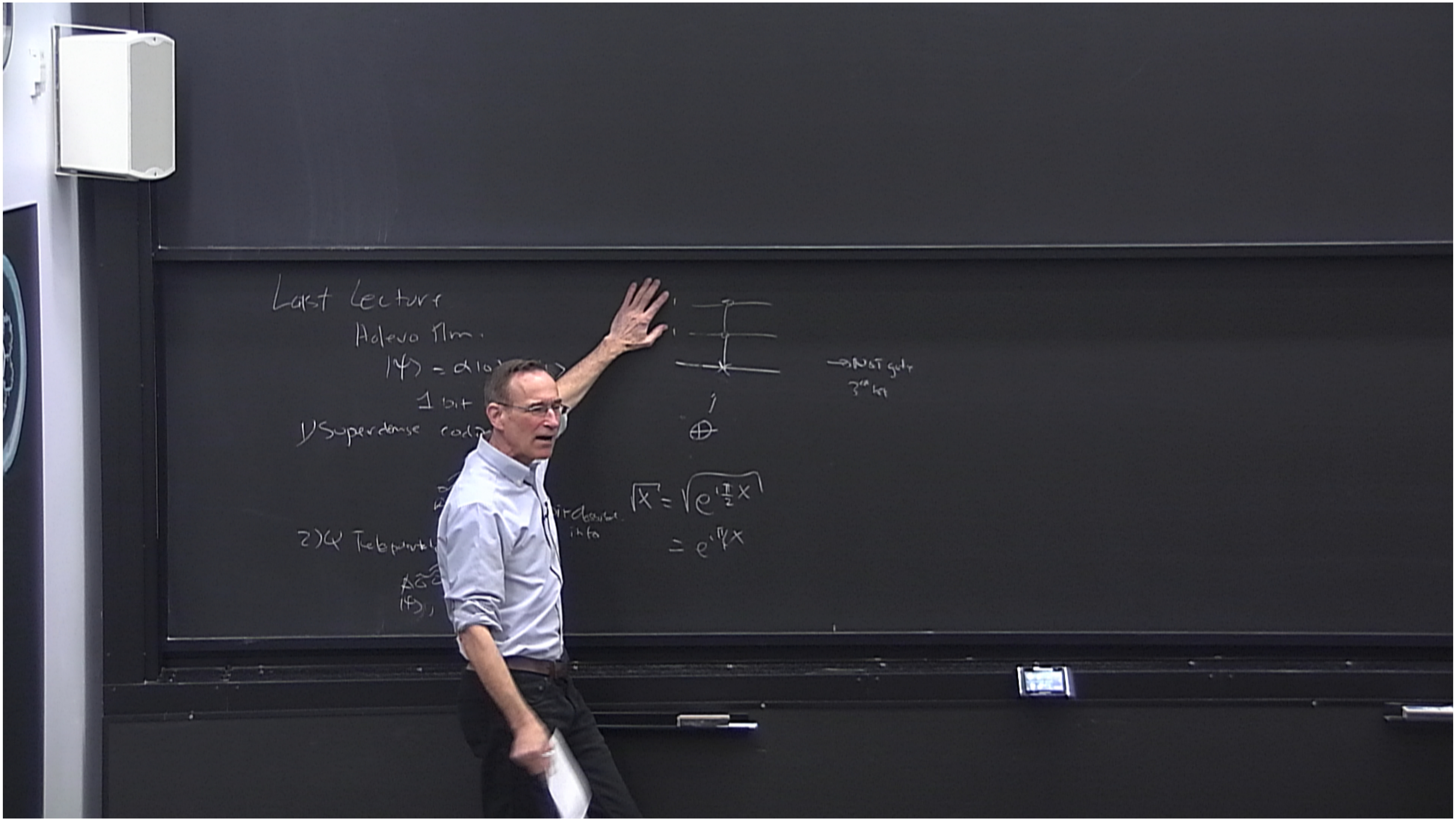
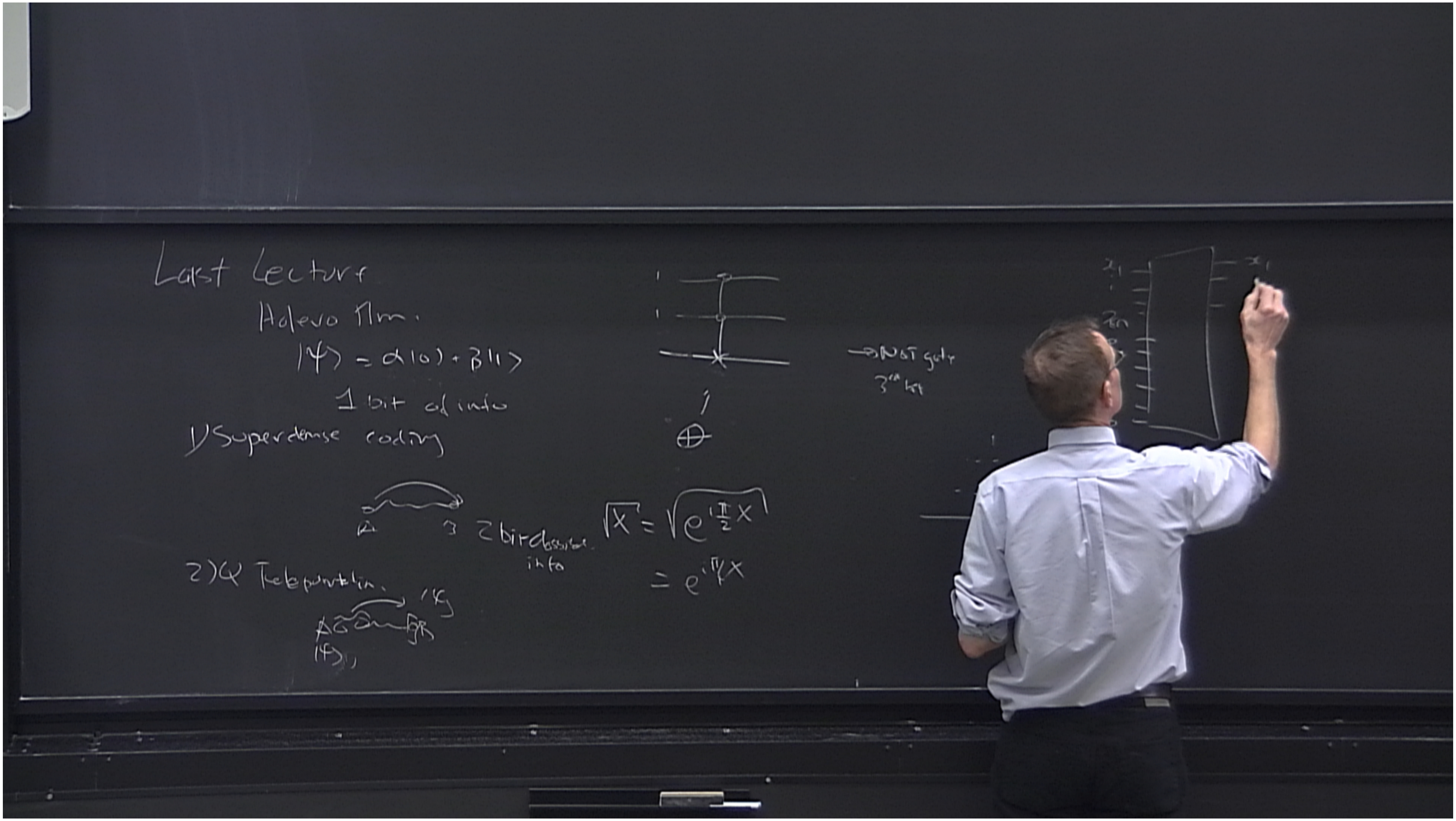
Title: PSI 2015/2016 Quantum Information - Lecture 3

