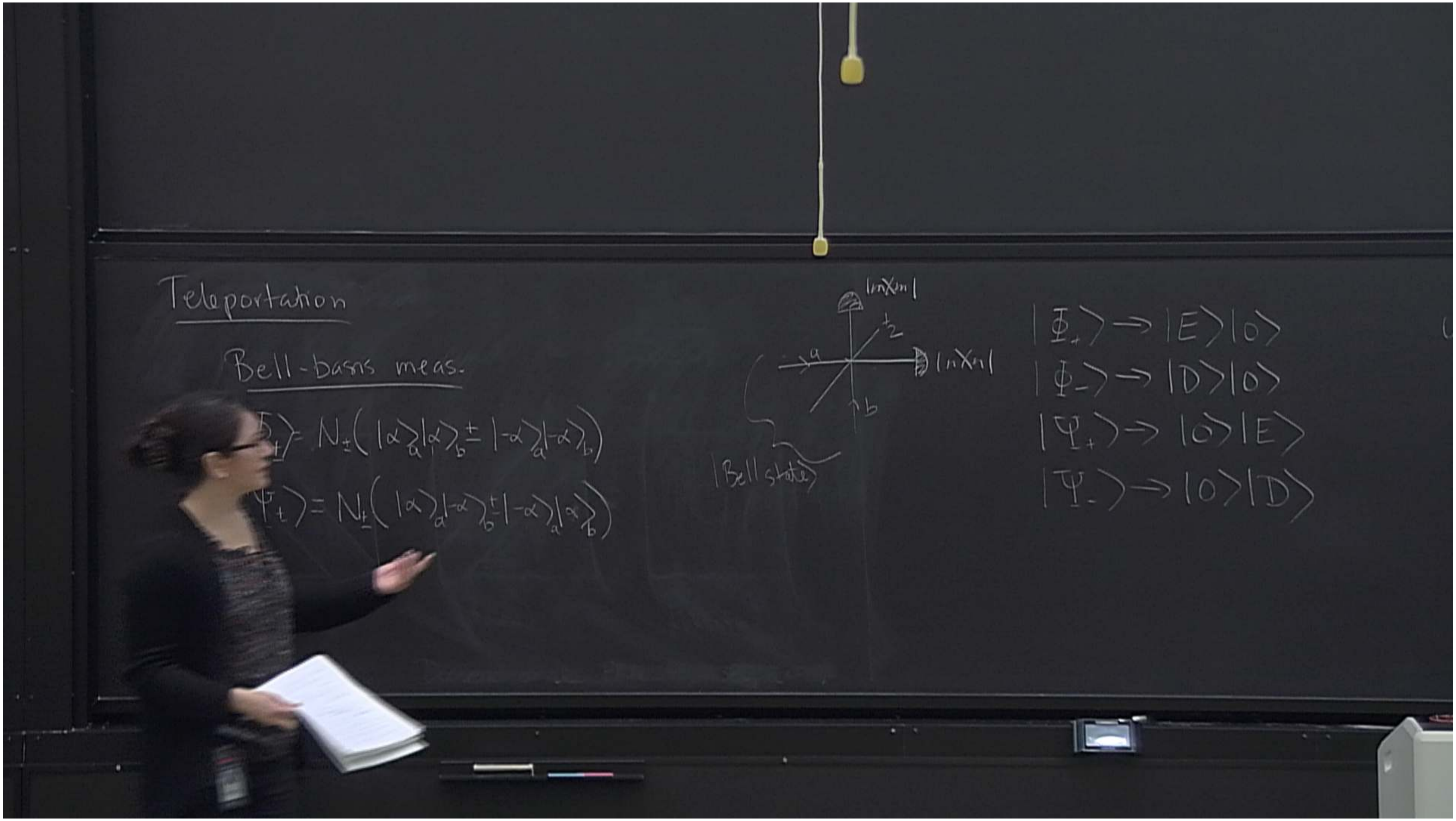

1) Dual rail
|0⟩ ≡
|1⟩ ≡
gates
2) Polarization
|0⟩ ≡ |H⟩ ; |1⟩ ≡ |V⟩ gates
HWP
* Bell-basis meas using linear optics
& photon counting have success prob P ≤ 1/2
(Calsamiglia & Lutkenhaus,
Applied Phys B 72, 67 (2001))
Teleportation
Bell meas
Coherent State Linear Optical Quantum Computing (LOQC)
Recall that |α⟩ = e^{-|α|²/2} Σ_{n=0}^∞ α^n/√n! |n⟩
φ = arg(α)
Interference on BS
|α⟩
|β⟩
|√η α + √(1-η) β⟩
|√(1-η) α - √η β⟩
Consider |α⟩ and |-α⟩

