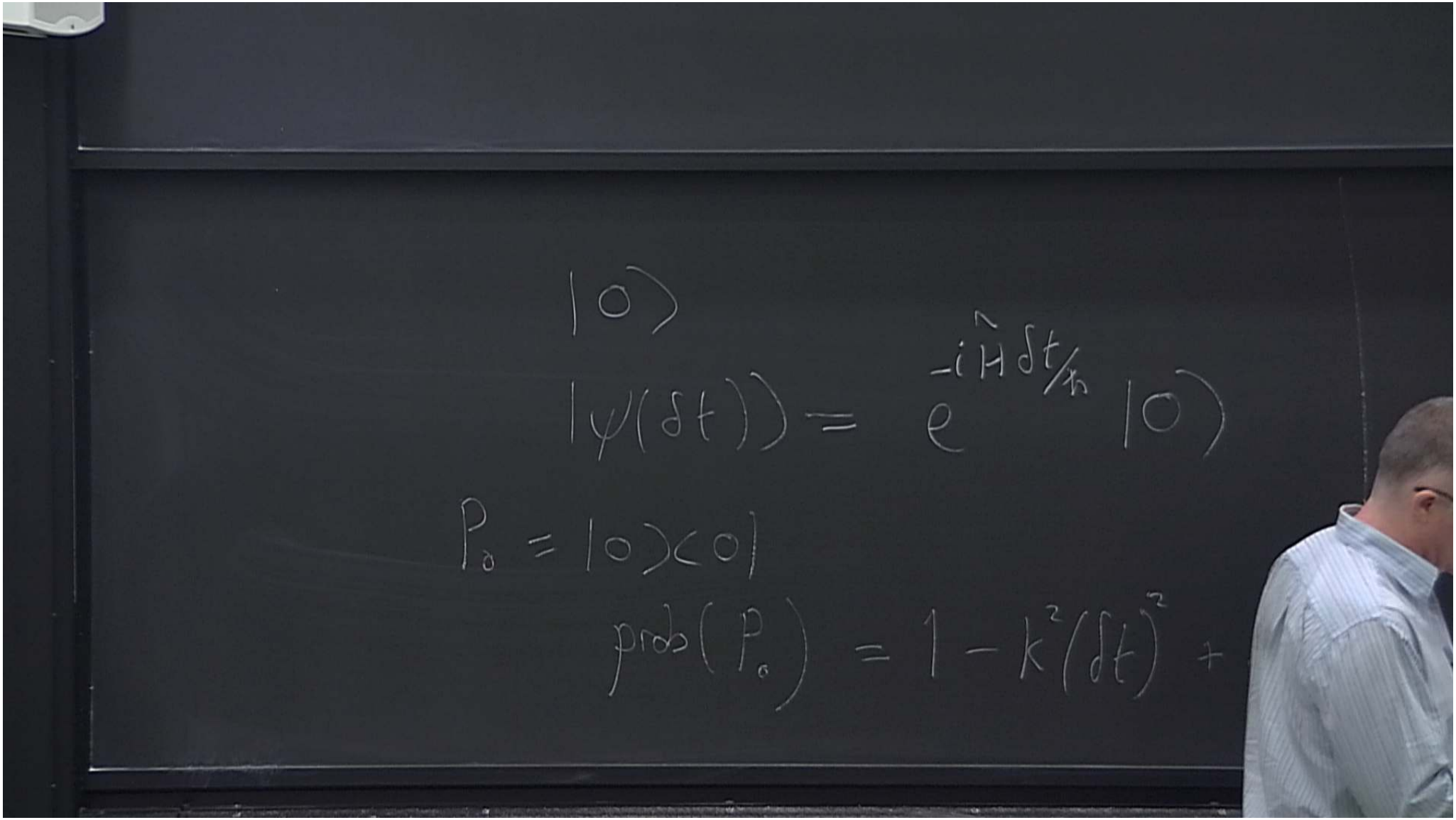
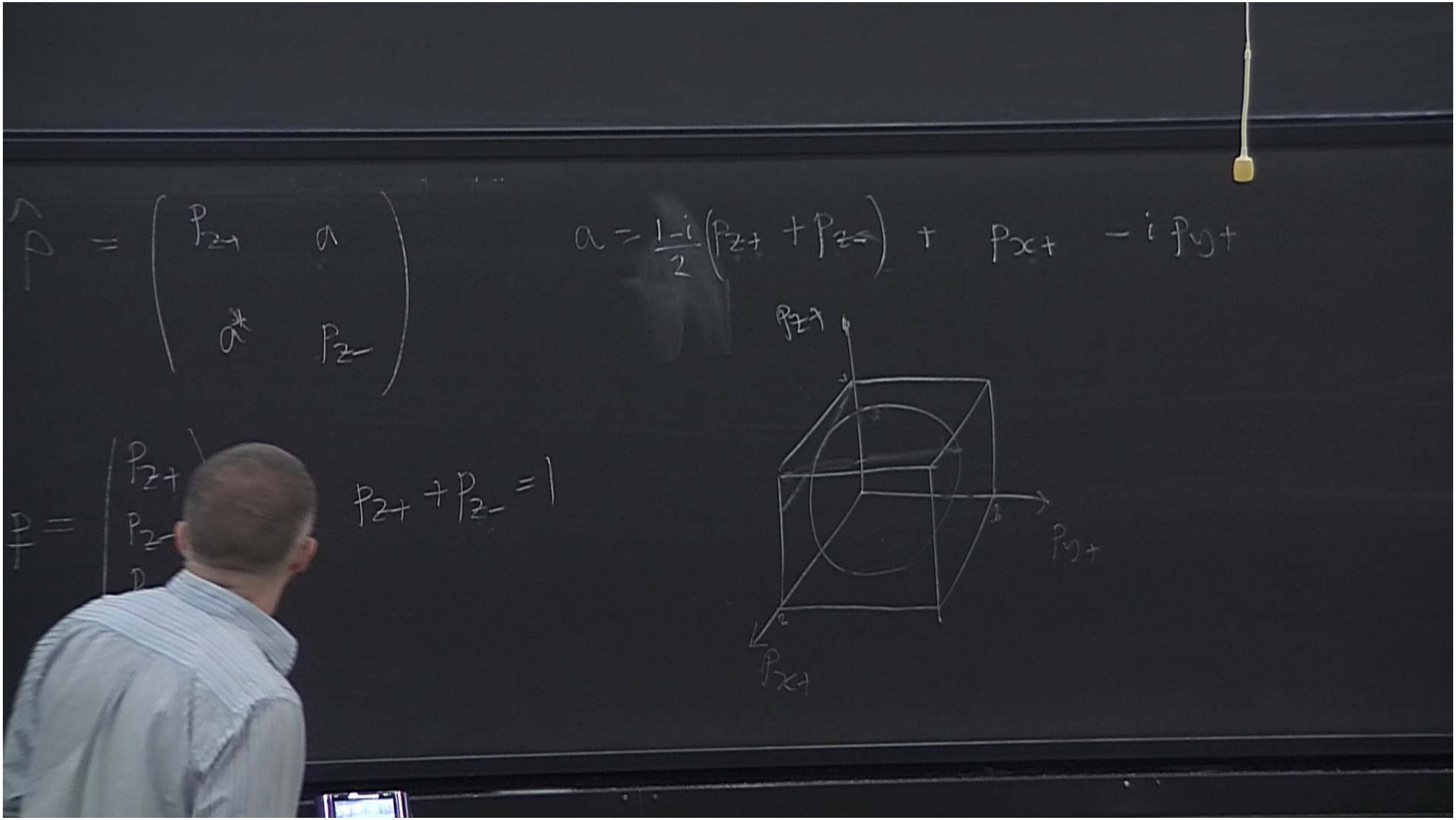
Title: PSI 2015/2016 Foundations of Quantum Mechanics - Lecture 3