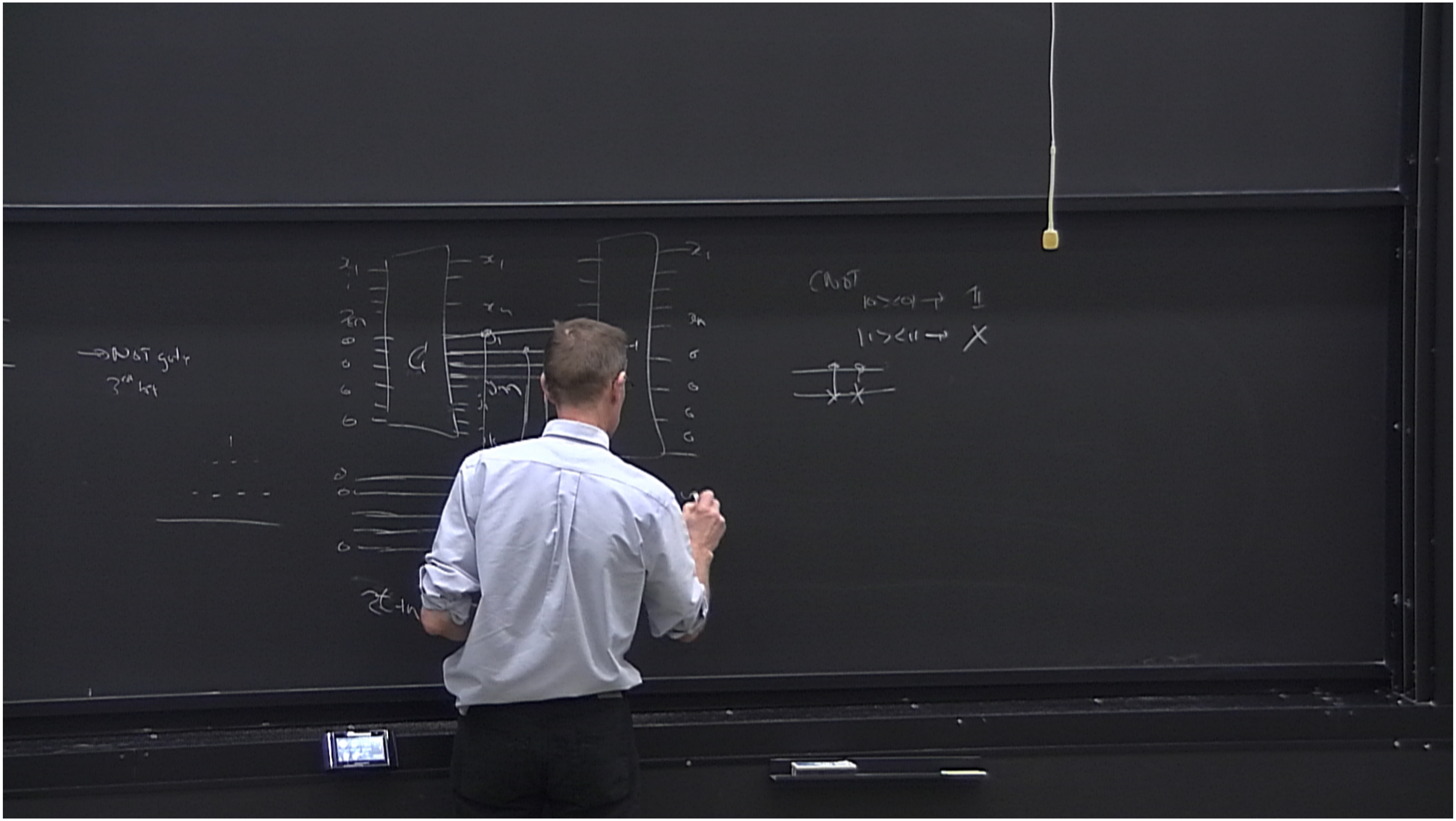
Date: Feb 24, 2016 11:30 AM

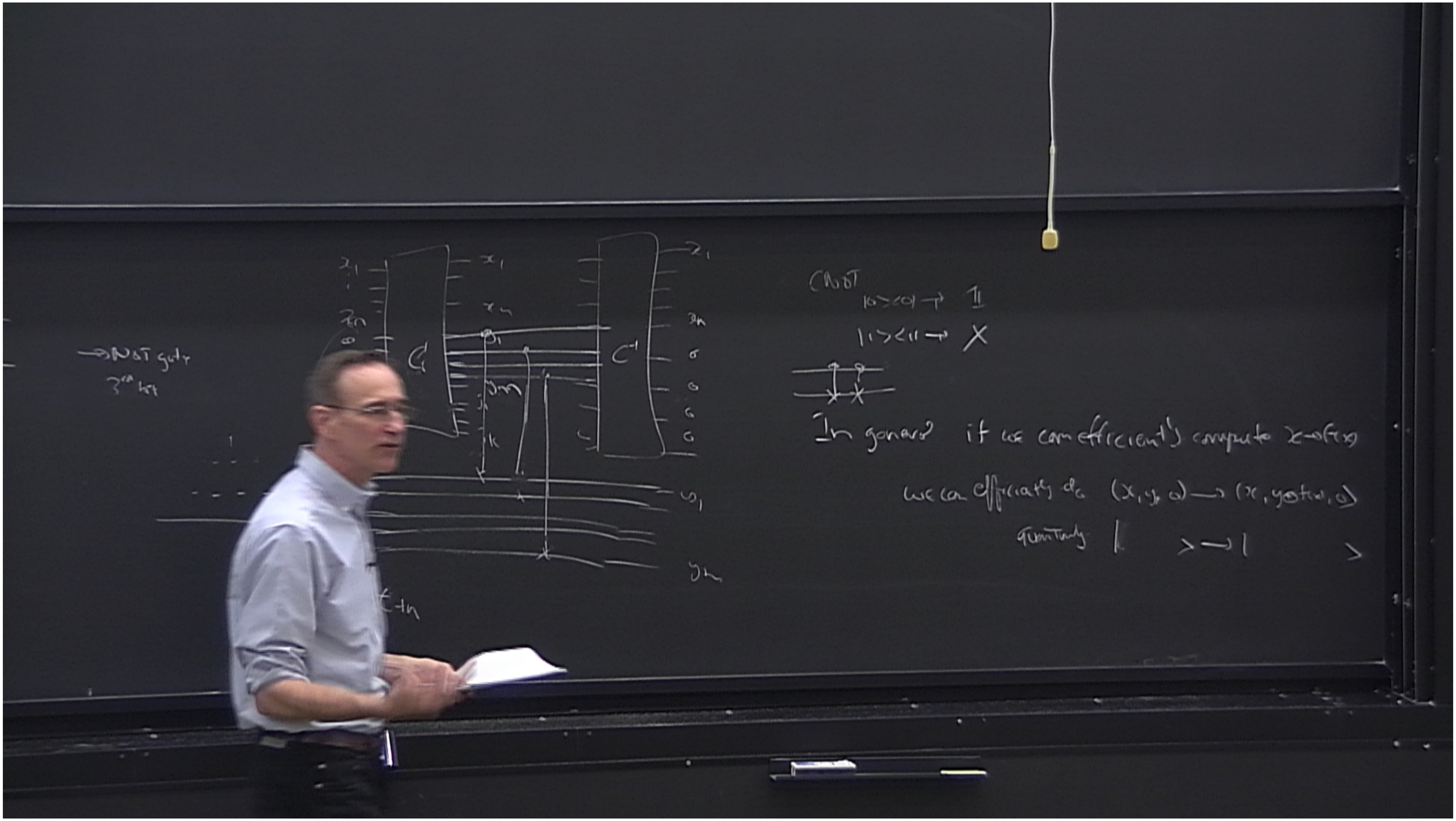
