

# Quantum Electronics - Video course

## COURSE OUTLINE

This course explores the various nonlinear optical phenomena and the quantum nature of light. Media behave in a nonlinear fashion when the light intensities are high and this leads to the generation of new frequencies through second harmonic generation and parametric processes.

Nonlinear effects such as self phase modulation etc. have also become very important in the field of optical fibre communications. The course will address the basic physics and applications of such nonlinear phenomena.

Although most optical effects can be explained using classical Maxwell's equations, there are many phenomena, which need the complete quantum mechanical description of light which will be discussed in the course.

Quantum nature of light is playing a very important role in the field of quantum information science with applications in quantum cryptography, quantum computing etc. and the basics learned in the course should be of interest to students wishing to pursue the field of quantum information.

## COURSE DETAIL

Sl.No.	Topics	No. of Lectures
1.	Brief review of electromagnetic waves; Light propagation through anisotropic media.	4
2.	Nonlinear optical effects, Nonlinear polarization.	2
3.	<b>Second order effects:</b> Second harmonic generation, Sum and difference frequency generation, Parametric amplification, parametric fluorescence and oscillation; Concept of quasi phase matching; Periodically poled materials and their applications in nonlinear optical devices.	11
4.	<b>Third order effects:</b> Self Phase modulation, Temporal and spatial solitons, Cross Phase modulation, Four wave mixing, Phase conjugation.	8
5.	Quantization of the electromagnetic field; Number states; Coherent states and their properties; Squeezed states of light and their properties; Application of optical parametric processes to generate squeezed states of light; Entangled states and their properties;	15



NP-TEL

# NPTEL

<http://nptel.iitm.ac.in>

## Physics

### Pre-requisites:

The student is expected to have gone through a course on basic Optics including interference, diffraction, polarization and on basic Quantum Mechanics.

### Additional Reading:

1. The Quantum Challenge, Jones and Bartlett, Ma, USA, 2006.
2. Quantum Optics: An Introduction, M. Fox, Oxford Univ. Press, 2006.
3. Principles of Nonlinear Optics, Y R Shen, John Wiley, Singapore, 1988.

### Coordinators:

**Prof. K. Thyagarajan**  
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Generation of entangled states; Quantum eraser, Ghost interference effects; Applications in quantum information science.	
<b>Total</b>	40

**References:**

1. Quantum Electronics , A Yariv, John Wiley, NY, 1989.
2. Optical Electronics, A Ghatak and K Thyagarajan, Cambridge Univ Press, UK, 1989.
3. Quantum optics, M O Scully and M S Zubairy, Cambridge Univ. Press, UK, 1997.
4. Nonlinear Fiber Optics, G P Agarwal, Academic Press, Boston, 1989.
5. Introduction to fiber optics, A Ghatak and K Thyagarajan, Cambridge Univ Press, UK, 1998.
6. Lasers: Theory and Applications, K. Thyagarajan and A. K. Ghatak, Plenum Press, N.Y., 1981; Reprinted by Macmillan India.
7. Introductory Quantum Optics, C. Gerry and P. Knight, Cambridge University Press, 2005.