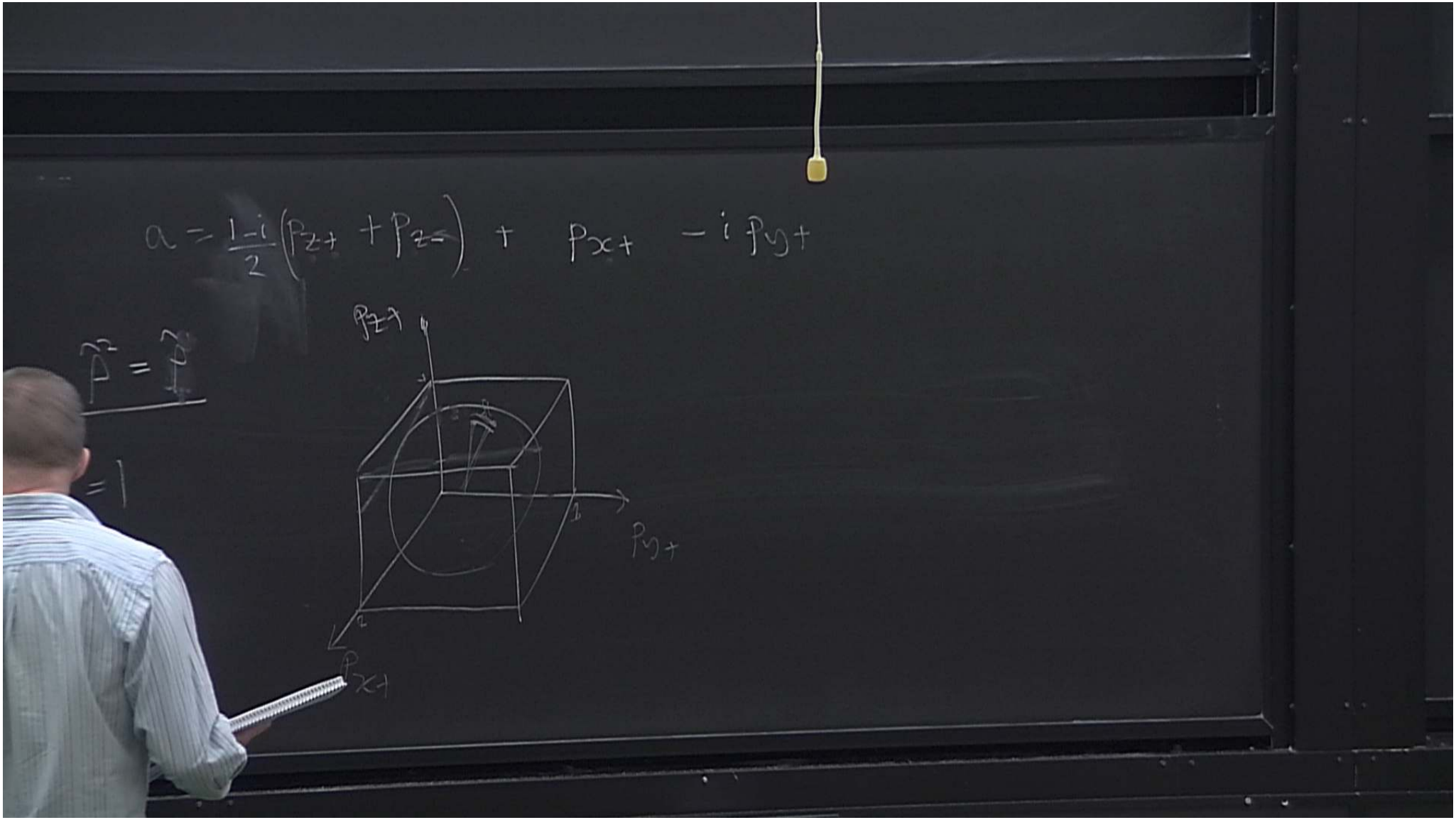
Date: Jan 06, 2016 11:30 AM

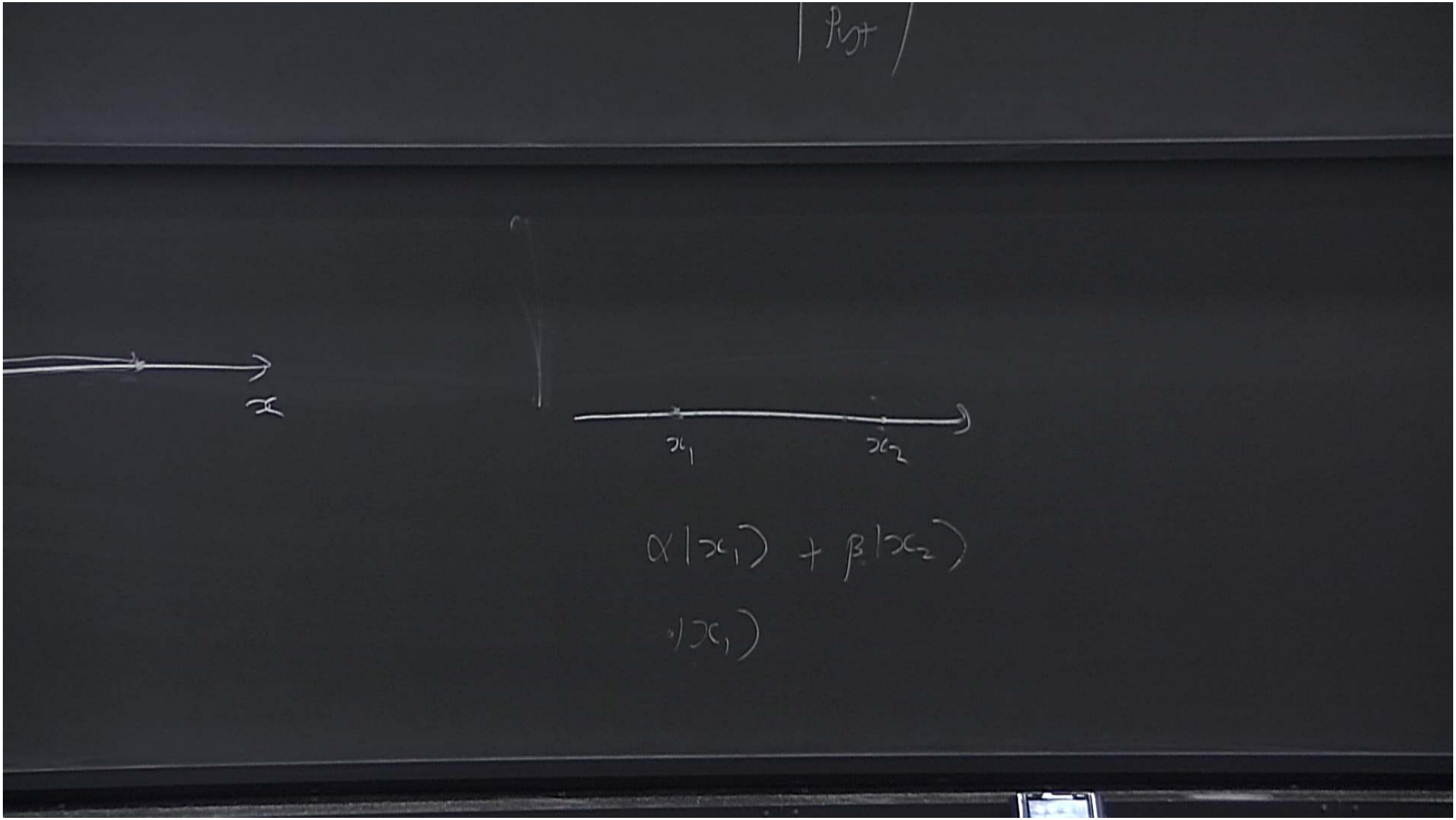
URL: http://pirsa.org/16010056

Abstract:


$|0\rangle$
$|\psi(\delta t)\rangle = e^{-i\hat{H}\delta t/\hbar}|0\rangle$
$P_0 = |0\rangle\langle 0|$
$\text{prob}(P_0) = 1 - k^2(\delta t)^2 +$


$\hat{\rho} = \begin{pmatrix} p_{z+} & a \\ a^* & p_{z-} \end{pmatrix}$