URL: http://pirsa.org/16020080

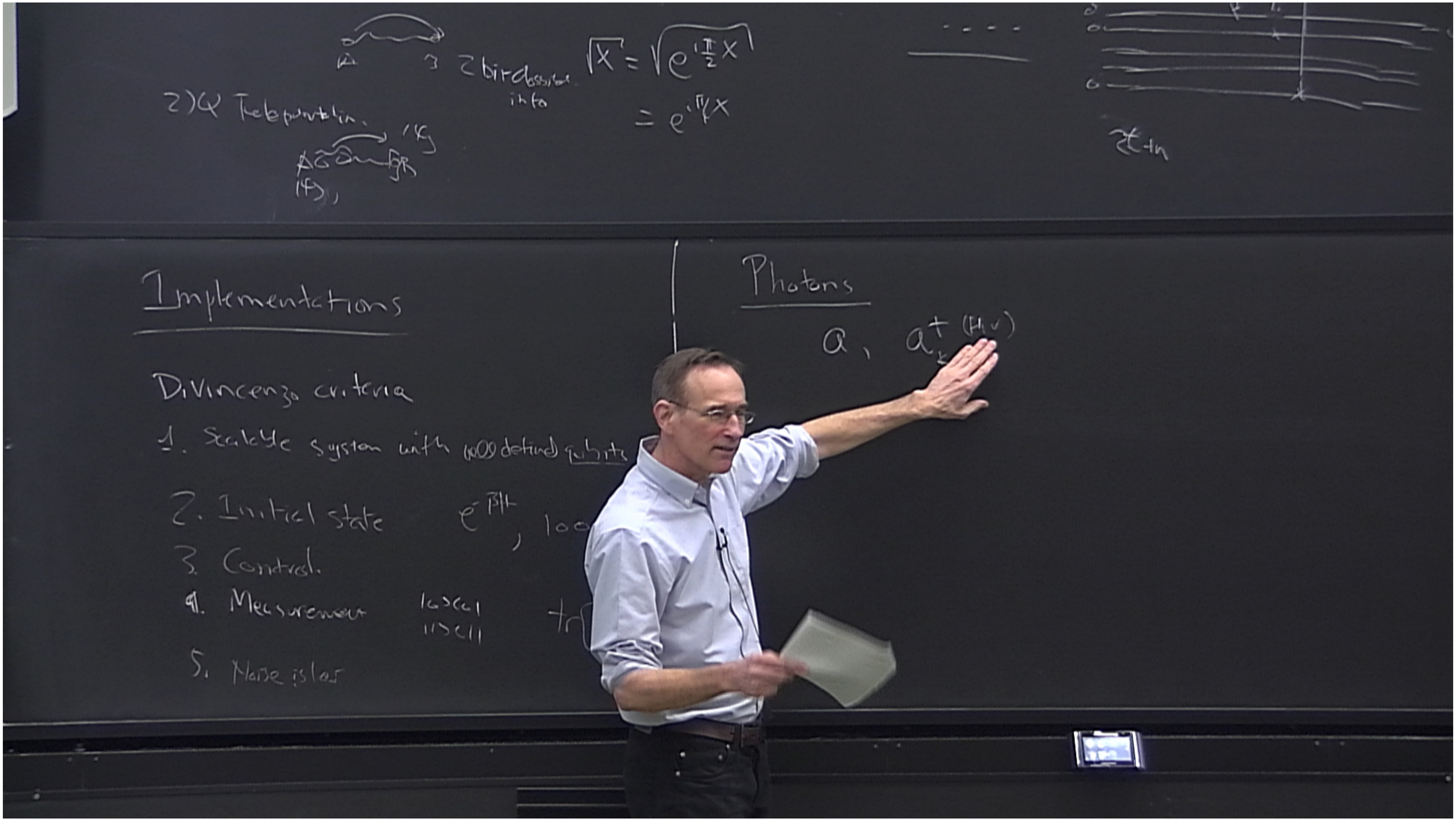
Abstract:


