**Fall2025**

**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.

**Nitrogen Vacancy centers:** Study the utility of NV centers as qubits. Probe with light and microwaves, learn various quantum computing pulse protocols.

**Time-Resolved Absorption Spectroscopy (TRAS):** Understand the principles and experimental design of Time-Resolved Absorption Spectroscopy for probing ultrafast excited-state dynamics in molecular systems. Investigate ZnTPP’s transient absorption behavior and its quenching by C70, relating kinetic measurements to underlying photophysical processes. Pump–probe setup, data acquisition, and analysis to extract decay rates and quenching constants.

**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.

**Classical and Quantum Chaos**: Map out the modes of a 2D electromagnetic cavity. Determine the mode statistics for various ca

**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).

**High Tc superconductivity:** Explore the signatures of superconductivity in high Tc superconductor.

**Nuclear Magnetic Resonance (NMR):** Use pulsed NMR to study the nuclear spin resonance conditions and decay times in liquids and solids.

**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. configurations.

**Nuclear and Particle Physics**

**The Compton Effect:** Measure the angular dependence of the energy shift and differential cross-section for gamma-ray photons scattered on quasi-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 successive gamma rays emitted in cascade decays of 60Co nuclei and use this correlation to determine the sequence of spins of the 60Ni nuclei involved in the decay chain.

**The Muon Lifetime:** Measure the mean lifetime of cosmic ray muons.

**Mössbauer Spectroscopy:** Use recoilless emission and absorption to obtain ultra-narrow line width and perform high-resolution spectroscopy with the 14.4 keV gamma rays from 57Co decays. Measure the isomer shift, magnetic field, and electric quadrupole field gradient at the resulting 57Fe nuclei.

**Learning Outcomes**

Students who have completed PHY445/515 should be able to

* Perform basic experiments in physics,
* Perform a statistical and systematic analysis of experimental data and extract physics information
* Write up the results of an experiment in the style of a scientific paper
* Present the results in a conference-style slide (PHY445) or poster presentation (PHY515)

The final grade will be based on four equally weighted components. Each of the three experiments, with particular emphasis on the quality of the paper-style write-up (lab report), will account for 30% of the grade, and the final presentation will contribute the remaining 10%.

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

* Atomic, Molecular, and Optical Physics

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* Condensed Matter Physics

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* Nuclear and Particle Physics

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**TAs**

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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.