$a = \frac{1-i}{2}(p_{z+} + p_{z-}) + p_{x+} - i p_{y+}$
$p_{z+} + p_{z-} = 1$
$p_{z+}$
$p_{y+}$
$p_{x+}$


$a = \frac{1-i}{2}(p_{z+} + p_{z-}) + p_{x+} - i p_{y+}$
$\hat{p}^2 = \hat{p}$
$= 1$
$p_{z+}$
$p_{y+}$
$p_{x+}$


Post
x
$x_1$
$x_2$
$\alpha|x_1\rangle + \beta|x_2\rangle$
$|x_1\rangle$

# quantum optical interferometer

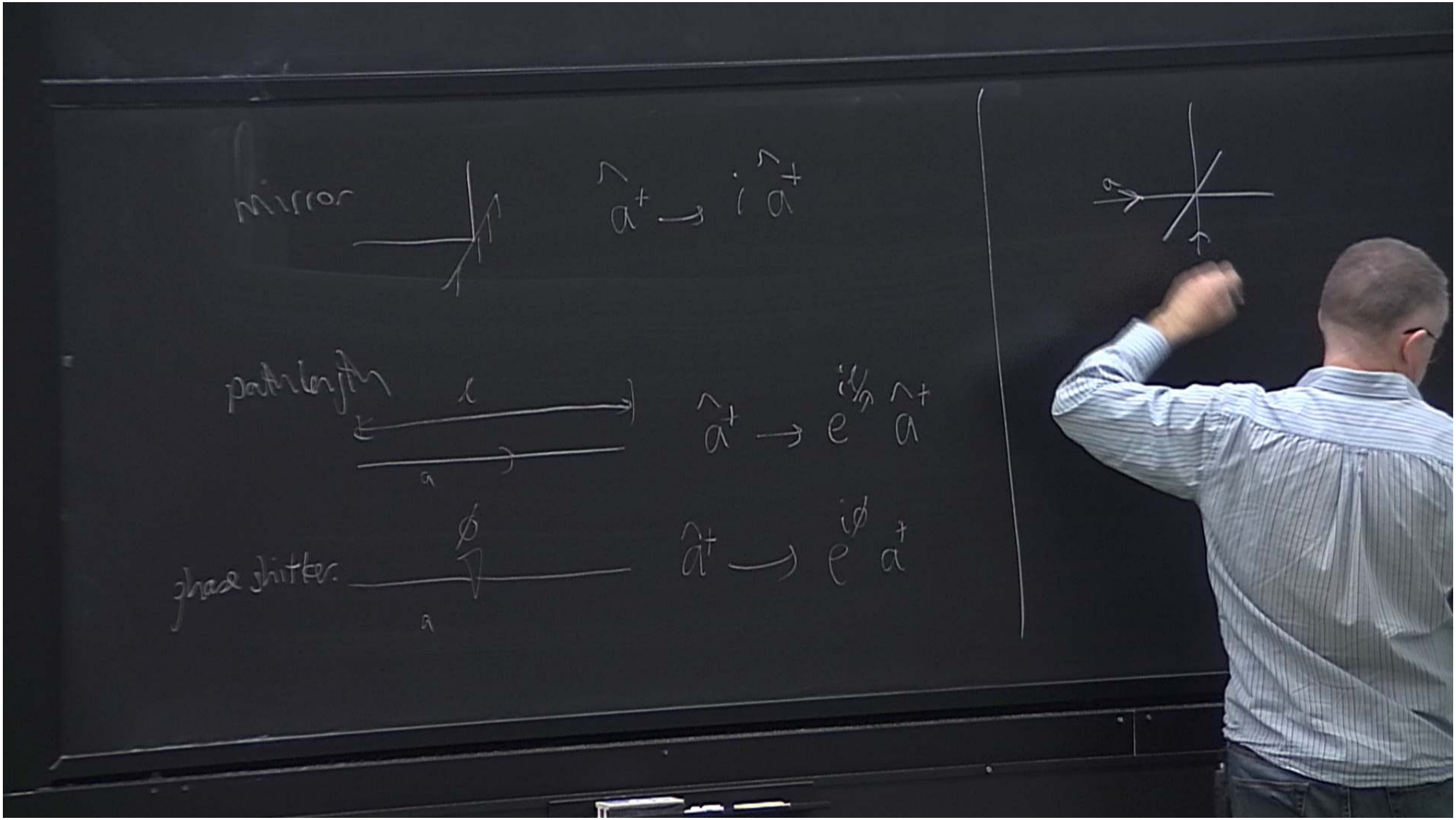
single mode.

