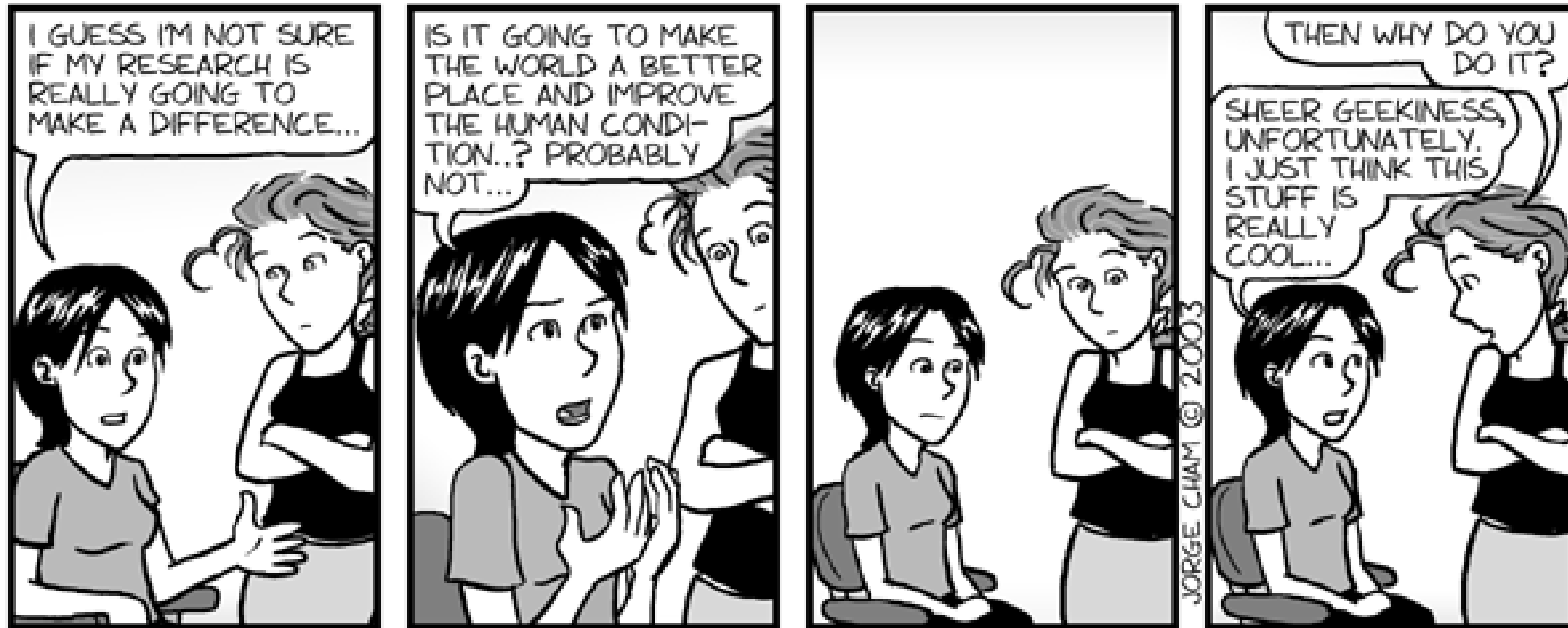


# Research in Physics for CWRU Undergraduates



*Presented by G. Chottiner, Professor of Physics, [gsc2@case.edu](mailto:gsc2@case.edu)*

*October 19, 2020, ~18 slides*

# Why do Research in Physics?

- Research expertise is a formal goal of a physics education at CWRU.

We are not a History of Physics department!

Although you CAN do research in the history of physics!

Graduate Program in the History of Science, Technology, Environment, and Medicine <https://history.case.edu/graduate/history-stem/>.

Research is expected of seniors & common for underclassmen, even first- year students.

- We train our majors to broaden the boundaries of knowledge.
  - Lecture courses provide necessary background knowledge.
  - Laboratory courses (~ 4 advanced labs ≠ intro labs) focus on research skills.
  - Departmental Seminar (PHYS 352) develops professional competencies.
  - Senior Capstone (PHYS 351/353) provides real research experience.
  - **Don't base your attitude about physics on intro physics courses & labs!**
- Research experience is important in physics graduate school admissions.