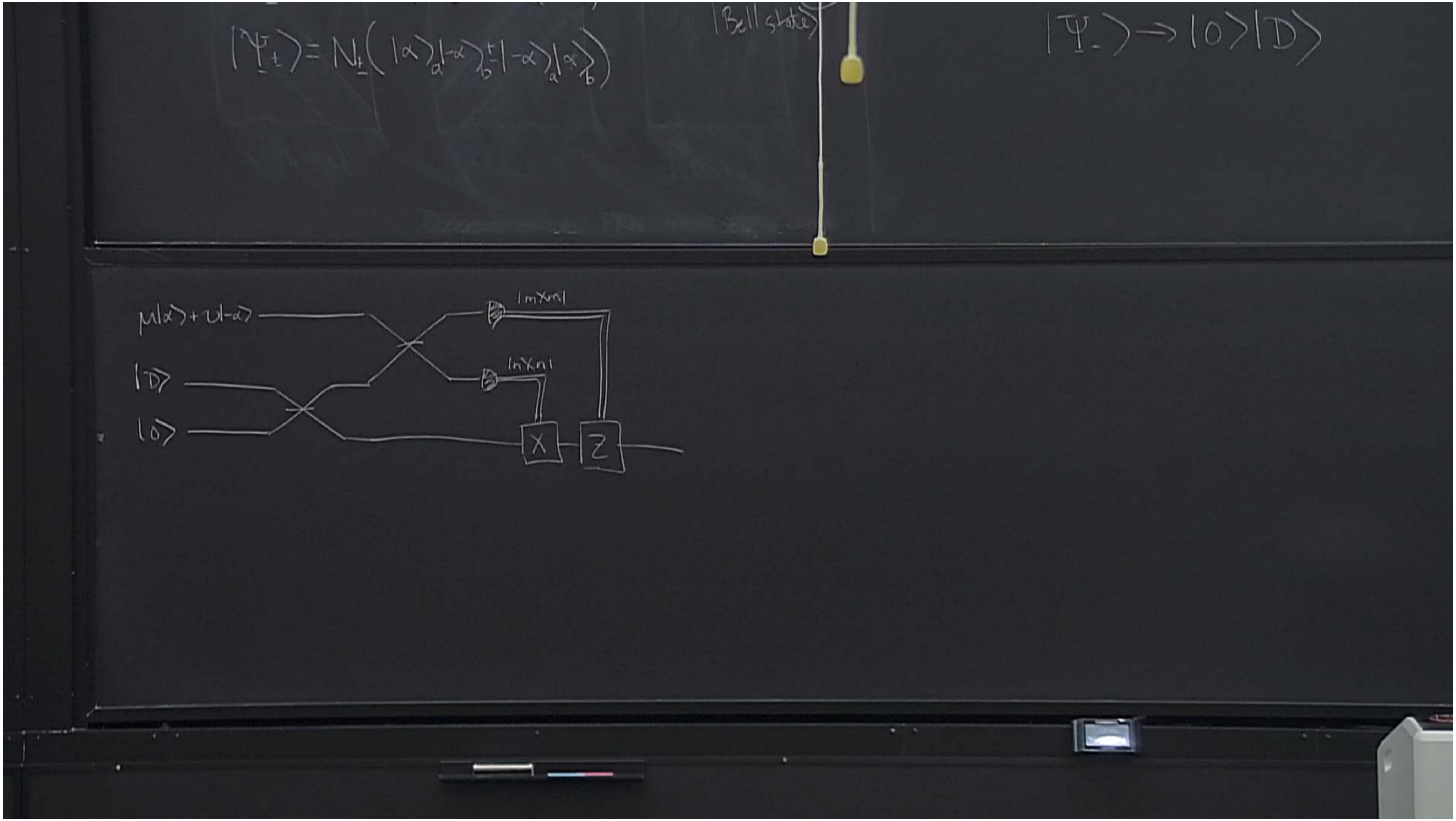

Coherent State Linear Optical Quantum Computing (LOQC)
Recall that |α⟩ = e^{-|α|²/2} Σ_{n=0}^{∞} αⁿ/√n! |n⟩
Interference on BS
|√η α + √(1-η) β⟩
|α⟩
|√(1-η) α − √η β⟩
|β⟩
Consider |α⟩ and |−α⟩
not orthogonal ⟨α|−α⟩ = e^{-4|α|²}
e.g. |α| = 2, overlap ≈ 10⁻⁷
Identify ±α as computational basis
|α⟩ → |0_L⟩
|−α⟩ → |1_L⟩