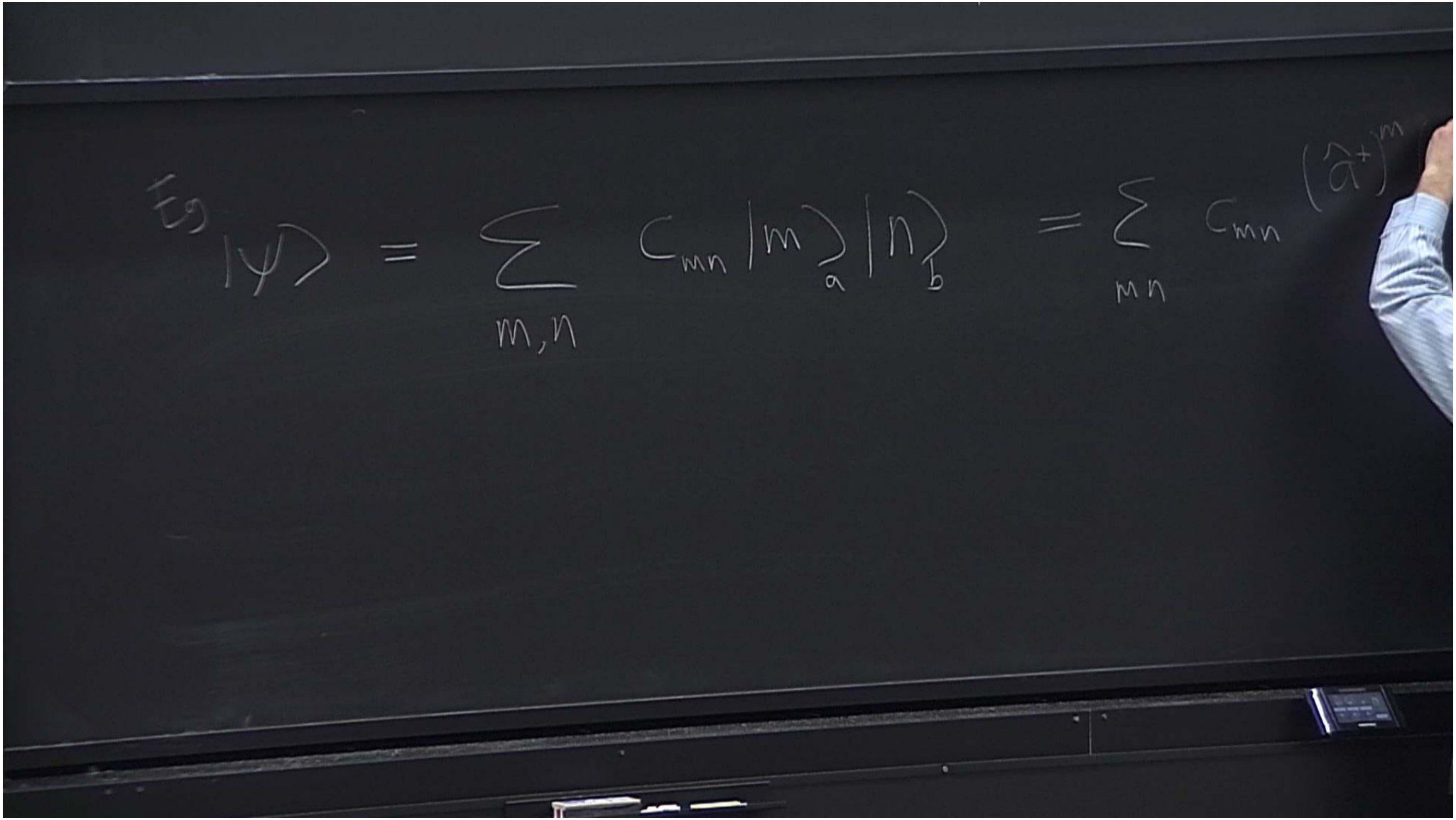
use creation $\hat{a}^\dagger$ and annihilation $\hat{a}$ operator.

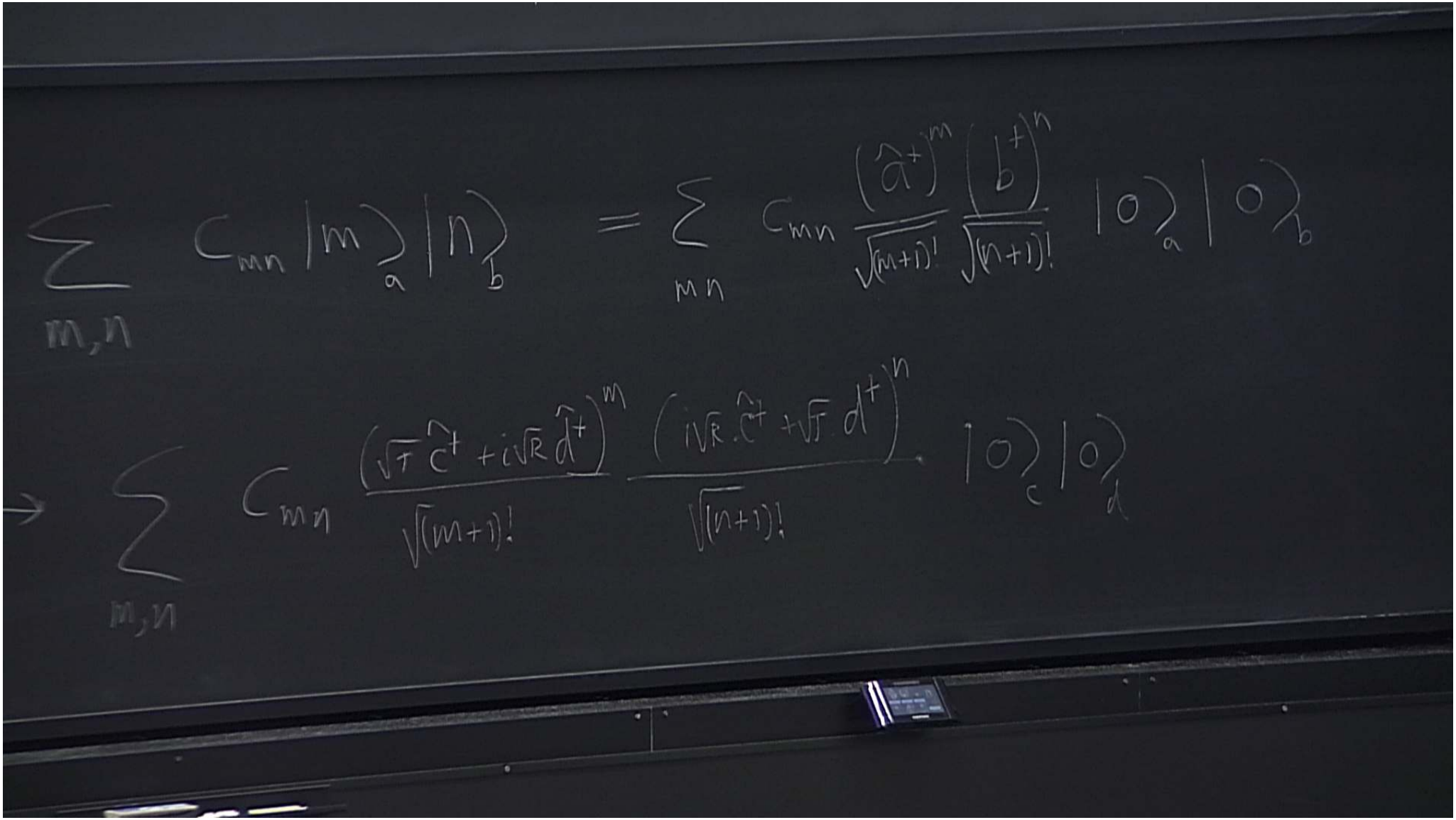
$$\hat{a}\,|n\rangle_a = \sqrt{n}\,|n-1\rangle_a$$

