Title: Lecture - Quantum Foundations, PHYS 639

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Collection/Series: Quantum Foundations (Elective), PHYS 639, January 6 - February 5, 2025

Subject: Quantum Foundations

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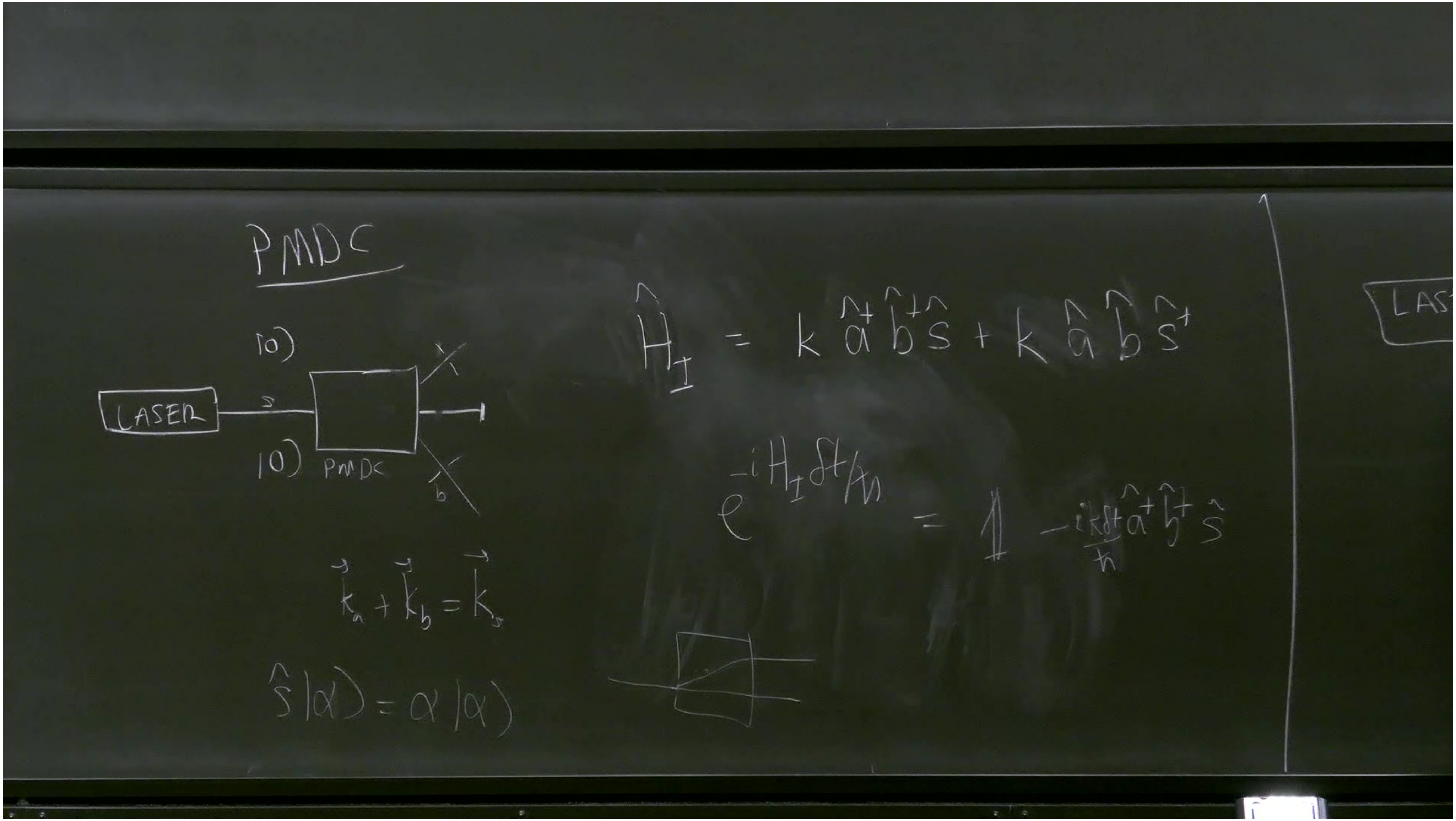
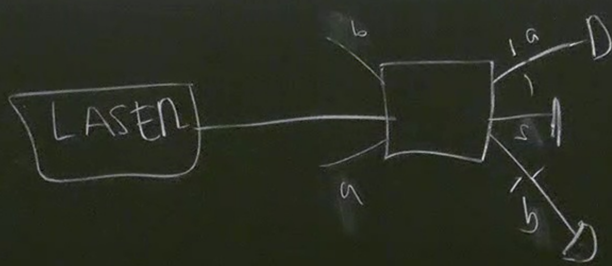

