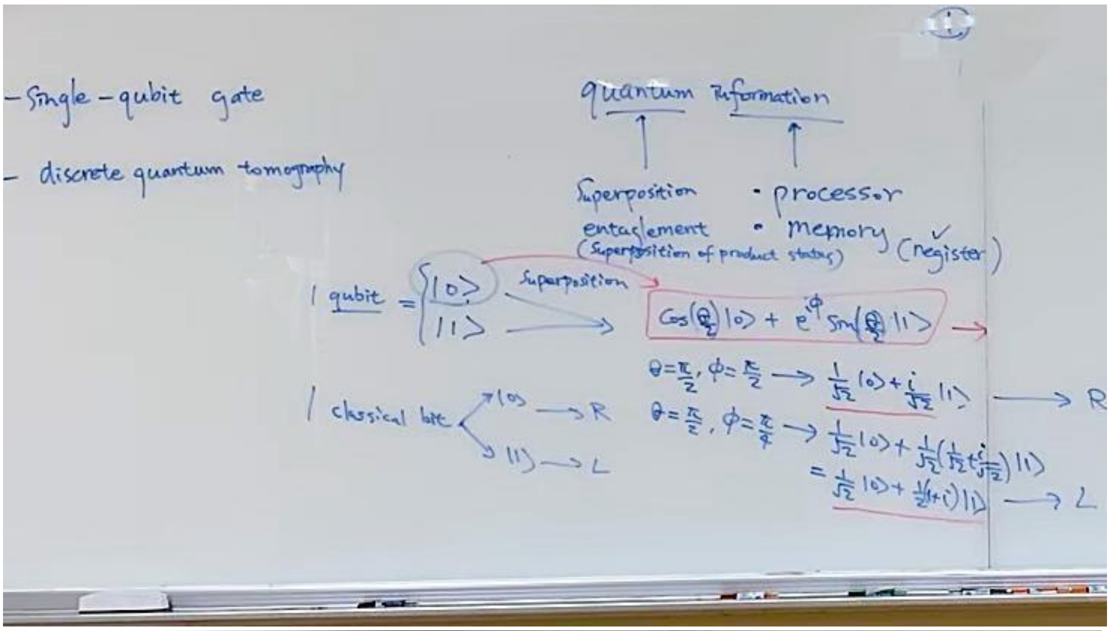
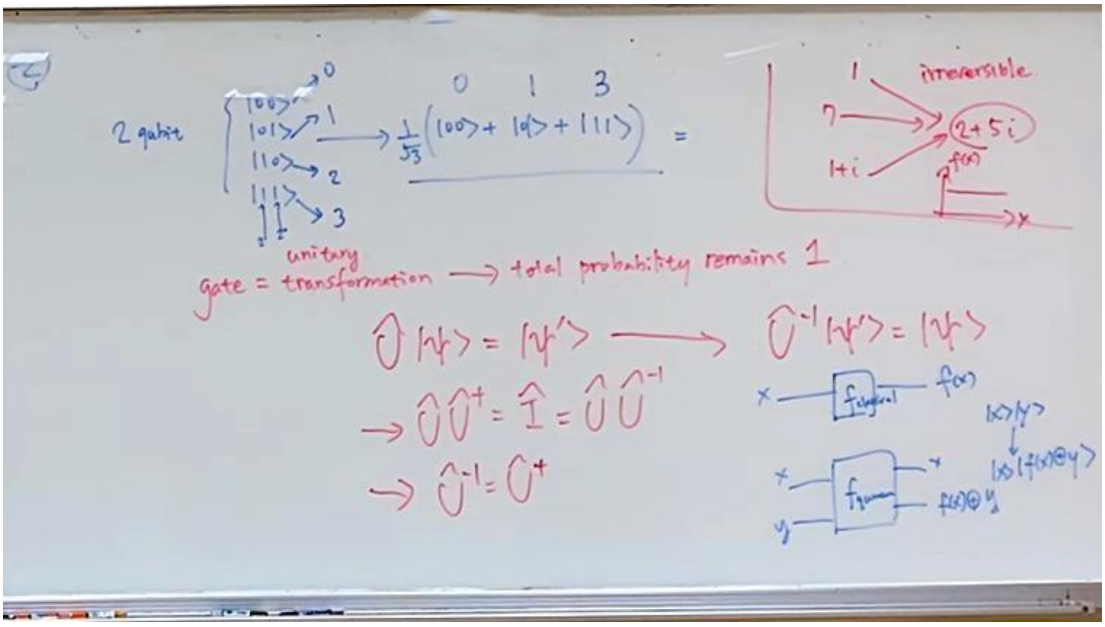
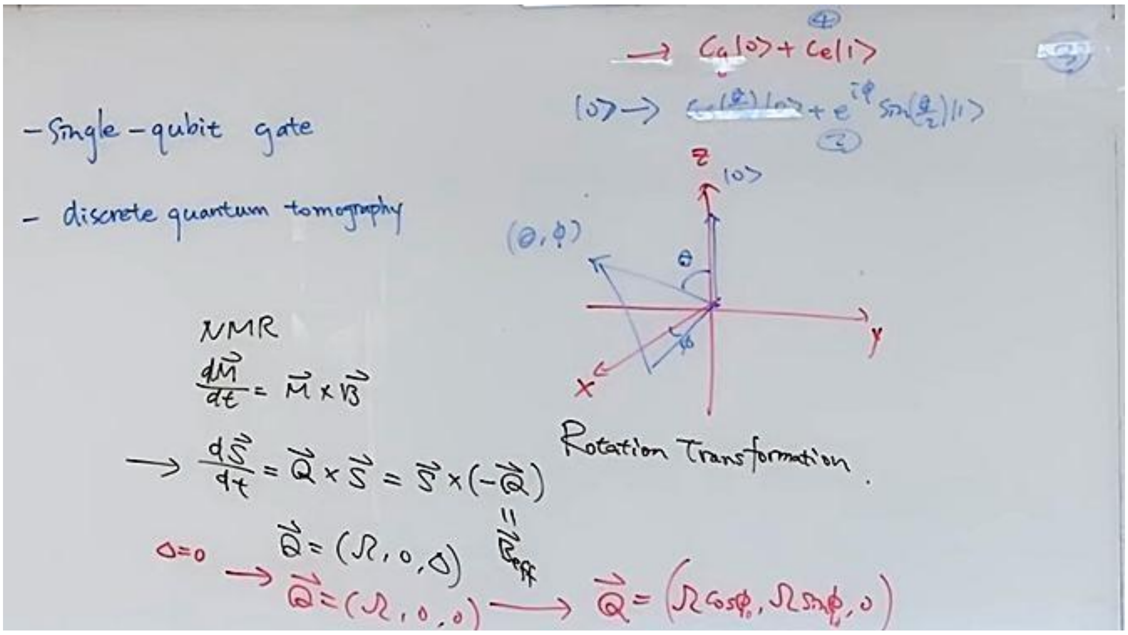
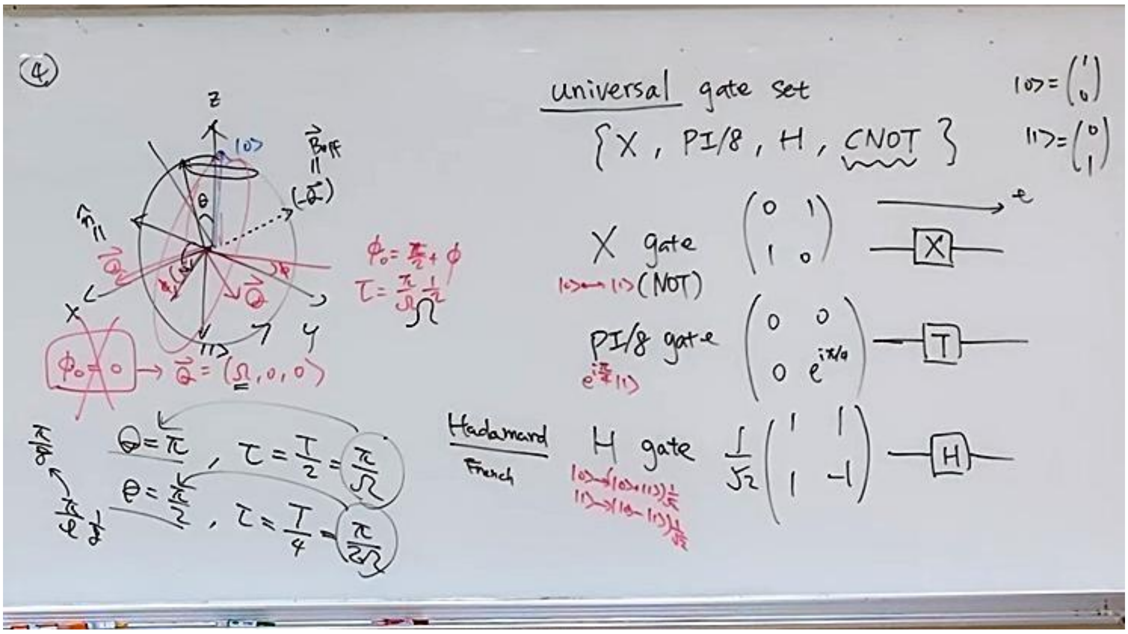
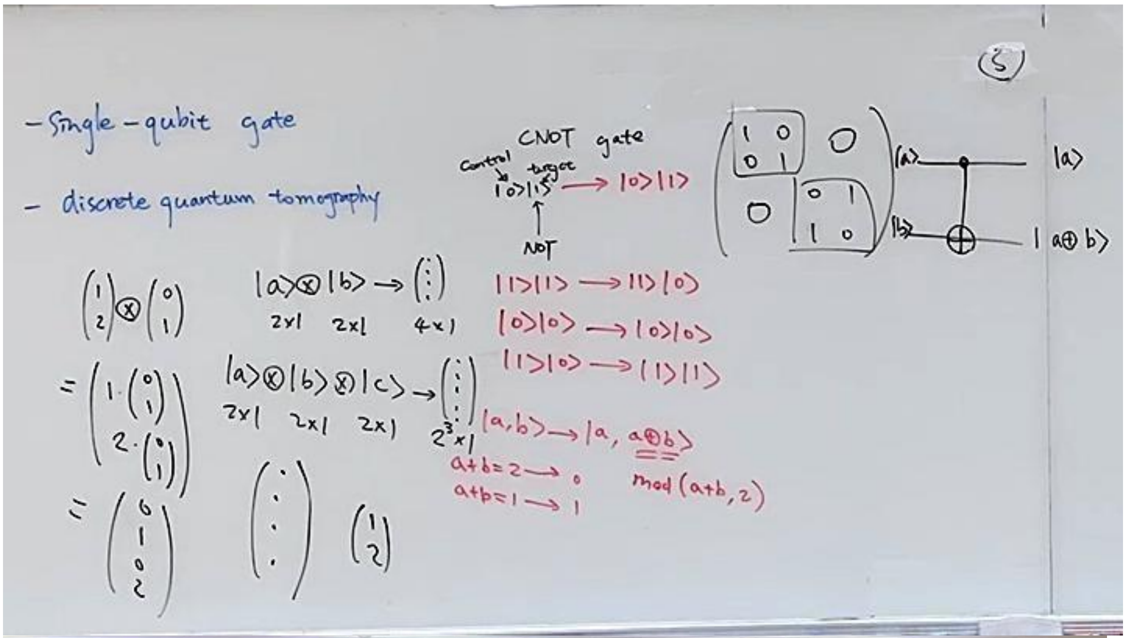
