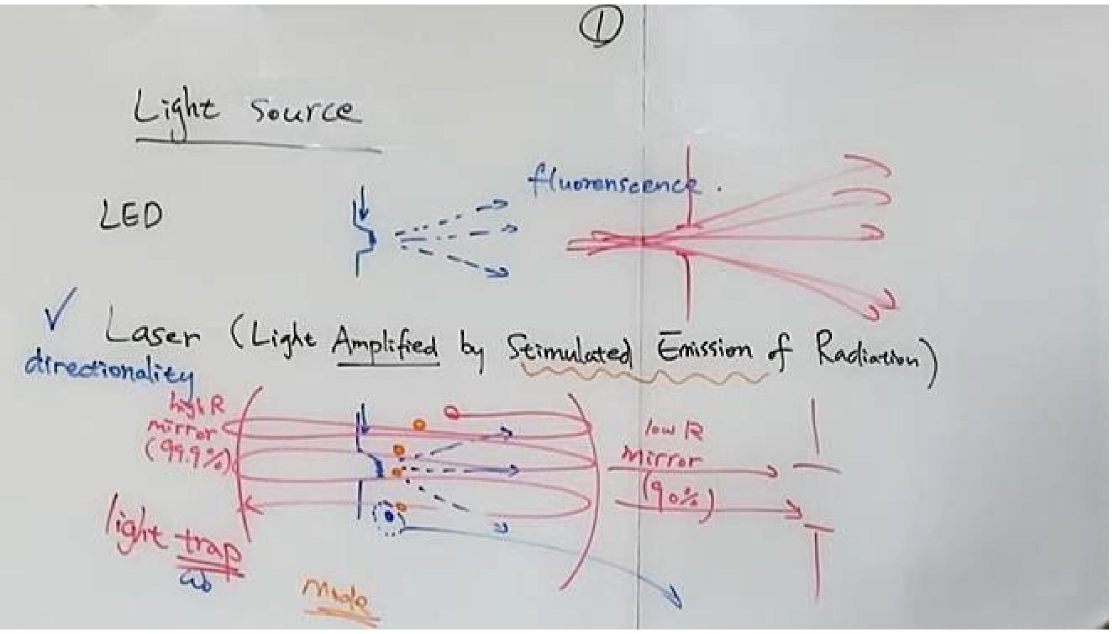
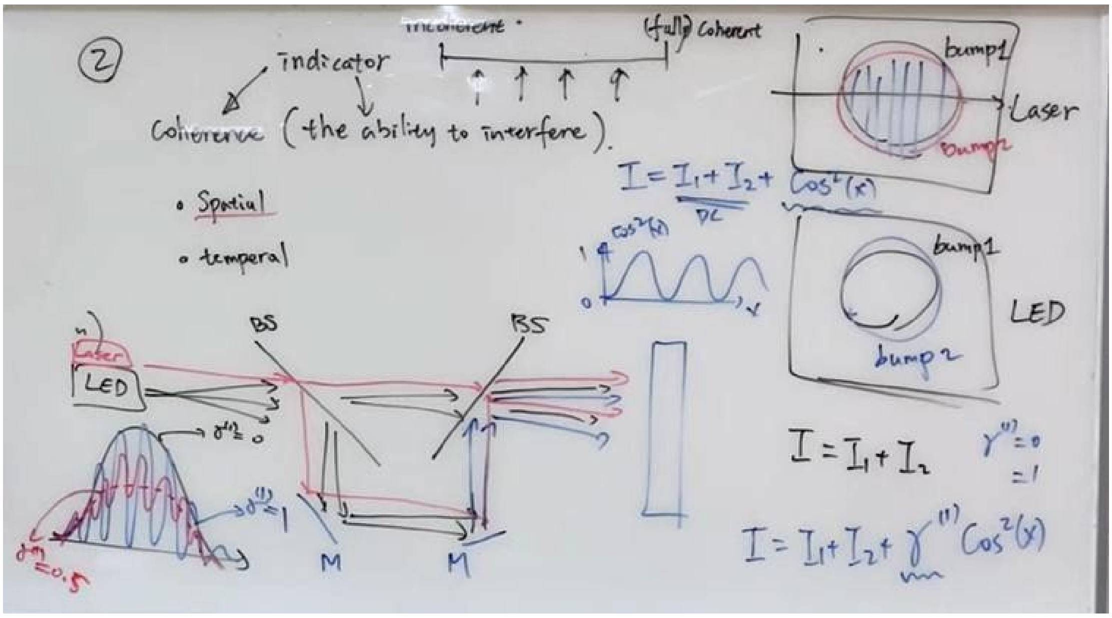