Letters of Recommendations from research mentors can outweigh GPA's.

# PHYSICS RESEARCH AREAS at CWRU

<https://physics.case.edu/research/>

- Nanoscale / Quantum Materials (Condensed Matter Physics)
- Biophysics / Soft Materials
- Cosmology /Particle-Astrophysics
- Check out individual faculty at <https://physics.case.edu/directory/faculty/> like
  - <https://physics.case.edu/faculty/jesse-berezovsky/>
  - <https://physics.case.edu/faculty/lydia-kisley/>
- A wide variety of jobs! <https://physics.case.edu/hsstudent-info/physics-majors-where-did-they-go-from-here/>  
Physicists do research and find jobs in a wide variety of fields.

# Identifying a Research Mentor

- Contact physics faculty members. (*Do your research about them first.*)
- Take PHYS 166 Physics Today and Tomorrow

“This course will provide students with an opportunity to learn about the most exciting and timely research areas in physics, as well as other topics germane to being a professional physicist. These discussions will cover fields such as nanoscience, ultrafast optics, exotic materials, biophysics, cosmology, string theory and the role of physicists in developing new technologies. Each week a member of the faculty will meet with students to discuss a topic of current interest, how a physicist approaches the problem, and how physicists interact with others to find a solution.”
- Talk to other students.
- **Declare a major in physics!** (You are not a major until you submit the form.)

[https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2020-09/Major%20Declaration-Change%20Form\\_Fa20\\_FILLABLE\\_0.pdf](https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2020-09/Major%20Declaration-Change%20Form_Fa20_FILLABLE_0.pdf)

# Identifying a Research Field

- Seminars (aimed at experts, including undergraduates involved in research):  
<https://physics.case.edu/event-archive/fall-2020-condensed-matter-seminars/>  
<https://physics.case.edu/event-archive/fall-2020-particleastrophysics-and-cerca-seminars/>  
<https://physics.case.edu/event-archive/biophysics-biomath-colloquia/>
  - Colloquia (aimed at new graduate students but useful for undergraduates, intro to a field):  
<https://physics.case.edu/event-archive/fall-2020-colloquia/>
  - Physics Department home page with news feeds, Facebook & Twitter:  
<https://physics.case.edu/>
  - Sign up for PHYSBOT to receive automated notifications. Email [Physbot@narya.phys.cwru.edu](mailto:Physbot@narya.phys.cwru.edu) with the topic ‘subscribe’.
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# Summer Research

- **SOURCE**

- Science, Technology, Engineering and Mathematics (SOURCE STEM)  
<https://case.edu/source/find-programs-and-funding/source-funded-programs/source-stem>
- Summer Undergraduate Research in Energy and Sustainability (SUREs)  
<https://case.edu/source/find-programs-and-funding/source-funded-programs/summer-undergraduate-research-energy-and>

- **NSF REU** <https://www.nsf.gov/crssprgm/reu/>

- 67 Physics Sites [https://www.nsf.gov/crssprgm/reu/list\\_result.jsp?unitid=69&showItems=All](https://www.nsf.gov/crssprgm/reu/list_result.jsp?unitid=69&showItems=All)
- 71 Materials Research Sites [https://www.nsf.gov/crssprgm/reu/list\\_result.jsp?unitid=5052&showItems=All](https://www.nsf.gov/crssprgm/reu/list_result.jsp?unitid=5052&showItems=All)
- List of REU experiences for CWRU physics majors is on an upcoming slide.
- Misc. other research areas: [https://www.nsf.gov/crssprgm/reu/reu\\_search.jsp](https://www.nsf.gov/crssprgm/reu/reu_search.jsp)

Physics is an excellent entrée into diverse STEM disciplines ~ acoustics, climate science, oceanography, quantum information, artificial intelligence, etc.