Lecture12 Single-qubit gates and discrete quantum tomography

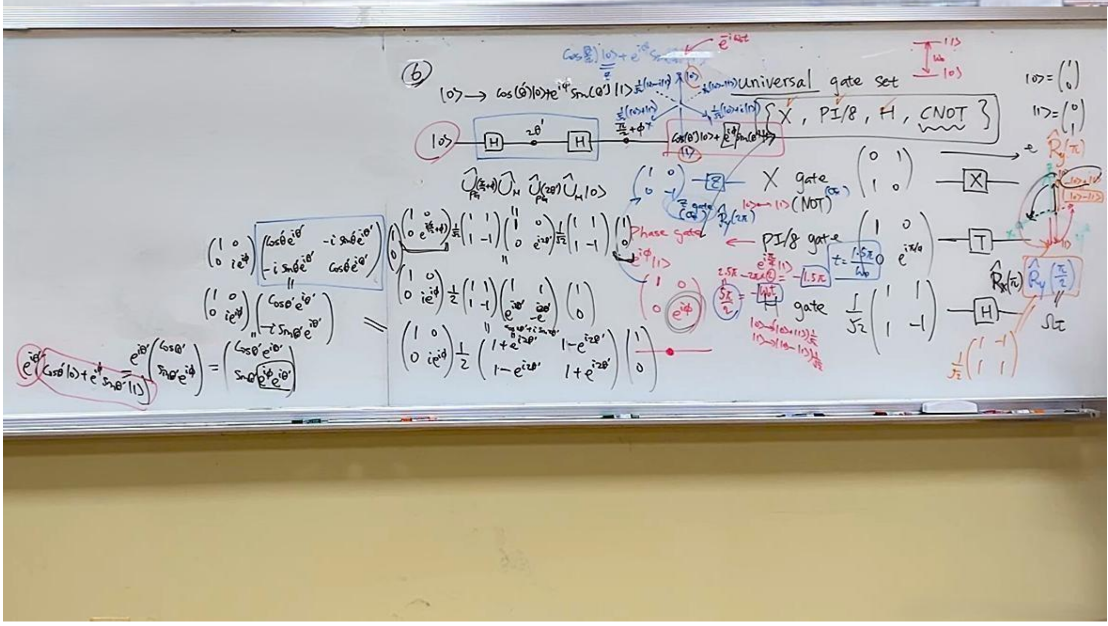


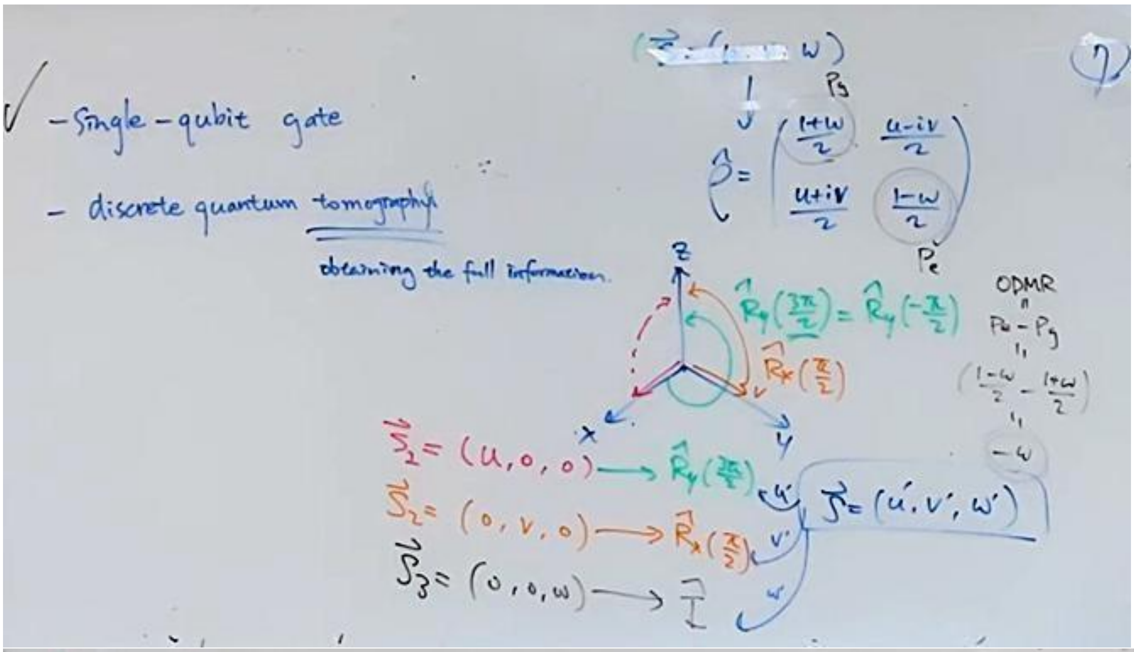


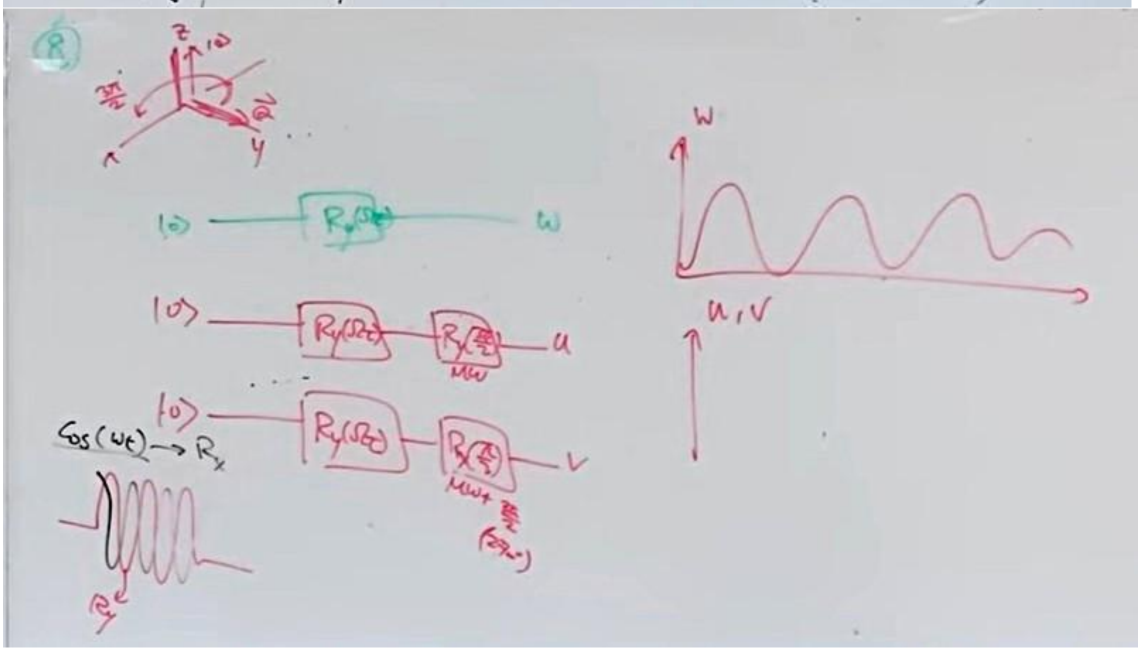

- Single-qubit gate
- discrete quantum tomography
NMR
$\frac{d\vec{M}}{dt} = \vec{M}\times\vec{B}$
$\longrightarrow \frac{d\vec{S}}{dt} = \vec{Q}\times\vec{S} = \vec{S}\times(-\vec{Q})$
$\vec{B}_{eff}$
$\vec{Q} = (\Omega, 0, \Delta)$
$\Delta=0 \longrightarrow \vec{Q} = (\Omega, 0, 0) \longrightarrow \vec{Q} = (\Omega\cos\phi_0, \Omega\sin\phi_0, 0)$
$\longrightarrow C_g|0\rangle + C_e|1\rangle$
$|0\rangle \longrightarrow \cos(\frac{\theta}{2})|0\rangle + e^{i\phi}\sin(\frac{\theta}{2})|1\rangle$
(θ, ϕ)
z
$|0\rangle$
θ
ϕ
x
y
Rotation Transformation.