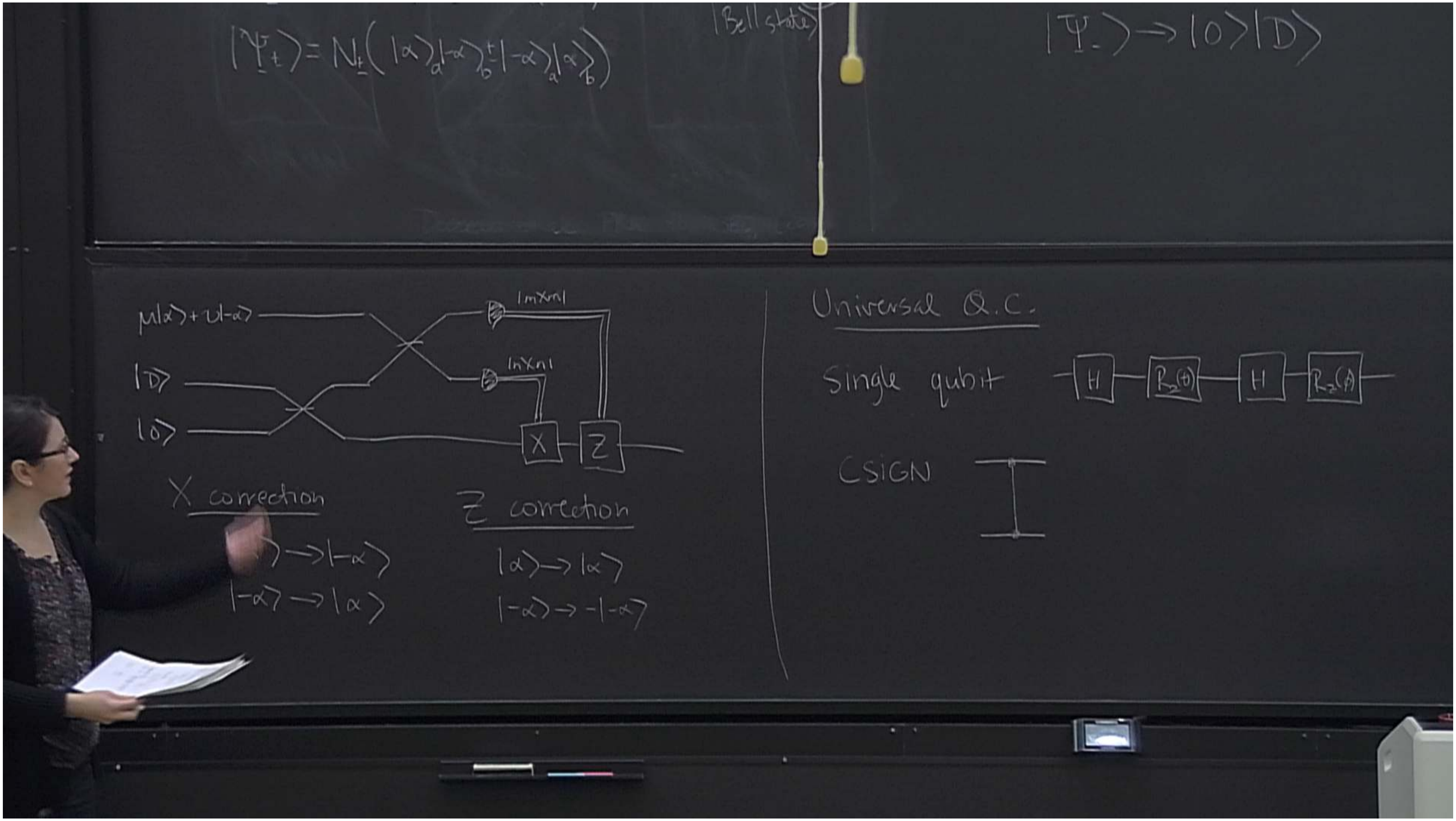

Identify ±α as computational basis
|α⟩ → |0_L⟩
|−α⟩ → |1_L⟩
qubit
Non-zero prob of failure
P_fail = |⟨00|ψ⟩|² = |μ+ν|² e^{−2|α|²}
between basis states,
|ψ⟩|α⟩ → μ|√2 α⟩_c|0⟩_d + ν|0⟩_c|√2 α⟩_d
Alternately
"even" |e⟩ = N_+ (|α⟩ + |−α⟩) → |0_L⟩
"odd" |d⟩ = N_− (|α⟩ − |−α⟩) → |1_L⟩
where N_± = 1/√(2(1 ± exp(−2|α|²)))
|e⟩ = 2N_+ e^{−|α|²/2} Σ_{n=0}^∞ α^{2n}/√((2n)!) |2n⟩
|d⟩ = 2N_− e^{−|α|²/2} Σ_{n=0}^∞ α^{(2n+1)}/√((2n+1)!) |2n+1⟩