PMDC
|0)
LASER
s
|0)
PMDC
a
b
$\hat{H}_I = k\hat{a}^\dagger\hat{b}^\dagger\hat{s} + k\hat{a}\hat{b}\hat{s}^\dagger$
$e^{-iH_I\delta t/\hbar} = \mathbb{1} - \frac{ik\delta t}{\hbar}\hat{a}^\dagger\hat{b}^\dagger\hat{s}$
$\vec{k}_a + \vec{k}_b = \vec{k}_s$
$\hat{s}|\alpha) = \alpha|\alpha)$

$\hat{S}^\dagger$

$\hat{b}^\dagger \hat{s}$



$$|0\rangle = \bigotimes_m |0\rangle_m$$

$$|\alpha\rangle_s|0\rangle_c|0\rangle_d \to e^{i\hat{H}_I dt/\hbar}|\alpha\rangle_1|0\rangle_a|0\rangle_b$$

$$= \left(\mathbb{1} - \frac{i\hat{H}_I dt}{\hbar}\right)|\alpha\rangle_1|0\rangle_a|0\rangle_b$$

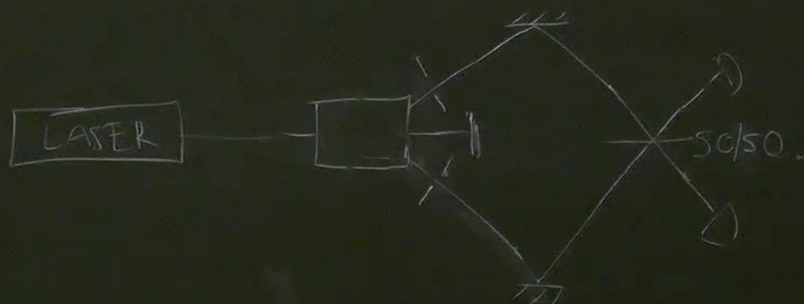
$$= |\alpha\rangle|0\rangle|0\rangle - \frac{ik\,dt}{\hbar}\alpha|\alpha\rangle_1|1\rangle_a|1\rangle_b$$

either 0 clicks

or 1 click in each detector

$S|\alpha\rangle = \alpha|\alpha\rangle$

Hong Ou Mandle Dip



$\omega_a = \omega_b$

$|\alpha\rangle_1 |0\rangle_a |0\rangle_b - c\alpha|$

$|\alpha\rangle_1 |0\rangle_a |0\rangle_b - c\alpha$

either 0 clicks

or 1 click in each detector

$$|\alpha\rangle_q|0\rangle_a|0\rangle_b - c\alpha|\alpha\rangle_a|1\rangle_a|1\rangle_b$$

$$|\alpha\rangle_q|0\rangle_a|0\rangle_b - c\alpha\,\hat{a}^\dagger\hat{b}^\dagger|\alpha\rangle_q|0\rangle_a|0\rangle_b$$

$$|\alpha\rangle_q|0\rangle_a|0\rangle_b - \frac{c\alpha}{2}\underbrace{(\hat{c}^\dagger + i\hat{d}^\dagger)(i\hat{c}^\dagger + \hat{d}^\dagger)}_{i\hat{c}^\dagger\hat{c}^\dagger + i\hat{d}^\dagger\hat{d}^\dagger + (\hat{c}^\dagger\hat{d}^\dagger - \hat{d}^\dagger\hat{c}^\dagger)}|\alpha\rangle_q|0\rangle_c|0\rangle_d$$

$$(\hat{c}^\dagger\hat{d}^\dagger - \hat{d}^\dagger\hat{c}^\dagger) = [\hat{c}^\dagger, \hat{d}^\dagger] = 0$$

