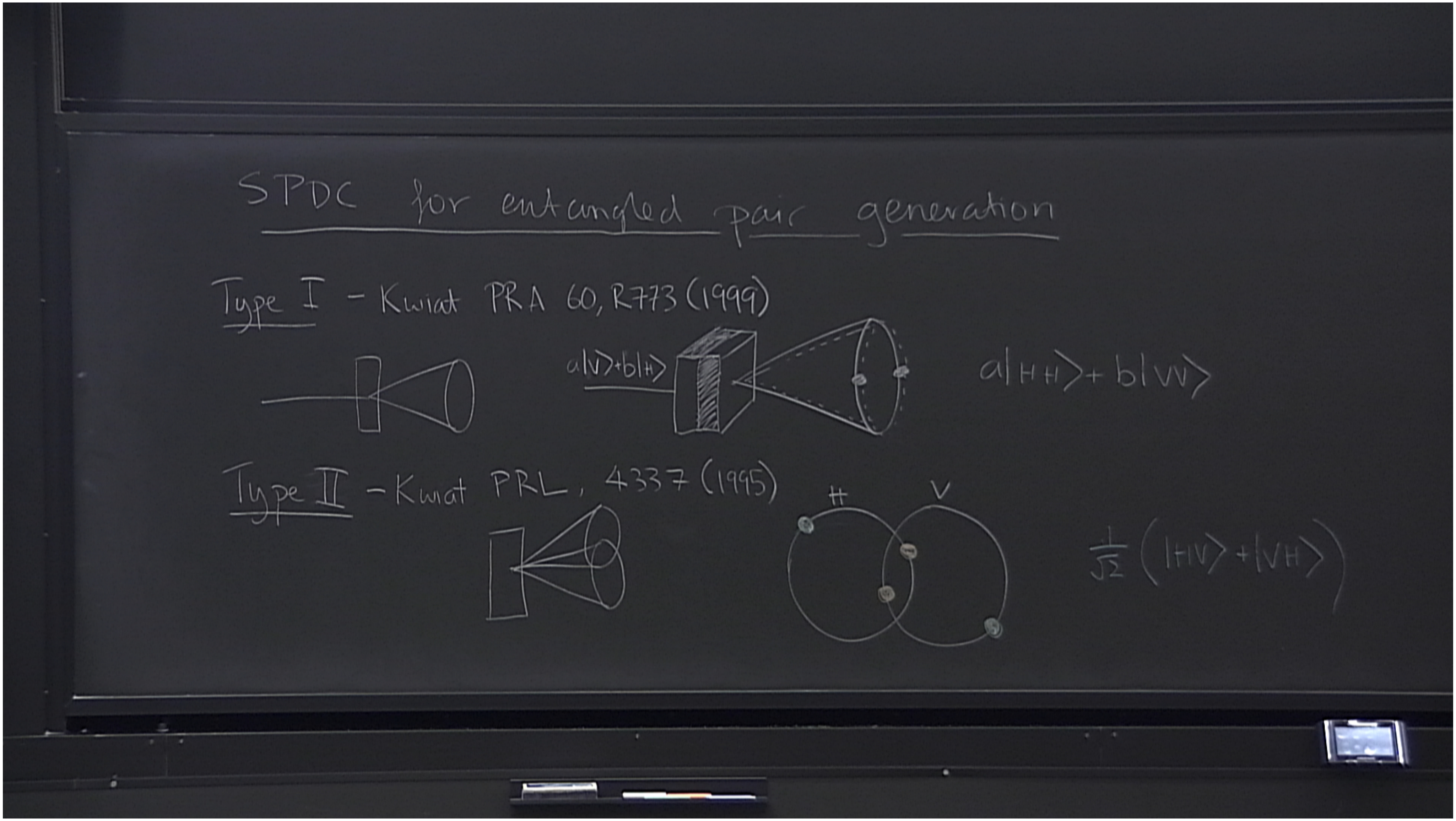
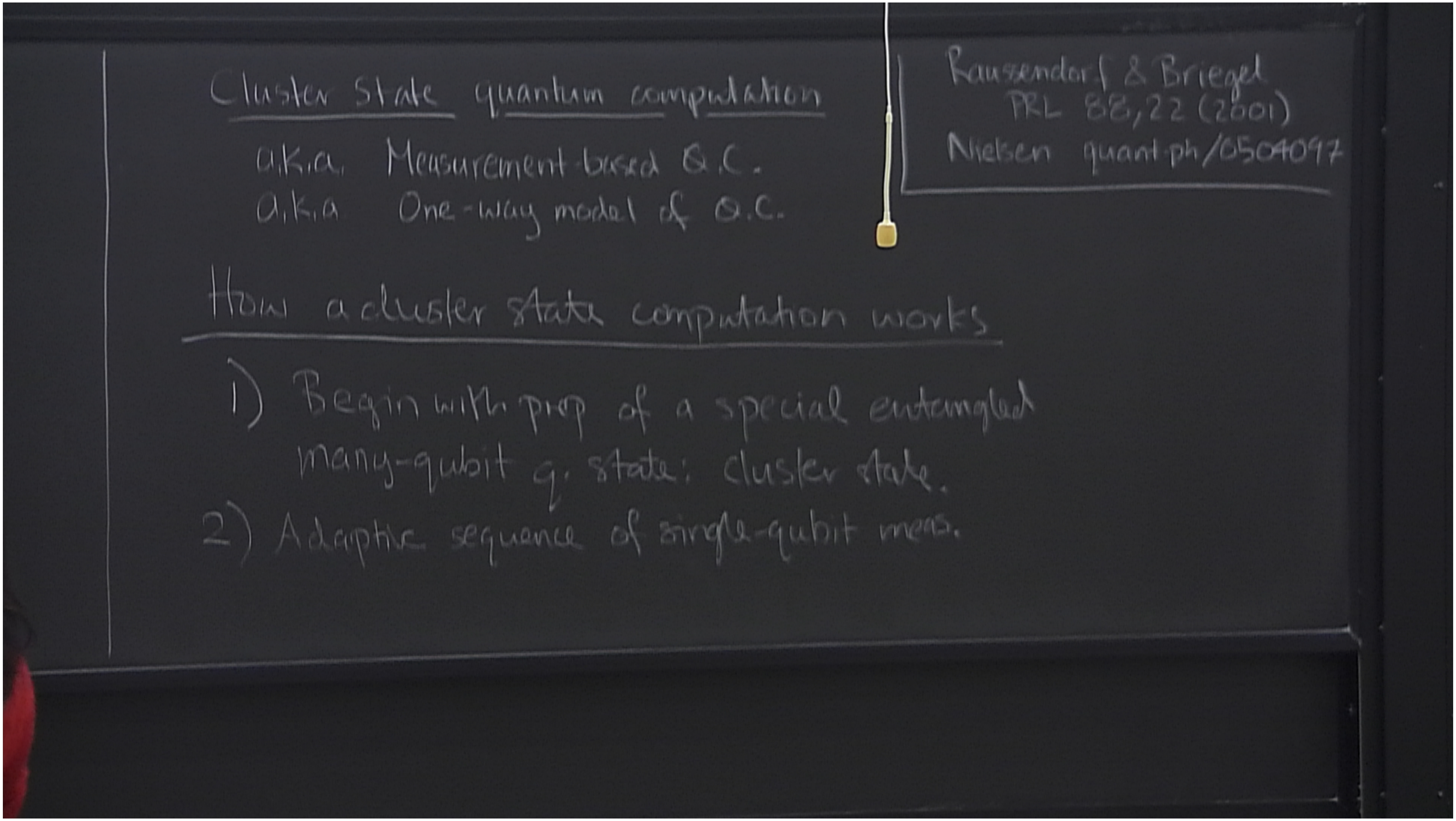
Title: PSI 2015/2016 Explorations in Quantum Information - Agata Branczyk - 14

Date: Apr 08, 2016 09:00 AM

URL: http://pirsa.org/16040005

Abstract:


SPDC for entangled pair generation
Type I - Kwiat PRA 60, R773 (1999)
a|V>+b|H>
a|HH>+b|VV>
Type II - Kwiat PRL, 4337 (1995)
H
V
1/√2 (|HV>+|VH>)


Cluster state quantum computation
a.k.a. Measurement-based Q.C.
a.k.a. One-way model of Q.C.
Raussendorf & Briegel
PRL 88, 22 (2001)
Nielsen quant-ph/0504097
How a cluster state computation works
1) Begin with prep of a special entangled many-qubit q. state: cluster state.
2) Adaptive sequence of single-qubit meas.

