Physics 307L

Spring 2021

Prof. Darcy Barron

Course webpage

https://ghz.unm.edu/juniorlab/

Will post course materials, experiment descriptions, schedule, etc to this wiki

Some content (lectures) will post to Microsoft Teams

Please check your email regularly for course announcements and updates.

Contact information

Instructor: Prof. Darcy Barron

Email: dbarron2@unm.edu

Office: 3216 PAIS

Office Hours by appointment

TA:	Duncan McGraw	mcgrawd@unm.edu
Lab manager:	Youngwoo Yi	yyi@unm.edu

What is this class?

Physics is a science, so it is based on experiment and observation.

Research physicists do experiments, make measurements, and analyze the results. This course is meant as an introduction to modern experimental techniques.

In this course you will:

- apply the theory you have learned in the real (experimental) world
- learn how to use various types of hardware, instrumentation, and software
- learn basic statistics, error analysis, and determination of statistical and systematic errors;
- perform the best possible (i.e. the most precise and accurate) experiment within the constraints of the available resources (equipment, time, etc.) - just like in real research!

Grading

- In-class participation and performance 25%
  - Includes lecture and lab session
- Lab Notebook 25%
- Formal Reports and Presentations 50%

Challenging Modern Physics experiments

These require independent problem solving – harder than intro physics labs

10 experiments

0) Intro (RC Circuits, the oscilloscope, Chua's Circuit)

1) Speed of Light
2) Poisson Statistics

3) Balmer Series

4) Planck's Constant
5) Compton Scattering
6) Electron Diffraction
7) Ratio e/m
8) Franck-Hertz experiment
9) Electron spin resonance
10) Millikan oil drop: electron charge

Grading - participation and performance

- Lecture attendance and participation
- Lab session attendance
- Successful completion of intro + 6 experiments

Grading – lab notebook

- This notebook is a diary of all your lab work
- Information is recorded as it is done, including include everything about the work so that another person can read the notebook and know exactly what was done (or so you can reproduce it)
- https://phys.libretexts.org/Bookshelves/Ancillary_Materials/Demos%2C_Techniques%2C_and_Experiments/The_Laboratory_Notebook
- http://pmaweb.caltech.edu/~phy003/notebooks/notebooks.html

Grading – formal reports and presentations

- Lab notebook is a chronological record of what was done
- Lab reports are a re-organized, structured report about what was done and what was found
- You will need to submit 3 formal reports and give 3 presentations (on separate experiments)
- Lab reports are written in the style of a scientific paper
- Presentations will be in the style of a conference talk

Overall Schedule

- You are expected to show up well-prepared for the lab sessions
- During the lab session, you will keep a lab notebook, make measurements, do some preliminary data analysis
- The instructors will be available to help you make progress and answer any questions
- More detailed data analysis, and writing of lab reports and presentations will be done outside of the lab session

In-person lab sessions

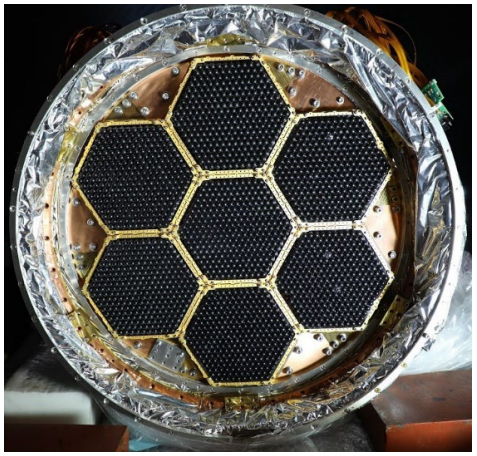
- All students must wear an acceptable face mask at all times, and maintain a distance of 6 feet from other people
- Since we will be spending multiple hours in a shared, poorly ventilated workspace, you should wear a comfortable and high-quality face mask to protect yourself, your classmates, and your community.
- You must sanitize your work station at the end of class.
  - Cleaning supplies will be provided
- Bring Back the Pack Website: https://bringbackthepack.unm.edu/academics/student-guide/index.html
- You should be receiving daily covidscreen emails, and everyone must complete these BEFORE coming to campus
- If you cannot come to campus, please let me know as soon as possible and we will make accommodations.
- No eating or drinking allowed in the lab

