Physics 403. Modern Physics Laboratory

Summer 2021

Eugene V Colla, Alexey Bezryadin

COVID-19 hybrid version
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Support from Paul Kwiat Team

Physics 403 Summer 2021
Special thanks to Virginia Lorenz for help in preparation Physics 403 course to online version!
I. Goals of the course
II. Teamwork / grades / expectations from you
III. Syllabus and schedule
IV. Your working mode
   In class and "after hours" access
   Safety, Responsibility
   Home and away computing
V. Take a Lab tour (only video)!
VI. Let’s get started
    electronic logbooks
    digital scopes
Course Goals. Primary goals:

• **Learn how to “do” research**

  ✓ Each project is a mini-research project

  ✓ **How are experiments actually carried out?**

    The procedures aren’t all written out

    The questions are not in the back of the chapter

    The answers are not in the back of the book

    You will have to learn to guide your own activities

  ✓ **Use of modern tools and modern analysis and data-recording techniques**
Course Goals. Primary goals:

- Learn how to document your work
  - Online - electronic logbook *
  - Online – saving data and projects in student area on server
  - Using traditional paper logbooks
  - Making an analysis report
  - Writing formal reports
  - Presenting your findings orally (online)

* In red gradable assignments
Course Goals. Secondary goals:

- **Learn some modern physics**
  - Many experiments were once awarded by Nobel-prize
  - They touch on important topics in the development of modern physics
  - Some will provide additional insight to understand advanced courses you have taken
The Experiments. Three main groups

• Nuclear / Particle (NP)

• Atomic / Molecular / Optics (AMO)

• Condensed Matter (CM)

You will do the experiment from all these groups
The Experiments

• **Nuclear / Particle (NP)**
  - Alpha particle range in gasses
  - $\gamma - \gamma$ correlation experiment
  - $\gamma$ – spectroscopy
  - Mössbauer spectroscopy
The Experiments

• **Nuclear / Particle (NP)**
  - Cosmic ray muons:
    - Lifetime, capture rate, magnetic moment
  - Angular distribution of cosmic rays
  - $\gamma$ – spectroscopy
  - Mössbauer spectroscopy (new)
The Experiments
Atomic/Molecular/Optics (AMO)

- Berry’s phase
- Quantum erasure
- Quantum Entanglement
The Experiments
Atomic/Molecular/Optics (AMO)

- Optical pumping of rubidium gas
- Fluorescence spectroscopy
The Experiments

- **Condensed Matter (CM)**
  - Superconductivity
  - Tunneling in superconductors
  - 2\textsuperscript{nd} sound in \(^4\)He superfluid state
The Experiments

- **Condensed Matter (CM)**
  - Ferroelectrics and ferroelectric phase transition
  - Pulsed NMR
  - Calibration of temperature sensors
The Experiments

- **Condensed Matter (CM)**
- **Special Tools:**
  - Vacuum film deposition
  - Atomic Force Microscope
  - Polarizing microscope
The “manuals”

- Many are just guides
- A only few purchased experiments have “real” manuals
- We serve as your guides ... like real research ... yes, we will do it in “online” mode too. We have prepared the materials explaining how to do the experiments and data analysis and you can find all these materials and examples of data analysis in folder in common drive.
The “manuals”

For most of the P403 experiments we have prepared the folders containing the most important materials related to the experiment. These folders are located on the shelves in ESB5105. You can borrow the folders until working on experiment and on the report.
Outline

I. Goals of the course

II. Teamwork / grades / expectations from you

III. Syllabus and schedule

IV. Your working mode
   - In class and “after hours” access
   - Safety, Responsibility
     - Home and away computing

V. Take a Lab tour!

VI. Let’s get started
   - Electronic logbooks
   - Digital scopes
**Grading: Distribution of “740” points**

<table>
<thead>
<tr>
<th>ASSIGNMENT</th>
<th>Points</th>
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<tr>
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<td>formal reports</td>
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<td><strong>1st Oral report</strong></td>
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The grading scale will be a percentage out of “740”:

Letter grading scale is approximately 97% = A+, 93% = A, 90% = A-, 87% = B+, 83% = B, 80% = B-, etc
Resubmission

