Approved in 36th BoA Meeting

Course Name : **Optical Properties of Solids**
Course Number : PH 604
Credits : (3-0-0-3)
Prerequisites : Mathematical Physics (PH511) or Mathematics-2 (EP301), Quantum Mechanics (PH513) or Quantum Mechanics and Applications (PH301), Electromagnetic Theory (PH521) or Foundation of electrodynamics (IC221), Condensed Matter Physics (PH523) or Solid State Physics (PH501)
Intended for Distribution: Elective
Semester : Odd/Even

Preamble : The study of optical properties of solids is very important to understand optoelectronics technology in the 21st century. The objective of this course is to know about the classical and the quantum theory of light-matter interactions, optical properties of low dimensional materials and the nonlinear optical effects in solids.

Course Outline : The course is focused on the optical properties of several classes of materials. It starts with the classical description of optical processes taking place in solids. Subsequently, it covers the treatment of absorption and luminescence by quantum theory, and the excitonic effects. The optical phenomena of semiconductors and metals are covered with emphasis on quantum structures. The course also includes discussion about the effect of phonons on optical properties. Finally, a brief introduction to nonlinear optical properties is introduced.

Modules:

Introduction: Optical processes, the complex refractive index and dielectric constant, quantum theory of radiative transition. [3]

Propagation of light in solid: Phenomenological models-Drude and Lorentz models. quantum mechanical description, linear response functions and Kramers–Kronig relations, dispersion, birefringence, optical anisotropy. [4]

Absorption of light: Interband transitions, transition rate, absorption in direct and indirect semiconductor, spin-orbit coupling, indirect gaps, Urbach tails, Landau levels, Franz-Keldysh effect, and absorption spectra. [3]

Excitons: Frenkel vs. Wannier excitons, optical selection rules, effect of Coulomb interaction on interband absorption, Franck-Condon approximation, Huang-Rhys model, Wannier exciton – LO phonon bound states. [3]

Luminescence: Emission from solids, Interband luminescence, photo and electro luminescence, photoluminescence spectroscopy. [3]

Quantum structures: Low dimensional materials and their electronic structures, absorption of quantum well, quantum confined Stark-effect, photoluminescence, optical properties of quantum dots, recent advancement in confined optical materials like zero and two-dimensional materials. [6]

Plasmonic systems: Metals, doped semiconductors, free carrier absorption and plasmons, surface and slab plasmons, plasmons in metallic particles, negative refraction. [3]

Light-phonon interactions: Infrared and Raman active phonons, Phonons absorption and reflectivity, polaritons, polarons, inelastic light scattering (Raman and Brillouin scattering), Feynman diagrams for light scattering. [4]

Impurity centers in semiconductors: Electronic spectrum of shallow donors, multiple valleys, valley-orbit coupling and acceptors, pseudospin-orbit coupling, impurity bands and metal-insulator transition, localized vibrational modes, LO modes bound to neutral impurities, lattice dynamics of isoelectronic impurities and mixed crystals. [5]
Nonlinear optics: optical nonlinearities, second order nonlinearities, third-order nonlinearties, optical Kerr effect, stimulated Raman scattering, generation and detection of terahertz radiation and recent advancement in this field. [6]

Books:

Text

1. Optical Properties of Solids by Mark Fox, Oxford University Press (2010)

References

1. Optical Processes of Solids by Yutaka Toyozawa, Oxford University Press (2010)
2. Optical Properties of Solids by Frederick Wooten, Academic Press (2013)
3. Solid State Physics Part II Optical Properties of Solids by M. S. Dresselhaus (2001).

Online resources: No

Similarity Content Declaration with Existing Courses:

Sl. No.	Course code	Similarity content	Percentage
1	PH 502 Photonics	Absorption and dispersion	<2%
2	PH 523 Condensed Matter Physics	Bound State and optical transitions in semiconductors	< 5%

Justification for new course proposal if cumulative similarity content is > 30%:
N/A

Approvals*:*
Other Faculty interested in teaching this course: Dr. Pradeep Kumar (SBS)

Proposed by: Dr. Suman Kalyan Pal **School:** School of Basic Sciences (SBS)

Signature: Date:

Recommended/Not Recommended, with Comments:

_____ Date:_____
Chairman, CPC

Approved / Not Approved

_____ Date:_____

Chairman, Senate