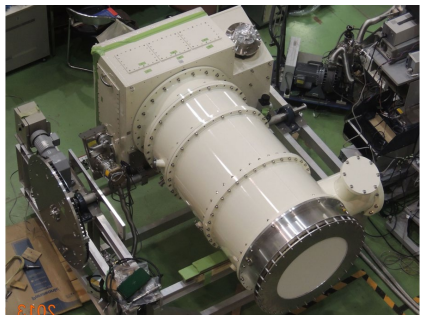
Remote Lectures and Lab Sessions

- We will use Microsoft Teams for remote lectures, and for remote lab sessions
- You can access Teams via web, desktop application, or phone app, logged in with your UNM credentials
- The class space in Teams is always open and available
- Use @ to mention someone directly in a channel, and they will get a notification.
- Everyone can see messages in all the channels
- You can use the “Chat” to privately message someone, including the instructors

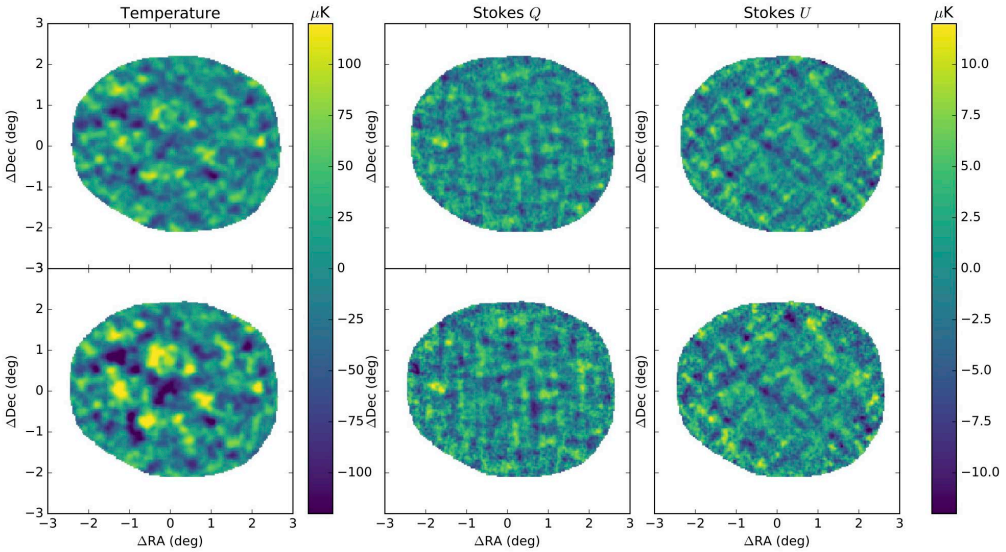
Cosmology with POLARBEAR and Simons Array

Prof. Darcy Barron





POLARBEAR/Simons Array is an experiment located in the Atacama desert in Chile, designed to map the cosmic microwave background's B-mode polarization signal. This faint pattern arises from gravitational lensing of the CMB, and is a powerful probe to study the composition and large-scale structure of the universe. A unique B-mode polarization pattern would also be imprinted by inflationary gravitational in the early universe. Measuring this signal would provide direct evidence for inflation, as well as provide insight into the mechanism and energy scale of inflation.



Keeping A Lab Notebook

- Keeping a detailed lab notebook will count for 25% of your grade in this course
- What to include?
  - What you did
  - How you did it
  - Why you did it
  - Why it was different than what was expected/calculated
- Order should be chronological, can leave some space to add in info later (add in a later printout, finish a calculation later)

Purpose of lab notebook for this class

- To communicate to the instructors how you performed an experiment and what result you got (and why)
  - Should re-create exactly what you did from your notes
  - Should be able to answer questions about what you did that day at the end of semester, based on lab notebook
  - **Should stand independent of provided experiment info**
- To document for yourself what you did, especially between lab sessions
  - Especially important if you need to come back and take more data
  - Order of notebook should be mostly chronological, and need to have clearly separated sections for each experiment
- To practice scientific documentation

Other purposes of lab notebooks

- Used for strict record-keeping for certain kinds of scientists, especially for patent verification
- Shared documentation in a collaboration
  - Shared lab notebook for an experimental setup
- Long-term record keeping
  - In graduate school and beyond, experiments last for months and years, and need to have a system to record all relevant information (not just important information)
- Reproducibility
  - For others, or for yourself (how did I do that?)
- Historical records

What format to use?

