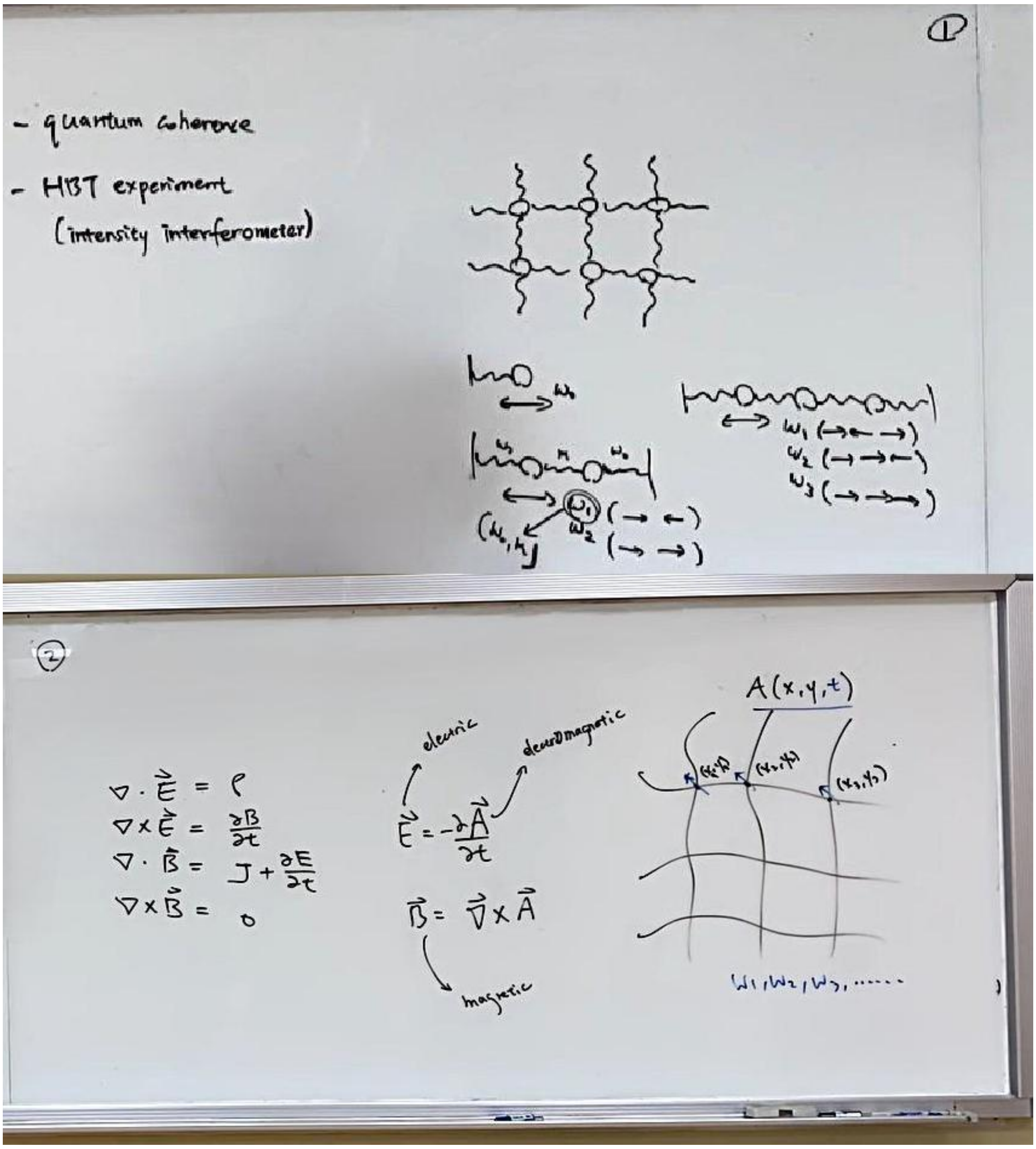
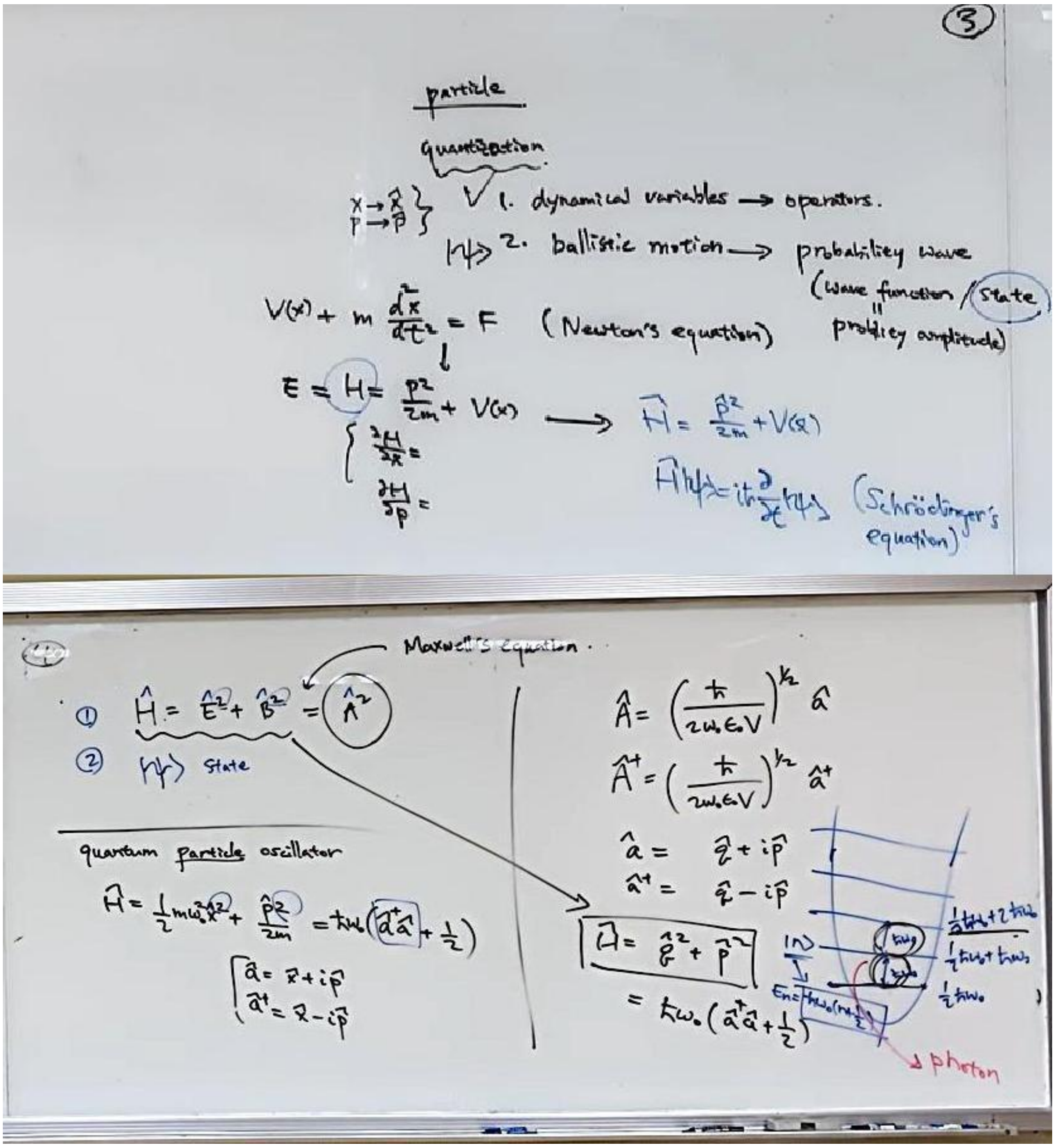
