Physics 905 – Summer 2010

Graduate Research in Condensed Matter and Optical Physics

Instructor: Chih-Wei Lai, cwla@msu.edu, Office: 4238 BPS.

Guest Instructors:

Prof. John McGuire, Prof. Brage Golding, Prof. Ruby Ghosh,
Tom Palazzolo, Dr. Baokang Bi, Dr. Reza Loloee.

Course Description and Objectives

A 6-week summer course will be offered for graduate students prior to embarking on PhD research. The objective is to provide each student with resources and tools for future research and career development.

Time period: July 12 to August 16

Format: a weekly 3-hr lecture/discussion plus a 3-hr lab

Lecture: 9-12 am Monday

Laboratory: 1:30-5 pm Monday

Location: BPS 4270 (Lecture) and BPS 1245 (Lab)

The analytical and experimental techniques covered in this course are basic to graduate research in condensed matter physics and in atomic, molecular, and optical physics. General topics such as literature searches, laboratory automation, and optical methods (which are applicable to chemistry and biophysics) will also be covered.

Students will keep an individual laboratory notebook, co-author a mini-report, and deliver an individual 10 minute APS-style presentation about an experiment or a specific research topic.
Course Outline

(1) Experimental Techniques for condensed matter physics and biophysics research: basic electronics and circuits, common laboratory electronics and instruments, mechanical design and machining, vacuum techniques, low temperature techniques, optical components and opto-mechanics, opto-electronic devices and instruments, spectroscopy and microscopy, light sources and laser systems, micro- and nano-fabrication facilities, laboratory automation and data acquisition.

(2) Analytical and Communication Skills – tools and resources: numerical simulation and modeling, data analysis and plotting, scientific and technical writing, and technical presentations.

(3) Career development: how to find an advisor and be a good graduate student, online resources and bibliographic tools.

(4) Hands-on experiments, mini-reports, and 10-minute talks: Students will be divided into groups to examine different aspects of a set of experiments related to optical pumping of 85Rb and 87Rb and pulsed nuclear magnetic resonance. Students are required to keep individual laboratory notebook, co-author a mini-report, and deliver an individual 10 minute APS-style presentation about the experiment.

Below is an outline of the content of the course.

Unit 1: CMP/AMO Research & Groups and Facilities at P-A

Unit 2: Mechanical Design and Fabrication

Unit 3: Optics – Laser, Microscopy and Spectroscopy

Unit 4: Electronics

Unit 5: Vacuum Technology and Cryogenics

Unit 6: Scientific Writing and Presentation, Computing

Unit 7: On Being a Scientist & a Graduate Student
Your Reading Material

This course does not use a traditional textbook. Instead, you will be reading from different websites and notes. Depending on your chosen field of research, you may consider buying some of the following books.


Computer Software

We will NOT offer training classes for computer software. However, we will give examples based on some of the following programs. You may obtain a student or academic license from MSU computer store (http://cstore.msu.edu/), the official website of the vendors, or online stores such as Academic Superstore (http://www.academicsuperstore.com/).

Data Acquisition and Analysis

*LabView* (‘free’ MSU site license) (http://www.ni.com/labview/)

*Origin Pro* (http://www.originlab.com/), or *Igor Pro* (http://www.wavemetrics.com/), or

*KaleidaGraph* (http://www.synergy.com/)

Computation

*Mathematica* (http://www.wolfram.com/) or *Maxima* (a descendant of Macsyma) (http://maxima.sourceforge.net/)

*Mathlab* (http://www.mathworks.com/) or *GNU Octave* (free Matlab ‘clone’) (http://www.gnu.org/software/octave/)

*MathCAD* (http://www.ptc.com/products/mathcad/)

Document Preparation

*MS Office, or Open Office, or Star Office*

*MikTeX + a TeX editor, or proTeXt* (http://www.tug.org/protext/), & *REVTeX 4.1* https://authors.aps.org/revtex4/

Bibliography

*EndNote X3* (http://www.endnote.com/) or any other bibliography manager
Class Syllabus and Schedule

CMP/AMO Research at P-A [7/12]

- 9am-12pm, 7/12, Lecture (CW: 2 hrs, JM: 1hr)

9 am – 9:30 am, Course objectives, on Being a Scientist, CMP/AMO Research
9:30 am – 10:30 am, Optical Components & Laser Systems
10:30 am – 11:30 am, John McGuire, Research activities & Ultrafast Spectroscopy

Optics – Laser, Microscopy, and Spectroscopy [7/19]