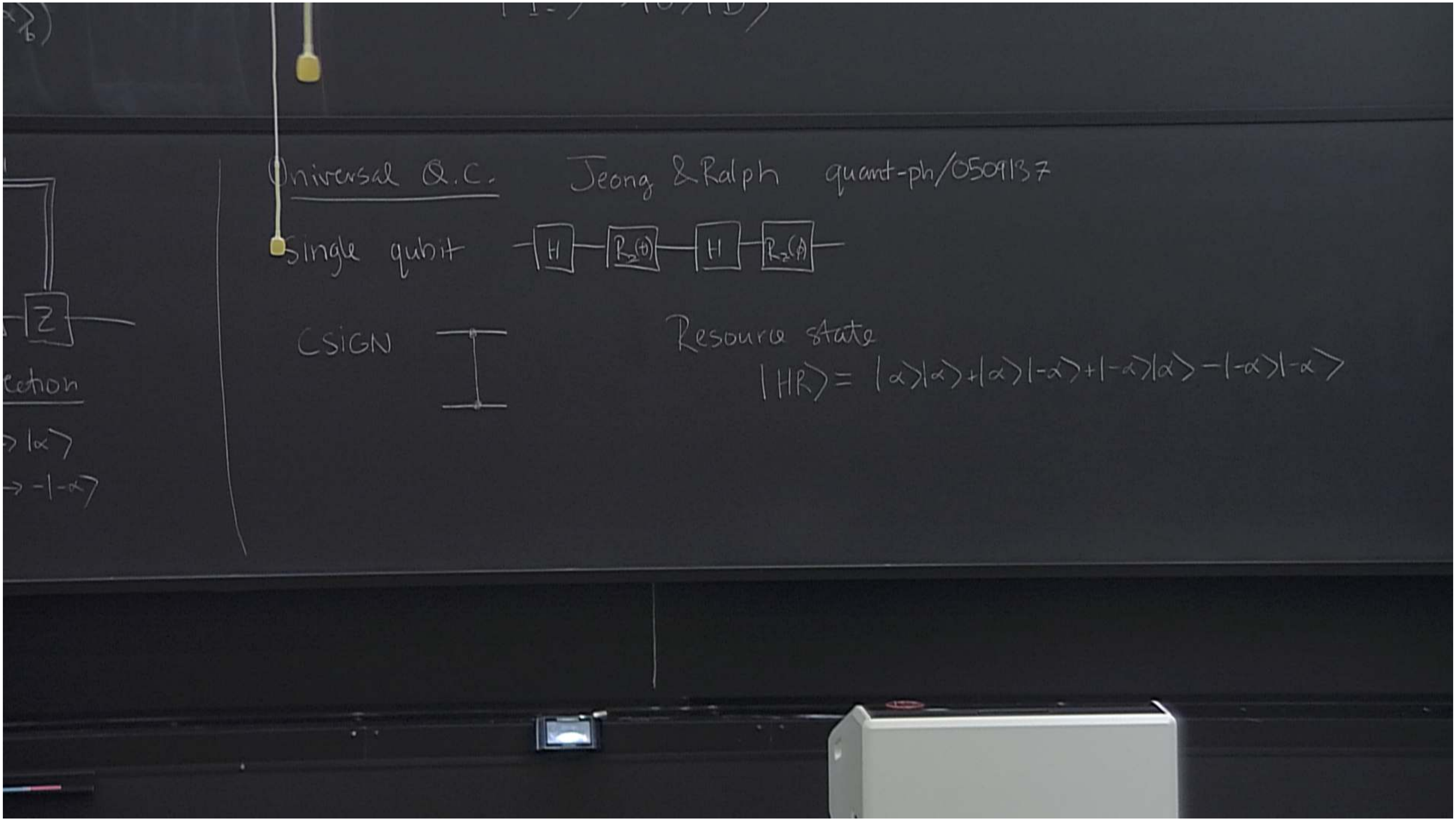


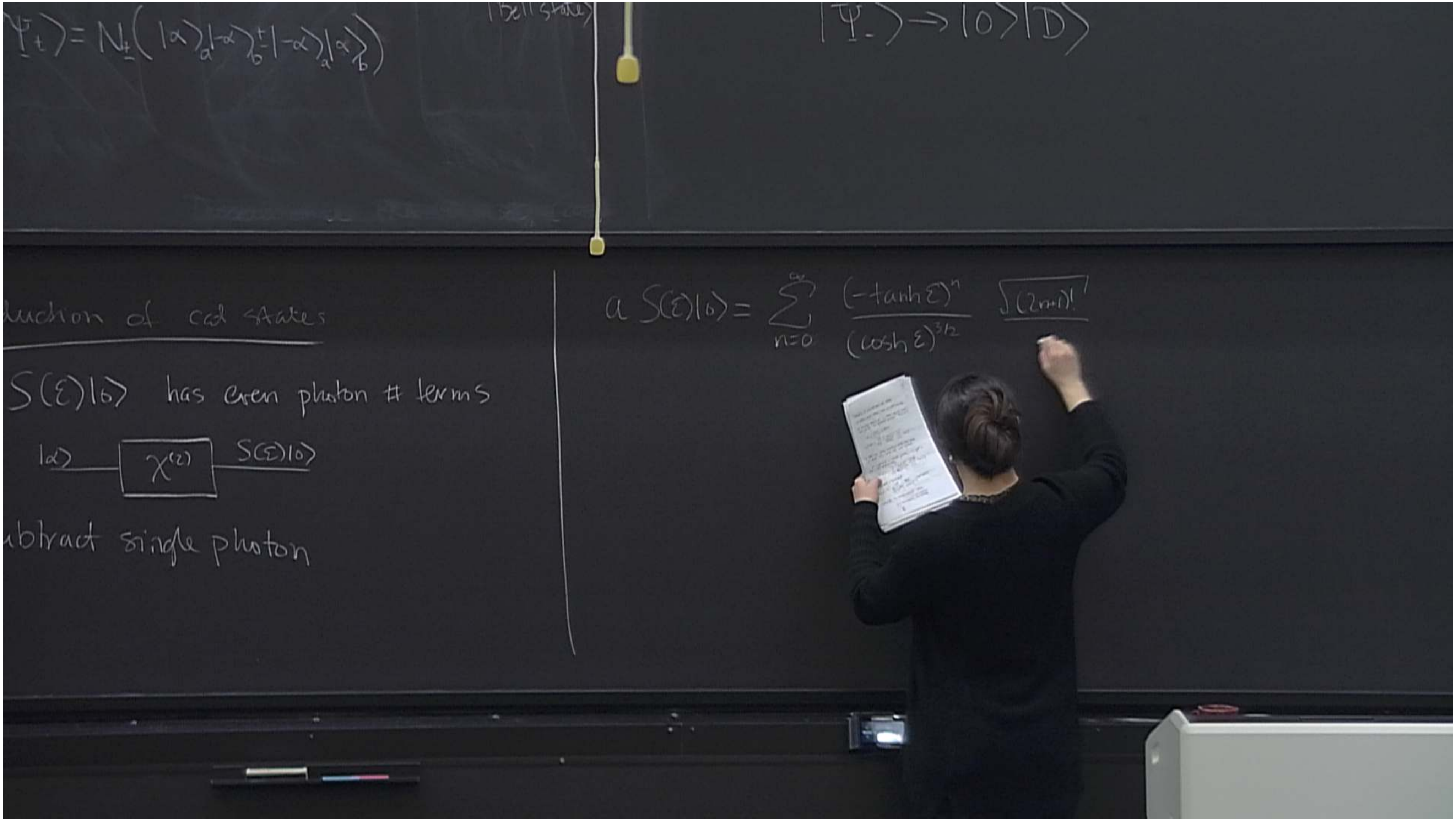
|Φ+⟩ → |E⟩|0⟩
|Φ−⟩ → |D⟩|0⟩
|Ψ+⟩ → |0⟩|E⟩
|Ψ−⟩ → |0⟩|D⟩
where |E/D⟩ = |√2 α⟩ ± |−√2 α⟩
|Bell state⟩

