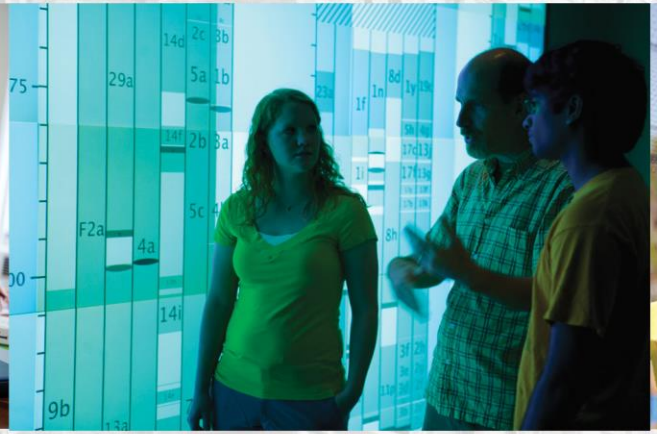
UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Physics 403 Modern Physics Laboratory

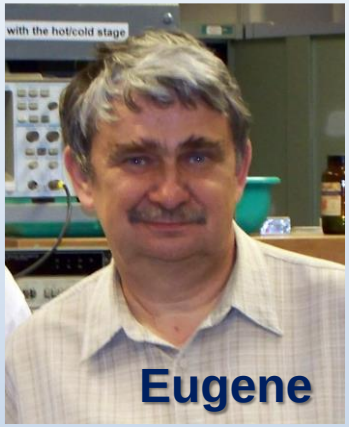
Summer 2014

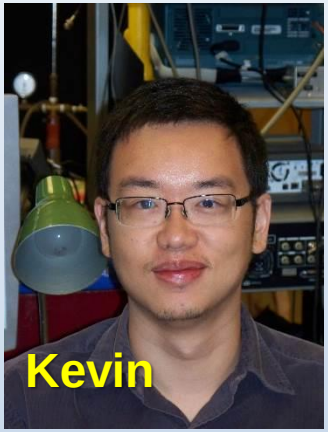
Eugene V Colla



Physics 403 Modern Physics Laboratory

Summer 2014, Teaching Team





Instructor:
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TA's:
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Matthew Coon mrcoon2@illinois.edu

Laboratory Specialist:
Jack Boparai
jboparai@illinois.edu

Support from Kwiat research group

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

Course Goals. Primary goals:

- **Learn how to "do" research**

  - ✓ Each project is a mini-research effort
  - ✓ 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

* In red gradable assignments

Course Goals. Secondary goals:

- Learn some modern physics
  - Many experiments were once Nobel-prize-worthy efforts
  - They touch on important themes in the development of modern physics
  - Some will provide additional insight to understand advanced courses you have taken
  - Some are just too new to be discussed in textbooks

The Experiments. Three main groups.

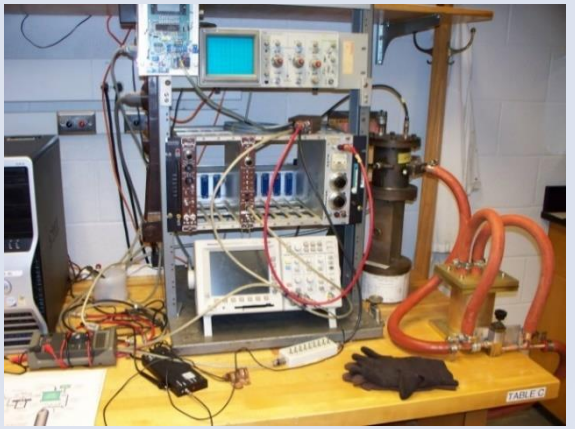
- Nuclear / Particle (NP)
- Atomic / Molecular / Optics (AMO)
- Condensed Matter (CM)

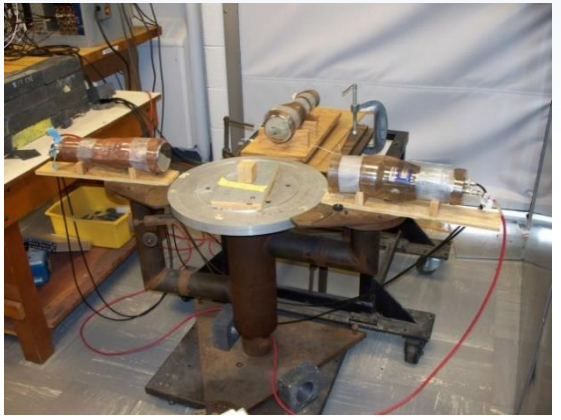
You will do the experiment from all these groups

The Experiments

- **Nuclear / Particle (NP)**
  - Alpha particle range in gasses
  - Cosmic ray muons:

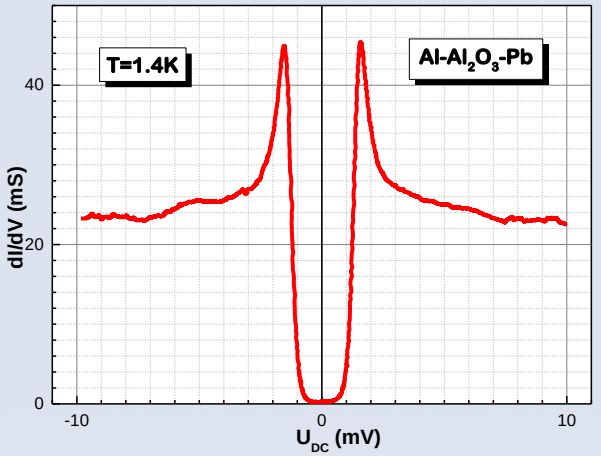
    Lifetime, capture rate, magnetic moment
  - Angular correlations in nuclear decay
  - Angular distribution of cosmic rays
  - γ–γ correlation experiment
  - γ - spectroscopy