- **CWRU P. I. (Principal Investigator) Grants** (NSF encourages undergraduate research)

# Mechanisms to Pursue Research in Physics at CWRU

- Work for pay (~ \$10 per hour) in a research lab (or with a theorist).
  - Work for course credit
    - See <https://casgroups.case.edu/physics-senior-projects/physics-390/> for details.
  - Volunteer work
  - Senior Projects
    - See <https://casgroups.case.edu/physics-senior-projects/senior-project-instructions/> for details.
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# Examples of Senior Projects

- This year: <https://casgroups.case.edu/physics-senior-projects/senior-projects-class-of-2021/>
- Previous 20 years (VPN required): <http://www.phys.cwru.edu/undergrad/Senior%20Projects/PhysicsSeniorProjectArchive.html>
- Note the posters & papers available for most.
- These projects are not just for seniors!

Many represent continuation of work started one or more years earlier.

- Physicists & physics students can work in almost any field. A few (of ~ 400 examples):
  - Ryan Buechele with J. Berezovksy; [A Renormalization Group Theory Approach to Ordered Phases in Music](#)
  - Samuel Ehrenstein with M. Bayat (*EECS*): [Ultrasonic Microvessel Imaging Using Machine Learning](#)
  - Hannah Messenger with L. Kisley: [Modeling the Single Molecule Microscopy Detection of Iron Corrosion](#)
  - Kyle Montiel with I. Martin & C. Taylor: [Culture Change for Climate Change](#)
  - Reid Bolding with P. Thomas (*MAMS*): [Predicting Muscle Forces from Neural Activity](#)
  - Gundeep Singh with M. Hinczewski: [Machine Learning to Match Paintings to their Artists Using Variation in Brushstroke Styles](#)
  - Tessa Stevens with W. Zhang (CSU Mech, Engr.): [Dynamics of Ballooning Spiders](#)



# Undergraduate Publications

See <https://casgroups.case.edu/physics-senior-projects/publications-with-undergraduate-authorship/>

*The undergraduate author is marked by an asterisk\* (updated January 9, 2020)*

- Benthara Hewage Dinushi Jayatunga, Md Rezaul Karim, **Rebecca A. Lalk\***, **Okey Ohanaka\***, Walter R.L. Lambrecht, Hongping Zhao and Kathleen Kash, “Metal-Organic Chemical Vapor Deposition of ZnGeGa<sub>2</sub>N<sub>4</sub>”, Cryst. Growth Des. 20, 1, 189-196, Nov. 27, 2019. <https://doi.org/10.1021/acs.cgd.9b00995>.
- Kai Ke, Michael McMaster, **William Christopherson\***, Kenneth D Singer, Ica Manas-Zloczower, “Highly sensitive capacitive pressure sensors based on elastomer composites with carbon filler hybrids,” Composites Part A: Applied Science and Manufacturing 105614 (2019).
- Kai Ke, Michael McMaster, **William Christopherson\***, Kenneth D Singer, Ica Manas-Zloczower, “Effects of branched carbon nanotubes and graphene nanoplatelets on dielectric properties of thermoplastic polyurethane at different temperatures,” Composites B: Engineering, 166, 673-680 (2019).
- Michael McMaster, Fei Liu, **William Christopherson\***, Richard A Gross, Kenneth Singer, “Switchable Liquid Crystal Composite Windows Using Bacterial Cellulose (BC) Mat Substrates,” ACS Applied Bio Materials, 1(4), 636-640 (2019).
- Mohamed ElKabbash, Ermanno Miele, Ahmad K. Fumani, Michael S. Wolf, Angelo Bozzola, **Elisha Haber\***, Tigran V. Shahbazyan, Jesse Berezovsky, Francesco De Angelis, and Giuseppe Strangi, “Cooperative Energy Transfer Controls the Spontaneous Emission Rate Beyond Field Enhancement Limits”, Phys. Rev. Lett. 122, 203901 – Published 22 May 2019, <https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.122.203901> .
- Sai Lyu, **Yuheng Liu\*** and Walter R L Lambrecht, “First-principles calculations of phonon derived Raman and infrared spectra in Be-IV-N<sub>2</sub> compounds” J. Phys. D: Appl. Phys. 52 , 385106 (2019) <https://doi.org/10.1088/1361-6463/ab2c90>.
- I. Zehavi, **S.E. Kerby\***, S. Contreras, E. Jimenez, N. Padilla, C.M. Baugh, “On the prospect of using the maximum circular velocity of halos to encapsulate assembly bias in the galaxy-halo connection”, ApJ, submitted (2019); <https://ui.adsabs.harvard.edu/abs/2019arXiv190705424Z/abstract>.

