**Department of Physics** **IIT Kanpur**

# PHY690G: Coherence and Quantum Entanglement; Semester-I, 2021-22; 3-0-0-9

## 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).