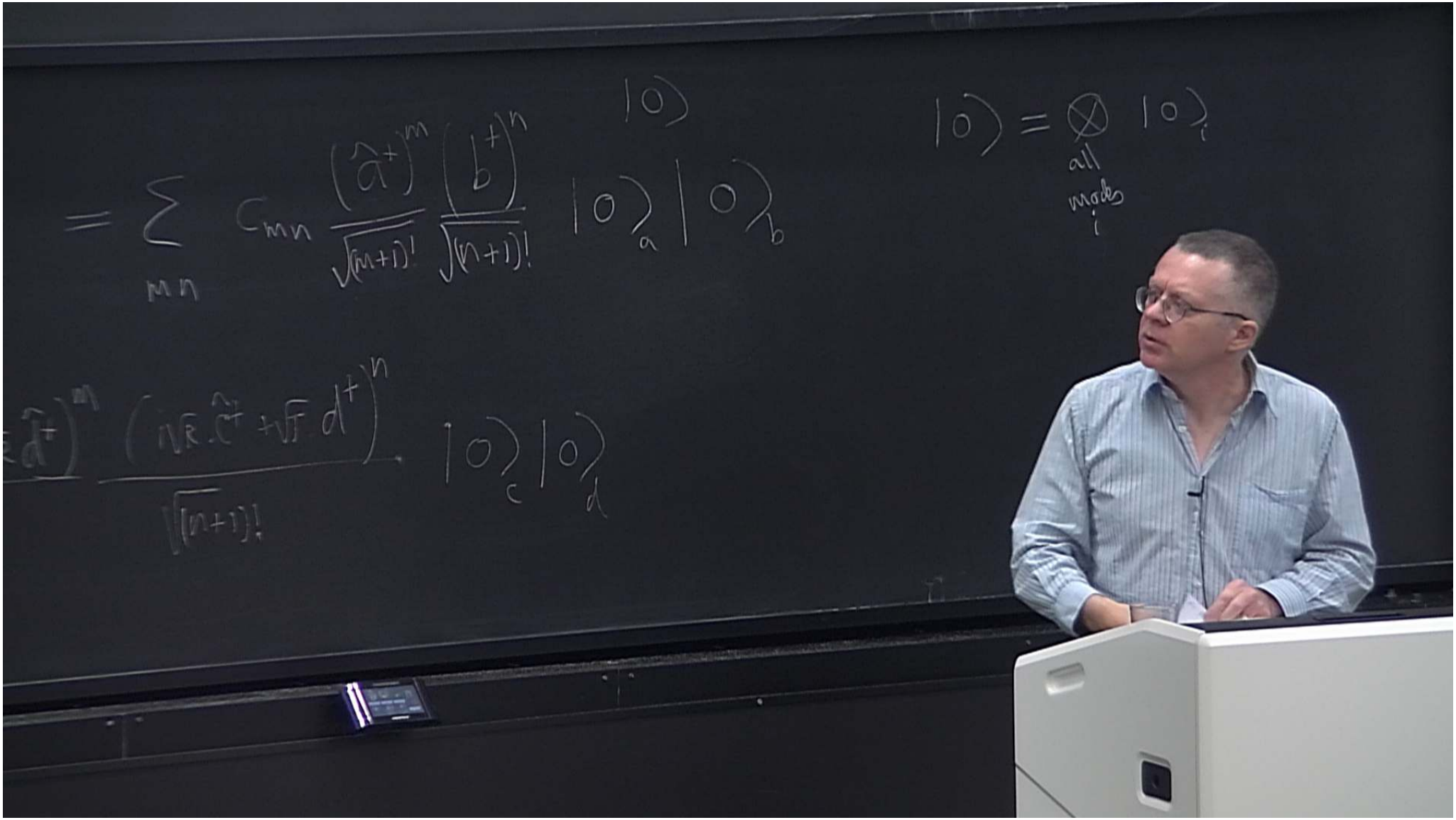
$$\hat{a}\,|0\rangle_a = 0$$

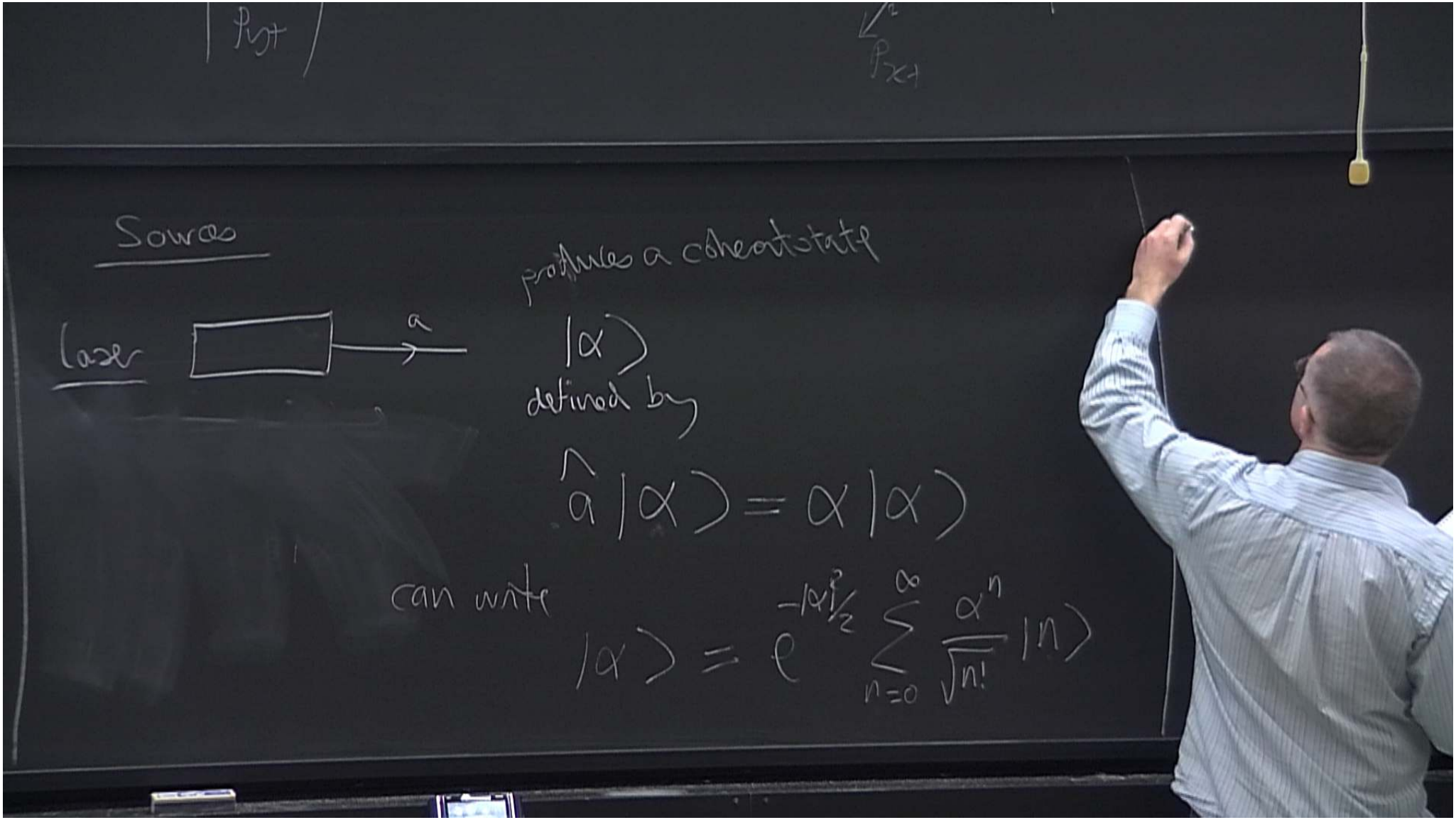
$$\hat{a}^\dagger\,|n\rangle_a = \sqrt{n+1}\,|n+1\rangle_a$$

