Indian Institute of Technology, Kanpur

Proposal for a New Course

1. Course No: A **600 level elective** number requested**.**
2. Course Title: Coherence and Quantum Entanglement
3. No. of Lectures per week: 3 (L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours[0]: 0 (A),

   Credits (3*L+T+P+A): 09 Duration of Course: Full Semester
4. Proposing Department/IDP : PHY.

   Other Departments/IDPs which may be interested in the proposed course: EE, MTH, CSE, CELP.

   Other faculty members interested in teaching the course: Prof. Harshawardhan Wanare (PHY); Prof. Saikat Ghosh (PHY).
5. Proposing Instructor: Anand Kumar Jha (PHY)
6. Course Description:

   A) 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 will discuss the concept of coherence; the remaining part of the course will focus on Quantum Entanglement.

   B) Contents:

S. No.	Broad Title	Topics	No. of Lectures
1.	**Introduction**	Introduction, Spectral properties of stationary random processes, Wiener-Khintchine theory, Angular spectrum representation of wavefields, Correlation functions in classical optics	**8**
2.	**Classical Correlation**	Introduction to the second-order coherence theory: temporal, spatial, angular and polarization. Propagation of coherence, The van Cittert-Zernike theorem, Coherent mode representation of sources and fields	**8**
3.	**Quantum correlations**	Review of quantum mechanics, quantum mechanical correlation function, EPR paradox, hidden variable interpretation of quantum mechanics, Bell inequalities.	**8**
4.	**Two-photon coherence and entanglement**	Basics of nonlinear optics, entangled two-photon states produced by parametric down-conversion. Two-photon coherence and interference effects, entanglement verification and quantification	**8**
5.	**Applications of quantum entanglement**	Introduction to Quantum Information: Quantum Cryptography, Quantum Dense Coding, Quantum Teleportation, Quantum Imaging	**8**
		Total number of lectures:	**40**

C) Pre-requisites: Basic quantum mechanics and optics courses.

D) Short summary for including in the Courses of Study Booklet: Spectral properties of stationary random processes, introduction to the second-order coherence theory, propagation of coherence, coherent mode representation of sources and fields, 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 interference effects, two-photon entanglement, introduction to quantum information, and applications of quantum entanglement such as quantum cryptography, quantum teleportation, quantum imaging.

7. Recommended books:

(i) L. Mandel and E. Wolf, Optical Coherence and Quantum Optics (Cambridge university press, New York, 1995).

(ii) R. W. Boyd, Nonlinear Optics, 3rd ed. (Academic Press, New York, 2008).

(iii) J. W. Goodman, Statistical Optics, (John Wiley and Sons, 2000)

(iv) R. Loudon, *The Quantum Theory of Light*, 3rd ed. (Oxford University Press, New York, USA, 2000).

(v) M. Born and E. Wolf, *Principles of Optics*, 7th expanded ed. (Cambridge University Press, Cambridge, 1999).

Dated: 07 March, 2024. Proposer: Anand Kumar Jha (Anand Kumar Jha).

Dated: 8/3/24 DPGC Convener (PHY):_____

The course is approved / not approved

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Chairman, SPGC

Dated:_____