Last Lecture
Holevo Thm.
1 bit

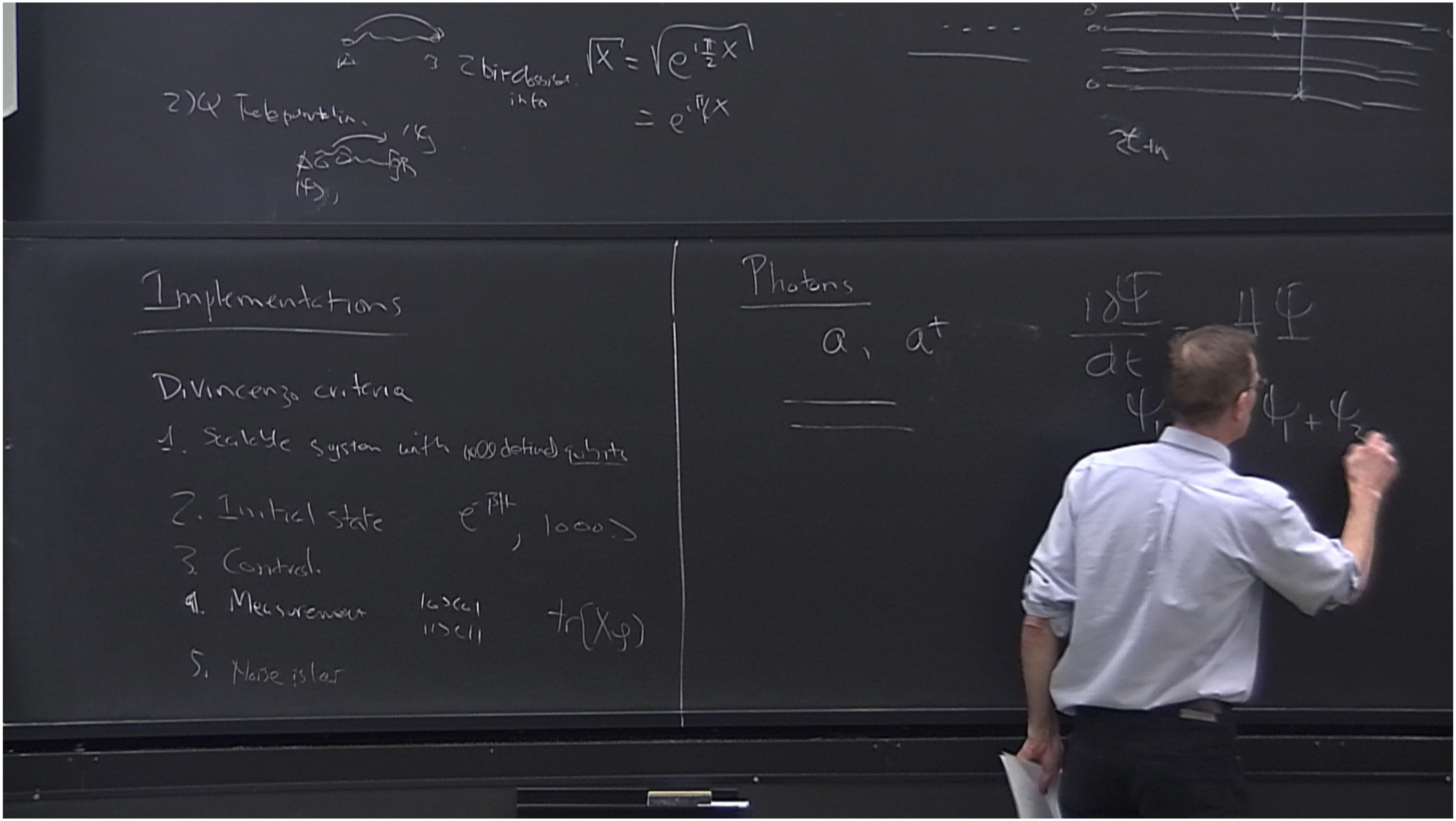

Last Lecture
Holevo Thm.
|ψ⟩ = α|0⟩ + β|1⟩
1 bit of info
1) Superdense coding
2 bits classical info
√X = √(e^{iπ/2 X})
= e^{iπ/4 X}
2) Q Teleportation
NOT gate
3rd bit


CNOT


CNOT
In general if we can efficiently compute x→f(x)
we can efficiently do (x, y, 0) → (x, y⊕f(x), 0)
Quantumly



2) Q Teleportation
Implementations
DiVincenzo criteria
1. Scalable system with well defined qubits
2. Initial state
3. Control.
4. Measurement
5. Noise is low
Photons



2) Q Teleportation
Implementations
Divincenzo criteria
1. Scalable system with well defined qubits
2. Initial state
3. Control.
4. Measurement
Photons

we can efficiently do $(x,y,\alpha) \to (x, y\oplus f(x), \alpha)$

quantumly $|\ \ \rangle \to |\ \ \rangle$

y_1

y_n

$\mathbb{Z}_n$

ons

$a,\ a^{+}$

mirror

mirror

$|0\rangle_q$

$|1\rangle_q$

phase shifter

$a^{+} \to e^{i\phi} a^{+}$

$\alpha|0\rangle_q + \beta|1\rangle_q = \alpha|01\rangle + \beta|10\rangle = (\alpha a_2^{+} + \beta a_1^{+})|v_{acuum}\rangle$

$|0\rangle$

$\to (\alpha a_2^{+} + \beta a_1^{+} e^{i\phi})|v\rangle$

$Z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix}$

$e^{-i\phi/2}\ \underbrace{e^{i\frac{\phi Z}{2}}}_{\underbrace{\left(\cos\frac{\phi}{2}\mathbb{1} + i\sin\frac{\phi}{2} Z\right)}_{e^{i\phi/2}}} (\alpha|0\rangle_q + \beta|1\rangle_q)$

