PHY445/515

Methods of Experimental Research

Students choose experiments in each of three major areas.

- Atomic, Molecular and Optical Physics
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- Condensed Matter Physics
  Prof. Mengkun Liu mengkun.liu@stonybrook.edu
  Prof. Xu Du xu.du@stnybrook.edu
- Nuclear and Particle Physics
  Prof. Clark McGrew clark.mcgrew@stonybrook.edu

TAs:

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Goal: provide experience in the scientific method

- Hands-on experience on a variety of modern experimental techniques

- Statistical and systematic error analysis, data-theory comparison

- Writing of journal-ready scientific manuscripts (Physical Review Letter style)

- Presentation of experimental results at a professional level

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.
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).

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. configurations.

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.

First week of classes:

Monday/Tuesday (Aug.28/29) study lab materials

Data Analysis lecture.

Review all the experiments online and find three experiments that interest you the most.

Wednesday/Thursday (Aug. 30/31) in front of B114

- Meet the professors and TAs
- Attend the lab tour (will send schedule).
- Find a lab partner.
- Decide which experiments you wish to do. We will assign the experiments to satisfy as many 1st and 2nd choices as possible.

Before starting lab work:

Read the Course Information, Course Notes and the write-up for your first experiment. Read the essential references as discussed in the write-up to prepare for your first experiment.

AUGUST						
Su	M	Tu	W	Th	F	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

SEPTEMBER						
Su	M	Tu	W	Th	F	Sa
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3	4	5	6	7	8	9
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17	18	19	20	21	22	23
24	25	26	27	28	29	30

OCTOBER						
Su	M	Tu	W	Th	F	Sa
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15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

NOVEMBER						
Su	M	Tu	W	Th	F	Sa
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DECEMBER						
Su	M	Tu	W	Th	F	Sa
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10	11	12	13	14	15	16
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24	25	26	27	28	29	30
31						

Fall 2023
PHY445/515 Course schedule

- Sept .6,7: Start experiment
- Prelab tests in the first weeks of experiments
  After 2 weeks working on exp: mid-lab report due

- After 4 weeks working on exp: final report due

- (…. x3 ….)

- Posters (PHY515) TBD
- Final oral exam time for PHY 445 Lab 1 TBD
- Final oral exam time for PHY 445 Lab 2 TBD

Reports

- Submit ONE report per group per experiment
- Delineate each partners main contributions
- Grading will be based on (i) quality of the report writing, (ii) quality of your experimental work, (iii) your contribution in the experimental work.

Report submission:

- You must submit your report to Brightspace. This determines the time at which your report is submitted. By the start of the next lab period you must be prepared in case the instructors want to look at your
(i) lab book and (ii) access to relevant data.

Grading

To **pass** this course, i.e. to receive a grade > F:

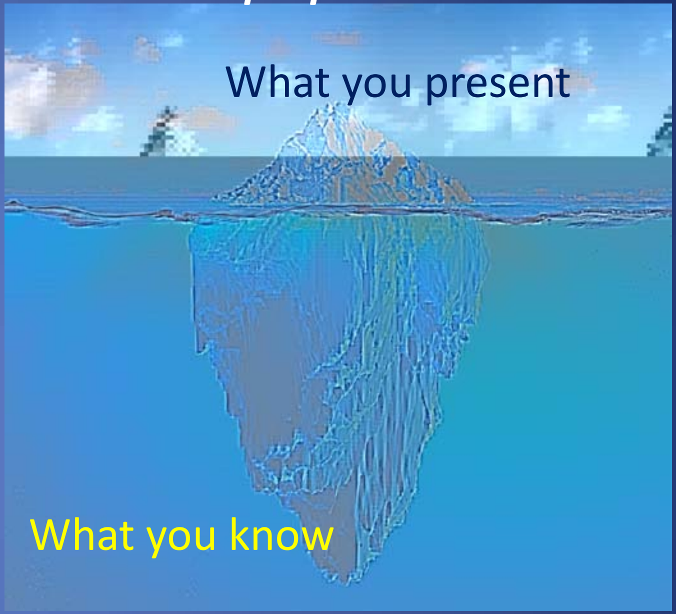
• You must complete 3 experiments, submit the reports and receive a passing grade, on each.

•You must present a talk or poster to the class explaining the results of one of your experiments, again receiving a passing grade.

Each lab report will count for 25% of your grade. The talk/poster will count for 25%.

Presentations

Be prepared!



Structure-wise

- Motivate your work
- Provide sufficient background
- Clearly present your results
- Summarize (back to the motivation)

Style-wise:

1) Use figures. Do NOT fill slides with sentences! (try hearing talks while reading long sentences)
2) Do NOT read from scripts!
3) Clarity is more important than quantity.

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.