Phys 415/615 - Elements of Photonics - 3 credits

Bulletin Description:

Analysis of optical systems using the matrix formulation, wave propagation in anisotropic media, electro-optic effect and laser modulation, physical origin of optical non-linearities, phase matching, optical second harmonic and parametric generation. Prereq: PHYS 252

Course Objectives:

The goals of this course are to introduce fundamental principles of photonics that complement the topics in the optics and laser courses and to help students develop problem-solving skills applicable to real-world photonics problems. The emphasis of the course will be on the manipulation of optical radiation, i.e., photons. Students will be able to represent the polarization states of optical waves in terms of Jones vectors, Stokes parameters and the Poincare sphere. Next, they will learn the principles of anisotropic media and be able to analyze the propagation of polarized light through anisotropic media. They will investigate the magneto-optic, acousto-optic, electro-optic, and photorefractive effects and be able to analyze their use for the modulation of laser beams. The theories of optical nonlinearities will be studied and applied to optical second and third harmonic and parametric generation of laser beams. Finally, wave propagation in periodic media will be studied as time permits.

Content Listing:

- **Polarization of light**: Poincare sphere and Stokes parameters, Jones vector, matrix representation of polarization devices.
- **Reflection and refraction**: Fresnel equations, reflectance and transmittance.
- Anisotropic media: Permittivity tensor, biaxial, uniaxial, and isotropic crystals, propagation along a principal axis, arbitrary direction propagation, dispersion relation, double refraction
- **Optical activity and Faraday effect**
- **Liquid crystals**
- **Polarization devices**: Polarizers, wave retarders, attenuators, polarization rotators
- **Acousto-Optic devices**: Acoustic wave Bragg diffraction, coupled-wave theory, acousto-optic modulators and scanners, space switches, filters, frequency shifters.
- **Electro-Optics of anisotropic media**: Pockels and Kerr effects, scanners and directional couplers, spatial light modulators.
- **Electro-Optics of liquid crystals**: Wave retarders and modulators, spatial light modulators.
- **Nonlinear optical media**: Second-harmonic generation and rectification, three-wave mixing, phase matching and tuning curves, quasi-phase matching, third-harmonic generation, optical Kerr effect, self-phase modulation, self-focusing.

If time permits: Four-wave mixing, optical phase conjugation, second-order coupled-wave theory, and third-order coupled-wave theory.