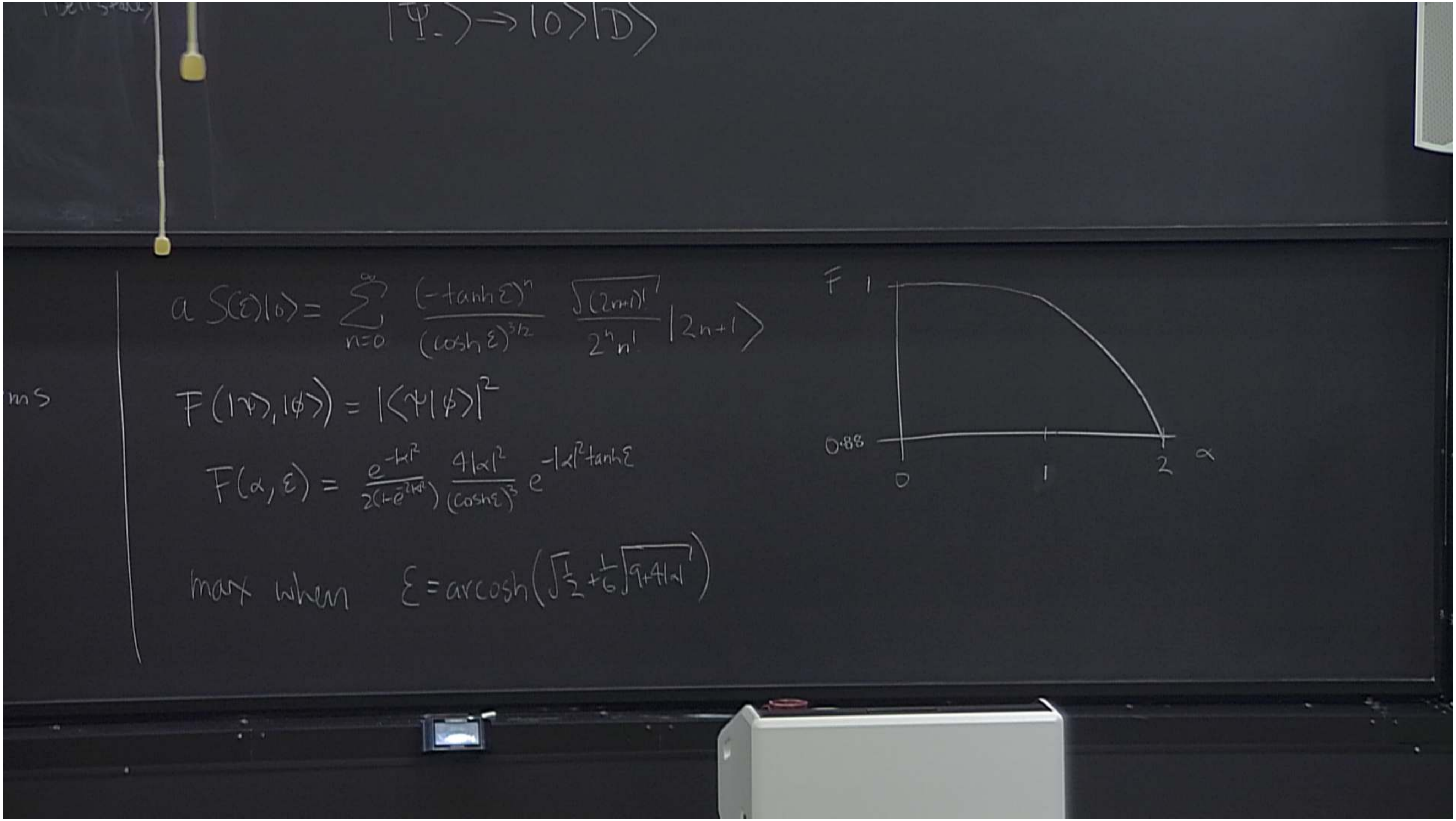

Teleportation
Bell-basis meas.
|Bell state⟩
|n⟩⟨n|
|Φ+⟩ → |E⟩|0⟩
|Φ−⟩ → |D⟩|0⟩
|Ψ+⟩ → |0⟩|E⟩
|Ψ−⟩ → |0⟩|D⟩

