OSE 5312: Light Matter Interaction – Syllabus Spring 2016

Class times	Tue - Th 9:00 AM to 10:15 AM
Classroom	CREOL A214
Instructor	Dr. Eric W. Van Stryland, Office 271, CREOL Phone 407-823-6835, mobile 407-222-1389, e-mail ewvs@creol.ucf.edu
Class website	Webcourses
Office hours	Tue - Th 10:15 AM –11:15 AM or just stop by
Catalog description	*Microscopic theory of absorption, dispersion, and refraction of materials; classical and quantum mechanical description of optical properties.*

Detailed description

This course discusses the interaction of light with matter. We will find 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 atomic transitions. We will include the interaction of light with oscillations of atoms (molecular vibrations and rotations, phonons) and consider how quantum mechanics describes molecular absorption spectra.

Short Description: Microscopic theory of absorption, dispersion, and refraction of materials; classical and quantum mechanical description of optical properties.

Approximate time distribution:

Continuum description of materials (4.5 hours)

- Review of Maxell's equations
- Wave propagation, introduction of complex index, dispersion
- Kramers-Kronig relations

Classical models of refractive index (6 hours)

- Lorentz model
- Drude model
- Anharmonic oscillator model
- Second harmonic generation, optical rectification, SFG, DFG

Refractive index from quantum mechanical oscillators (10.5 hours)

- Introduction to Schrödinger equation, states of infinite well
- States of a finite well, the quantum harmonic oscillator
- Functional form of atomic wavefunctions
- Static perturbation of infinite well, static susceptibility
- Time dependent Schrodinger equation, time dependent perturbation theory, transition rates
- QM expressions for absorption coefficient, absorption cross-section, susceptibility

Molecular vibration and rotation (3 hours)

- Debye model, susceptibility of polar liquid
- Vibrations in diatomic and triatomic molecules
- Rotational modes, rovibrational transitions
- Vibronic transitions, Raman scattering

Vibrations in solids (3 hours)

- Phonons in monoatomic solids, phonon dispersion, mode counting
- Phonons in diatomic lattice, zone folding, optical vs. acoustic branch, Reststrahlen band

Optical properties of semiconductors (6 hours)

- Development of band gaps, Kronig-Penney model
- Direct vs. indirect bandgap, interband transitions
- Absorption from joint density of states and Fermi Golden Rule
- Dopants, excitons, intraband transitions

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, and understand the role of quantum mechanics in optical properties.

Recommended reference Texts - Class notes (P. Kik, D. Hagan, G. Stegeman, E. Van Stryland)

- *Optical Properties of Solids*	M. Fox (Oxford University Press)
- *Optical Properties of Solids*	Fred Wooten (Academic Press)
- *Quantum Mechanics for Scientists and Engineers*	D. A. B. Miller (Cambridge)
- *"Applied Classical Electrodynamics",*	F.A. Hopf and G.I. Stegeman (Wiley)

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	due at the beginning of class1 week from the day assigned
Assessment	Homework/quizzes (20%), two mid-term exams (25% each), final exam (30%).
Final Exam	Th, April 28 7:00 am -10:50 am room 102-103