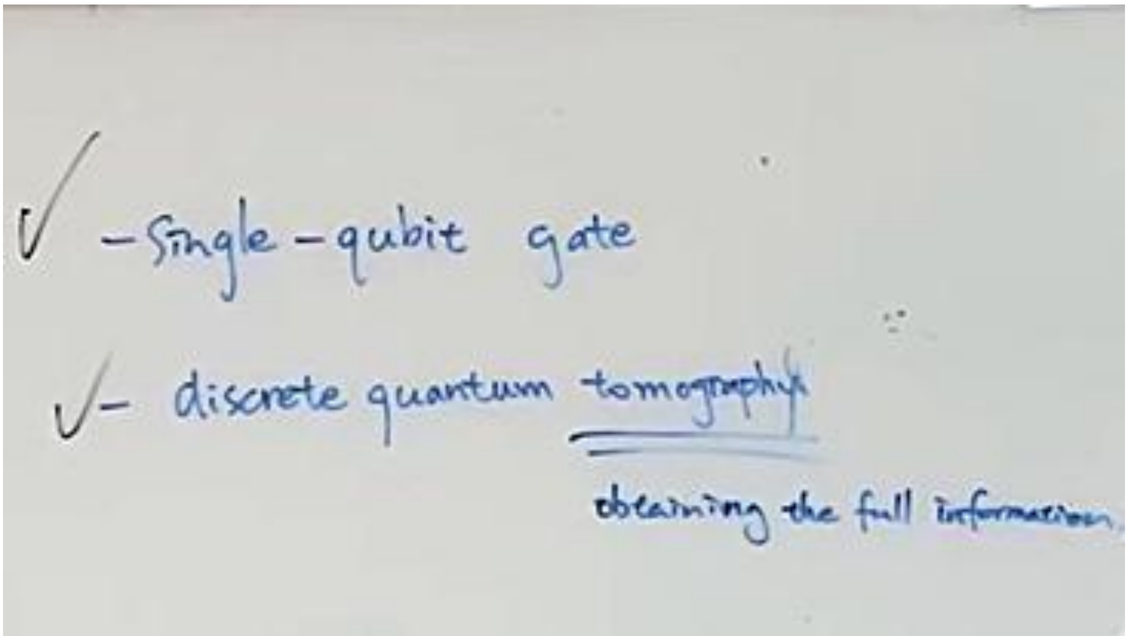

④
z
$|0\rangle$
$\vec{B}_{eff}$
$(-\vec{Q})$
$\hat{n}$
$\vec{Q}$
x
y
$|1\rangle$
$\phi_0 = \frac{\pi}{2}+\phi$
$\tau = \frac{\pi}{\Omega}\frac{1}{2}$
$\phi_0 = 0 \longrightarrow \vec{Q} = (\Omega, 0, 0)$
$\theta = \pi, \tau = \frac{T}{2} = \frac{\pi}{\Omega}$
$\theta = \frac{\pi}{2}, \tau = \frac{T}{4} = \frac{\pi}{2\Omega}$
$\frac{\pi}{8}$
universal gate set
$\{X, PI/8, H, CNOT\}$
$|0\rangle = \begin{pmatrix}1\\0\end{pmatrix}$
$|1\rangle = \begin{pmatrix}0\\1\end{pmatrix}$
X gate $\begin{pmatrix}0&1\\1&0\end{pmatrix}$
$|0\rangle \to |1\rangle$ (NOT)
X
PI/8 gate $\begin{pmatrix}0&0\\0&e^{i\pi/4}\end{pmatrix}$
T
Hadamard
French
H gate $\frac{1}{\sqrt{2}}\begin{pmatrix}1&1\\1&-1\end{pmatrix}$
$|0\rangle \to (|0\rangle+|1\rangle)\frac{1}{\sqrt{2}}$
$|1\rangle \to (|0\rangle-|1\rangle)\frac{1}{\sqrt{2}}$
H


(5)
- Single-qubit gate
- discrete quantum tomography
CNOT gate
Control
target
NOT
|0>|1> → |0>|1>
|1>|1> → |1>|0>
|0>|0> → |0>|0>
|1>|0> → |1>|1>
|a>⊗|b> →
2x1 2x1 4x1
|a>⊗|b>⊗|c> →
2x1 2x1 2x1 2^3x1
|a, b> → |a, a⊕b>
a+b=2 → 0
a+b=1 → 1
mod(a+b, 2)
|a>
|b>
|a>
|a⊕b>


(6)
universal gate set
{X, PI/8, H, CNOT}
X gate
(NOT)
Phase gate
PI/8 gate
gate


- Single-qubit gate
- discrete quantum tomography
obtaining the full information.
ODMR
Pe - Pg
-w


z
y
|0⟩
w
|0⟩
u
MW
|0⟩
v
cos(ωt) → Rx
u, v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