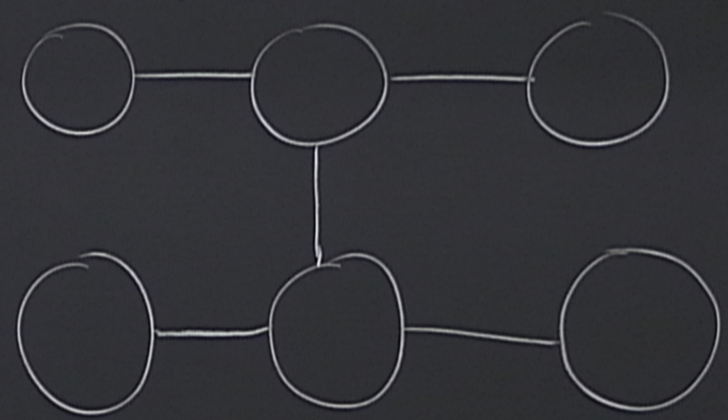
Define this cluster:

1) Prepare each qubit $|+\rangle = \frac{|0\rangle + |1\rangle}{\sqrt{2}}$

2) Apply a CZ gate between qubits that are connected.

$$CZ: \quad |x\rangle|y\rangle \longrightarrow (-1)^{xy}|x\rangle|y\rangle$$

Eg. Six qubit cluster state



Define th

1) Pr

2) A

q

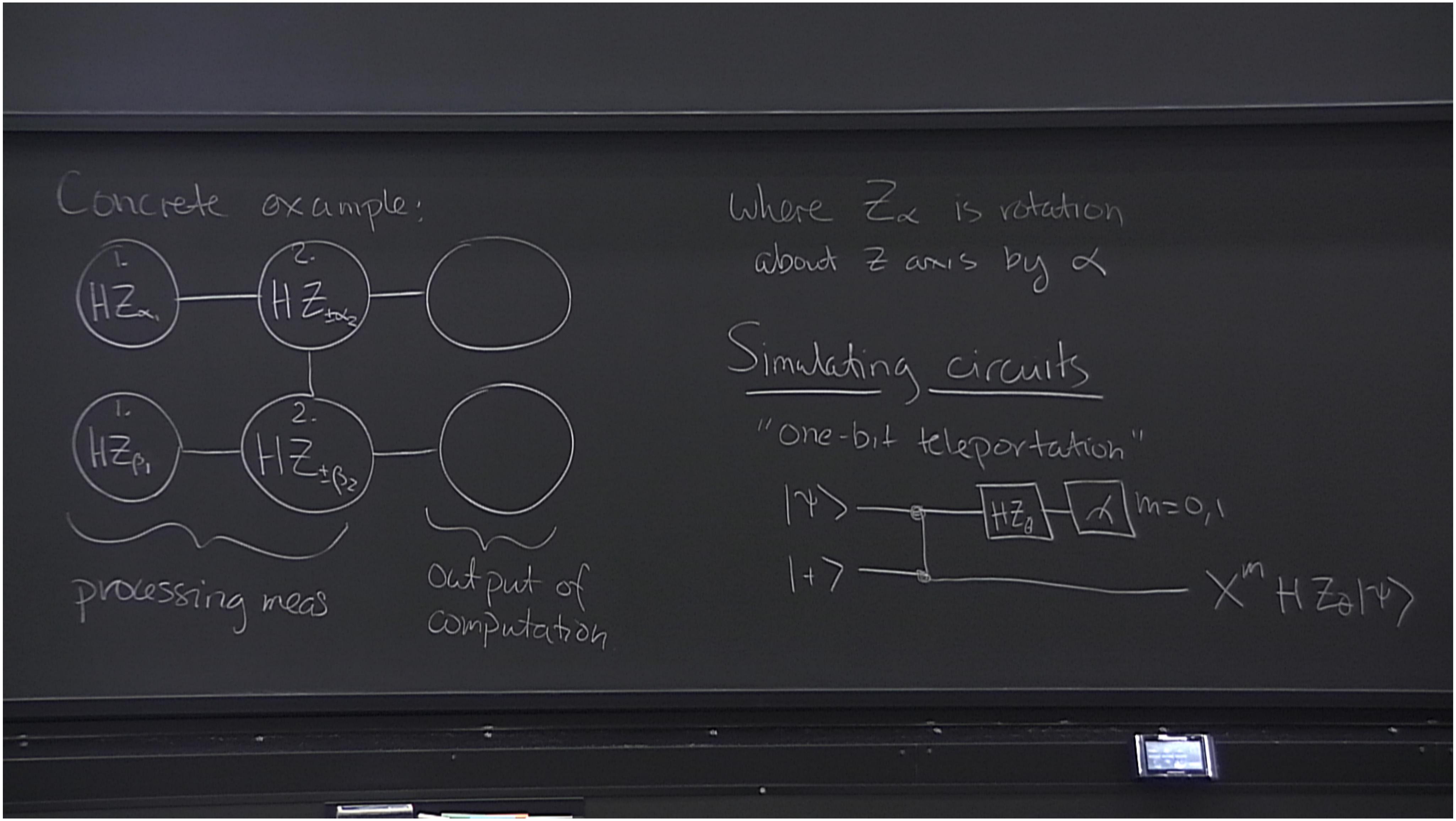
$= \frac{|0\rangle+|1\rangle}{\sqrt{2}}$

