OSE 5312: Light Matter Interaction – Syllabus Fall 2017

Class times and room	M/W 9am - 10.15 am, CREOL room 102
Instructor	Dr. Pieter G. Kik, Office 270, CREOL Phone 407-823-4622, e-mail kik@creol.ucf.edu
Class website	https://webcourses.ucf.edu
Office hours	M/W 3pm-4pm
Catalog description	*Microscopic theory of absorption, dispersion, and refraction of materials; classical and quantum mechanical description of optical properties.*
Credit Hours	3
Prerequisites	Graduate standing or consent of instructor

Detailed description

This course discusses the interaction of light with matter. It will be shown that many important optical properties can be described quite accurately using surprisingly simple models. Initially we will model atoms as classical dipole oscillators ("electrons on springs"). We will use the calculated behavior of these model atoms together with Maxwell's equations to obtain expressions for the frequency dependent refractive index, absorption, and susceptibility. Using this theory we will be able to understand the optical properties of gases, liquids and solids, including metals, semiconductors and dielectrics. To improve on our model descriptions we will discuss the foundations of quantum mechanics, and derive a quantum mechanical description of the refractive index. We will include the interaction of light with oscillations of atoms (molecular vibrations and rotations, phonons) and consider how quantum mechanics affects molecular absorption spectra.

List of Topics

Maxwell's Equations and the Dielectric Function: free charge, meaning of susceptibility and polarization response, bound electron polarization, causality & Kramers-Kronig relations

Optical Properties of Solids Liquids, and Gases: molecules, liquids, metals, insulators, semiconductors

Classical Treatment of Light-Matter Interaction: Lorentz oscillator, Drude model, Debye model, calculation of susceptibility and complex refractive index, Sellmeier equations and Abbe number, electronic transitions in atoms, anharmonic classical oscillator model, second order effects, third order effects, molecular rotational/vibrational transitions in molecules, dipole-active and Raman-active modes, phonons in solids, acoustic modes, optical modes, magneto-optic effects

Quantum mechanical description of light matter interaction: time dependent Schrödinger equation, Fermi Golden Rule, Kronig-Penney Model and Energy bands, Band gaps, Excitons, impurities (n- and p-type), Thermal distributions (Bose-Einstein, Fermi-Dirac, Maxwell-Boltzmann)

Learning outcomes

Students will be able to identify materials based on reflection, transmission, absorption spectra, predict optical properties based on dopant concentrations and resonances, predict refractive index spectra based on absorption spectra, understand the role of quantum mechanics in optical properties.

Recommended reference Texts

- *Optical Properties of Solids*	M. Fox (Oxford University Press)
- *Quantum Mechanics for Scientists and Engineers*	D. A. B. Miller (Cambridge)
- *Course notes (online PDF)*	

Optional reference Texts

- *Optical Materials*	J. Simmons and K. S. Potter (Academic Press)
- *Introduction to Solid State Physics*	C. Kittel (Wiley)
- *Optical Electronics in Modern Communications*	A. Yariv (Oxford)

Homework	Weekly, handed out on Wednesday, due in class the following Wednesday
Assessment	Homework and quizzes (15%), two mid-term exams (25% each), final exam (35%). Plus and minus grades will be used
Final Exam	Wednesday, Dec 6, 2017, 7am – 9.50am (CREOL rooms 102/103)
Makeup exam policy	Makeup exams *only with prior permission from instructor*