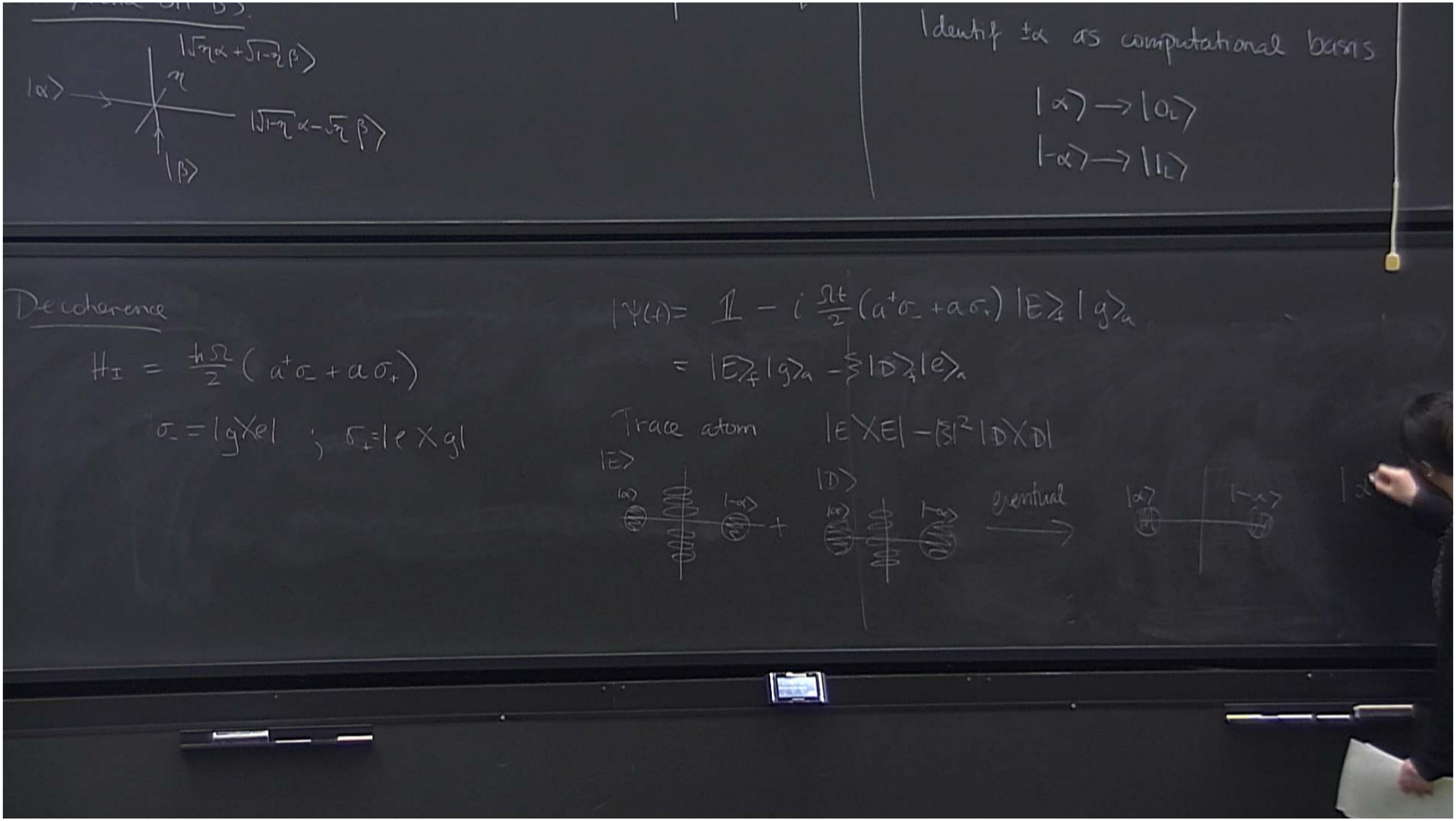

|Ψ±⟩ = N±(|α⟩a|-α⟩b ± |-α⟩a|α⟩b)
|Bell state⟩
|Ψ-⟩ → |0⟩|D⟩
μ|α⟩+ν|-α⟩
|D⟩
|0⟩
|m⟩⟨m|
|n⟩⟨n|
X
Z


|Bell state⟩
|Ψ₋⟩ → |0⟩|D⟩
|D⟩
|0⟩
X correction
|−α⟩ → |α⟩
Z correction
|α⟩ → |α⟩
|−α⟩ → −|−α⟩
Universal Q.C.
Single qubit
H
X
Z
CSIGN


Universal Q.C.
Jeong & Ralph quant-ph/0509137
Single qubit
H
Rz(θ)
H
Rz(ϕ)
CSIGN
Resource state
|HR> = |α>|α> + |α>|-α> + |-α>|α> - |-α>|-α>


Bell state
uction of cat states
S(ε)|0⟩ has even photon # terms
|α⟩
χ(2)
S(ε)|0⟩
ubtract single photon


|Ψ₋⟩ → |0⟩|D⟩
a S(ε)|0⟩ = Σ_{n=0}^∞ (−tanh ε)^n / (cosh ε)^{3/2} · √((2n+1)!) / (2^n n!) |2n+1⟩
F(|ψ⟩, |φ⟩) = |⟨ψ|φ⟩|²
F(α, ε) = e^{−|α|²} / 2(1−e^{−2|α|²}) · 4|α|² / (cosh ε)³ · e^{−|α|² tanh ε}
max when ε = arccosh(√(1/2 + 1/6 √(9+4|α|)))
F
1
0.88
0
1
2
α