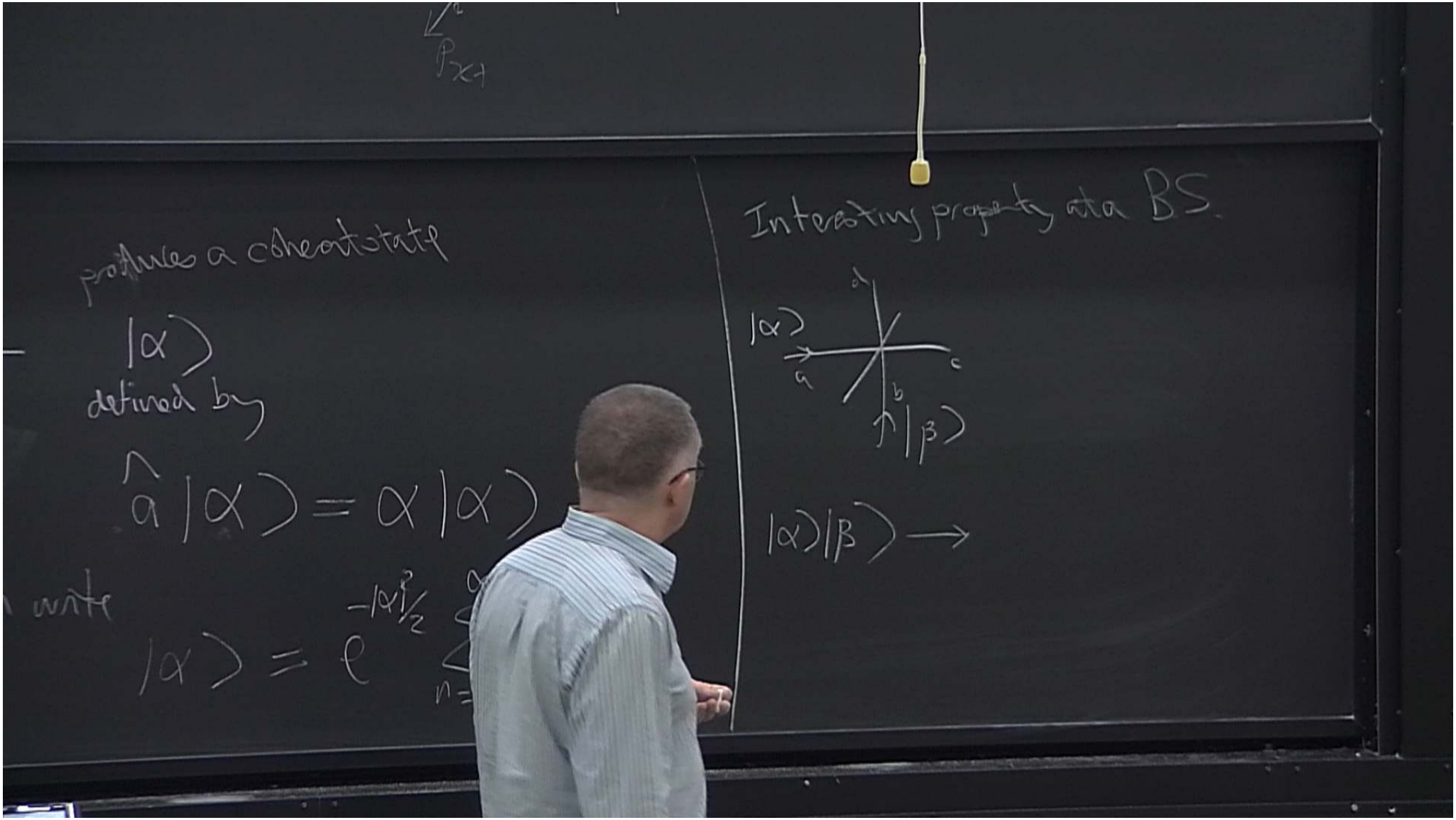

mirror
$\hat{a}^\dagger \rightarrow i\hat{a}^\dagger$
path length
$\hat{a}^\dagger \rightarrow e^{i\phi} \hat{a}^\dagger$
phase shifter
$\hat{a}^\dagger \rightarrow e^{i\phi} a^\dagger$