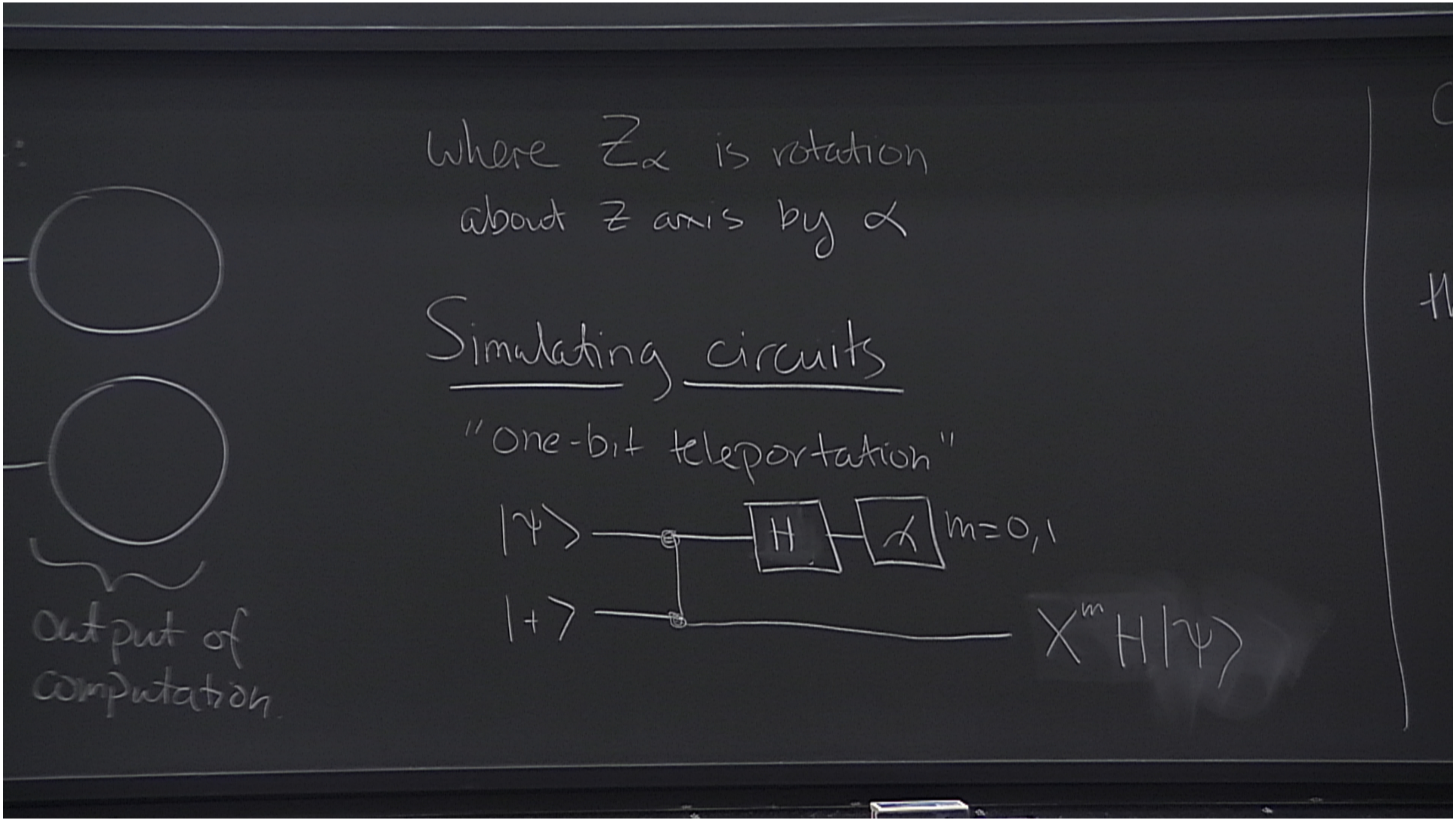
een

$-1)^{xy}|x\rangle|y\rangle$

Now perform meas that satisfy:

1) Single qubit meas
2) Choice of basis may depend on outcome of earlier meas.
3) Meas. result may be processed by a classical computer.


Concrete example:
1. HZ_{α_1}
2. $HZ_{\pm\alpha_2}$
1. HZ_{β_1}
2. $HZ_{\pm\beta_2}$
processing meas
output of computation
where Z_α is rotation about z axis by α
Simulating circuits
"one-bit teleportation"
$|\psi\rangle$
$|+\rangle$
HZ_θ
$m=0,1$
$X^m HZ_\theta|\psi\rangle$


where Z_α is rotation
about z axis by α
Simulating circuits
"one-bit teleportation"
$|\psi\rangle$
$|+\rangle$
H
α
m=0,1
$X^m H|\psi\rangle$
output of
computation

Can see as follows.

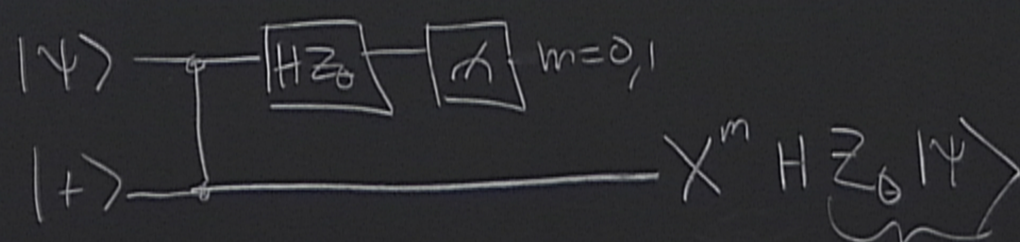
if $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$

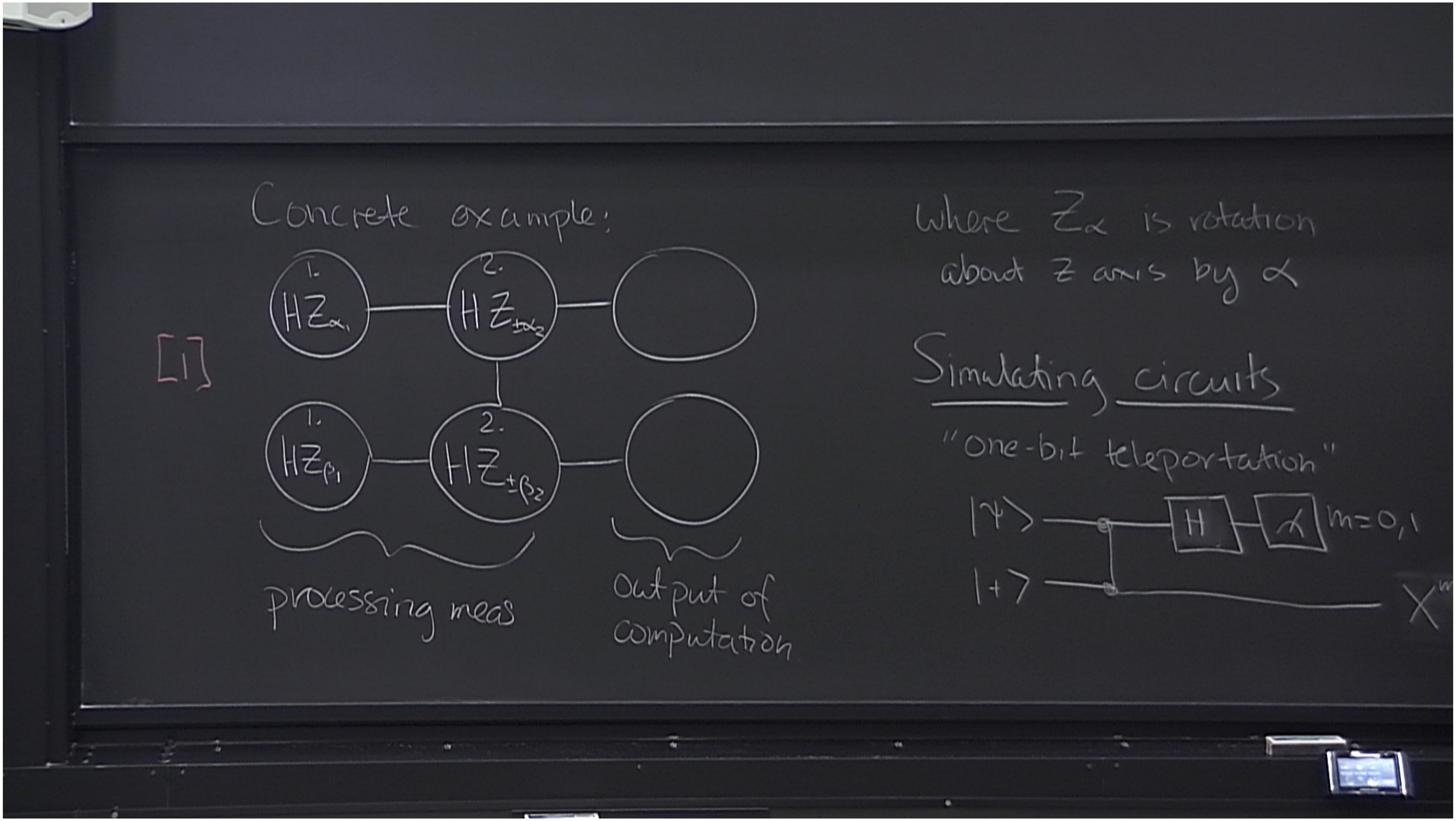
then $|\psi\rangle|+\rangle \xrightarrow{CZ,\, H} \alpha|++\rangle + \beta|--\rangle$

$$= \frac{1}{\sqrt{2}}\left(|0\rangle_a \otimes (H_b|\psi\rangle_b) + |1\rangle_a \otimes (\hat{X}_b \hat{H}_b|\psi\rangle_b)\right)$$