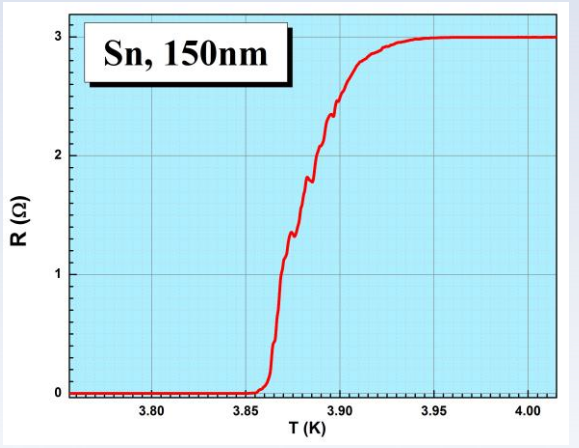


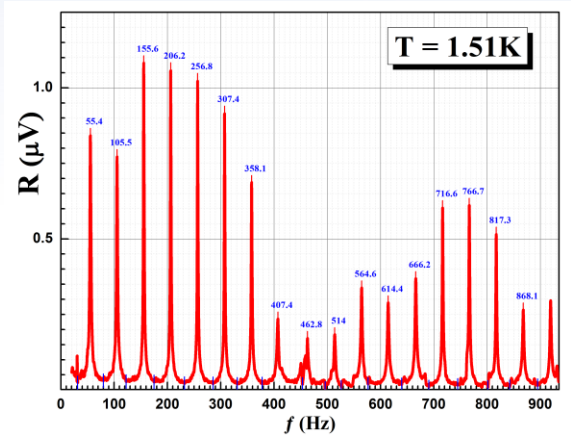


The Experiments

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

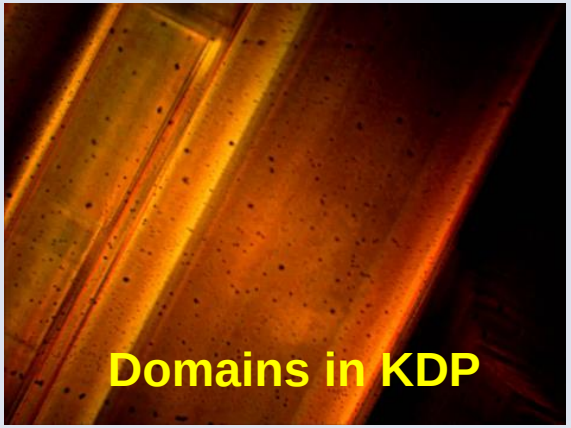


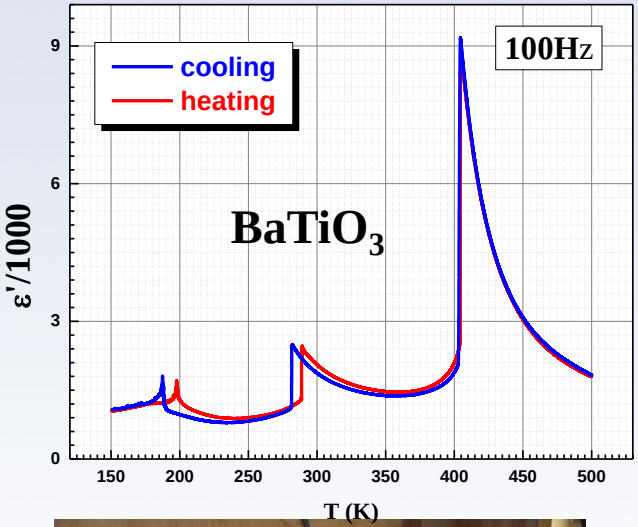


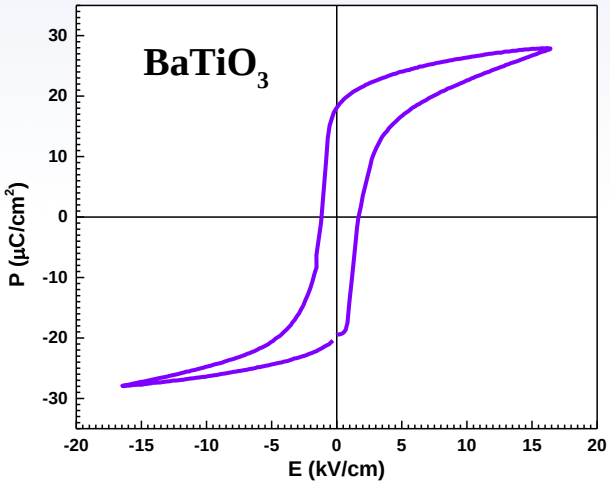


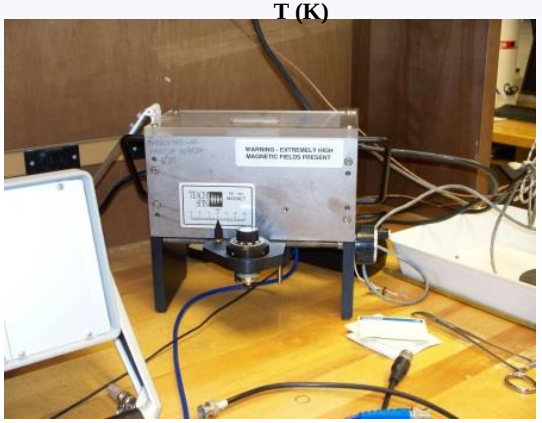
The Experiments

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









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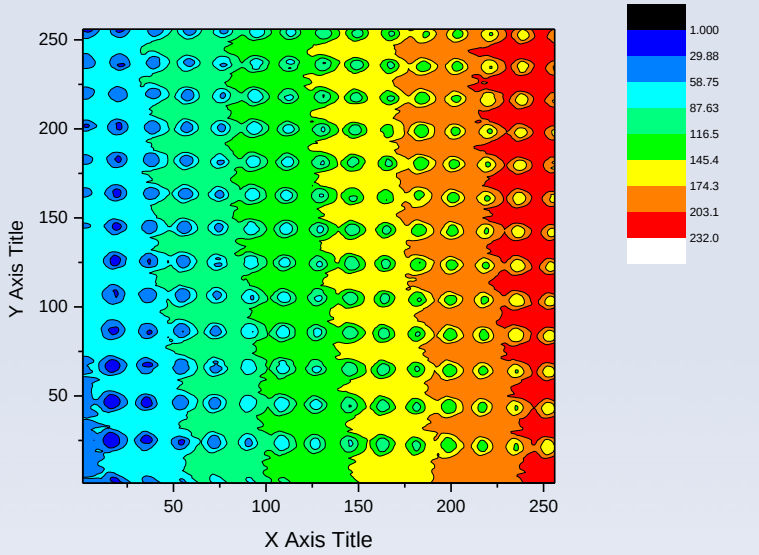
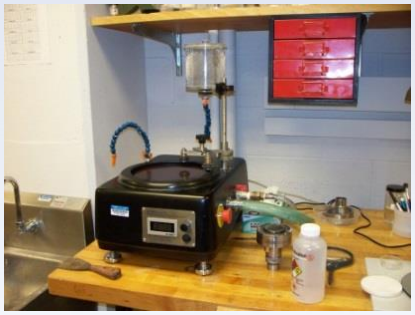
The Experiments

- **Condensed Matter (CM)**



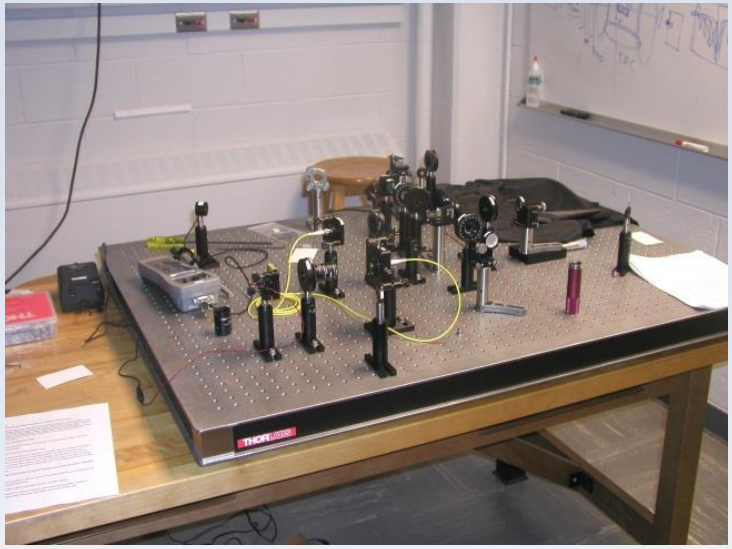
- **Special Tools:**
- **Vacuum film deposition**
- **Atomic Force Microscope**
- **Polarizing microscope**