You can RESUBMIT one lab report to improve your grade
(deadline for resubmissions and for report #4 August 6th 2021)

The general rules for resubmission:

1. Original report should be submitted in time with no using of the late ticket
2. The original report should be a real report but not only the title page
3. We do not recommend to resubmit the report if the original grade was over 90 points
Grading: a piece of history and analysis of the results

Physics 403
2005-2021
572 students total
Submission of Lab-Reports

• Due dates as on syllabus at midnight

• The reports should be uploaded to the server:
  
  • https://my.physics.illinois.edu/courses/upload/

• Accepted MS-Word or PDF*

• For orals – MS-PowerPoint* or PDF

* preferable
Absences

• If you are sick, let Eugene know by email (kolla@Illinois.edu). Don’t come in and get others sick. We are working side-by-side in a close environment for many hours.

• You can “make up” the time with arrangements and you can have access to the rooms. We will be accommodating.
Absences. Excuse Policy.

- You can be excused from **only one** missed assignment, and only if you **provide medical or any other acceptable documentation**\(^1\).
- If you have **missed the oral presentation** (oral #1) by acceptable reason, you need to discuss this with us and we will arrange the date for your oral talk.
- The **Final Oral cannot be excused**, as it is equivalent to a final exam. **You cannot pass the course without credit for this assignment**\(^2\).

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1. Student Code: [https://studentcode.illinois.edu/article1/part5/1-501/](https://studentcode.illinois.edu/article1/part5/1-501/)
2. Ibid: [https://studentcode.illinois.edu/article3/part2/3-201/](https://studentcode.illinois.edu/article3/part2/3-201/)

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Late Reports

- Policy for late reports
  - You can have ONE “late ticket” for a “free” delay of up to 3 business days, but you must tell us you are using the ticket.
  - Reports are due at midnight on the date shown on the syllabus. After that we will charge:
    - 5 points for up to 1 week late. 10 points for up to 2 weeks late.
    - After that, it’s too late.
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VI. Let’s get started
   electronic logbooks
   digital scopes
# Syllabus

## Physics 403 Summer 2021

*Lecture topics are subject to change*

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Activity</th>
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<th>Note</th>
<th>Due days</th>
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Assignment of experiments

2 cycles with 2 experiments

- teams change after cycle or by starting new experiment

- joint team reports and elogs but oral presentations will be done by each student personally
After 2 experiments (1 cycle) we will have oral session. The topic of the presentation will be chosen from the experiments done in this cycle.
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digital scopes
Lab Access

Use Your ID Card to Access the Lab

You can access the Lab not only on “Lab days”

Late time rules:

You can stay in the Lab until 8pm but need to

**Sorry, not for hybrid option**

After 8pm and on weekend days – you have to discuss

this schedule with your instructor and in general it is

preferable to avoid working after 8 pm and on week
Safety is your responsibility!

Hazards: *high voltage, radioactive sources, cryogens, chemical materials, high pressure*

In class work and “after hours” access & work requires responsible conduct with regards to

(I) safety/hazards and with

(II) equipment

Discuss potential hazards at the beginning of each experiment with an instructor or TA

When in doubt stop and ask

Problems after hours: 217 493 1576 (Eugene’s cell)

(Alexey's cell)
Follow Directly the Recommendations of Safety Working

https://www.drs.illinois.edu/

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**NEWS AND ANNOUNCEMENTS**

**Laser Registration and Management**

9/23/2010

The Division of Research Safety has added a tool to their website to allow laser users to manage their laser registrations and inventory online.

**New Tier 1 Select Agent**

9/23/2010

As of 9/14/16, the CDC/dHHS has added Bacillus cereus Bilea anthracis as a Tier 1 select agent under 42 CFR Part 73.

**Laser Safety Eyewear Warning**

7/2/2010

Filters not matching specifications on packaging.
Follow Directly the Recommendations of Safety Working

Chemical Waste Collection and Storage

Before generating chemical waste, the researcher should determine how it will be collected and stored and obtain the necessary equipment (containers, labels) in advance. The choice of procedures depends on the type of waste and its final disposition. This section explains how to determine the final disposition of waste, select the appropriate waste container, and store waste in the lab or work area. It also suggests waste minimization strategies.