<u>Generalize to</u>

$|\psi\rangle$

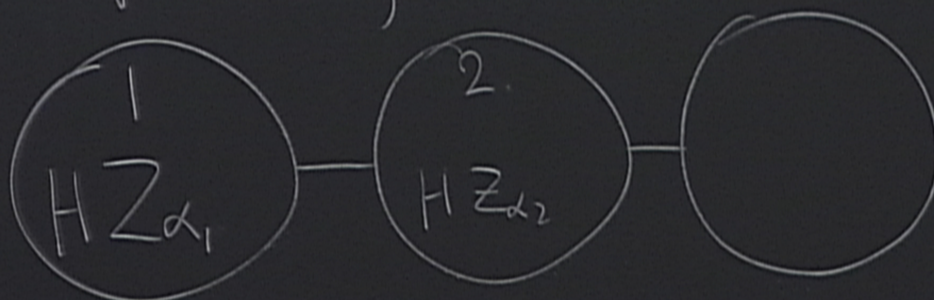


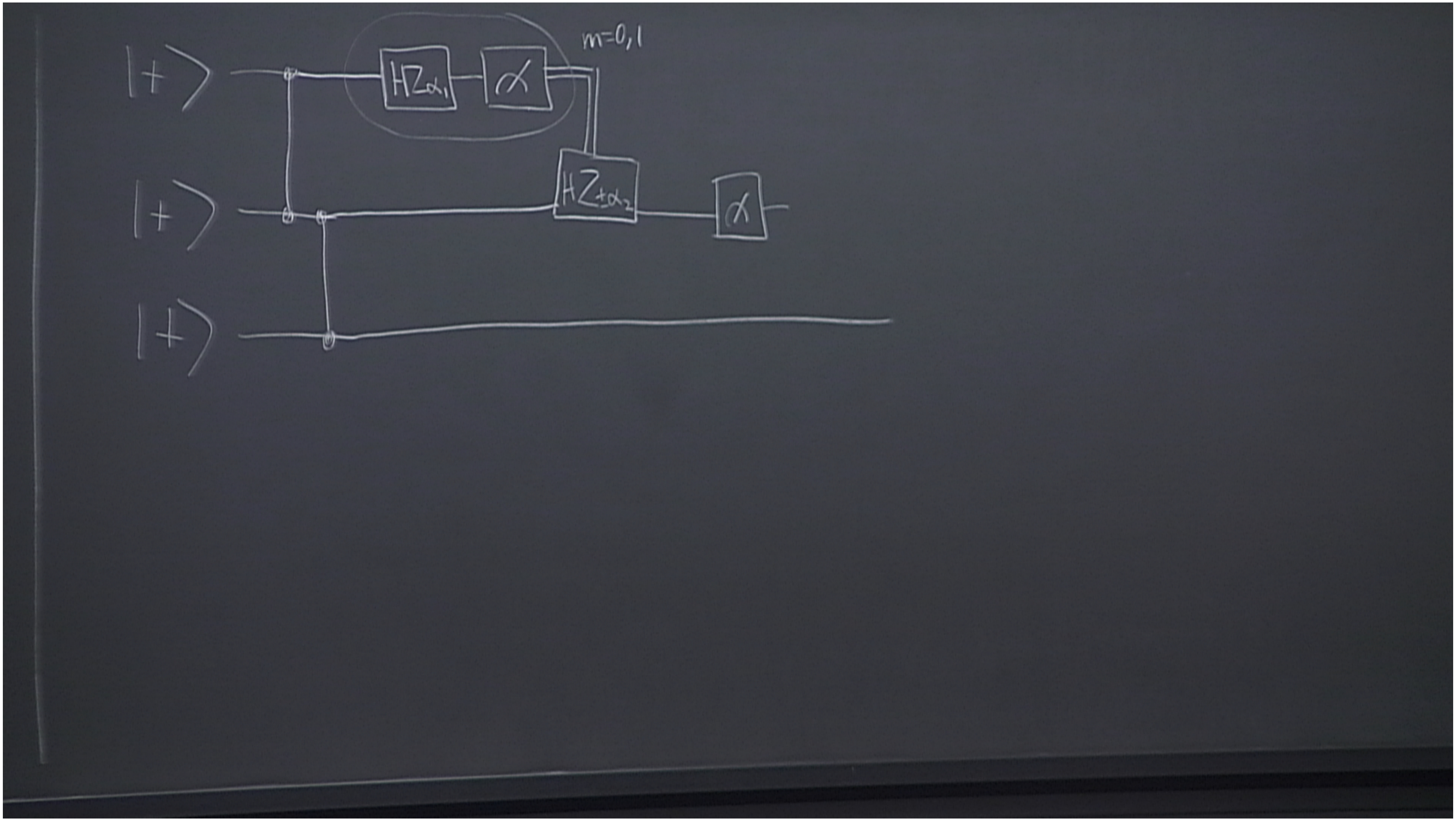

Concrete example:
[1]
1. HZα1
2. HZ±α2
1. HZβ1
2. HZ±β2
processing meas
output of computation
where Zα is rotation about Z axis by α
Simulating circuits
"one-bit teleportation"
|ψ>
|+>
H
m=0,1
X

Begin by simulating

[2] $$|+\rangle \;—\; \boxed{HZ_{\alpha_1}} \;—\; \boxed{HZ_{\alpha_2}} \;—\; HZ_{\alpha_2} HZ_{\alpha_1} |+\rangle$$

Corresponding cluster



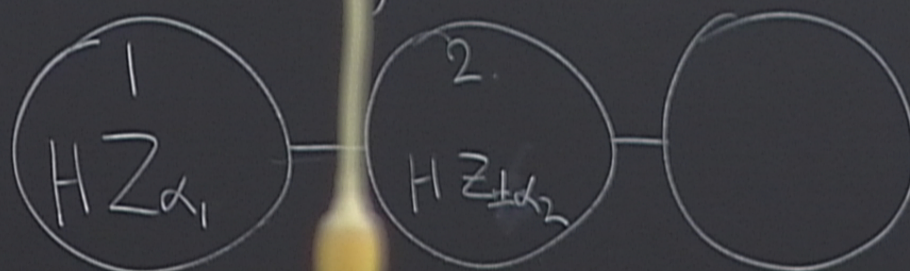


m=0,1
|+⟩
|+⟩
|+⟩
HZα₁
α
HZ±α₂
α

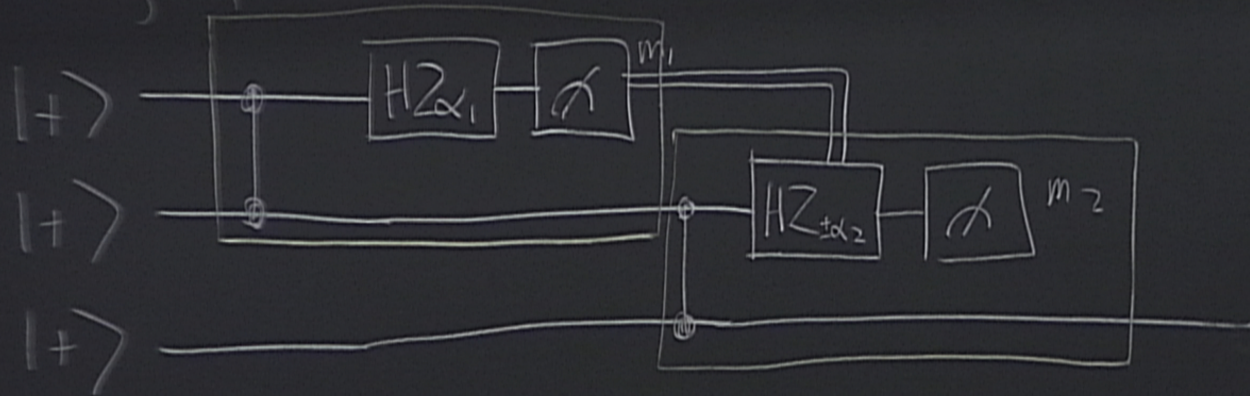
Begin by simulating

[2] $|+\rangle - \boxed{HZ_{\alpha_1}} - \boxed{HZ_{\alpha_2}} - \quad HZ_{\alpha_2} HZ_{\alpha_1} |+\rangle$

