Fall 2024

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

Quantum Entanglement and Bell's Inequalities Measure correlations between entagled photon pairs generated via spontaneous parametric down conversion. Test Bell's inequalities.

Condensed Matter Physics

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

Nuclear Magnetic Resonance (NMR): Use pulsed NMR to study the nuclear spin 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.

First and 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 μ^{+} lepton and the lifetime of the μ^{-} in matter.

Mössbauer Spectroscopy: Use recoilless emission and absorption to obtain a resolution of one part in 10^{11} 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 PHY515

- 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

Each lab report will count for 25% of your grade. The final poster presentation will count for 25%.

Students can reach the faculty and TA's via email and Brightspace. We will response as soon as feasible.

- Atomic, Molecular and Optical Physics
  Dr. Eden Figueroa eden.figueroa@stonybrook.edu
- Condensed Matter Physics
  Dr. Xu Du xu.du@stonybrook.edu
- Nuclear and Particle Physics
  Dr. Hannah Arnold hannah.arnold@stonybrook.edu
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If you cannot reach your instructor, please email CAS_Dean@stonybrook.edu.

Student Accessibility Support Center Statement

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, 128 ECC Building, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.