

## Syllabus of 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

**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.

**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 high field regimes and measure the earth's magnetic field.

**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.

**Semi-Classical and Quantum Chaos** (by permission): Map out the modes of a 2D electromagnetic cavity. Determine the mode statistics for various cavity configurations.

### Low Temperature and Solid State 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:** (by permission) 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.

## 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 wave-particle duality predicted by quantum mechanics (Klein-Nishina cross section).

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

**The Muon Lifetime:** Measure the lifetime of the free  $\mu^+$  lepton and the lifetime of the  $\mu^-$  in matter

**Mössbauer Spectroscopy:** Use recoilless emission and absorption to obtain a resolution of one part in  $10^{11}$  of the 14.4 keV gamma ray in  $^{57}\text{Co}$  decay. Measure the isomer shift, magnetic field and electric quadrupole field gradient at the resulting  $^{57}\text{Fe}$  nuclei.

**Van de Graaff –  $^{11}\text{C}$  Lifetime:** Use the Van de Graaff accelerator to make  $^{11}\text{C}$  nuclei and measure their lifetime.