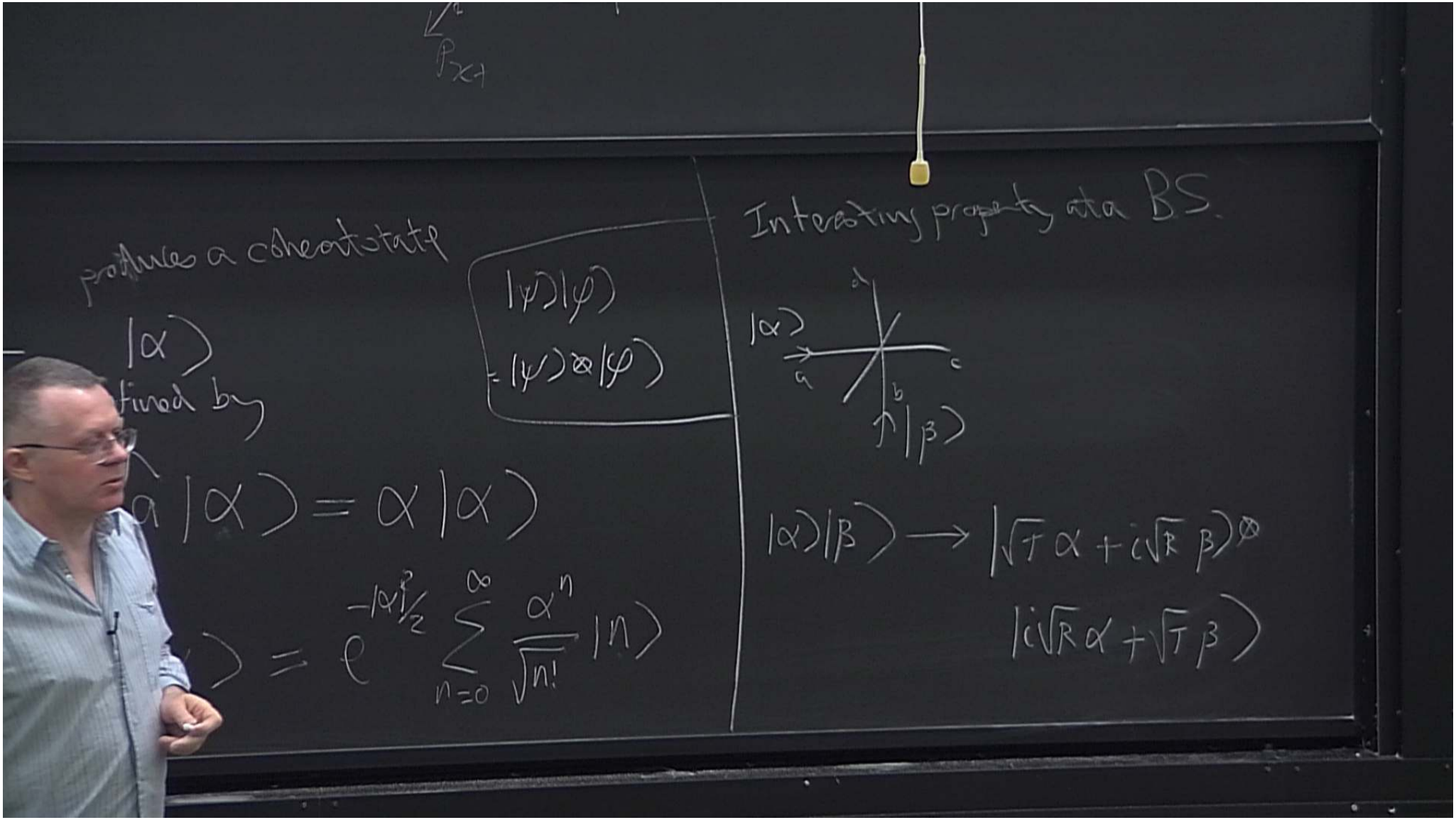

Eg
$|\psi\rangle = \sum_{m,n} c_{mn} |m\rangle_a |n\rangle_b = \sum_{mn} c_{mn} (\hat{a}^\dagger)^m$


$\sum_{m,n} c_{mn} |m\rangle_a |n\rangle_b = \sum_{mn} c_{mn} \frac{(\hat{a}^\dagger)^m}{\sqrt{(m+1)!}} \frac{(\hat{b}^\dagger)^n}{\sqrt{(n+1)!}} |0\rangle_a |0\rangle_b$
$\rightarrow \sum_{m,n} c_{mn} \frac{(\sqrt{T}\hat{c}^\dagger + i\sqrt{R}\hat{d}^\dagger)^m}{\sqrt{(m+1)!}} \frac{(i\sqrt{R}\hat{c}^\dagger + \sqrt{T}\hat{d}^\dagger)^n}{\sqrt{(n+1)!}} \cdot |0\rangle_c |0\rangle_d$


$= \sum_{mn} c_{mn} \frac{(\hat{a}^\dagger)^m}{\sqrt{(m+1)!}} \frac{(\hat{b}^\dagger)^n}{\sqrt{(n+1)!}} |0\rangle |0\rangle_a |0\rangle_b$
$|0\rangle = \bigotimes_i |0\rangle_i$
all modes
$\frac{(\sqrt{R}\,\hat{c}^\dagger + \sqrt{T}\,\hat{d}^\dagger)^n}{\sqrt{(n+1)!}} |0\rangle_c |0\rangle_d$


Source
laser
a
produces a coherent state
$|\alpha\rangle$
defined by
$\hat{a}|\alpha\rangle = \alpha|\alpha\rangle$
can write
$|\alpha\rangle = e^{-|\alpha|^2/2} \sum_{n=0}^{\infty} \frac{\alpha^n}{\sqrt{n!}} |n\rangle$


produces a coherent state
$|\alpha\rangle$
defined by
$\hat{a}|\alpha\rangle = \alpha|\alpha\rangle$
$|\alpha\rangle = e^{-|\alpha|^2/2}$
Interesting property of a BS.
$|\alpha\rangle$
$|\beta\rangle$
$|\alpha\rangle|\beta\rangle \longrightarrow$


produces a coherent state
$|\alpha\rangle$
found by
$\hat{a}|\alpha\rangle = \alpha|\alpha\rangle$
$|\psi\rangle|\varphi\rangle$
$= |\psi\rangle \otimes |\varphi\rangle$
Interesting property of a BS.
$|\alpha\rangle$
$|\beta\rangle$
$|\alpha\rangle|\beta\rangle \longrightarrow |\sqrt{T}\alpha + i\sqrt{R}\beta\rangle \otimes |i\sqrt{R}\alpha + \sqrt{T}\beta\rangle$