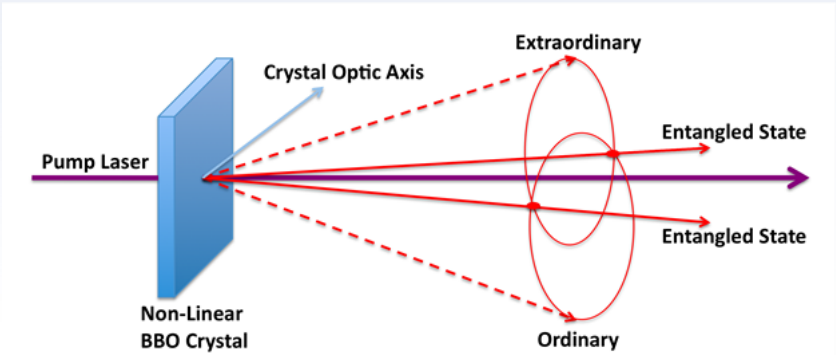


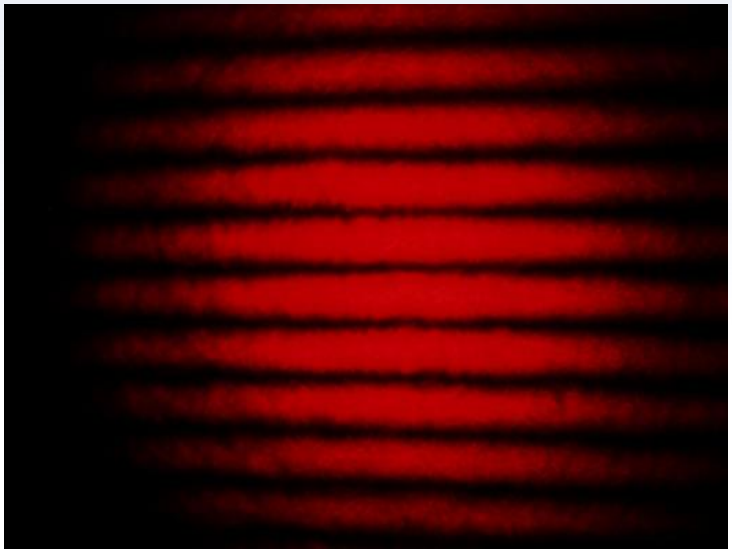
The Experiments

Atomic/Molecular/Optics (AMO)

- Berry's phase
- Quantum erasure
- Quantum Entanglement



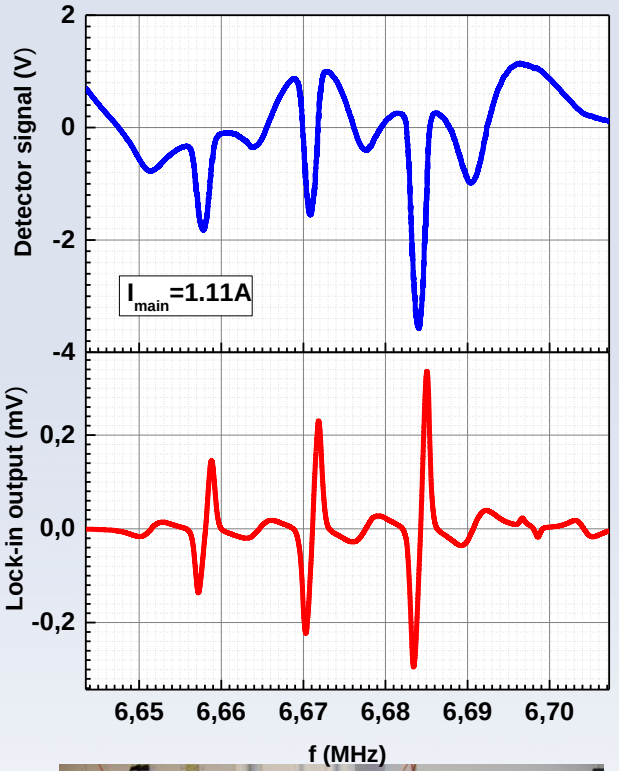


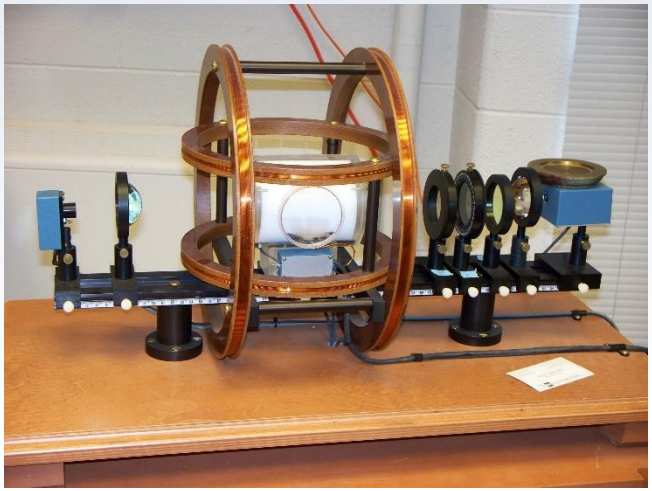


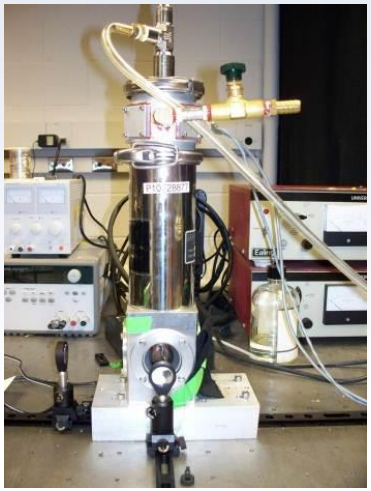
The Experiments

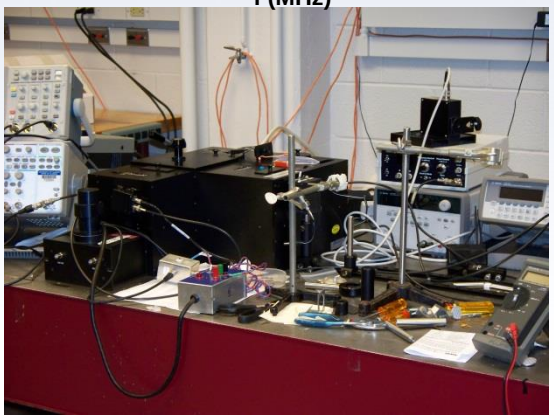
Atomic/Molecular/Optics (AMO)