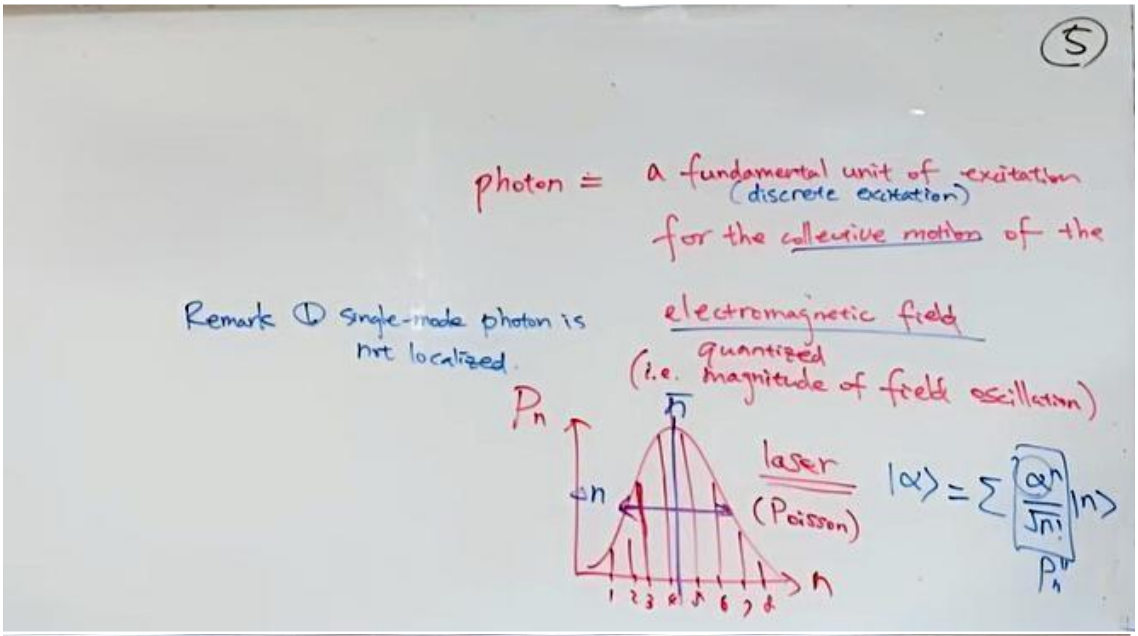
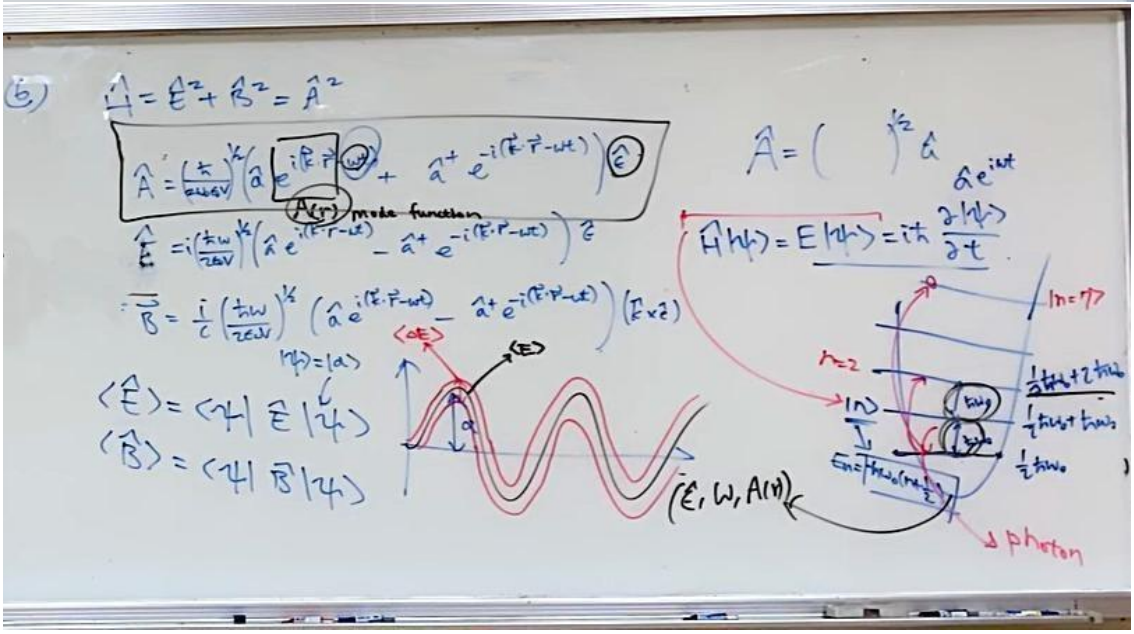
