Approval: 8th senate meeting

Course Name: X-rays as a probe to study material properties

Course Number: PH507

Credits: 3-0-0-3

Prerequisites: IC 121 Mechanics of Particles and waves

Intended for: UG /PG

Distribution: Elective

Semester: Odd/Even

Course Preamble: This course deals with understanding the basic interaction of x-rays with matter and the kind of information one can draw to understand material properties using some of the state-of-the-art techniques installed on laboratory and synchrotron radiation sources. The application of x-rays have not only revolutionized our knowledge of matter at the fundamental level of atoms, electrons and spins but also redefined entire fields of science like physics, chemistry, biology and medicine. There are about 19 Nobel prizes awarded for x-ray related works.

Course Outline: You will get the experimental flavour of the quantum mechanics and solid state physics using the state of the art techniques. The techniques which we study here are currently used in understanding the emergent phenomena which forms the basis for making magnetoelectric, spintronic, superconducting, ferroelectric, dielectric, magnetic, thermoelectric, fuel cell and battery applications etc. Focus will be made to understand the basic theory, experimental and the extraction of information from the experimentally collected data.

Modules:

1. The discovery of x-rays [1 Lecture]

2. Interaction of radiation with matter [5 Lectures]

Time independent perturbation theory

Time dependent perturbation theory

Fermi Golden rule

3. State-of-the art Techniques

(a) X-ray sources

Conventional laboratory sources

Synchrotron radiation sources

(b) X-ray Diffraction **[10 Lectures + lab visit]**

- **Theory**

Scattering by electrons

Scattering by atoms

Scattering by unit cell

Crystal axes and Reciprocal lattice

Structure factors

Diffraction Intensity calculations

- **Diffractometer measurements**

Various diffraction geometries –

This includes geometries used for (a) ambient conditions (b) extreme (high pressure using diamond anvil cell) conditions.

Basic idea behind the generation of high pressure conditions in the laboratory.

- **Detection systems**

- **Applications**- understanding the order-disorder transformation

(c) X-ray absorption Spectroscopy [7 Lectures]

- Basic theory

- Experimental Importance of local structural measurements

Local structural link with the physical properties of different materials

- X-ray magnetic circular dichroism

(d) Photoemission spectroscopy [12 Lectures]

- Electron Spectroscopy- Basic Concepts

- Electron spectrometer Design

- Electron spectrum- Qualitative and Quantitative

- Different Photoemission spectroscopic techniques

Angle integrated photoemission spectroscopy

Angle resolved photoemission spectroscopy

Spin resolved photoemission spectroscopy

Inverse photoemission spectroscopy

- Application of spectroscopy in Material Science

Text books:

1. X-rays in Theory and Experiment Arthur Holly Compton, Samuel King Allison, 1935.

2. Elements of x-ray diffraction B.D. Cullity, Prentice Hall; 3 edition (February 15, 2001).

3. X-ray absorption: Principles, Applications, Techniques of EXAFS, SEXAFS and XANES Edited by D.C. Konningsberger and R.Prins , Wiley, 1988

4. Photoelectron Spectroscopy Stephan Hüfner, Springer, 2003.