- Optical pumping of rubidium gas
- Fluorescence spectroscopy



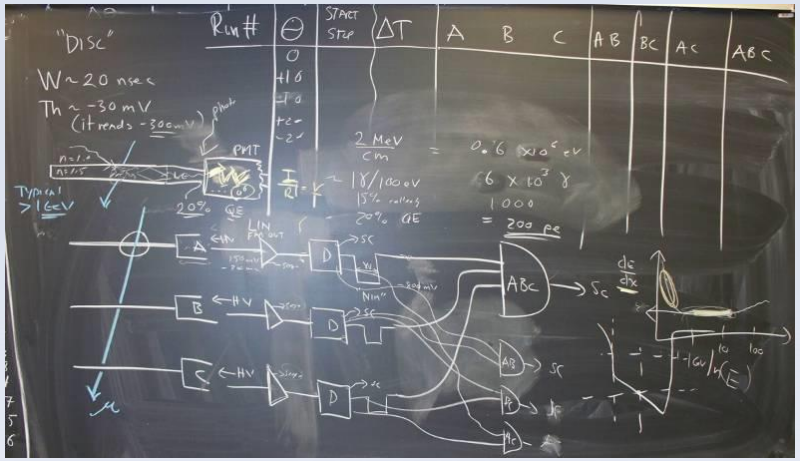






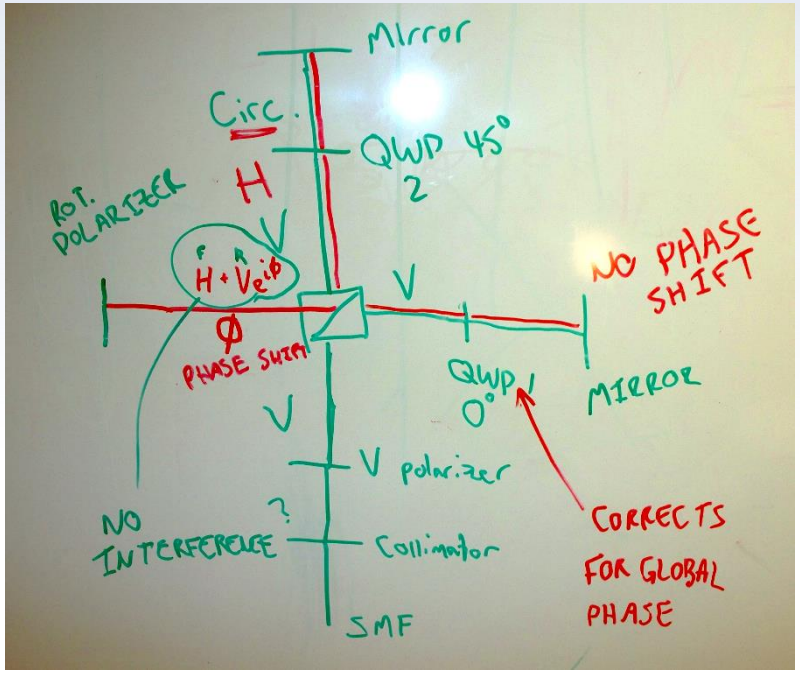
The “manuals”

- Many are just guides
- A only few purchased experiments have “real” manuals
- We serve as your guides … like real research



TEACH SPIN
Instruments Designed for Teaching

OPTICAL PUMPING OF RUBIDIUM OP1-A



Grading: Distribution of "1000" points

Item	Points
Expt. documentation: elog reports, shift summaries, plot quality; paper logbooks	120 Total 60 / cycle
Formal reports: physics case, quality of results, depth of analysis, conclusions	400 Total 100 / report
Oral reports: motivation, organization of presentation; fielding questions	150 75 / oral
Total	670

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

You can RESUBMIT one lab report to improve your grade (deadline for resubmissions August, 7 – reading day).

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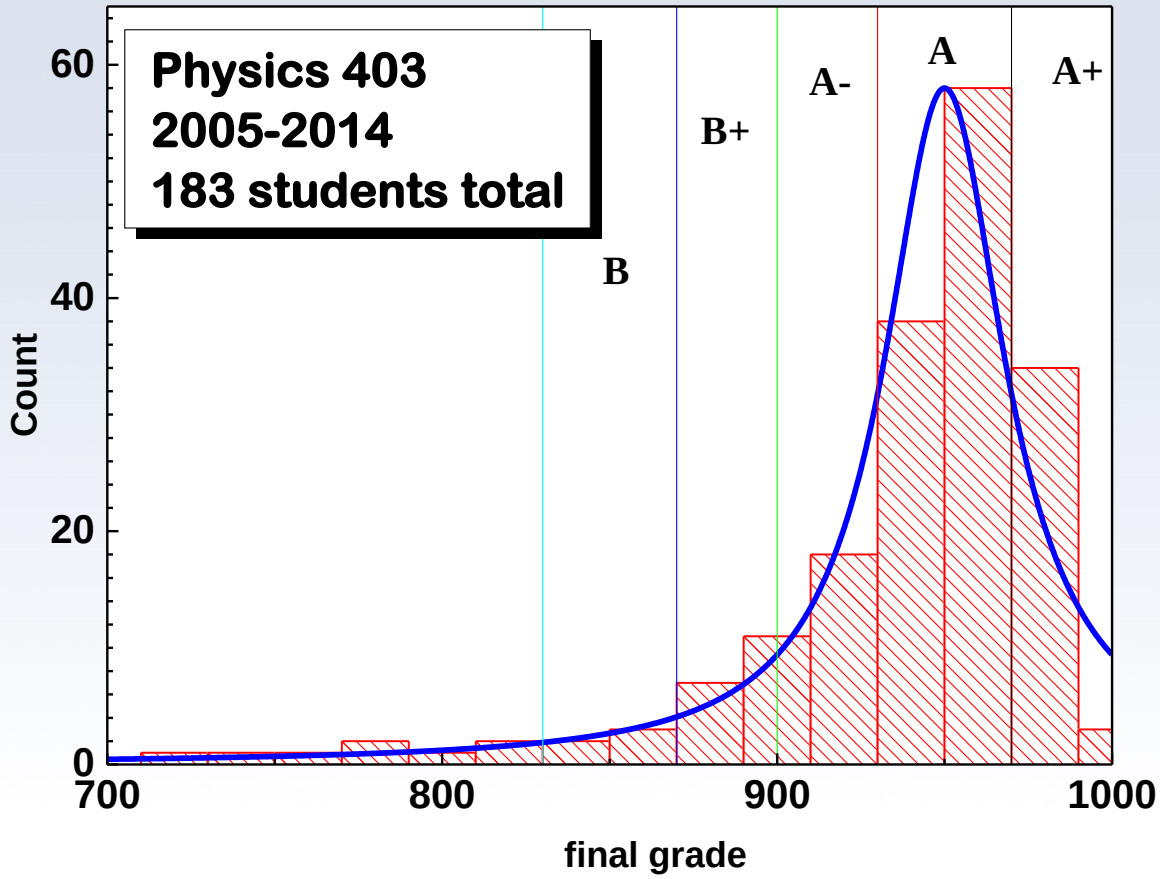
Grading: a piece of history and analysis of the results



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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

Absences

- If you are sick, let Eugene know by email. 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.

Late Reports

- **Policy for late reports**
  - You can have ONE "late ticket" for a "free" delay of up to 3 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.

Syllabus

Cycles

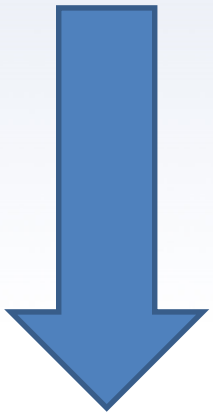
	Date	Day	Activity	Comment	Due	Note
1	6/16	Mon	Orientation	About Phy403 (ec)		
2	6/17	Tues	Cycle 1-1	OriginPro Intro		
3	6/18	Wed	Cycle 1-2	Elog Comments		
4	6/19	Thurs	Cycle 1-3			
5	6/23	Mon	Cycle 1-4	Lock-in Amps and FT		
6	6/24	Tues	Cycle 1-5			
7	6/25	Wed	Cycle 1-6	Written Reports		
8	6/26	Thurs	Cycle 1-7		Rotate	
9	6/30	Mon	Cycle 1-8	High Energy Physics		
10	7/1	Tues	Cycle 1-9			
11	7/2	Wed	Cycle 1-10	Error analysis		C1-Ex1
12	7/3	Thurs	Cycle 1-11			
13	7/7	Mon	Cycle 1-12	Oral Reports/Talks		
14	7/8	Tues	Cycle 2-1		Rotate	
15	7/10	Thurs	Cycle 2-2			
16	7/14	Mon		ORALS Cycle 1		
17	7/15	Tues	Cycle 2-3			C1-Ex2
18	7/16	Wed	Cycle 2-4	Optical spectroscopy		
19	7/17	Thurs	Cycle 2-5			
20	7/21	Mon	Cycle 2-6	Noise		
21	7/22	Tues	Cycle 2-7		Rotate	
22	7/23	Wed	Cycle 2-8	Measuring Temperature		
23	7/24	Thurs	Cycle 2-9			
24	7/28	Mon	Cycle 2-10	Ferroelectricity		C2-Ex1
25	7/29	Tues	Cycle 2-11			
26	7/30	Wed	Cycle 2-12	Entanglement		
27	7/31	Thurs		Working Day / Catch-up		
28	8/4	Mon		ORALS Cycle 2		
	8/7			READING DAY		C2-Ex2