$e^{i\frac{\pi}{2}X}$

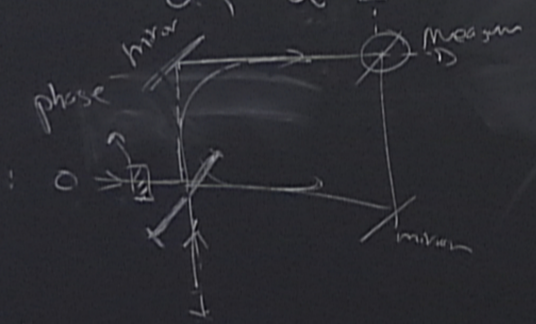
$e^{i\frac{\pi}{4}X}$

we can efficiently do $(x, y, \omega) \to (x, y \oplus f$

Similarly $\to 1$

Photons

a, $a^\dagger$



phase shifter

$a^\dagger \to e^{i\phi} a^\dagger$

$\alpha|0\rangle_q + \beta|1\rangle_q = \alpha|01\rangle + \beta|10\rangle = (\alpha a_2^\dagger + \beta a_1^\dagger)|\text{vacuum}\rangle$

$\to (\alpha a_2^\dagger + \beta a_1^\dagger e^{i\phi})|v\rangle$

$Z = \begin{pmatrix}1 & 0\\ 0 & -1\end{pmatrix}\begin{pmatrix}1\\ 0\end{pmatrix}$ $|0$

$e^{-i\phi/2}\, e^{i\frac{\phi Z}{2}} (\alpha|0\rangle_q + \beta|1\rangle_q)$

$\underbrace{\left(\cos\frac{\phi}{2}\mathbb{1} + i\sin\frac{\phi}{2} Z\right)}_{e^{i\phi/2}}$

$a_2^\dagger|v\rangle = |01\rangle = |0\rangle_q$

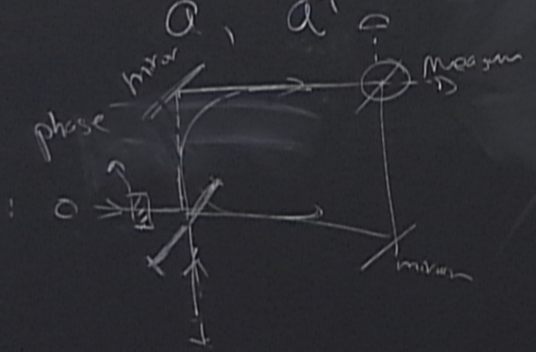
$a_1^\dagger|v\rangle = |10\rangle = |1\rangle_q$

$e^{i\frac{\pi}{2}X}$

$e^{i\pi/4 X}$

Photons

a , $a^\dagger$



$a_2^\dagger|v\rangle = |01\rangle = |0\rangle_q$

$a_1^\dagger|v\rangle = |10\rangle = |1\rangle_q$

phase shifter

$a^\dagger \to e^{i\phi} a^\dagger$

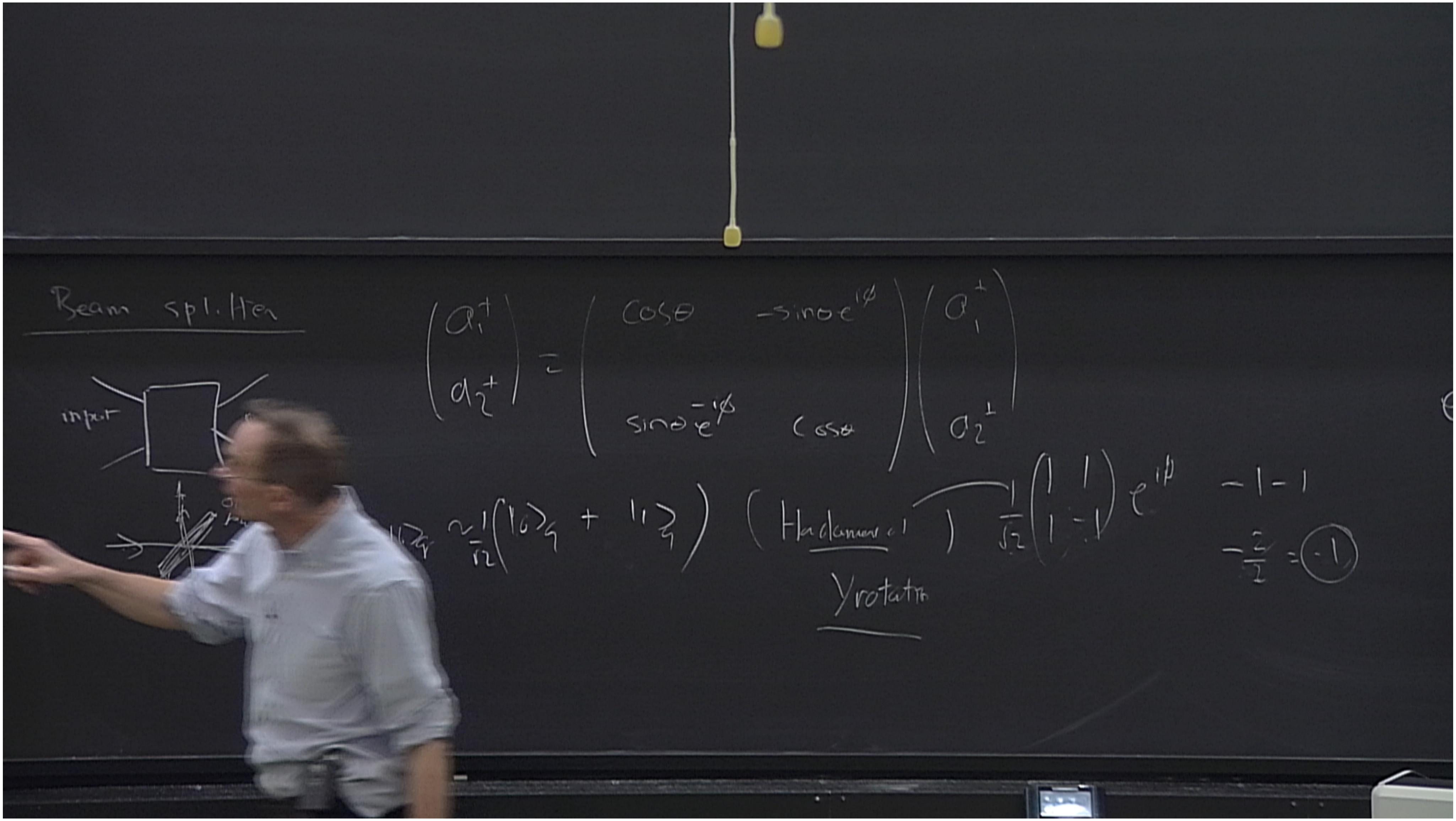
$\alpha|0\rangle_q + \beta|1\rangle_q = \alpha|01\rangle + \beta|10\rangle = (\alpha a_2^\dagger + \beta a_1^\dagger)|vac\rangle$

