PHYSICS ELECTIVE in 2010-2011 (I semester)

PHY690B Special topics in Physics: Electromagnetic metamaterials and plasmonics

Instructor: S. Anantha Ramakrishna

This 40 lectures, one-semester long course will discuss the electromagnetic properties of composite structured materials across the electromagnetic spectrum, from radio frequencies and microwaves to optical frequencies. Primarily concentrating on the developments in the past two decades, the students will be exposed to the theoretical modeling of structured materials, homogenization theories, as well as numerical computations on such media. Novel properties such as negative refractive index, extreme anisotropy, plasma-like properties, chirality and bianisotropy that become possible with these structures will be discussed as well as the properties of radiation propagating in such structures. The latter part of the course will concentrate on the topics of surface electromagnetic waves on metallic surfaces, spectroscopy using surface plasmons and near-field imaging.

Prerequisite: A strong background in electromagnetism or Optics.
Pre-requisite courses:PHY 224 Optics or PHY 551 Electromagnetism I or EE 340 Electromagnetic theory or equivalent

Course contents:

1. Electromagnetic and optical response of materials and introduction to structured composite materials (3 lectures)
2. Ideas of homogenization and effective medium theories (4 lectures)
3. Design of metamaterials with specified effective material parameters: artificial plasmas, artificial dielectrics, artificial resonant magnetic materials, negative refractive index, structural chirality and bianisotropy. (7 lectures)
4. Wave propagation in negative refractive index media, anisotropic media, chiral media and bianisotropic media (4 lectures)
5. Computing photonics bandstructures: transfer matrix method and finite difference time domain methods. (6 lectures)
6. Surface plasmons, localized surface plasmon resonances (4 lectures)
7. Applications of surface plasmons: spectroscopy and sensors (2 lectures)
8. Negative refraction and perfect lenses, optical near field imaging (6 lectures)
9. Transformation optics and electromagnetic invisibility (4 lectures)

Textbooks and references:

1. S. A. Ramakrishna and T.M. Grzegorczyk, Physics and applications of negative refractive index materials (CRC Press, Boca Raton, 2009)
2. S.A. Maier, Plasmonics (Springer, Berlin, 2008)
3. T.G. Mackay and A. Lakhtakia, Electromagnetic anisotropy and bianisotropy: a field guide, W(old Scientific, Singapore, 2010)