Assignment of experiments

2 cycles with 2 experiments

➔ teams change after each experiment

➔ joint team reports and oral presentations



	Nuclear / Particle	Condensed Matter	Atomic + CM	Optics
	A. Cosmic Muon Stand i. Muon lifetime ii. Capture rate iii. Magnetic moment B. Alpha range C. Gamma Gamma D. Cosmic angular distribution	A. Ferro 1 B. Ferro 2 (imaging) C. 2nd sound of ^{4}He D. pNMR E. Hysteresis loops F. Tunneling G. AFM H. T calibration	A.Optical pumping B.Superconductivity C.Mutual inductance	A. Quantum Table i. Berry's phase ii. Quantum erasure iii. Entanglement B. Florescence spectroscopy
	Matthew	**Eugene**	**Eugene**	**Kevin and TA's from Kwiat Lab**
C1-1	1,2	3,4	5,6	7,8
C1-2	7,4	1,6	3,8	5,2
C2-1	6,5	8,2	1,7	4,3
C2-2	3,8	5,7	2,4	1,6

Safety is your responsibility !

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

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)

How to record 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
- Use a software drawing program to make a detailed sketch

How to record 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 data

- Many experiments require you to "change and measure" something by hand
  - Make a table in a paper logbook for this
  - Be prepared to state your measurement uncertainty
  - Make a "quick sketch" of your results by hand; then, enter the data in an electronic table and make a final plot
    - 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

How to record data

- 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.

(i) Your data, projects, tables etc

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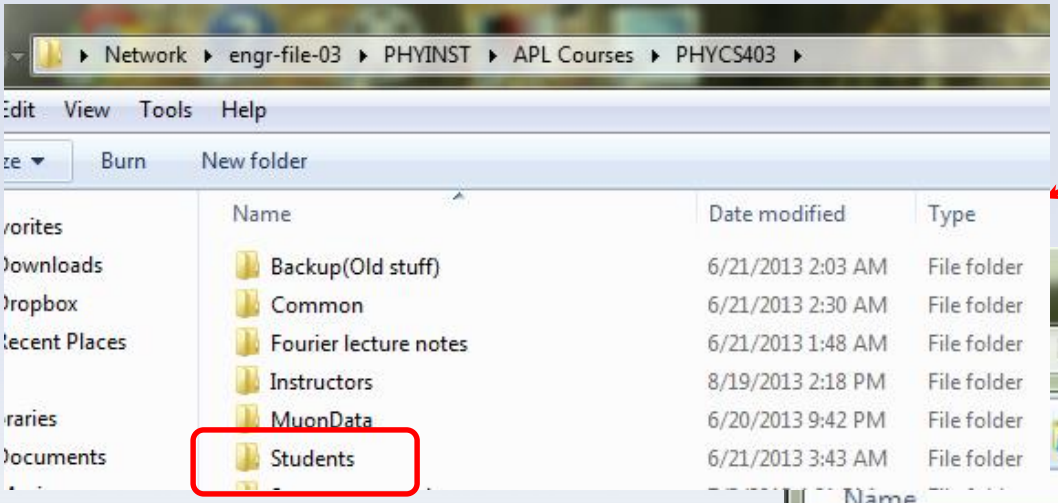
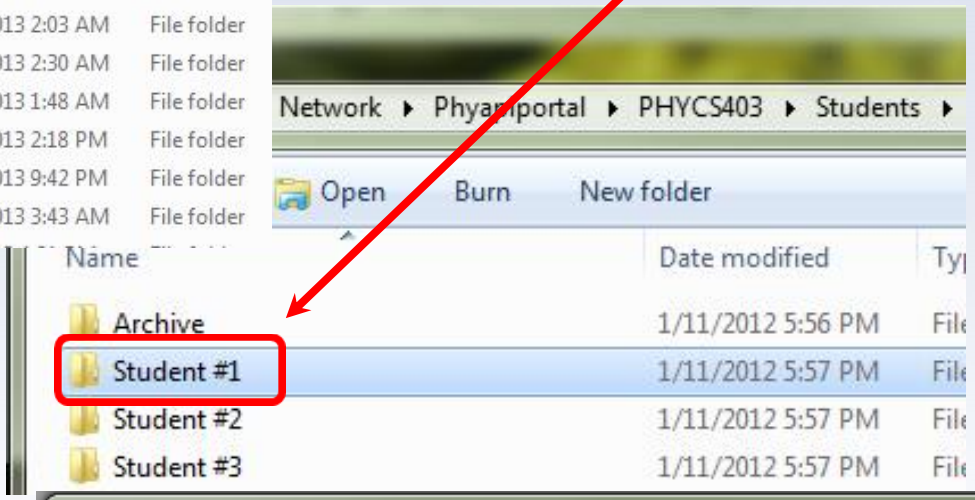
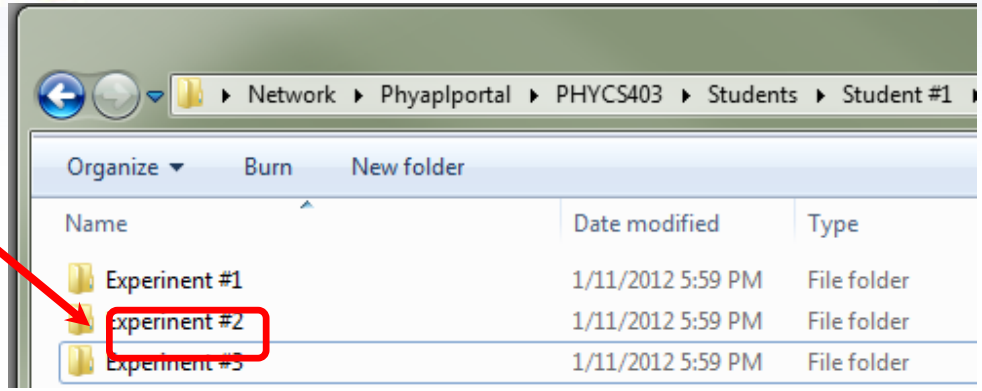