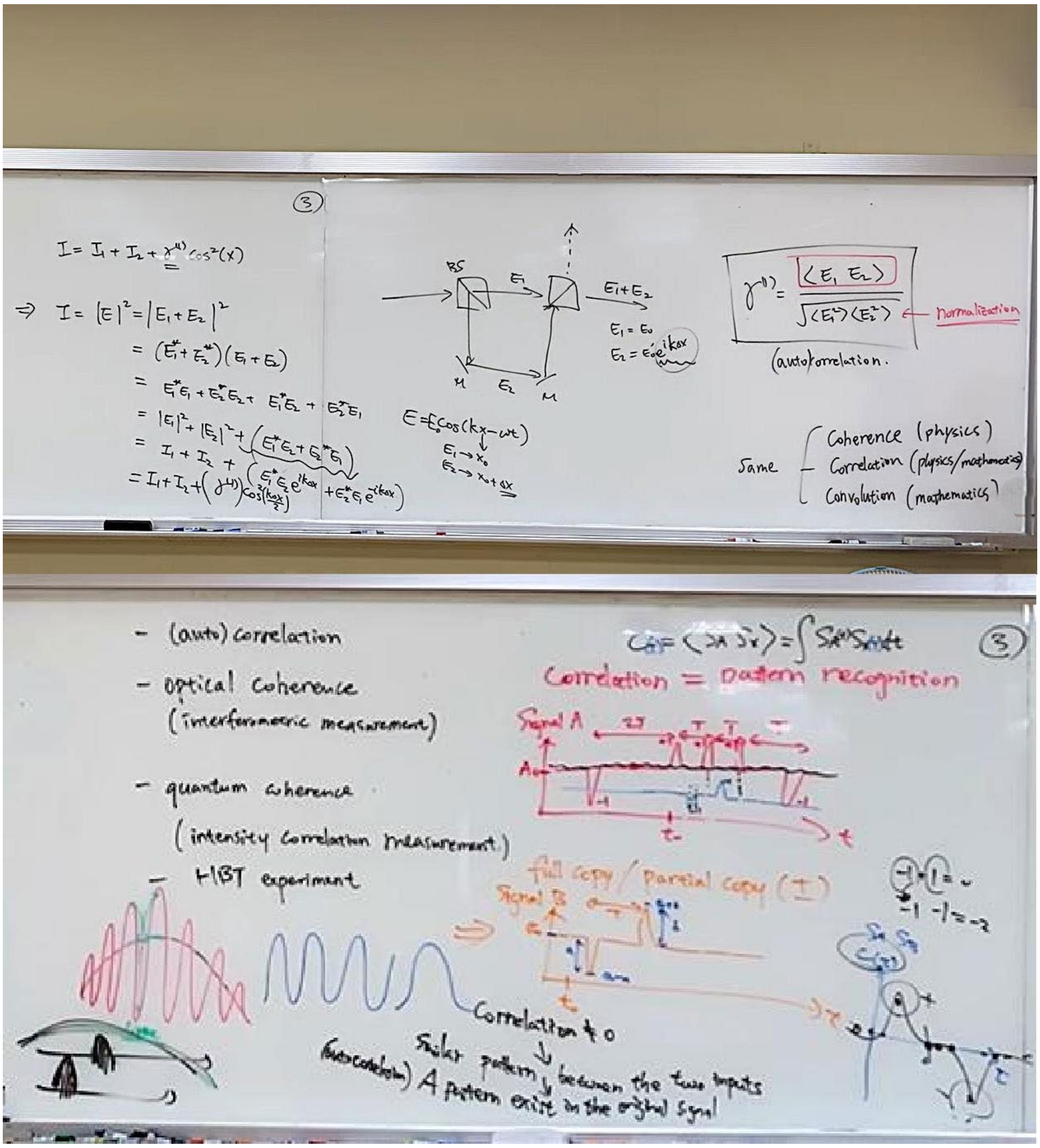
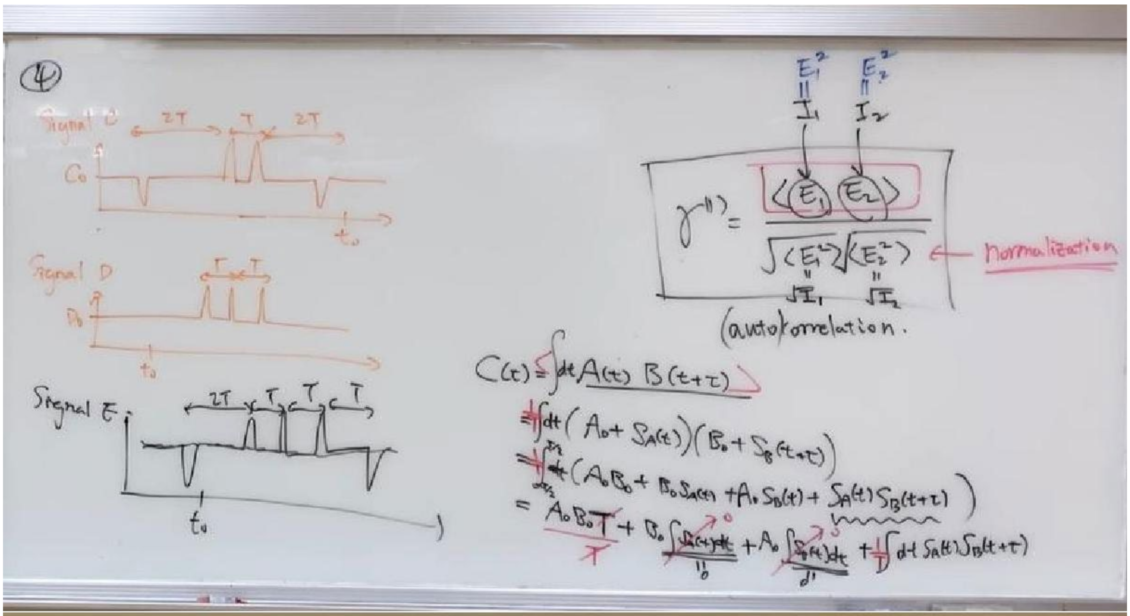
