

Course Objectives:

This course is for PhD and advanced undergraduate students who want to gain a solid understanding of the concept of coherence as well as its applications in modern quantum optics. The course will have two main parts. The first part, which will cover about 1/3rd of the course, will discuss the concept of coherence; the remaining part of the course will focus on Quantum Entanglement.

Course content:

- (1) Coherence:** Spectral properties of stationary random processes, Wiener-Khintchine theorem, Angular spectrum representation of wavefields, Introduction to the second-order coherence theory, Propagation of coherence, The van Cittert-Zernike theorem, Coherent mode representation of sources and fields. **(About 14 Lecture hours)**

- (2) Quantum Entanglement:** Basics of nonlinear optics, Two-photon field produced by parametric down-conversion, EPR paradox, Bell inequalities and its experimental violations, Quantum theory of higher-order correlations, Two-photon coherence and two-photon interference effects. Two-photon entanglement in the following variables: time-energy, position-momentum, and angle-orbital angular momentum; Introduction to Quantum Information: Quantum Cryptography, Quantum Dense Coding, Quantum Teleportation, Quantum Imaging. **(About 26 Lecture hours)**

Instructor:

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Reference books:

1. L. Mandel and E. Wolf, *Optical Coherence and Quantum Optics* (Cambridge university press, New York, 1995).
2. R. W. Boyd, *Nonlinear Optics*, 3rd ed. (Academic Press, New York, 2008).
3. J. W. Goodman, *Statistical Optics*, (John Wiley and Sons, 2000)
4. R. Loudon, *The Quantum Theory of Light*, 3rd ed. (Oxford University Press, New York, USA, 2000).
5. M. Born and E. Wolf, *Principles of Optics*, 7th expanded ed. (Cambridge University Press, Cambridge, 1999).