Make your own folder and put your work there



Store all experiment related materials in corresponding folder



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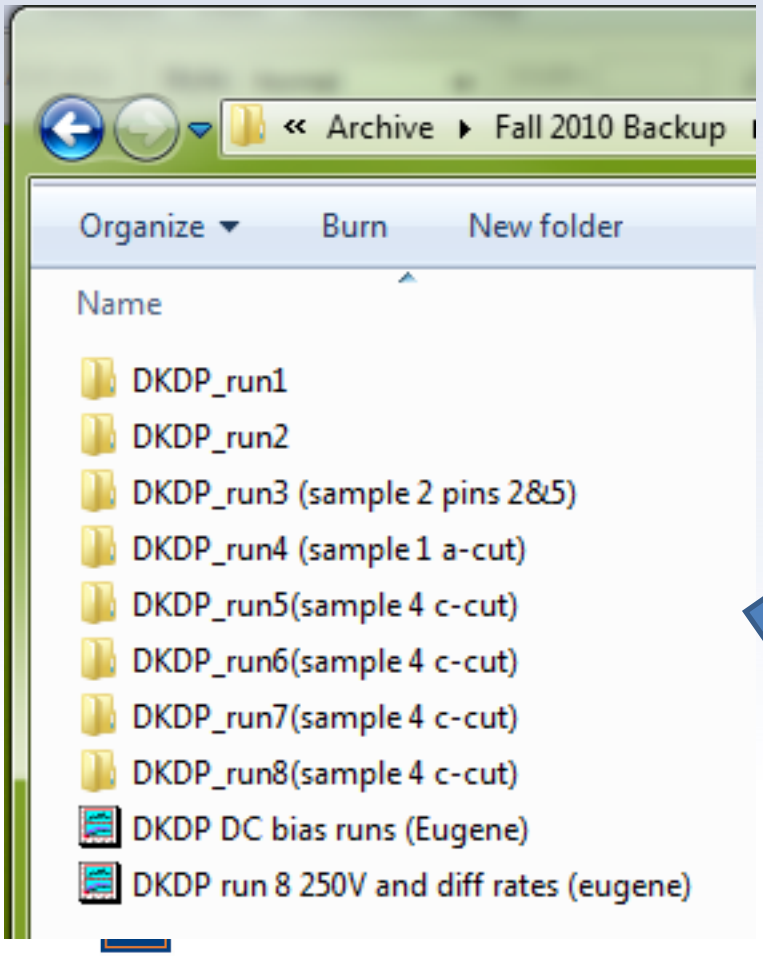
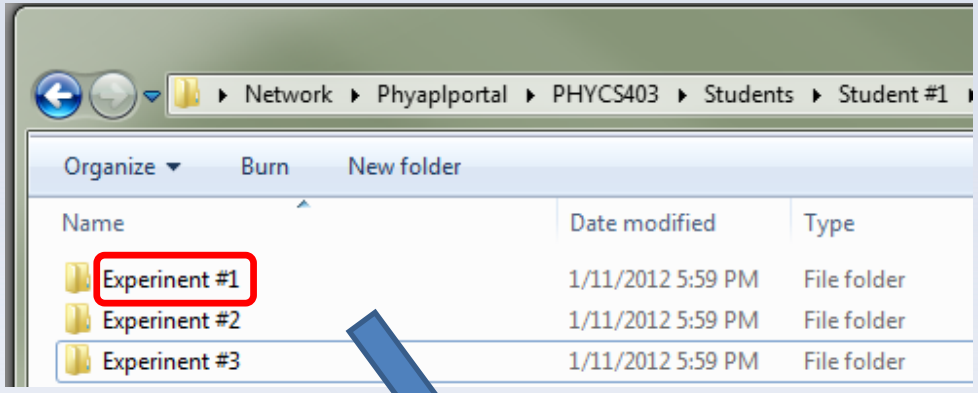
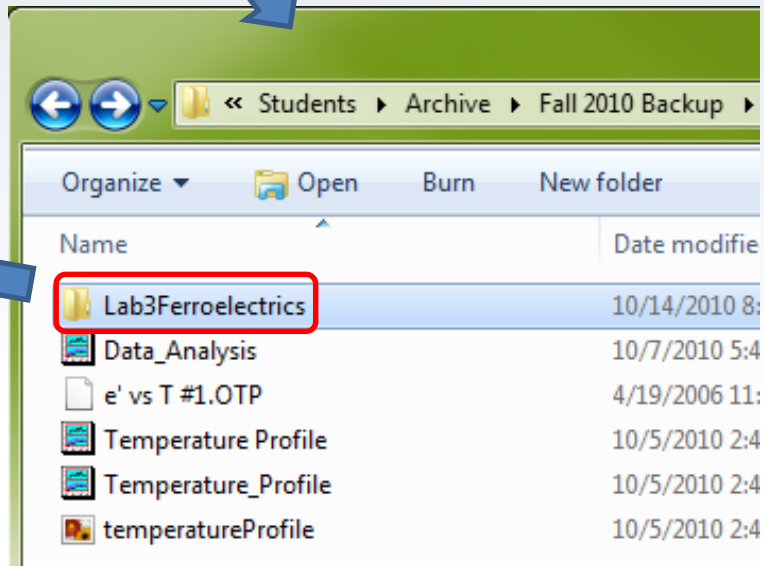
Where to exchange, store and retrieve course information. *(i)*
Your data, projects, tables etc

An example of the "smart" structure of folders containing the raw data and data analysis projects