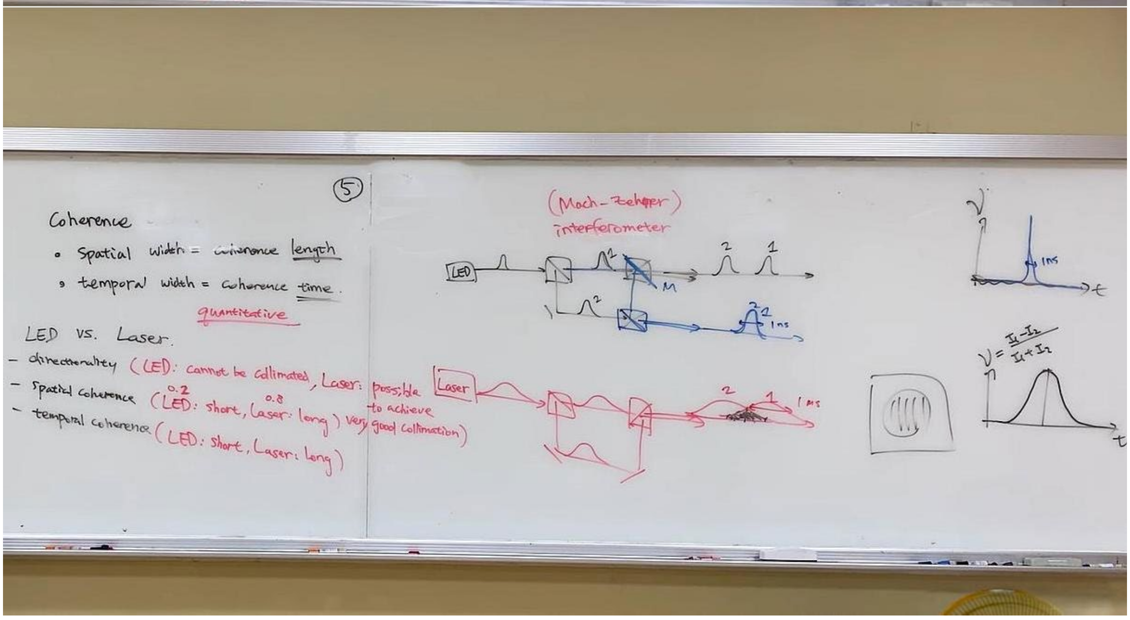
Lecture3 Correlation and optical coherence