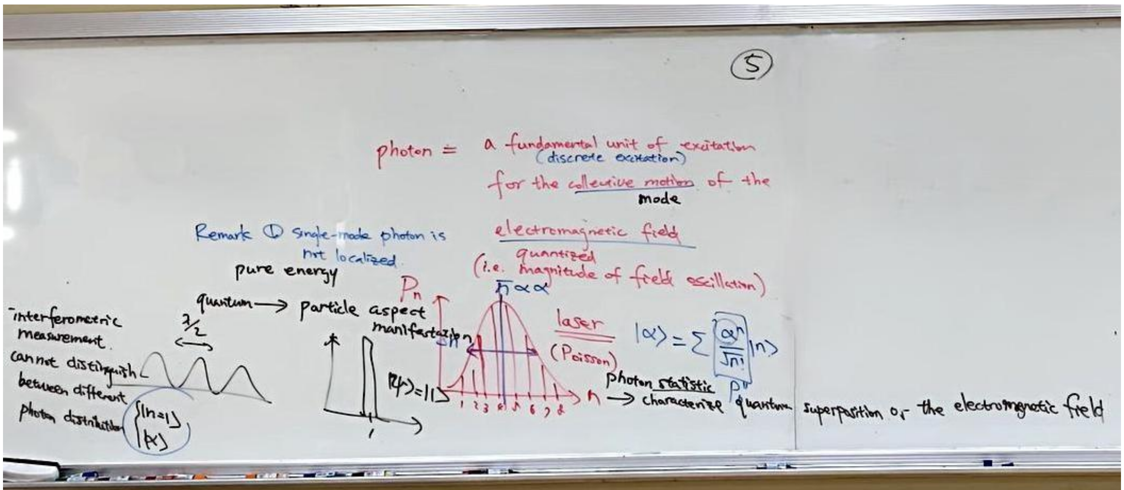
Lecture4 Field quantization and