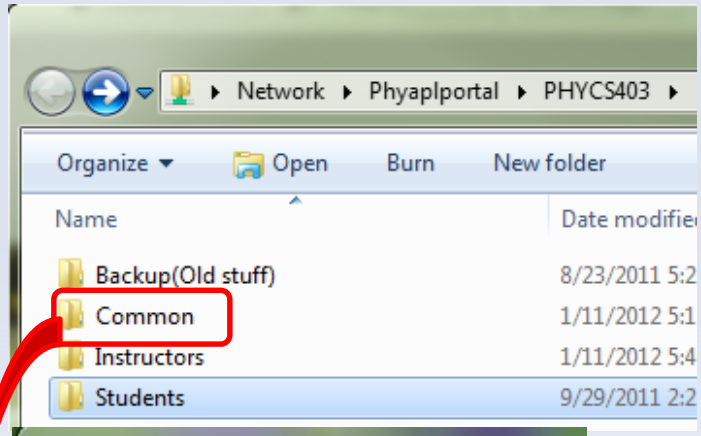


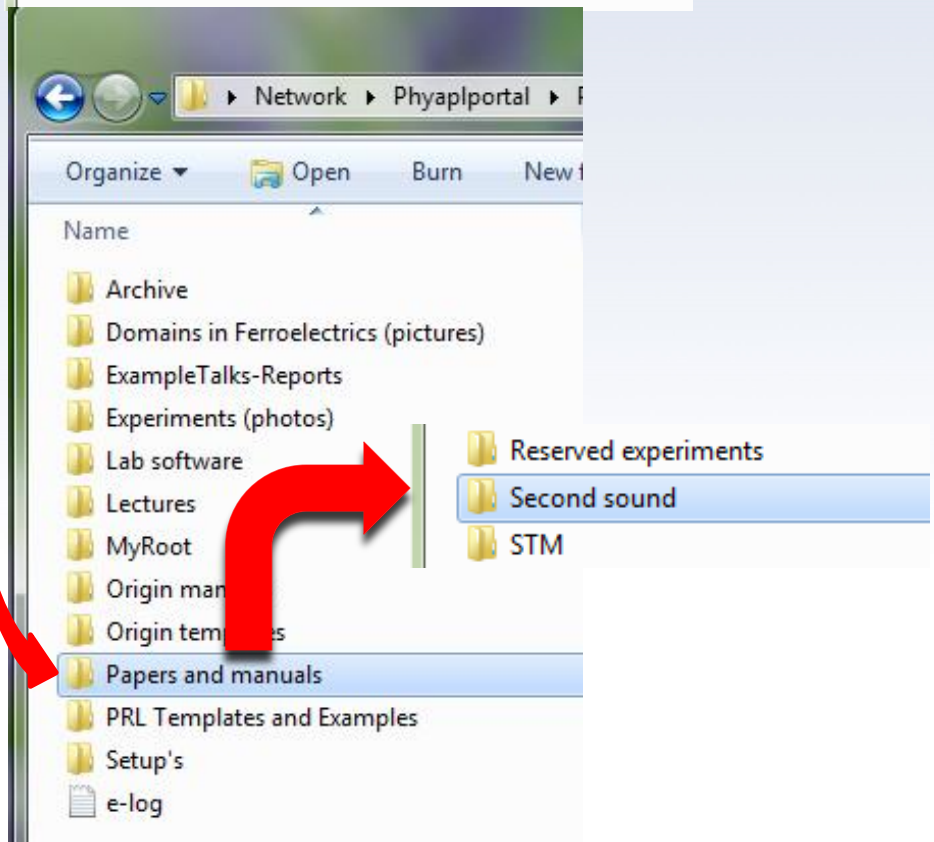


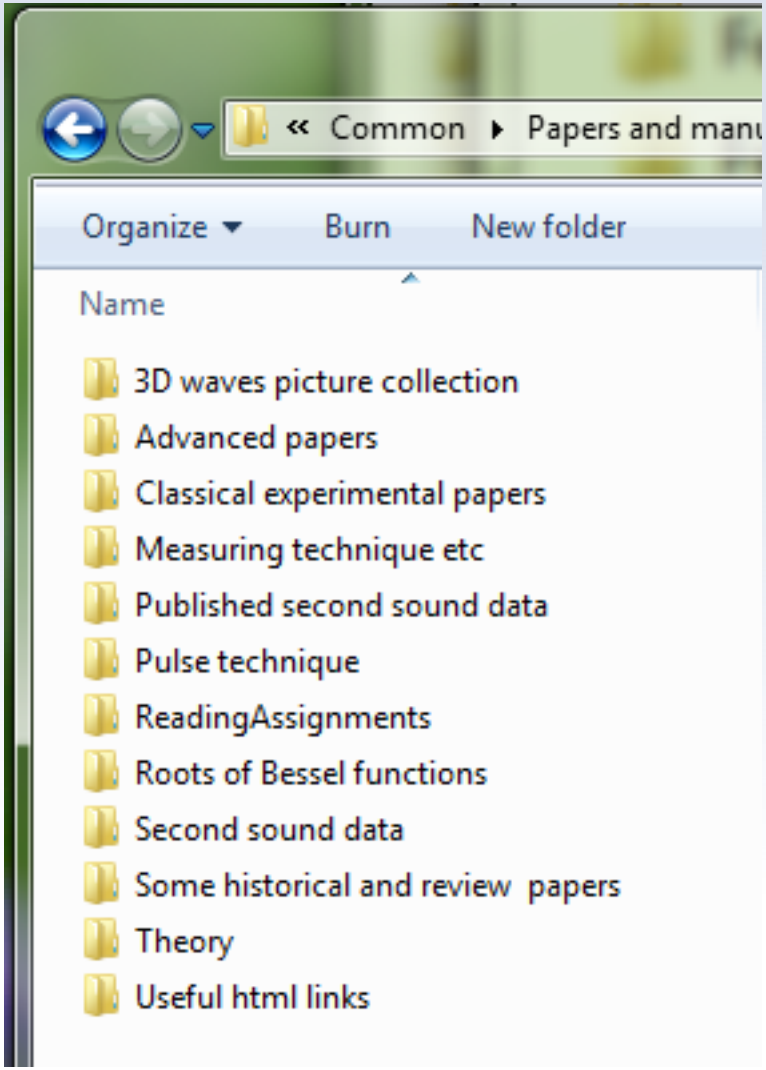


Where to retrieve course information.

Manuals, papers, setup diagrams and other useful materials

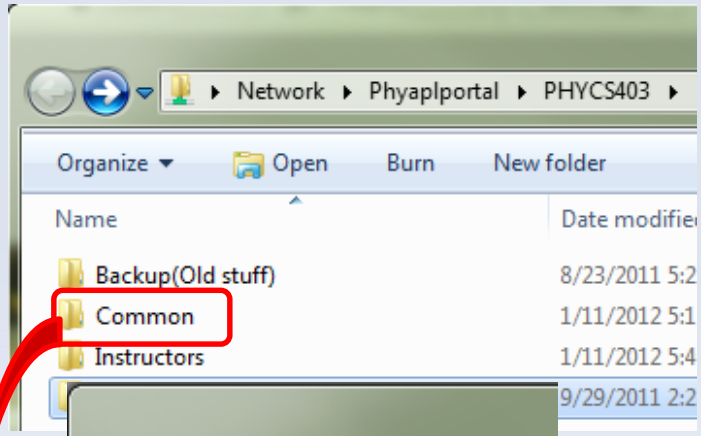


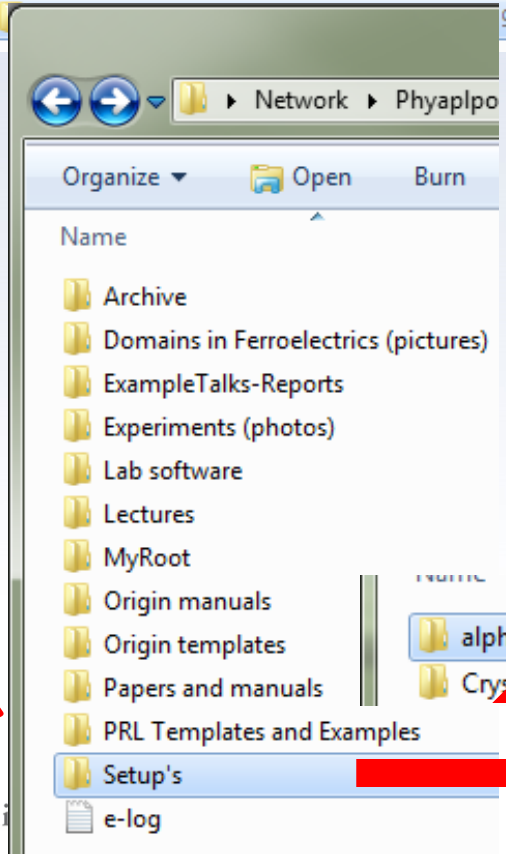


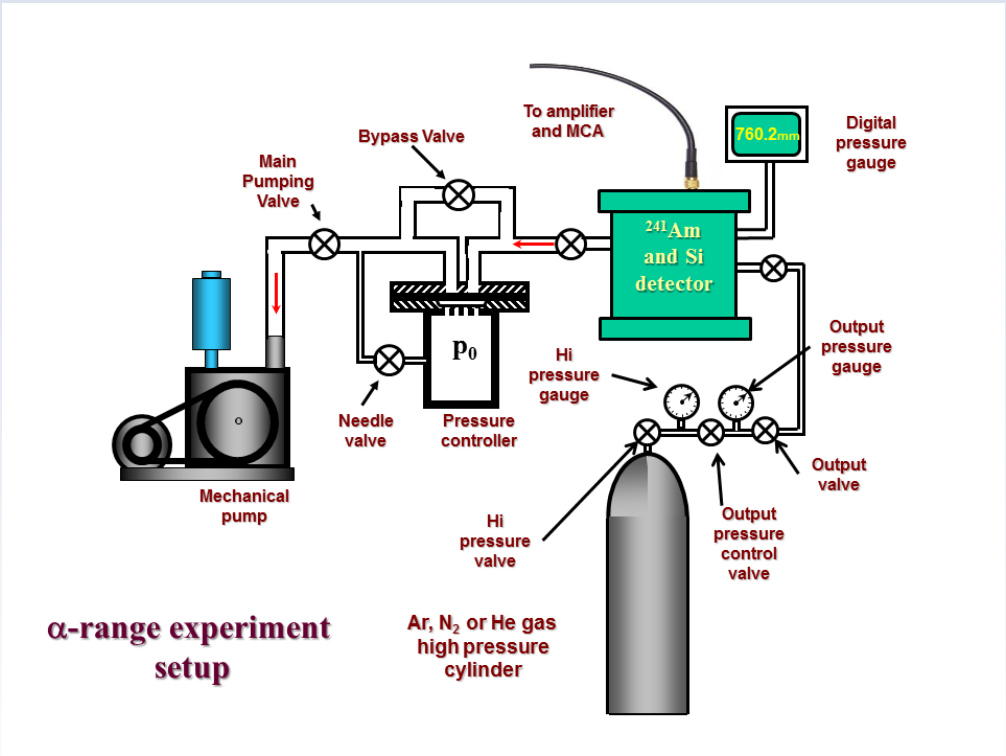


Where to retrieve course information.