# Survey of Research Experiences

40 physics majors replied to an August 2018 survey about research experiences the previous year.

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- 31 sought a research position the previous year.
  - 26 found at least one research position.
  - 20 were compensated (financially) for their research.
  - 1 earned course credit.
  - 13 found two different research positions ~ 1 at CWRU + 1 REU.
  - 11 did experimental work, 9 were computational, 1 was theoretical, 5 were ‘other’.
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# Examples of Research Experiences, CWRU Mentors

**CWRU Physics:** Profs. Kenneth Singer, Rolfe Petschek x 2, Kathleen Kash, Idit Zehavi, Corbin Covault, Michael Hinczewski, Giuseppe Strangi, Xuan Gao, Glenn Starkman x2, Ben Monreal x2, Harsh Mathur

**CWRU Astronomy:** Profs. Mihos, McGaugh & Morrison

**CWRU Geological Sciences:** Prof. Hauck, Li

**CWRU mechanical and aerospace engineering:** Dr. Alexis Abramson

**CWRU Interactive Commons:** Dr. Mark Griswold, BME & SOM

**CWRU math:** Dr. Zhao

**CWRU Department of Physiology and Biophysics:** Dr. Julian Stelzer

**CWRU Physiology and Biophysics:** Dr. Mukesh Jain

# Examples of Research Experiences, External Mentors

NSF REU at the Smithsonian Astrophysical Observatory with Drs. Yuanyuan Su and Felipe Andrade-Santos

Rutgers, Dr Andrew Baker

University of Illinois at Urbana-Champaign REU, Dr Jeff Filippini

University of Tokyo, School of Engineering, Department of Applied Physics

University of Michigan Physics REU with Professor Alex Kuzmich

University of Miami, Dr. Imelda Moise

University of Chicago, Physics

SJTU BME, Dr. Ning Lan

Los Alamos National Lab, Dr. Htoon

Argonne National Lab, Dr. Zach Conway

Cornell, Dr. Gordon Stacy

RIT Color Science, Dr. Fairchild

Johns Hopkins Applied Physics Lab with Dr. Joshua Cahill

# Examples of Research Experiences, P/A Projects

I used Chandra X-ray data to analyze a Planck-detected merging galaxy cluster at an intermediate redshift & analyzed the thermodynamic properties of the intracluster medium in the merging system.

I created rotation curves for low mass galaxies with the end goal of determining whether they obey the Tully Fisher Relation.

I have helped adjust settings for electronics that will help in the detection of cosmic rays and in SETI projects

I scoured deep-sky images of galaxies and galaxy groups in search of dwarf galaxy candidates. I then build a code that would do photometry on each dwarf galaxy candidate.

Astrophysics focusing on the Chandra Deep afield South

I worked on a cosmology experiment called SPIDER which is mapping the polarization of the CMB. my project was creating beam maps of a telescope to characterize it.

Particle accelerator R&D

Creating a program to model the seismic impact of macro dark matter going through Mars

# Examples of Research Experiences, more P/A Projects

Electronics for OSETI telescope

Using dynamical simulations to investigate the galaxy-halo relationship.

I worked to constrain a portion of the macroscopic dark matter parameter space using seismological constraints from Martian seismology.

Computed stellar distances & how various errors may have affected those calculations.

I built a surrogate model to interpolate between results of Kilonovae simulations

I run simulations of high velocity impacts to investigate the morphology of planetary impacts from macro dark matter particles.

Using far infrared fine structure lines to characterize star formation in nearby galaxies.

Study lunar surface features with Lunar Reconnaissance Orbiter LAMP UV spectrometer and other instruments on the LRO. Mostly computer work using ArcGIS, IDL.

# Examples of Research Experiences, CM Projects

Hyperbolic metamaterials

Fabrication and characterization of metamaterials

Making nanoscale devices.

Fabricating van der Waals heterostructure devices.