HBT experiment

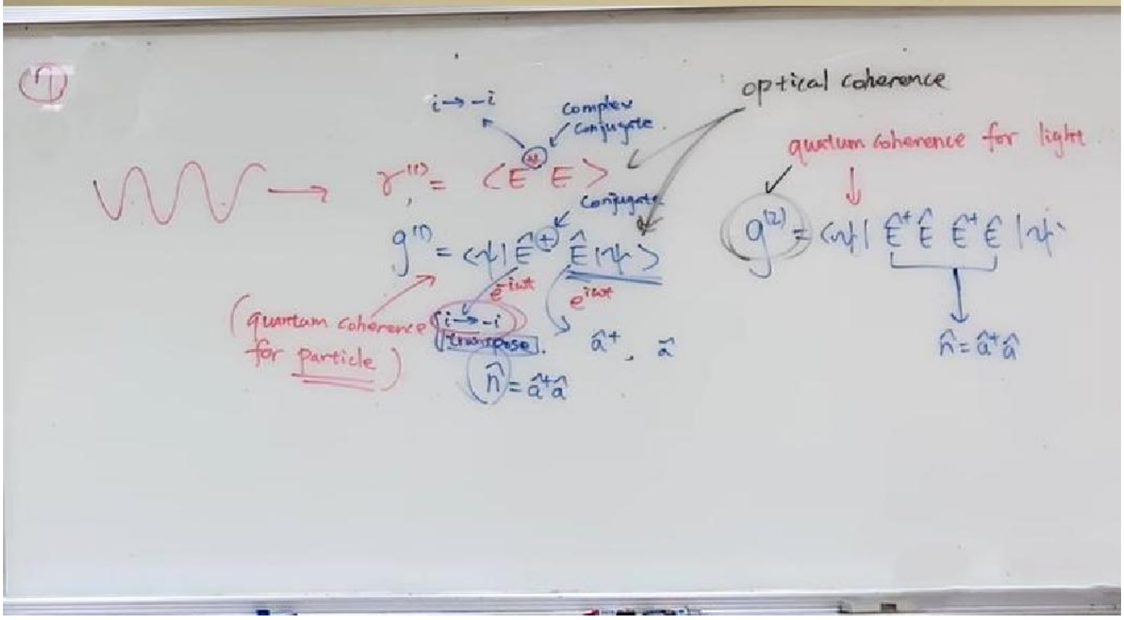


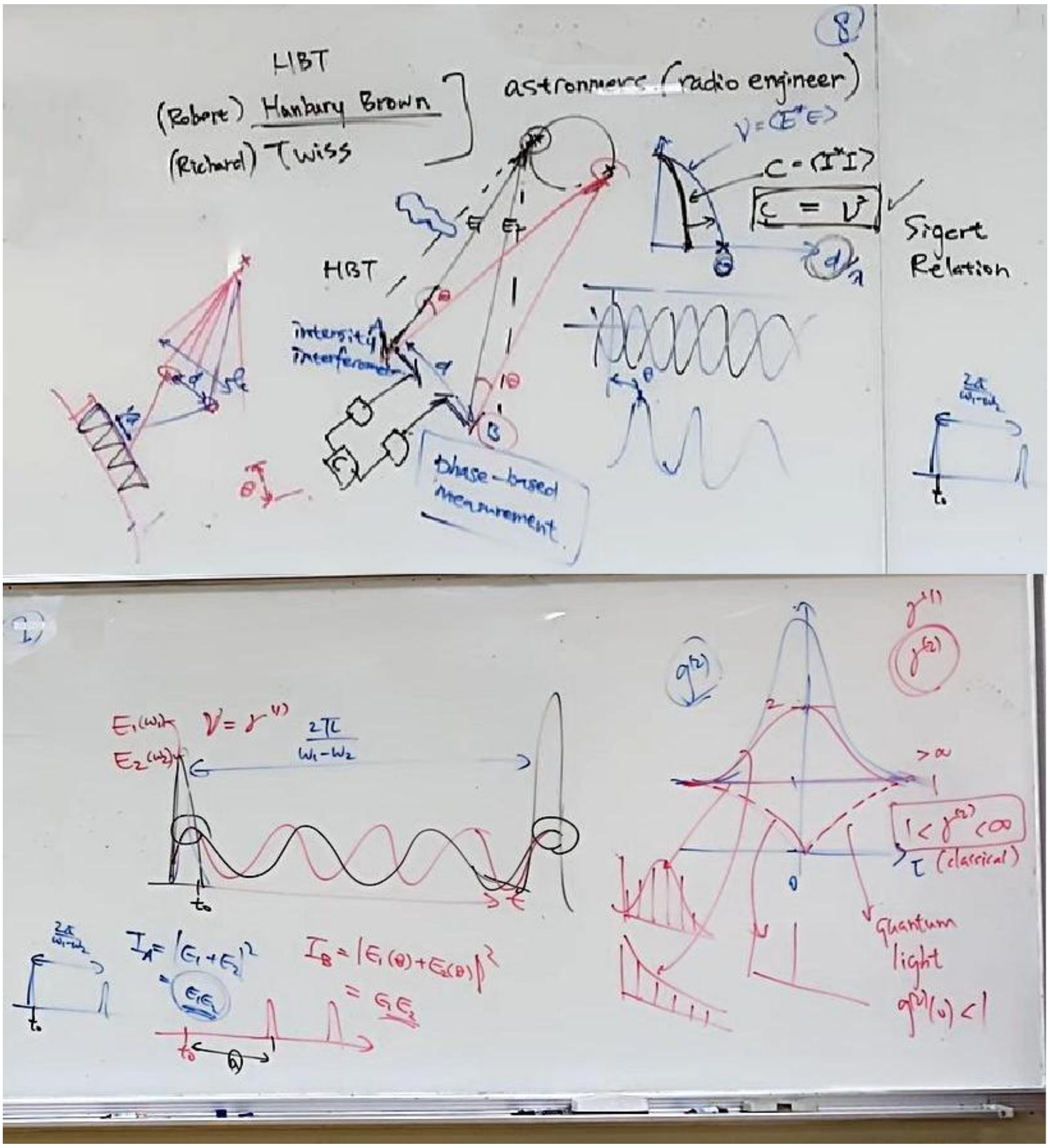

③
particle
quantization
1. dynamical variables → operators.