$P_{x+}$

produces a coherent state

$|\alpha\rangle$

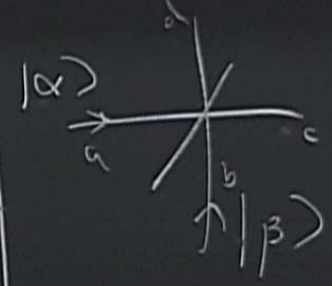
defined by

$\hat{a}|\alpha\rangle = \alpha|\alpha\rangle$

$|\psi\rangle|\varphi\rangle$

$= |\psi\rangle \otimes |\varphi\rangle$

Interesting property of a BS




$\hat{C}|\sqrt{T}\alpha + i\sqrt{R}\beta\rangle$

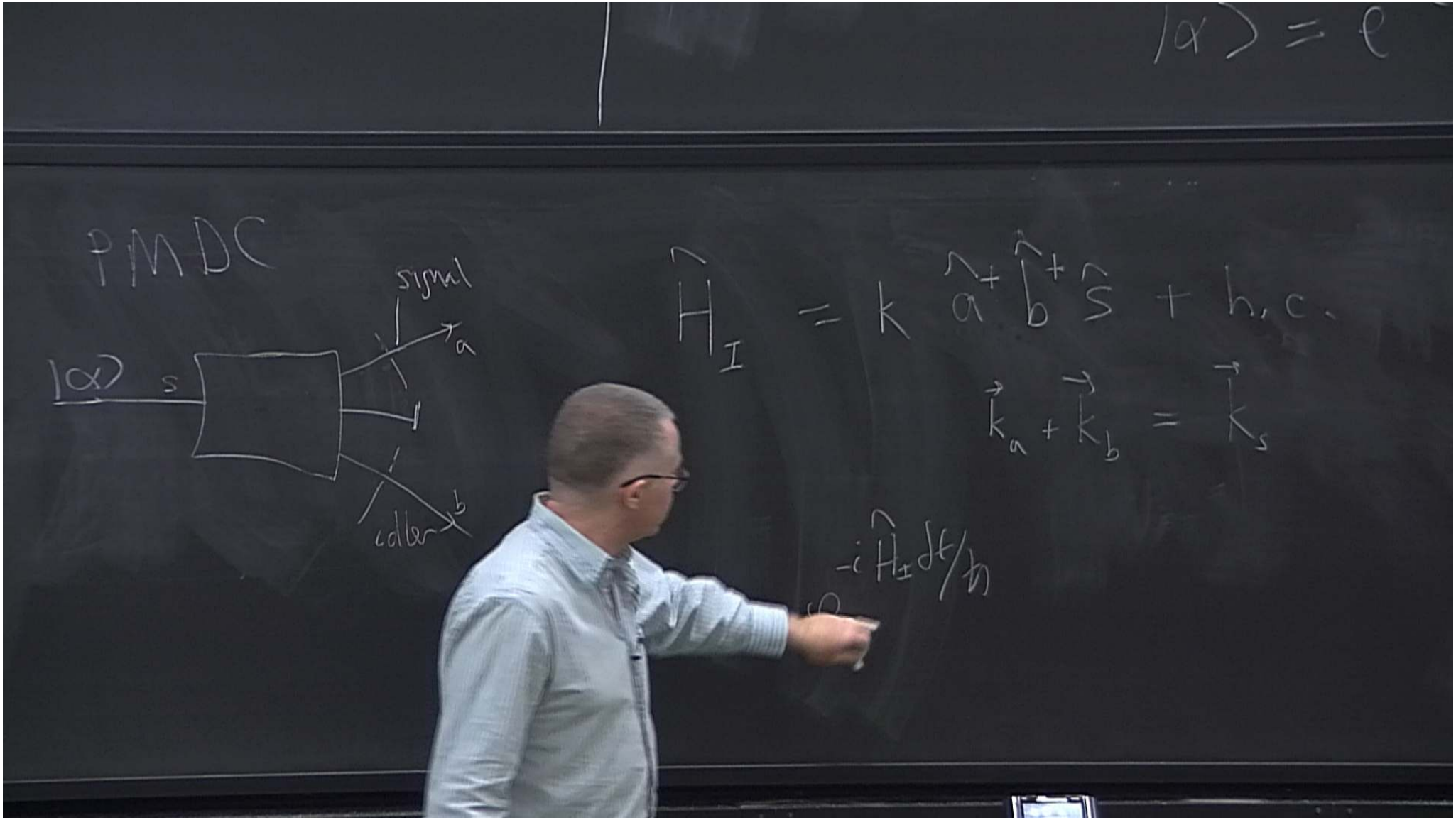
$= |\sqrt{T}\alpha + i\sqrt{R}\beta\rangle$

$|\sqrt{T}\alpha + i\sqrt{R}\beta\rangle$

$|\alpha\rangle|\beta\rangle \longrightarrow |\sqrt{T}\alpha + i\sqrt{R}\beta\rangle \otimes |i\sqrt{R}\alpha + \sqrt{T}\beta\rangle$

with

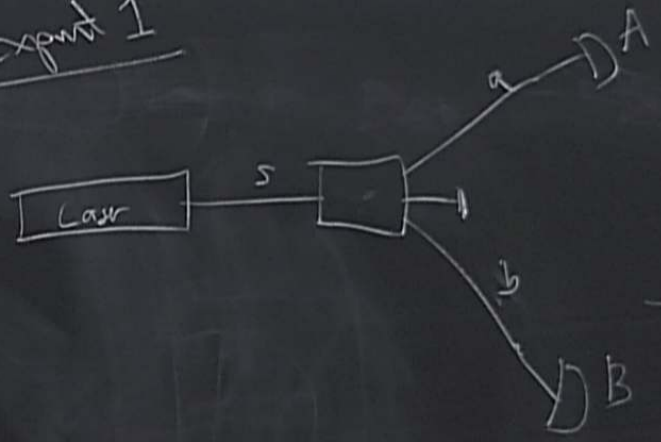
$$|\alpha\rangle = e^{-|\alpha|^2/2} \sum_{n=0}^{\infty} \frac{\alpha^n}{\sqrt{n!}} |n\rangle$$


PMDC
signal
a
|α⟩
s
idler
b
$\hat{H}_I = k\,\hat{a}^\dagger \hat{b}^\dagger \hat{s} + h.c.$
$\vec{k}_a + \vec{k}_b = \vec{k}_s$
$-i\hat{H}_I dt/\hbar$

$|\alpha\rangle = e^{\sum_{n=0}^{\infty} \frac{}{\sqrt{n!}}} |n\rangle$

$|(\sqrt{R}\alpha + \sqrt{T}\beta)$

Expmt 1




$|\alpha\rangle_s |0\rangle_a |0\rangle_b$

$\hat{a}^\dagger \hat{b}^\dagger \hat{s} + h.c.$

$\vec{k}_a + \vec{k}_b = \vec{k}_s$

$\longrightarrow \left(\mathbb{1} - i H_I \frac{\delta t}{\hbar}\right) |\alpha\rangle |0$

$\simeq \mathbb{1} - i H_I \frac{\delta t}{\hbar}$

$|\alpha\rangle = e^{\sum_{n=0}^{\infty} \frac{\alpha^n}{\sqrt{n!}} |n\rangle}$

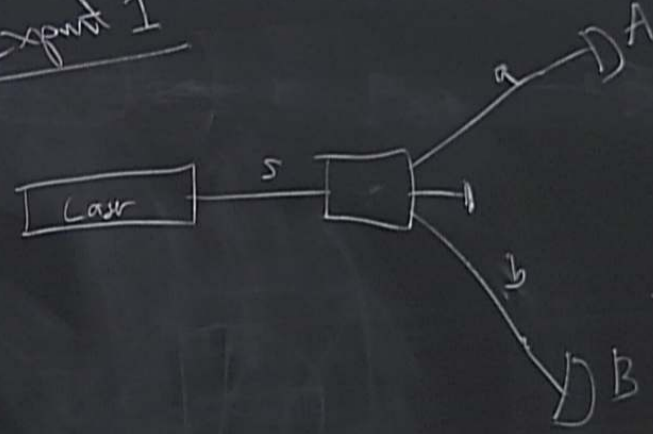
$|(\sqrt{R}\alpha + \sqrt{T}\beta)$

$+ \hat{s} + h.c.$

$\vec{k}_b = \vec{k}_s$

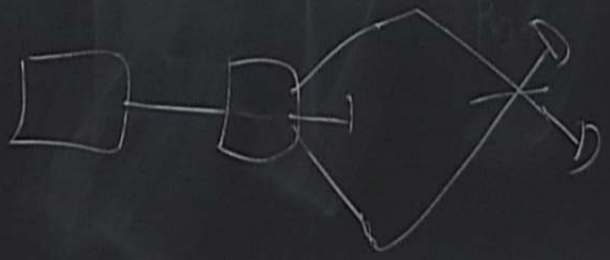
$\approx \mathbb{1} - i H_I \frac{\delta t}{\hbar}$

Expmt 1




$|\alpha\rangle_s |0\rangle_a |0\rangle_b$

$\rightarrow \left(\mathbb{1} - i H_I \frac{\delta t}{\hbar}\right) |\alpha\rangle |0\rangle |0\rangle$



$= |\alpha\rangle_s |0\rangle_a |0\rangle_b$

$- \frac{i \delta t \alpha' k}{\hbar} |\alpha\rangle_s |1\rangle_a |1\rangle_b$