Manuals, papers, *setup diagrams* and other useful materials



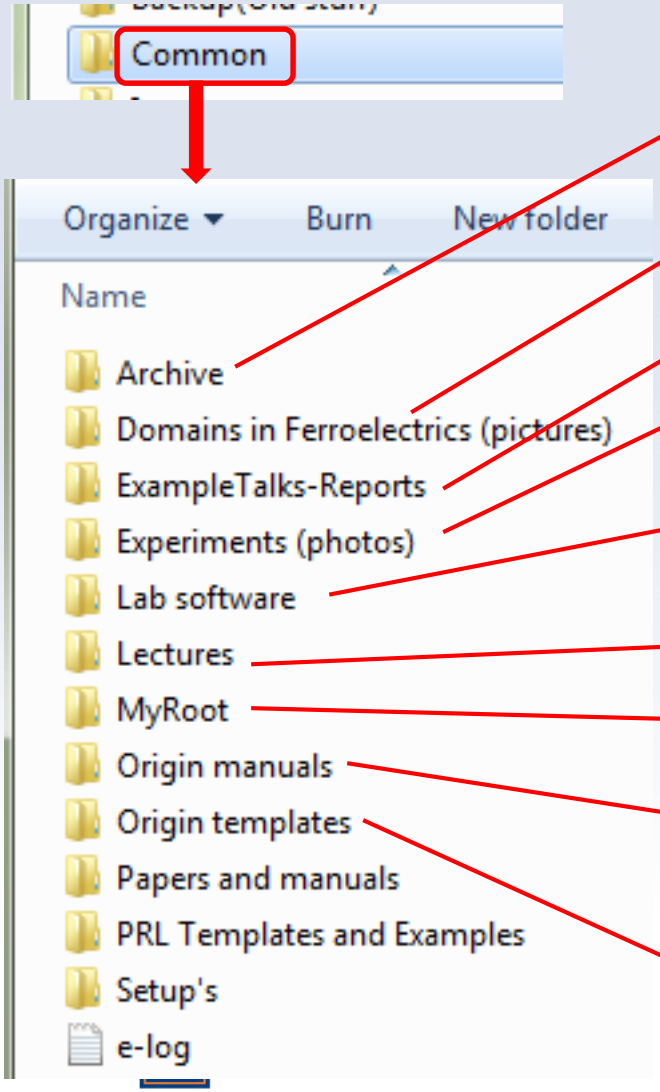




α-range experiment setup diagram

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

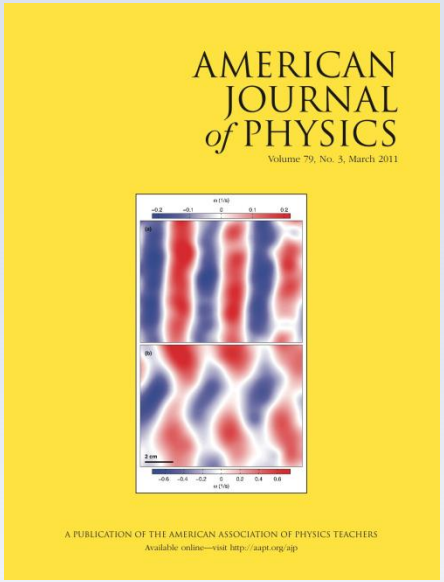
P403 lecture notes

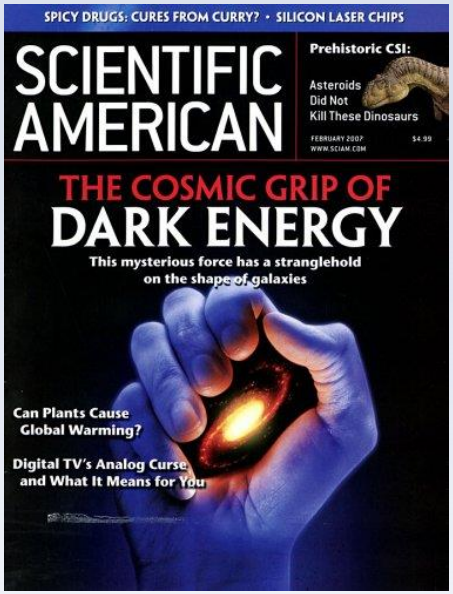
C++ scripts for Root

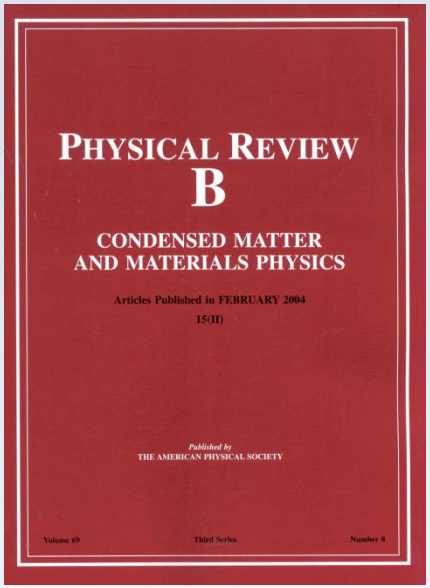
Origin manuals + a very compressed version written by Eugene

Origin templates (how to use them will be discussed in next lecture)

"Journal club"







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

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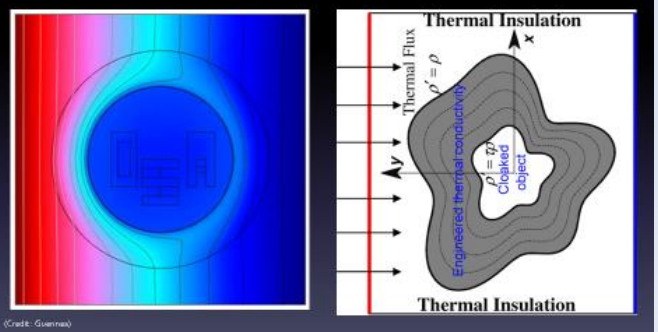
Walking with Coffee: Why Does it Spill?

Fabrication and Characterization of Ultrathin Three-Dimensional Thermal Cloak



Student #1

University of Illinois at Urbana-Champaign

Supersolid Helium?

Student #2

References

1. E. Kim and M. H. W. Chan, "Probable Observation of a Supersolid Helium Phase," Nature 427, 225 (2004); E. Kim, "Observation of Superflow in Solid Helium," Science 305, 1941 (2004).
2. H. J. Maris, "Effect of Elasticity on Torsional Oscillator Experiments Probing the Possible Supersolidity of Helium," Phys. Rev. B 86, 020504 (2012).

Displacement of entanglement back and forth between the micro and macro domains

Article from Nature Physics
-Volume 9, September 2013-

Presentation by Student #3
September 19, 2013

e-logs: First a brief tour …

http://www.npl.illinois.edu/elog/modphys/

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 a temporary folder on your desktop.**
- **Near the end of the class, make a "Shift Summary" providing a rather complete overview of the highlights of your work. There, you can upload your plots, scope shots, etc. and describe the data**

Entering the e-Log …
(at this point, you need to work on a computer)

Registering as a new user

•Go to
http://www.npl.illinois.edu/elog/modphys/Modern+Physics+Laboratory+Fall+2013+Semester/
•Click "Register as new user" on the bottom right

•Fill in information for login name, Full Name, e-mail address, and password
PASSWORD IS NOT SECURE, DO NOT USE A "SENSITIVE" PASSWORD

•Click "Save" in the upper left hand corner

e-logs: Making a post …

- Create a New Post
- To create a new post, click "New" from the menu bar.
- Fill in the Author, Experiment, Post Type, and Subject
  - If the post is written by more than one person, use a comma separated list.
  - Be sure the Author name is the same you used when registering so that you can edit/delete the post if necessary.