2. ballistic motion → probability wave
(wave function / state
probability amplitude)
(Newton's equation)
(Schrödinger's equation)
Maxwell's equation
① $\hat{H} = \hat{E}^2 + \hat{B}^2 = \hat{A}^2$
② $|\psi\rangle$ state
quantum particle oscillator
photon

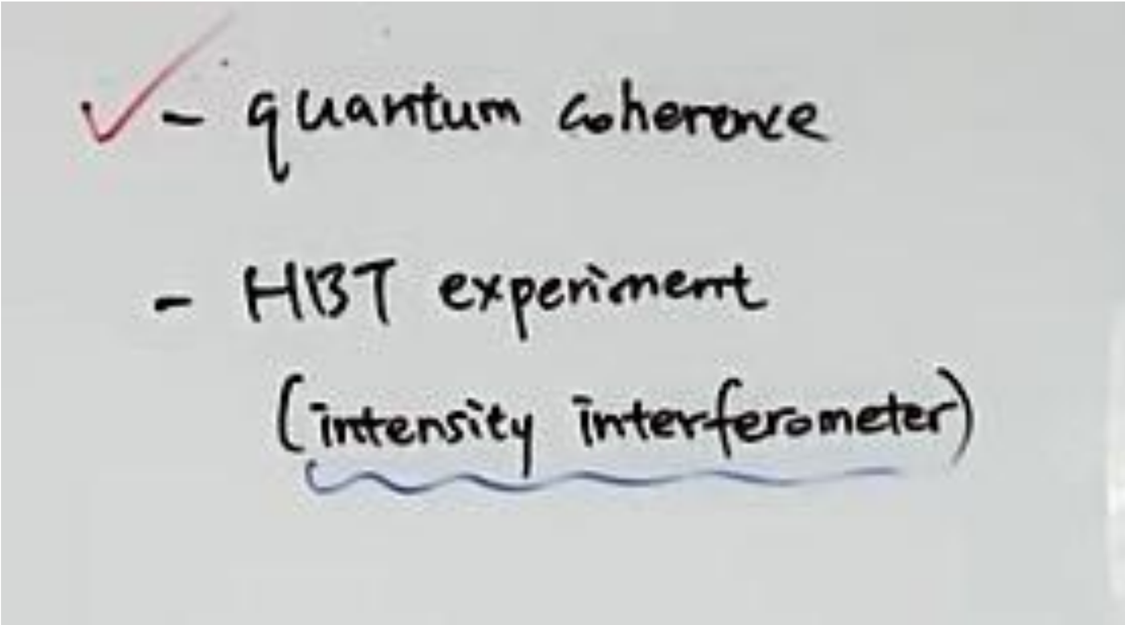

5
photon = a fundamental unit of excitation
(discrete excitation)
for the collective motion of the
electromagnetic field
quantized
(i.e. magnitude of field oscillation)
Remark ① single-mode photon is
not localized.
Pn
laser
(Poisson)
|α> = Σ α^n/√n! |n>
n
1 2 3 4 5 6 7 8


6
H = E² + B² = A²
A = (ħ/2ωε₀V)^½ (a e^{i(k·r−ωt)} + a⁺ e^{−i(k·r−ωt)}) ε
A(r) mode function
E = i(ħω/2ε₀V)^½ (a e^{i(k·r−ωt)} − a⁺ e^{−i(k·r−ωt)}) ε
B = i/c (ħω/2ε₀V)^½ (a e^{i(k·r−ωt)} − a⁺ e^{−i(k·r−ωt)}) (k×ε)
|ψ> = |α>
<E> = <ψ| E |ψ>
<B> = <ψ| B |ψ>
<E>
<ΔE>
A = ( )^½ a
a e^{iωt}
H|ψ> = E|ψ> = iħ ∂|ψ>/∂t
(ε, ω, A(r))
|n>
n=2
|n=7>
En = ħω₀(n+½)
½ħω₀+2ħω₀
½ħω₀+ħω₀
½ħω₀
photon


5
photon = a fundamental unit of excitation
(discrete excitation)
for the collective motion of the
mode
electromagnetic field
quantized
(i.e. magnitude of field oscillation)
Remark ① single-mode photon is
not localized
pure energy
quantum ⟶ particle aspect
manifestation
interferometric
measurement
cannot distinguish
between different
photon distribution
laser
(Poisson)
photon statistic
characterize quantum superposition of the electromagnetic field


optical coherence
complex
conjugate
conjugate
quantum coherence for light
(quantum coherence
for particle)
transpose


HBT
(Robert) Hanbury Brown
(Richard) Twiss
astronmers (radio engineer)
HBT
intensity interferometer
phase-based measurement
Sigert Relation
C = V
2π / ω1-ω2
E1(ω1)
E2(ω2)
V = γ(1)
I_A = |E1+E2|^2
I_B = |E1(θ)+E2(θ)|^2
g(2)
γ(1)
γ(2)
1 < γ(2) < ∞
τ (classical)
Quantum light
g(2)(0) < 1


- quantum coherence
- HBT experiment
(intensity interferometer)