- 9 am – 10:30 am and 11:30 am -12 pm, 7/19, Lecture (CW: 2hrs)

Laser systems and light sources
Microscopy
Spectroscopy
Charge-particle Optics & Electron Microscopy

Mechanical Design and Fabrication [7/19]

- 10:30 am – 11:30 pm, Machine Shop: Tom Palazzolo palazzolo@pa.msu.edu

Introduction to technical drawings and the machine shop

Vacuum Technologies and Cryogenics [7/26]

- 9am – 10:40 am, 8/9, Lecture (1.5 hrs)

Vacuum (gases, pumps, hardware and system construction)

Practical Cryogenics

- 10:30am – 12pm, 7/26, Guest Lecture and Tours

1. 10:40 – 11:10 am, KMF - Keck Microfabrication Facility: Baokang Bi bi@pa.msu.edu
2. Tour - Laser, microscopy, and spectroscopy systems (Lai, Ruan, Zhang, Lapidus, McGuire)
3. Tour - Cryogenic systems in CMP (Golding, Lai, Birge, Tessmer, Pratt/Bass)
Electronics [8/2]

- 9am – 12 pm

Electronics Parts

Electro-optical instruments and systems

Instrument Control & Data Acquisition

Scientific Writing and Presentations, and Computing [8/9]

- 9 am – 10:30 am

Data/Error Analysis & Scientific Graphing

Reference/Bibliography Management, Literature Research

10:30 am – 12:00 pm

Scientific Writing and Presentation,

Guest Lecturer

CMP/AMO Research Groups (faculty, staff, and students)

- 11:30 am – 12:00 pm, Tour – Facilities in CMP and BPS

CMP common facilities: Reza Loloee loloee@pa.msu.edu
Utilities in BPS, Gases, Chemicals, CMP shared facilities

Electronic shop: Barry Tigner tigner@pa.msu.edu

On Being a Scientist and a Graduate Student [8/16]

- 9 am – 12 pm

LaTeX, Mathematica/Matlab/MathCAD/IDL/Maple

PA computing services, Linux

Scientific attitude and ethics

Others Topics (TBA)
Lab Sessions
1:30 pm to ~5:00 pm, Monday

Structure of Labs
You will be divided into three teams working on two major sets of experiments – Optical Pumping and Pulsed NMR. Each team has two to three members.

Each team will give one coherent final presentation.

Presentation Format: 25-30 mins (8 mins each at least).

“Grading”
You will keep an individual laboratory book. Your lab book will be peer reviewed. This means you will review others’ laboratory books, too.

“Awards”
Best Presentation (Team and Individual)
Best Group Report
Best Laboratory Book(s) (Individual)

07/12 | Orientation and Planning Experiments

➤ Distribute manuals for Optical Pumping and Pulsed NMR
➤ Make a very “detailed” list of instruments (0.5 hr)
➤ Search and Organize reading materials, manuals, and specifications data sheets of instruments for Optical Pumping & Pulsed NMR (1 hr)
➤ Study manuals/instructions for the experiments and materials found online (0.5-1hr)
➤ Peer review and open discussion session ➔ Form teams & select tentative presentation topic (0.5-1hr)
➤ Plan experiments & tasks for the next week

07/19 | Experiment - Take I

➤ Review & finalize plans (15 mins)
➤ Select and plan specific sub-experiment to do (15-30 mins)

Review materials relevant to the sub-experiment – What instruments are required? What measurements to be made? What do you expect and why?
• Study instrument manuals and specs, Perform sub-experiments (2 hrs)
• Peer review and discussion: (15-30 mins)
  
  Compare experimental results, Explain the limit and functions of instruments + Q&A

07/26 | Experiment – Take II

• Plan experiments (15 mins)
• Perform sub-experiments as a team (3 hrs)

08/02 | Experiment – Take III

• Optimize Experiments

08/09 | Experiment – Final Take

• Revise experiment instructions/manuals as a team
• Write an abstract (individual)
• Analyze data and Prepare slides

8/16 | Presentation Session

• Lab – Presentations & Exit Survey & Party
  9 students ➔ 3 teams, 15 + 3 minutes each

8/16 | Getting Oriented and Plotting a Course in a Research Lab
(Highlights of Ch. 1 to Ch. 5, “At the Bench”, by Barker)

1. General Lab Organization and Procedures
2. Laboratory Setup and Equipment
3. Getting Started and Staying Organized
4. How to Set Up an Experiment
5. Laboratory Notebooks