either 0 clicks

or 1 click in each detector

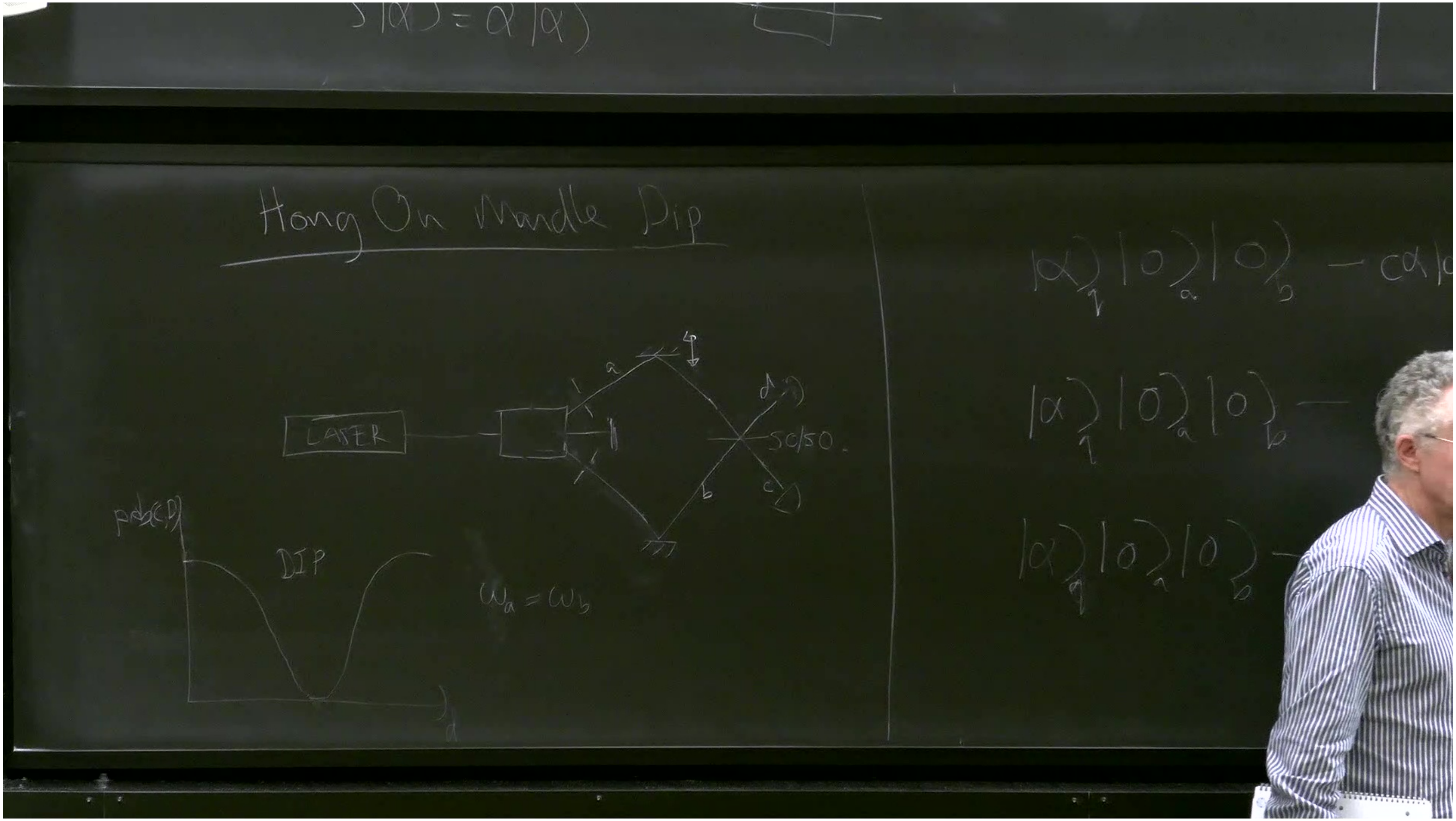
$$|0\rangle_a|0\rangle_b - c\alpha|\alpha\rangle_a|1\rangle_a|1\rangle_b$$

