

# ADVANCED QUANTUM OPTICS

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## Contents

Advanced quantum optics will take on from the compulsory first term Quantum Optics subject, and apply the fundamentals learnt there to more specific applications. In this regard, this subject will focus more on the experimental aspects of quantum optics. Half of the subject (2 credits) will be of classroom lectures, revisiting a number of legacy experiments and learning the history of their lab implementations, difficulties, achieved feats, et cetera. The second half (2 credits), will be lab practices of some of the learnt experiments using quTools company's quED (QUantum Entanglement Demonstrator) machine.

List of topics covered in the theoretical part:

- **Experimental Aspects of Interferometry.** Single photon Michelson interferometer (wave nature of the light), double Michelson interferometer, Hong-Ou-Mandel 2-photon interference, Franson Interference.
- **Measurements and Entanglement.** Violation of Bell's inequality, Quantum Zeno effect, measurement of central wavelength, measurement of coherence length, interaction free measurements.
- **Quantum Tomography.** Tomographic state reconstruction, single photon and entangled photon states, methods and application.
- **Hanbury-Brown Twiss.** Particle nature of photons, wave-particle dualism (Michelson+HBT), HOM+HBT.
- **Experimental Aspects of Quantum Cryptography.** Quantum key distribution, quantum random number generation, BB84 protocol, BBM92 protocol, Ekert protocol.

List of quED experiments:

- **Single photon Michelson Interferometer**
- **Violation of Bell's Inequality**
- **Entangled photon state tomographic reconstruction**
- **Hanbury-Brown Twiss experiment**
- **BB84 cryptographic protocol**

## **Bibliography**

*Introduction to Quantum Optics*, C.C. Gerry and P.L. Knight. Cambridge Univ. Press.

*Elements of Quantum Optics*, P. Meystre and M. Sargent II. Springer.

*Quantum Optics*, D.F. Walls and G. J. Milburn. Springer.

*Quantum and Atom Optics*, D.A. Steck (notes).

*Optical Resonance and Two-Level Atoms*, L. Allen and J.H. Eberly. Wiley.

*Lasers*, J.H. Eberly and P. Milonni. Wiley.

*Quantum Continuous Variables, A Primer of Theoretical Methods*, A. Serafini. CRC Press, 2017.

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

<https://qutools.com/qued/>

List of journal references to be found in moodle

## **Assessment**

Assessment by continuous evaluation through **lab reports of the experimental part, and an individual work of the theoretical part**