- Handwritten notebooks still have advantages over digital notebooks, but it usually depends on the context
- In normal semesters, you would use 100% physical lab notebooks, with some content printed and taped into the notebook
- For this semester, you can use a combination of physical and digital notebook (appropriately cross-referenced), or 100% digital (not recommended)

Why a handwritten notebook?

- An extremely “portable” format
- Encourages you to be selective and thoughtful about what is recorded
- Can include a wide variety of information (drawings, tables, printed photos, hand-drawn plots, printed plots, calculations, etc)
- Be sure to include references to any relevant data files, programs, etc!
- You will need to turn in legible scans or photos of your handwritten notebook

Why a digital notebook?

- Can be easier to organize or easier to find information (search, hyperlinks, cross-index, etc)
- Easier to include detailed data analysis information, including code snippets, plots
- More easily shareable
- For remote lab sessions, you will use Microsoft Team's Class Notebook, which is similar to OneNote
- Your class notebook is viewable by the instructors at all times, which helps us 'look over your shoulder' and make sure you are on the right track (just like in-person lab)

Lab Notebook Grading Rubric

Category	Proficient (2)	Developing (1)	Insufficient (0)	Weight	Score
Organization and Presentation	Experiment contains a title and clearly labeled sections with date. All observations, recorded data, and calculations are clearly labeled and legible.	Experiment is missing a key section, or insufficient detail is given for context. Some sections are not clearly labeled.	Experiment is missing or doesn't clearly label more than one key section (intro, procedure, data). Multiple sections are not labeled or not legible to reader.	x1	
Description of experiment	Procedure is clearly described in detail with figures (diagrams, cartoons, photos) to complement text to aid in understanding and reproducing setup.	Procedure is adequately described but missing key details	Procedure is not described in sufficient detail to understand basic elements of setup. Reader is unable to understand experiment without lab manual information.	x2	
Answers to questions from lab write-up	Correct and complete answers to all questions from lab write-up, including brief context for question.	All questions from lab write-up are answered but some answers are incomplete or incorrect.	Missing answers to questions from lab write-up, or mostly incomplete, incorrect answers without any context for answer.	x2	
Data collection	All data is recorded and neatly presented, including units and appropriate number of significant figures.	Data is recorded but is not presented neatly or is sometimes missing units and appropriate significant figures.	Recorded data is not present or illegible, completely unlabeled, missing units and appropriate significant figures.	x2	
Analysis	Methods of analysis are described with appropriate detail. Calculations and graphs are explained and labeled appropriately. Sources of error are explained and quantified.	Data analysis methods are not explicitly recorded or described. Incomplete calculations, or incomplete graphs of data. Sources of error are included but not described or quantified in sufficient detail.	Data analysis is not included. Calculations are missing. Graphs are missing or incorrect. Sources of error are not explored.	x3	

Lab Notebook Resources

- http://www.unm.edu/~mph/307/notebook.pdf
- http://web.mit.edu/me-ugoffice/communication/labnotebooks.pdf
- https://phys.libretexts.org/Bookshelves/Ancillary_Materials/Demos%2C_Techniques%2C_and_Experiments/The_Laboratory_Notebook
- http://pmaweb.caltech.edu/~phy003/notebooks/notebooks.html

Uncertainty and error analysis

- In this class, and in real research, making the measurement is only part of the effort.
- Lab notebook – record enough detail so that someone can reproduce your results
- Lab report – disseminate your results
- Talk – publicize your results

- Error analysis – convince other scientists that your results are valid

Uncertainty and error analysis

- The textbook for this class is an important reference for understanding and calculating uncertainties
  - Taylor, An Introduction to Error Analysis
- We will discuss some content from the textbook during lectures, but you will also be expected to use it and other references to determine and complete the appropriate error analysis techniques for your unique experimental data set
- For review, see the pdf linked on the class webpage titled ‘Uncertainty’ – from UNM lower-level physics lab manual

This week

- Complete the pre-class survey
- Complete lab safety trainings and email certificate of completion
  - Bringing Back the Pack (Infectious Disease safety)
  - Laser Safety Training, UNM Physics and Astronomy
  - Radiation General Awareness
  - Email me if you aren't able to access Learning Central
- Review the syllabus and lab notebook rubric
- Review 'Uncertainty' (from Physics 1 lab manual)
- Lab Session – Intro – Oscilloscopes and RC Circuits

Any questions?