③
I = I1 + I2 + γ(1) cos²(x)
⇒ I = |E|² = |E1 + E2|²
= (E1* + E2*)(E1 + E2)
= E1*E1 + E2*E2 + E1*E2 + E2*E1
= |E1|² + |E2|² + (E1*E2 + E2*E1)
= I1 + I2 +
= I1 + I2 + (γ(1)) cos²(kx/2)
E1*E2 e^{ikx} + E2*E1 e^{-ikx}
BS
E1
E1+E2
M
E2
M
E1 = E0
E2 = E0 e^{ikx}
E = E0 cos(kx − ωt)
E1 → x0
E2 → x0 + δx
γ(1) = ⟨E1 E2⟩ / √(⟨E1²⟩⟨E2²⟩)
normalization
(auto)correlation.
Same
Coherence (physics)
Correlation (physics/mathematics)
Convolution (mathematics)
- (auto) correlation
- optical coherence
(interferometric measurement)
- quantum coherence
(intensity correlation measurement)
- HBT experiment
Correlation = pattern recognition
Signal A
Signal B
full copy / partial copy (±)
Correlation ≠ 0
Similar pattern between the two inputs
(autocorrelation) A pattern exist in the original signal
-1 -1 = -2


④
Signal C
2T
T
2T
Signal D
Signal E
$\gamma^{(1)} = \frac{\langle E_1 E_2 \rangle}{\sqrt{\langle E_1^2 \rangle}\sqrt{\langle E_2^2 \rangle}}$
normalization
(auto)correlation.
$C(\tau) = \int dt\, A(t)\, B(t+\tau)$
$= \frac{1}{T}\int dt\,(A_0 + S_A(t))(B_0 + S_B(t+\tau))$
$= \frac{1}{T}\int dt\,(A_0B_0 + B_0 S_A(t) + A_0 S_B(t) + S_A(t)S_B(t+\tau))$
$= A_0B_0 + B_0\int S_A(t)dt + A_0\int S_B(t)dt + \frac{1}{T}\int dt\, S_A(t) S_B(t+\tau)$


⑤
Coherence
• Spatial width = coherence length
• temporal width = coherence time.
quantitative
LED vs. Laser
- directionality (LED: cannot be collimated, Laser: possible to achieve very good collimation)
- Spatial coherence (LED: short, Laser: long)
- temporal coherence (LED: short, Laser: long)
(Mach-Zehnder)
interferometer
LED
Laser
M
1ns
$V = \frac{I_1 - I_2}{I_1 + I_2}$

√ - (auto) correlation

√ - optical coherence
(interferometric measurement)

- quantum coherence
(intensity correlation measurement)
- HBT experiment

Classical
nonclassical