Building a crystal growth (MOCVD) device & planning experiments using it

Symmetries of various crystal space groups and making Mathematica plots to visualize these symmetries.

I fabricated samples and performed measurements on them using broadband dielectric spectroscopy, voltage switching, and various other techniques. Training on many instruments and techniques have been necessary, including training for thin film deposition, ellipsometry, profilometry, chemical safety, etc.

# Examples of Research Experiences, more CM Projects

I took spectra of some crystal samples using a 532 nm class4 laser I call "Baby Panda."

Studying the fluid flow generated by rotating nanowire tweezers using computer simulations in Matlab.

Landau theory and order parameters of quasicrystals forming in hard tetrahedral fluids, both computational and theoretical work.

I designed a labview controller double optical filter configuration for tuning the wavelength and bandwidth of a laser source to study room temperature sp<sup>3</sup> defects of carbon nanotubes.

Looking at the electromagnetic properties of topological insulators, in particular using the method of images.



# Examples of Research Experiences, misc. Projects

Designing a computational muscle model

Alcohol policy analysis in Illinois

Perform biophysical measurements on cardiac cells for mathematical modeling purposes.

Writing code to describe chromatic adaptation (how your eyes adapt to different light conditions)

Various research projects with scientists and M.D/Ph.D students

Building a platform for conducting virtual energy audits, using data science to identify energy saving opportunities.

Laser cooling of Rb-87. Mostly laboratory work to set up and optimize the lab's laser cooling procedures.

Designing virtual reality software.

I wrote code in Matlab to calculate the power of TEM modes in a rectangular chasm.

# THE END

What your research supposedly looks like:

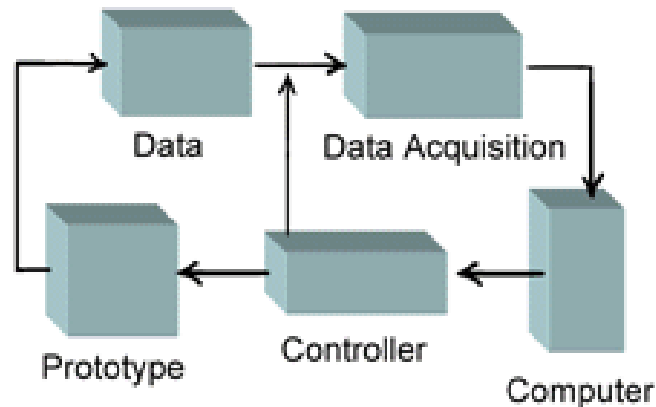


Figure 1. Experimental Diagram

What your research *actually* looks like:

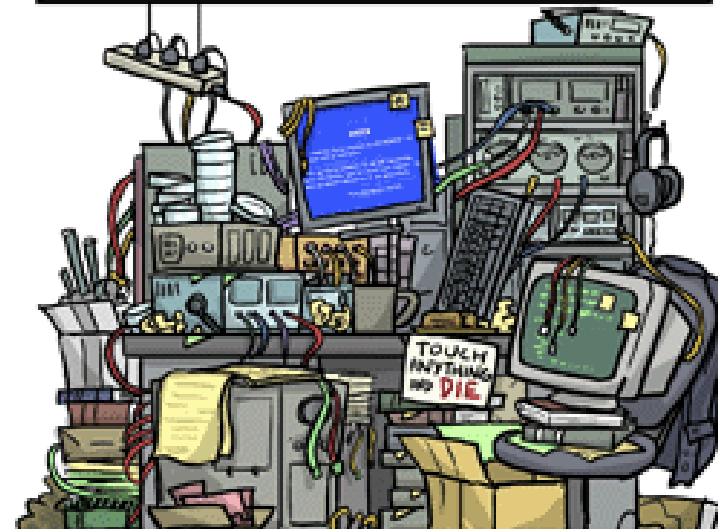


Figure 2. Experimental Mess

WWW.PHDCOMICS.COM JORGE CHAM ©2008

Contact G. Chottiner, [gsc2@case.edu](mailto:gsc2@case.edu) with questions.

But contact individual physics faculty members to ask about research positions!