Corresponding cluster



Delay operations on 2nd & 3rd qubit



$$X^{m_2} H Z_{\pm\alpha_2} X^{m_1} Z_{\alpha_1} |+\rangle$$

Feed forward to choose sign $\pm\alpha_2$ so that

$$Z_{\pm\alpha_2} X^{m_1} = X^{m_1} Z_{\alpha_2} \qquad \text{also } HX^{m_1} = Z^{m_1} H$$

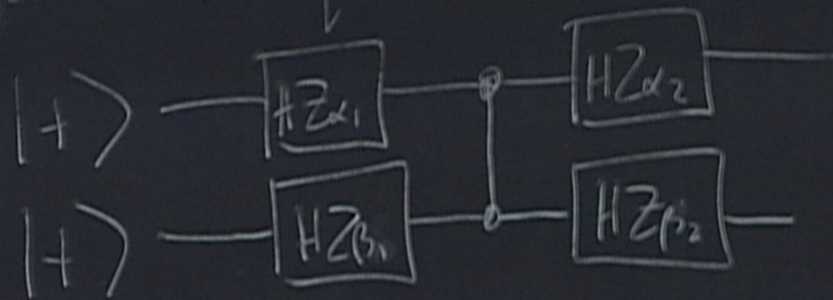
$$\to X^{m_2} Z^{m_1} \underbrace{H Z_{\alpha_2} H Z_{\alpha_1} |+\rangle}_{\text{identical to [2]}}$$

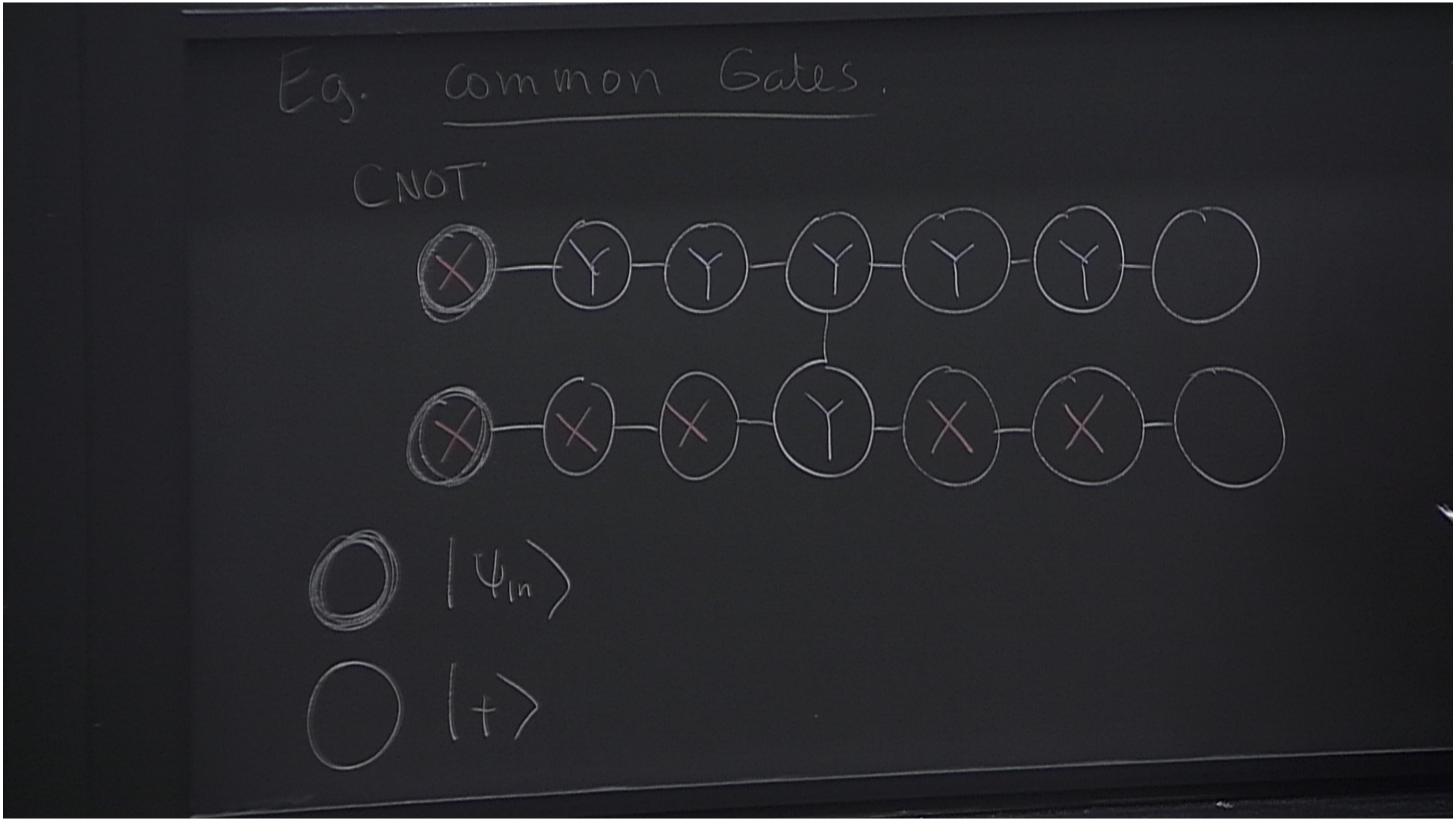
$$X^{m_2} H Z_{\pm\alpha_2} X^{m_1} Z_{\alpha_1} |+\rangle$$