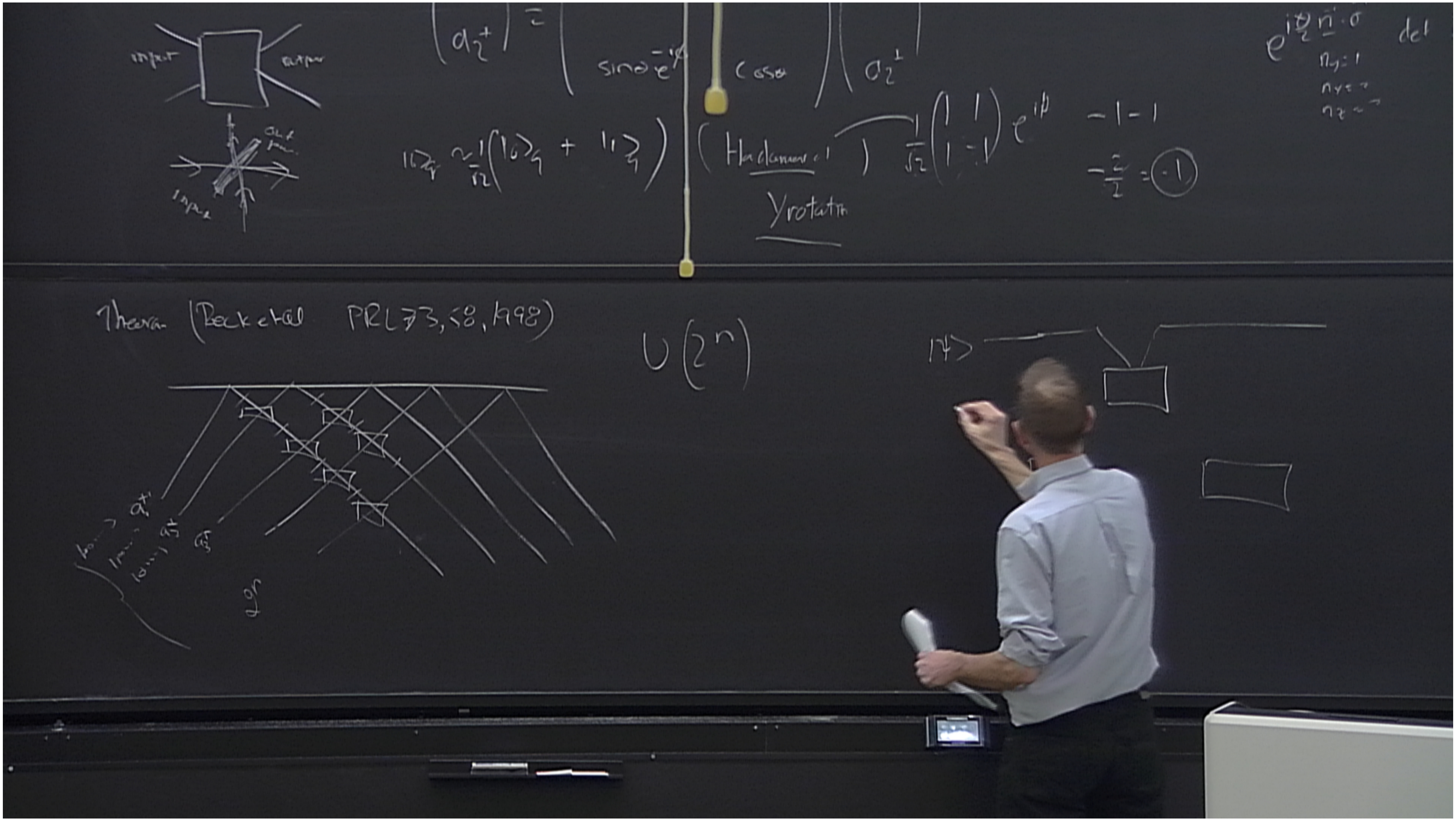
$\to (\alpha a_2^\dagger + \beta a_1^\dagger e^{i\phi})|v\rangle$