|√η α + √(1-η) β⟩
|α⟩
η
|√(1-η) α − √η β⟩
|β⟩
Identify ±α as computational basis
|α⟩ → |0_L⟩
|−α⟩ → |1_L⟩
Decoherence
H_I = ħΩ/2 (a†σ₋ + a σ₊)
σ₋ = |g⟩⟨e| ; σ₊ = |e⟩⟨g|
|ψ(t)⟩ = 𝟙 − i Ωt/2 (a†σ₋ + a σ₊) |E⟩_f |g⟩_a
= |E⟩_f |g⟩_a − ξ |D⟩_f |e⟩_a
Trace atom |E⟩⟨E| − |ξ|² |D⟩⟨D|
|E⟩
|α⟩
|−α⟩
|D⟩
|α⟩
|−α⟩
eventual
|α⟩
|−α⟩

Identify $\pm\alpha$ as computational basis

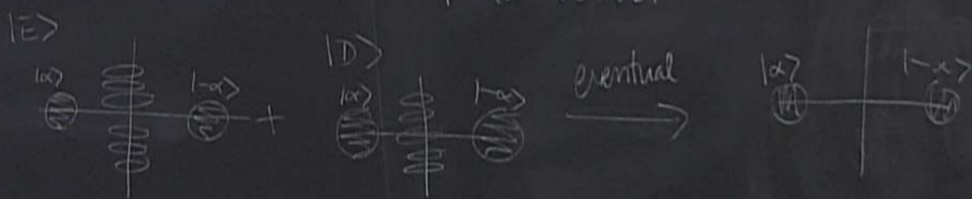
$$|\alpha\rangle \rightarrow |0_L\rangle$$

$$|-\alpha\rangle \rightarrow |1_L\rangle$$

$$|\psi(t)\rangle = \mathbb{1} - i\frac{\Omega t}{2}(a^\dagger\sigma_- + a\sigma_+)|E\rangle_f|g\rangle_a$$

$$= |E\rangle_f|g\rangle_a - \xi|D\rangle_f|e\rangle_a$$

Trace atom $\quad |E\rangle\langle E| - |\xi|^2|D\rangle\langle D|$



$$|\alpha\rangle\langle\alpha| + |-\alpha\rangle\langle-\alpha|$$