

ADVANCED QUANTUM OPTICS

[Mikel Palmero, Mikel Sanz]

Contents

- **Applications of quantum optics.** Continuous vs discrete variables. Codification of quantum information in photons. Gaussian states and symplectic notation. Williamson theorem. Negativity. Gaussian measurements.
- **Quantum metrology.** Classical and quantum Fisher information. Gaussian quantum metrology. Quantum parameter estimation. Hypothesis testing. Quantum illumination and quantum radar. Heisenberg limit interferometry.
- **Quantum computation with photonics.** Fundamentals of quantum computing. QC with single photons. Knill-Laflamme-Milburn protocol. Postselection. QC with continuous variables. Gottesman-Knill theorem for continuous variables. (Boson sampling).
- **Quantum communication.** Quantum teleportation (continuous & discrete variables). Entanglement swapping and distillation. Remote state preparation. Quantum key distribution with continuous variables. (Satellite secure communication).
- **Quantum cryptography.** Quantum key distribution, quantum random number generation, BB84 protocol, BBM92 protocol, Ekert protocol.
- **Interferometry.** Single photon Michelson interferometer (wave nature of the light), double Michelson interferometer, Hong-Ou-Mandel 2-photon interference, Franson Interference.
- **Hanbury-Brown Twiss.** Particle nature of photons, wave-particle dualism (Michelson+HBT), HOM+HBT.
- **Quantum tomography.** Tomographic state reconstruction, single photon and entangled photon states, methods and application.
- **Measurements and entanglement.** Violation of Bell's inequality, Quantum Zeno effect, measurement of central wavelength, measurement of coherence length, interaction free measurements.

Bibliography

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Lectures on Quantum Information, D. Bruss and G. Leuch Eds., Wiley VCH Verlag, 2007.

The Quantum Illumination Story, J. H. Shapiro, ArXiv: 1910.12277 (2019).

Assessment

Assessment by continuous evaluation through **weekly homework assignments**