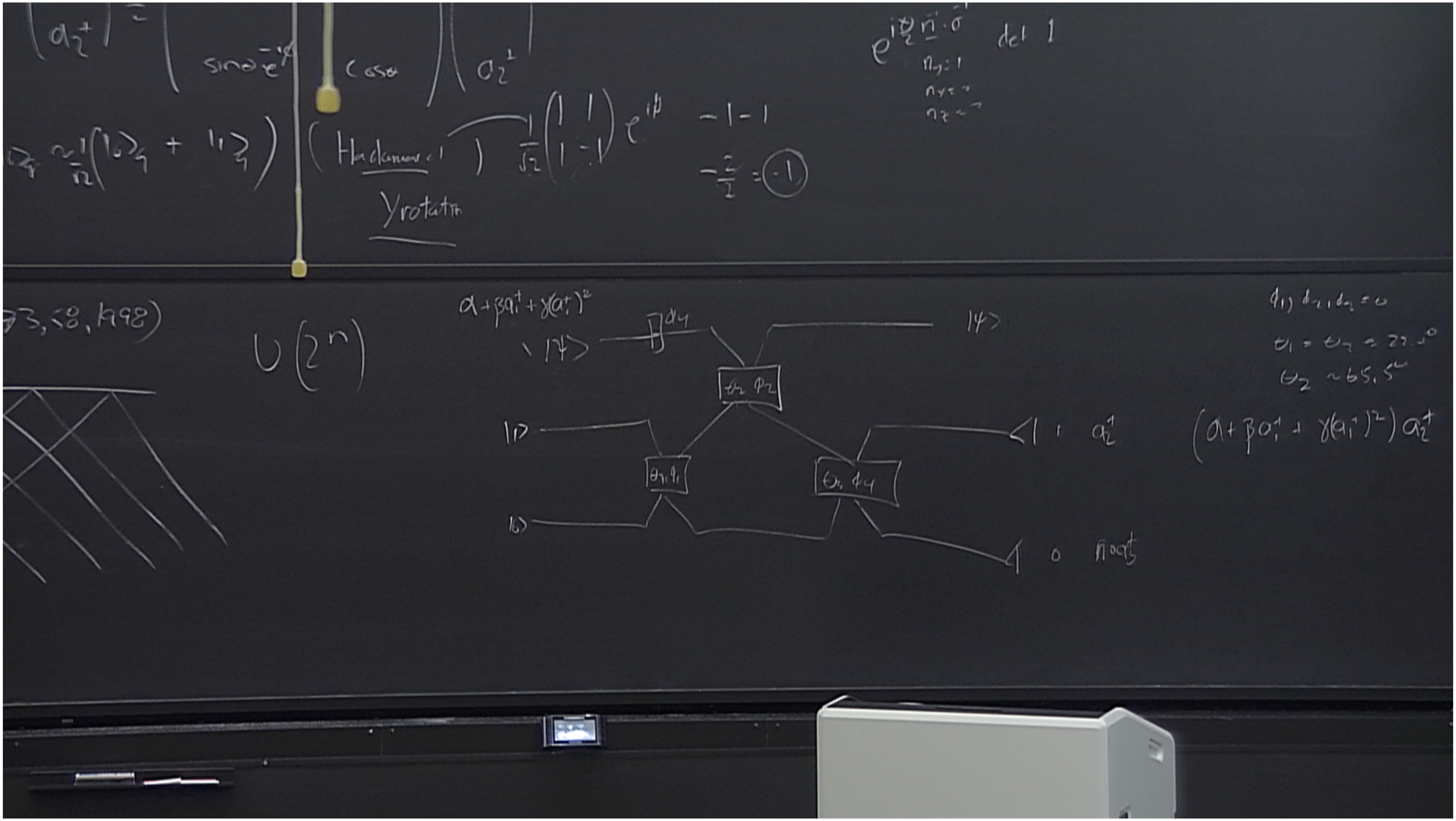
$Z = \begin{pmatrix}1 & 0\\ 0 & -1\end{pmatrix}\begin{pmatrix}1\\ 0\end{pmatrix}$

$e^{-i\phi/2}\, e^{i\phi\frac{Z}{2}} (\alpha|0\rangle_q + \beta|1\rangle_q)$

$\underbrace{\left(\cos\frac{\phi}{2}\mathbb{1} + i\sin\frac{\phi}{2} Z\right)}_{e^{i\phi/2}}$


Beam splitter
input
Hadamard
Yrotation


input
Theorem (Reck et al PRL 73, 58, 1998)
U(2^n)
|ψ>
Hadamard
Yrotation


Hadamard
Y rotation
det 1
U(2^n)
|ψ>
|1>
|0>
θ₂ φ₂
θ₁ φ₁
θ₂ ~ 65.5°