Spring 2020

Course Syllabus for PHY445/515

The goal of this course is to provide students with experience in the scientific method specifically including: statistical and systematic analysis of data in comparison to theory; hands-on experience in a variety of modern experimental techniques; and presentation of experimental results at a professional level. Students must choose experiments in each of three major areas. The experiments currently available are listed here.

Atomic, Molecular and Optical Physics

Magnetic Resonance and Optical Pumping: Use optical pumping and magnetic resonance to measure the Zeeman splitting of energy levels in atomic Rb. Study the low and higher field regimes and measure the earth's magnetic field.

Diode Laser Saturation Spectroscopy: Measure the Doppler broadened absorption spectrum of atomic Rb (5s-5p) using a tunable diode laser. Then, use saturation spectroscopy to measure the Doppler free spectrum which allows one to resolve the hyperfine structure of both the ground and excited states.

X-Ray Diffraction: Use X-ray diffraction to measure the lattice spacing of several crystalline materials using characteristic X-Ray lines from a copper target. Make a measurement of Planck's constant using bremsstrahlung X-Rays.

X-Ray Fluorescence and Mosley's Law: Use x-ray fluorescence to measure the energies of inner shell transitions in an array of samples. This allows one to test Mosley's law and to identify unknown samples.

Condensed Matter Physics

The Hall Effect: You will study the Hall effect in a two-dimensional electron gas and determine microscopic physical parameters of the system (such as the type, density, and mobility of the charge carriers).

Nuclear Magnetic Resonance: Learn the basics of NMR by using pulsed NMR to observe the resonance conditions and decay times in liquids and solids.

Superconductivity: Superconductivity occurs when normal electrons begin condensing into superconducting pairs, creating a superconducting gap in the electron energy spectrum. You will use tunnel junctions with Nb electrodes to study the DC Josephson effect and properties of superconducting Nb.

Second Order Phase Transitions: Measure the temperature dependence of the dielectric properties of a ferroelectric material and the magnetic susceptibility of a ferromagnet. Follow the transition from the low temperature (ordered) state to the high temperature (disordered) state.

Nuclear and Particle Physics

The Compton Effect: Measure the angular dependence of the differential scattering cross section for gamma-ray photons incident on free electrons and verify the waveparticle duality predicted by quantum mechanics (Klein-Nishina cross section).

The Gamma-Gamma Angular Correlation: Measure the angular correlation of the gamma rays emitted by ^{60}Co nuclei and use this correlation to determine the sequence of spins of the ^{60}Ni nuclei involved in the decay chain.,

The Muon Lifetime: Measure the lifetime of the free lepton and the lifetime of the   in matter.

Mössbauer Spectroscopy: Use recoilless emission and absorption to obtain a resolution of one part in of the14.4 keV gamma ray in ^{57}Co decay. Measure the isomer shift, magnetic field and electric quadrupole field gradient at the resulting ^{57}Fe nuclei.

Learning Outcomes

Students who have completed PHY445/515

- should be able to perform basic experiments in physics,
- should be able to perform a statistical and systematic analysis of experimental data
- should be able to write up the results of an experiment in the style of a scientific paper