Determining How to Dispose of a Chemical Waste

The final disposition of a chemical waste is determined by the answers to a series of questions:

**Step 1.** Is the waste **Contaminated Debris** (glassware, paper towels, clean-up materials), or is it a chemical or chemical mixture?
- If it is contaminated debris: Go to Step 5.
- If it is a chemical or chemical mixture: Go to Step 2.

**Step 2.** Is the chemical a DEA (Drug Enforcement Agency) controlled substance? (Refer to the [DEA list of controlled substances](https://www.deadiversion.usdoj.gov/druginfo/daws/index.html))
- Yes: Refer to the **DEA Controlled Substances Guide** for disposal procedures.
- No: Go to Step 3.

**Step 3.** Is the chemical a solid (not liquid or gas)?
- Yes: Collect and store the waste as described in the waste container and storage guidelines listed below and dispose of it through the Division of Research Safety (DRS) chemical waste disposal program. See the section [Procedures for Requesting Chemical Waste Disposal](https://www.research.illinois.edu/safety/chemical-waste-disposal) for the disposal procedures. (No solid chemical waste, hazardous or non-hazardous, should be placed in the regular trash.)
- No: Go to Step 4.

**Step 4.** Is the chemical a liquid non-hazardous waste as listed in the section **Liquid Non-Hazardous Chemical Waste Disposal**?
- Yes: The chemical may be poured down the sanitary sewer (sink drain) with copious amounts of water.
- No: Collect and store the waste as described in the waste container and storage guidelines listed below, and dispose of it through the DRS chemical waste disposal program. See the section [Procedures for Requesting Chemical Waste Disposal](https://www.research.illinois.edu/safety/chemical-waste-disposal) for the disposal procedures.

**Step 5.** Is the contaminated debris laboratory glassware (broken and unbroken)?
- Yes: See the **Laboratory Glassware Waste Disposal** section.
- No: Go to Step 6.

**Step 6.** Is the debris contaminated with a substance listed in the section **Liquid Non-Hazardous Chemical Waste Disposal**?
- Yes: The contaminated debris can be disposed of in the regular frozen.
- No: Collect and store the contaminated debris as described in the waste container and storage guidelines listed below: disperse.
Definition

Materials that qualify as “sharps” are defined at the state level and shall be disposed of as Potentially Infectious Medical Waste (PIMW). In Illinois, the Illinois Environmental Protection Agency (IEPA) has designated the following material (used or unused) as sharps:

• Any medical needles,
• Syringe barrels (with or without needle),
• Pasteur pipettes (glass),
• Scalpel and razor blades,
• Blood vials,
• Microscope slides and coverslips,
• Glassware contaminated with infectious agents.

NEVER dispose of these items in SDCs:

• Plastic items (except for syringes),
• Beverage containers (no pop cans!),
• Non-biologically contaminated laboratory glassware,
• Solvent/chemical bottles,
• Light bulbs,
• Any paper materials,
• Pipette tips,
• Plastic pipettes,
• Aerosol cans or cans of any type,
• Scintillation vials,
• Any item with liquid (except for blood in vacutainer tubes).
Follow Directly the Recommendations of Safety Working

https://www.drs.illinois.edu/

Safety working in online mode is completely your responsibility. Working from home you are only faced to your electronic gadgets, no radiation from isotopes used in Lab, no cryogenics, no chemistry components, no high voltage.
V. Take a Lab tour! It will be virtual tour.