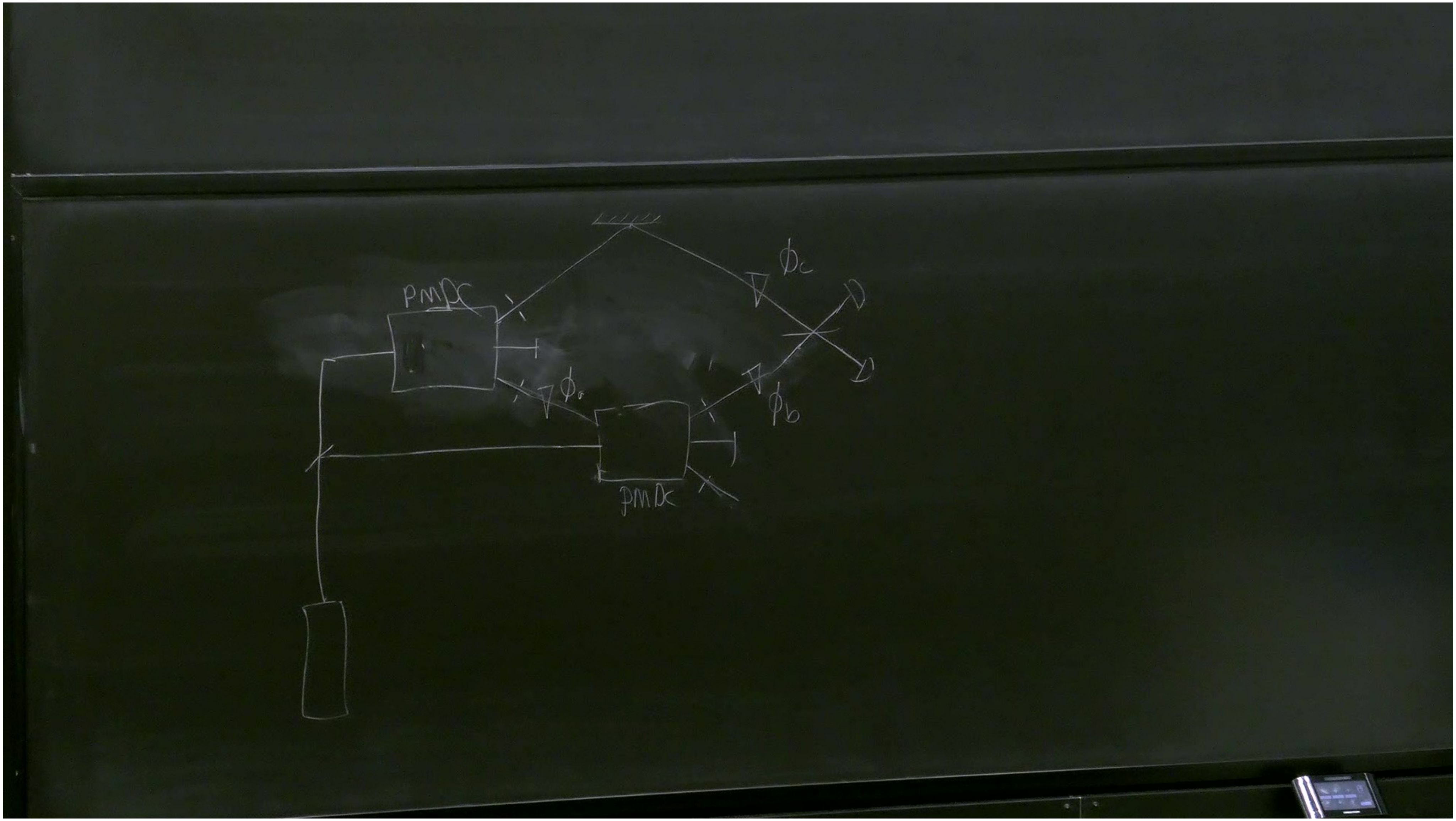
$$|0\rangle_a|0\rangle_b - c\alpha\,\hat{a}^+\hat{b}^+|\alpha\rangle_q|0\rangle_a|0\rangle_b$$

$$|0\rangle_a|0\rangle_b - \frac{c\alpha}{2}\underbrace{(\hat{c}^+ + i\hat{d}^+)(i\hat{c}^+ + \hat{d}^+)}_{i\hat{c}^+\hat{c}^+ + i\hat{d}^+\hat{d}^+ + (\hat{c}^+\hat{d}^+ - \hat{d}^+\hat{c}^+) = [\hat{c}^+,\hat{d}^+]=0}|\alpha\rangle_q|0\rangle_c|0\rangle_d$$

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

$$-\frac{c\alpha}{2}\left(\sqrt{2}|2\rangle_c|0\rangle_d + \sqrt{2}|0\rangle_c|2\rangle_d\right)$$


Hong Ou Mandle Dip
LASER
50/50.
DIP


PMDC
ϕ_c
ϕ_a
ϕ_b
PMDC