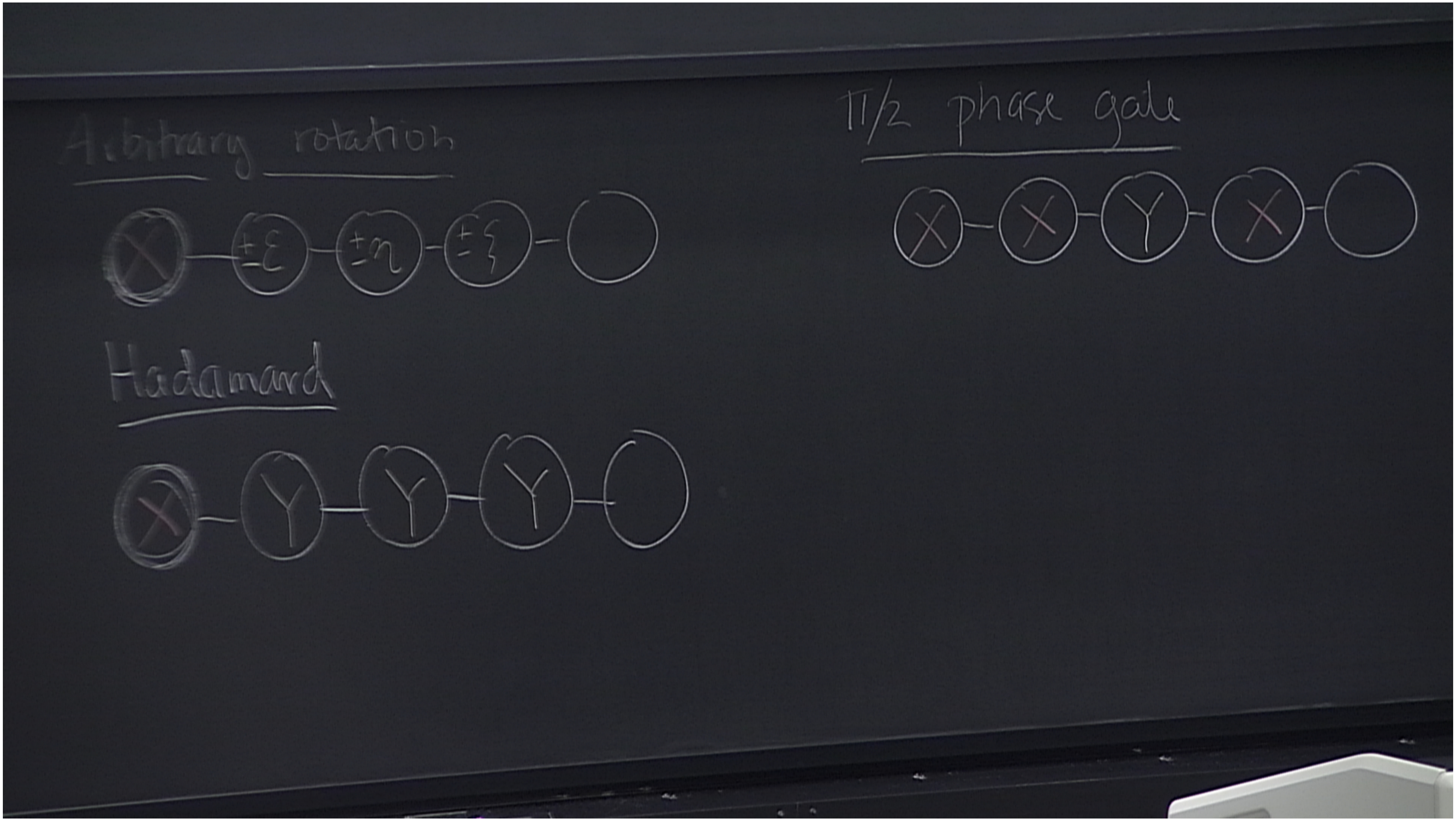
that

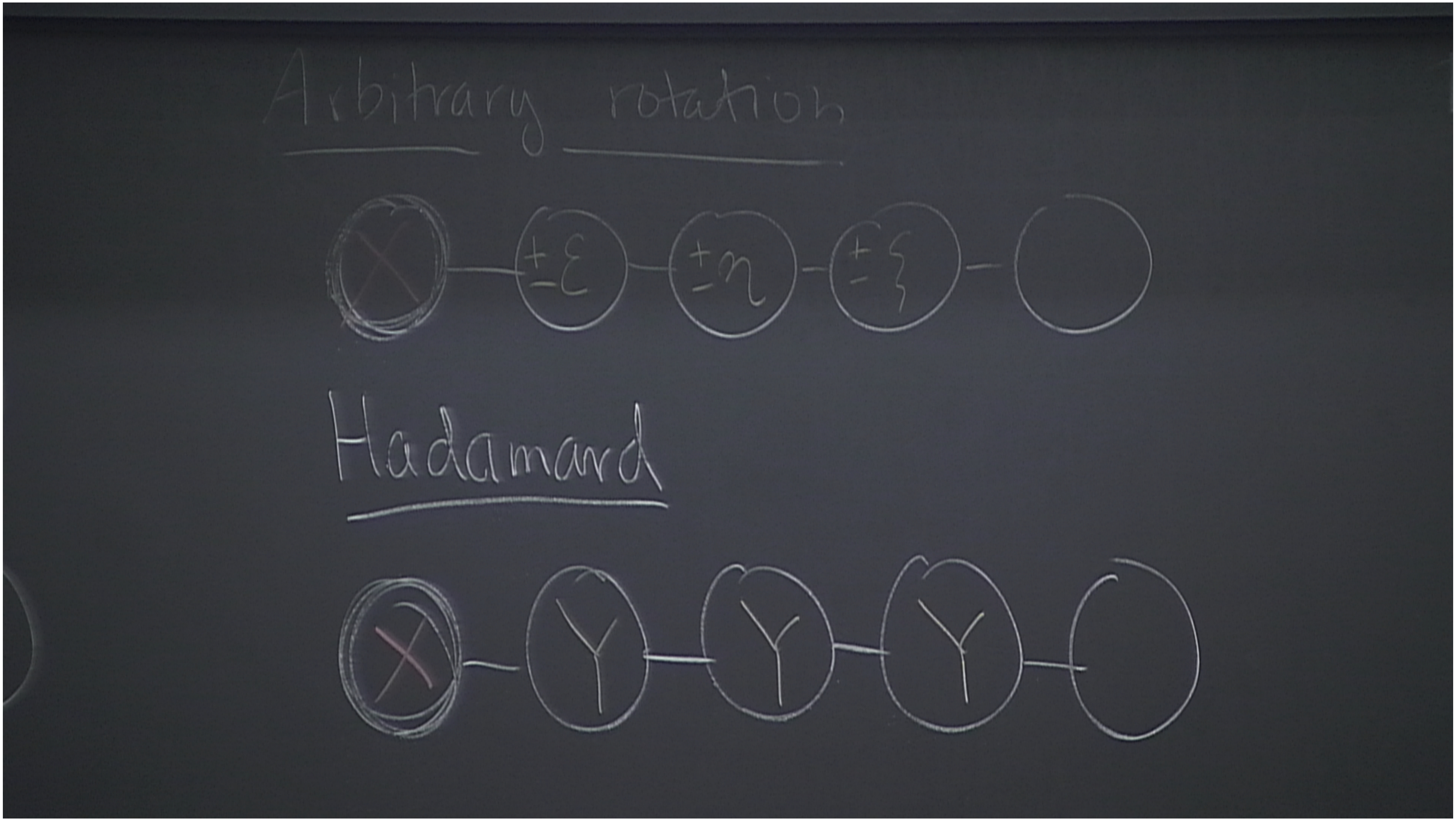
$$H X^{m_1} = Z^{m_1} H$$

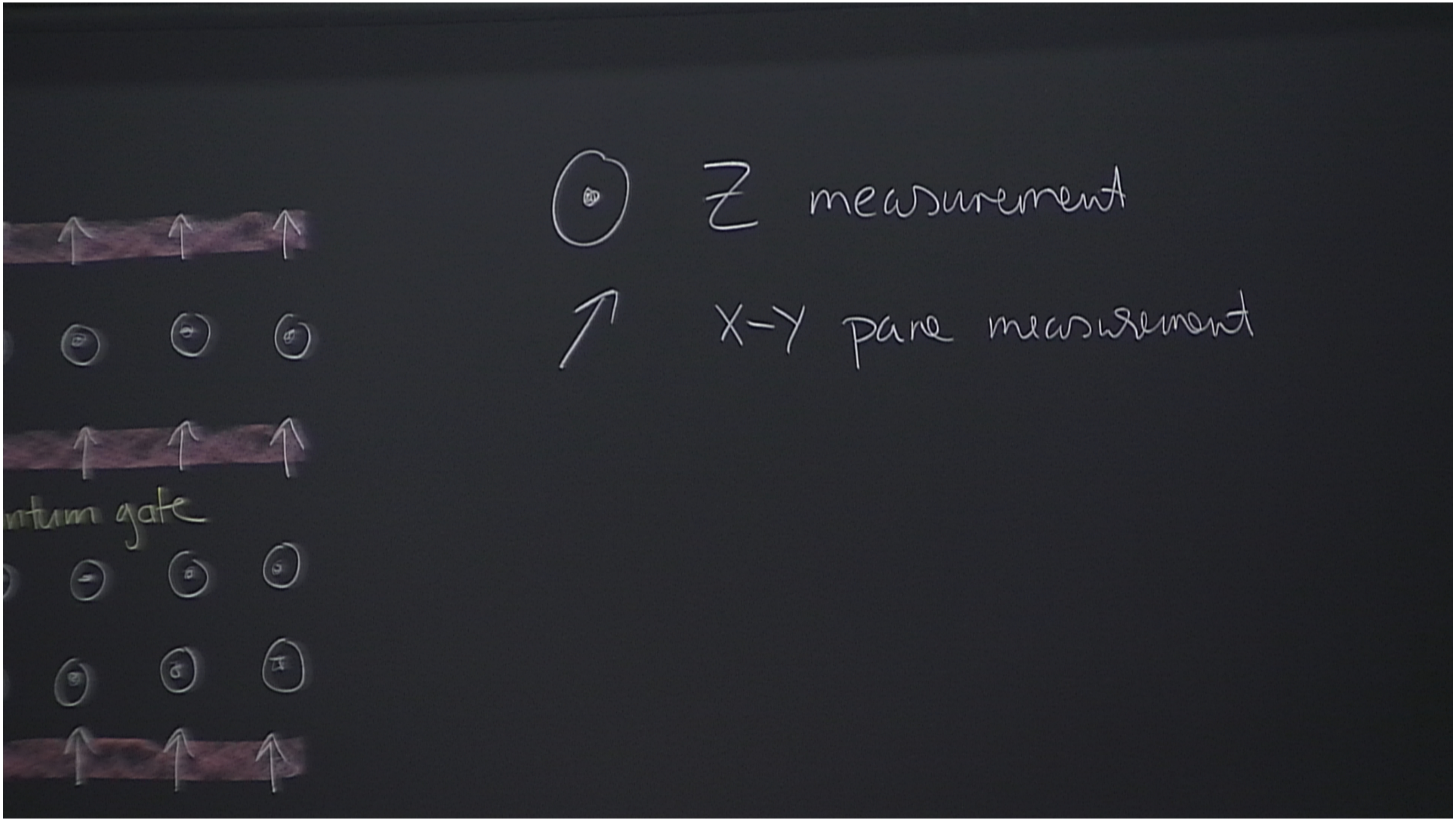
Eg. multi qubits,




Eg. Common Gates.
CNOT
X Y Y Y Y Y
X X X Y X X
|ψin⟩
|+⟩


Arbitrary rotation
X
±ε
±η
±ξ
Hadamard
X
Y
Y
Y
π/2 phase gate
X
X
Y
X


Arbitrary rotation
±ε
±η
±ξ