VI. Let’s get started
   electronic logbooks
   digital scopes
Outline

I. Goals of the course
II. Teamwork / grades / expectations from you
III. Syllabus and schedule
IV. Your working mode
    In class and "after hours" access
    Safety, Responsibility
    Home and away computing
V. Take a Lab tour!
VI. Let’s get started
    electronic logbooks
digital scopes
How to record the data

- **Work together**
- **Write down the equipment used**
- **Make a diagram of the setup**
- **Note the settings of dials, switches, gauges**
- **Take a digital photo if appropriate (we have prepared and will prepare more pictures of the setups  equipment etc.)**
- **Use a software drawing program to make a detailed sketch** *(PowerPoint works this very well)*
How to record the data

- Use the eLog (see next).
- Write down what you did in real sentences.
- Provide enough detail that you can reconstruct later what you did!
- How will you look at the data later?
- Do you have enough information?
- Did the equipment perform as expected?
How to record the data

• Many experiments require you to “change and measure” something by hand
  – Make a **table** in a **paper logbook** or put the data directly into **electronic worksheet** (**preferable**).
  – Make a “**quick sketch**” of your by plotting the data using **OriginPro** or other software

Looking on the graph you can answer the questions:

• Do you have enough points?
• Do you have any obvious anomalies?
• You can repeat points but do not throw them out.
  Use other measurements to check reliability
Many experiments have built-in, computer-based data acquisition (DAQ)

- You will not have time to fully understand the DAQ, but
  - Be sure you know functionally what it is doing – ask
  - A good idea is to make test measurements of something you know
    - As before, anomalies? enough points? uncertainties?
Where to exchange, store and retrieve course information.  

P403 Lab server

\engr-file-03\PHYINST\APL Courses\PHYCS403
Connecting to the PHYS403 server

Connect to VPN following the instructions on the UIUC VPN website:
https://techservices.illinois.edu/services/virtual-private-networking-vpn/download-and-set-up-the-vpn-client

To connect to the PHYS403 Server:

• Connect to the VPN first, then enter the following as the share to connect to:
  – **Mac users:** Open Finder: Go: Connect to Server, type in address:
    smb://engr-file-03.engr.illinois.edu/PHYINST/APL Courses/PHYCS403
  – **Windows users:** Open Windows Explorer, type in address:
    \engr-file-03.engr.illinois.edu\PHYINST\APL Courses\PHYCS403

• **When prompted for username and password, enter:**
  “UofI\[your netID]” and “[your netID password]”
Where to exchange, store and retrieve course information.

(i) Your data, projects, tables etc

\texttt{\textbackslash engr-file-03\textbackslash PHYINST\textbackslash APL Courses\textbackslash PHYCS403}

There is a lot useful and not very useful stuff in many folders you can find there

“Useful” folders are shown in red frames
Where to exchange, store and retrieve course information.

(i) Your data, projects, tables etc

\`\`\engr-file-03\`\`\PHYINST\`\`\APL Courses\`\`\PHYCS403

Each student has a folder

Store all experiment related materials in corresponding folder
Where to exchange, store and retrieve course information. (i)

Your data, projects, tables etc

An example of the “smart” structure of folders containing the raw data and data analysis projects
Where to retrieve course information.

Manuals, papers, setup diagrams and other useful materials
Where to retrieve course information.

Manuals, papers, *setup diagrams* and other useful materials
Where to retrieve course information.

Setup diagrams – do not use cellphones to take the image of the setup from manual – for most setups we have PowerPoint projects with setups.
Where to retrieve course information.

Manuals, papers, setup diagrams and other useful materials

- Some old stuff (not very useful)
- Sample pictures of ferroelectric domains
- Examples of report and oral presentation
- Pictures of the setups of the experiments
- Software including DAQ software for different experiments. Newest version of Origin is also there
- P403 lecture notes
- C++ scripts for Root
- Origin manuals + a very compressed version written by Eugene
- Origin templates (how to use them will be discussed in next lecture)
Where to retrieve course information.

Material Prepared for Online Teaching

- Summer 2021 online

- High excitation modes
- Reading materials
- References
- Setup
- Software
- SecondSound_Graham

- Alpha Range
- Ferro1
- Ferro3
- gamma-gamma

- Introduction (videos)
- Moessbauer
- Optical Pumping
- PNMR
- Quantum Entanglement
- Quantum Erasure
- Second Sound
- Superconductivity
- Tunneling

- Donnelly09_Two-fluid theory and second...
- LiquidHeliumTwoFluidModel_Ch3_Tilley
- published results
- Second sound experiment
“Journal club”

http://ajp.aapt.org/#mainWithRight

http://www.scientificamerican.com/

http://www.nature.com/nature/index.htm

http://www.sciencemag.org/journals

http://publish.aps.org  or  http://prola.aps.org/
“Journal club”

Walking with Coffee: Why Does it Spill?

Growth of Diamond Films from Tequila

J. Morales$^{1,2}$, L. M. Apátiga$^2$, V. M. Castaño$^2$

1. Facultad de Ciencias Físico Matemáticas, Universidad Autónoma de Nuevo León
2. Centro de física Aplicada y Tecnología Avanzada, Universidad Nacional Autónoma de México

Fabrication and Characterization of Ultrathin Three-Dimensional Thermal Cloak

Student #1
University of Illinois at Urbana-Champaign

The Physics of Beer Tapping

PRESENTATION BY JOSEPH MIRABELLI
JAVIER RODRÍGUEZ-RODRÍGUEZ, J.*, ALMUDBA CASADO-CHACÓN, AND DANIEL FUSTER
1 FLUID MECHANICS GROUP, CARLOS III UNIVERSITY OF MADRID
2 CNRS, UNIVERSITÉ PIERRE ET MARIE CURIE

Physics 403 Summer 2021
“Journal club”

**Journal Access**

If you cannot access journal papers using VPN, go to UIUC’s library proxy test site and enter the address of the paper you want to read:

http://www.library.illinois.edu/proxy/test/

**Recommended journal websites**

- American Physical Society Journals: https://journals.aps.org/about
- Nature: http://www.nature.com/nature/index.html
- Science: http://www.sciencemag.org/journals
- American Journal of Physics: http://scitation.aip.org/content/aapt/journal/ajp
Entering the e-Log ...

Welcome to Modern Experimental Physics, where you will learn techniques and experience the physics of atoms, atomic nuclei, molecules, the solid state, quantum optics and other aspects of physical research. Please see the course description for an explanation of how this course may seem complicated at first, but all the pieces do work together to enhance understanding.

Please consult the schedule to help you keep track of what is due when.

The goal of this lab course is to emulate the experience of working in an experimental research setting. Students will learn to use sophisticated equipment and learn how to correctly write a lab report.
Entering the e-Log ...

Use your University Username and Password

Please Sign In

Illinois Login

Or login as a guest
Entering the e-Log ...
Entering the e-Log ...

Welcome to Physics 403 Summer 2021 course!
Templates are not “ready to go” eLog records. There are some suggestions and comments which you need to read, accept/decline and remove from the final version of the eLog record.
e-logs: First a brief tour

How to use it

• Pause and summarize your work at natural stopping points in the action. This is useful for particular findings and measurement sequences.

• Along the way, save data, plots, scope shots to your folder on the server.

• Near the end of the class, add a summary/conclusion, indicate future directions, and make sure the e-log provides a rather complete overview of the highlights of your work. Upload your plots, scope shots, etc. and describe the data.
e-logs: Making a post ...

- To create a new post, click `Create New Log`
- Fill in the **Author, Experiment, Post Type, and Subject.**
  Don’t forget to enter the name of the **second author**
Goal: Be specific. Not, “Learn about experiment,” but, for example, “In helium below temperatures of 2.17K, a second sound due to thermal effects becomes measurable. We will measure the speed of the second sound using a resonant cavity...”

Settings / Equipment Notes: Note important environmental and experimental parameters such as atmospheric pressure, settings on equipment, etc.

[Time Range 1]: Give time range, not just “before tea.”
  • Note important steps and results
  • Include plots, photos, or scope shots in attachments below
  • Use bullet points to make it easy to read

[Time Range 2]: ...

Conclusions & Future Plans: What did you find and what is the next step? Be specific. Not, “We measured decay times,” but, for example, “Ruby #2 sample with higher concentration chromium was observed to decay with a form...”
Some General Physics 403 Rules.

No Food or Drinks in Lab except ESB 5105
Some General Physics 403 Rules.

You can have a short break in ESB 5105 where you will find coffee, tea, cookies.
Some General Physics 403 Rules.

Because of COVID19 restriction we can’t invite all of you at the same time in ESB 5105. Please follow the room capacity as shown on the wall in this room.