Hadamard
Y
Y
Y

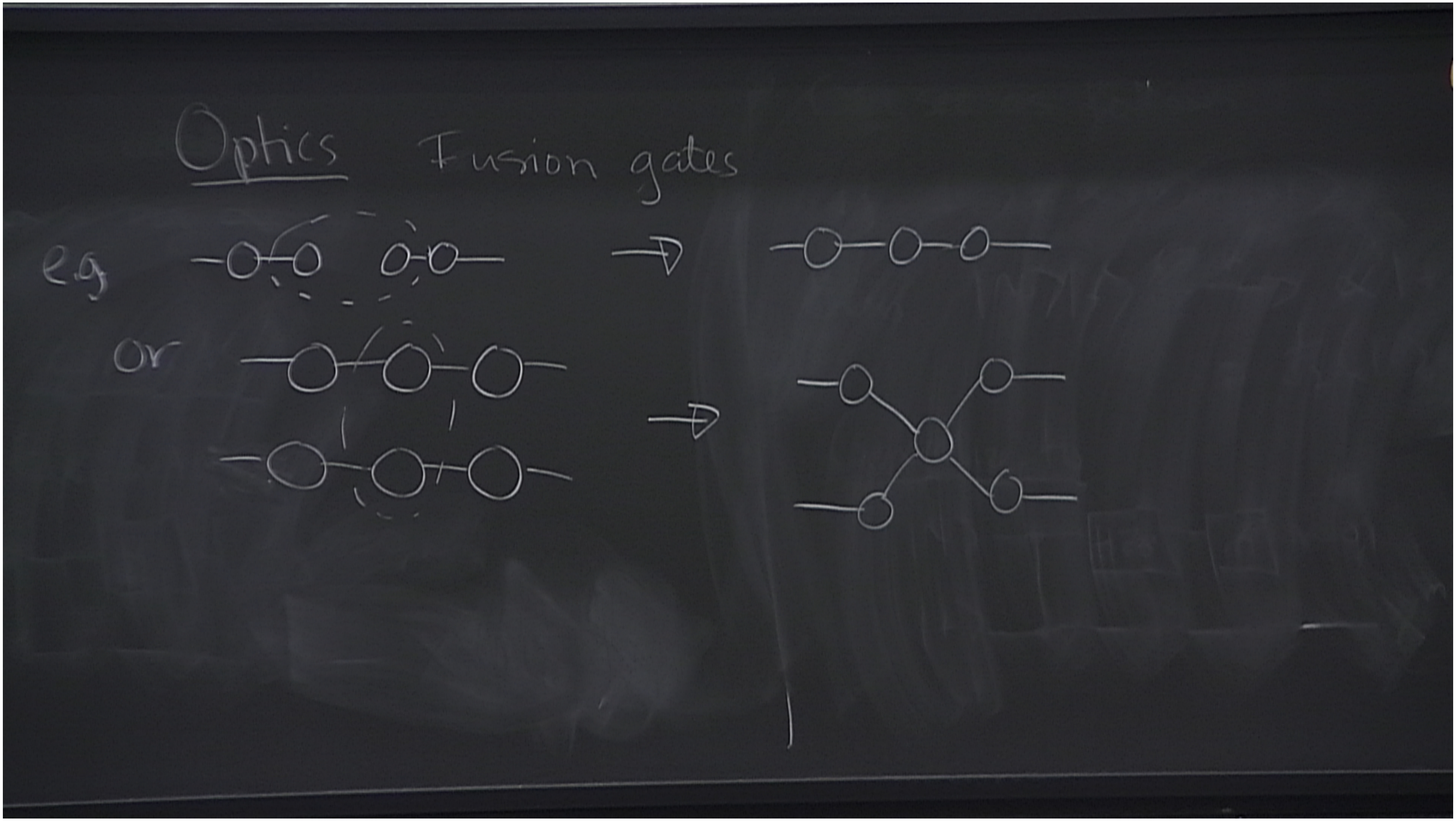

Z measurement
X-Y pane measurement
ntum gate

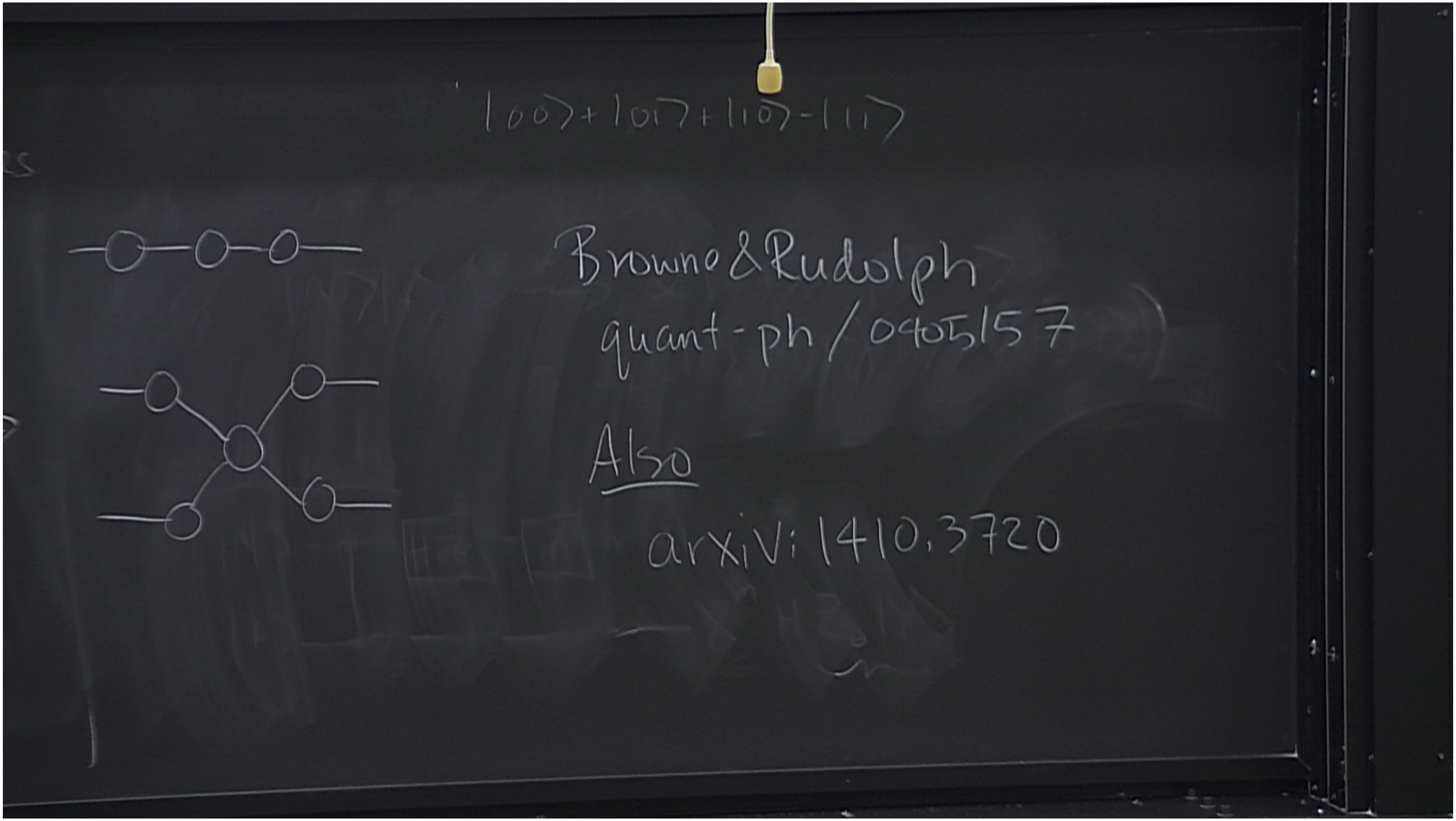
$$H_{int} \simeq -\frac{1}{4} g(t) \sum_{\langle a, a' \rangle} \sigma_z^{(a)} \sigma_z^{(a')}$$

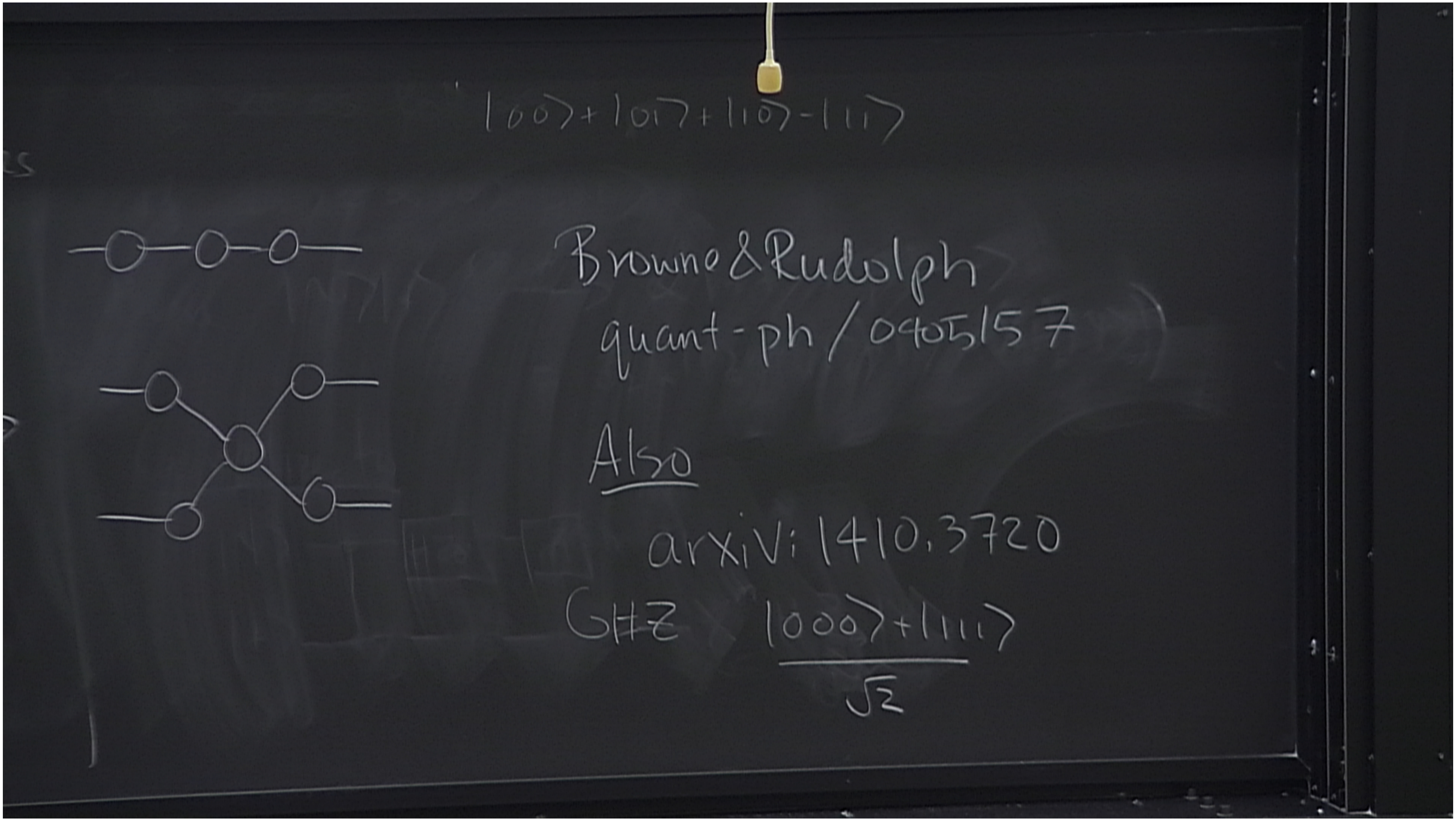
1) Prepare qubits in $|+\rangle = \frac{|0\rangle + |1\rangle}{\sqrt{2}}$

2) Switch on H_{int} for a time T

$$\int_0^T dt\, g(t) = \pi$$


Optics
Fusion gates
e.g.
or


|00⟩+|01⟩+|10⟩-|11⟩
Browne&Rudolph
quant-ph/0405157
Also
arxiV:1410.3720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Browne&Rudolph
quant-ph/0405157
Also
arxiV:1410.3720
GHZ
$\frac{|000\rangle+|111\rangle}{\sqrt{2}}$