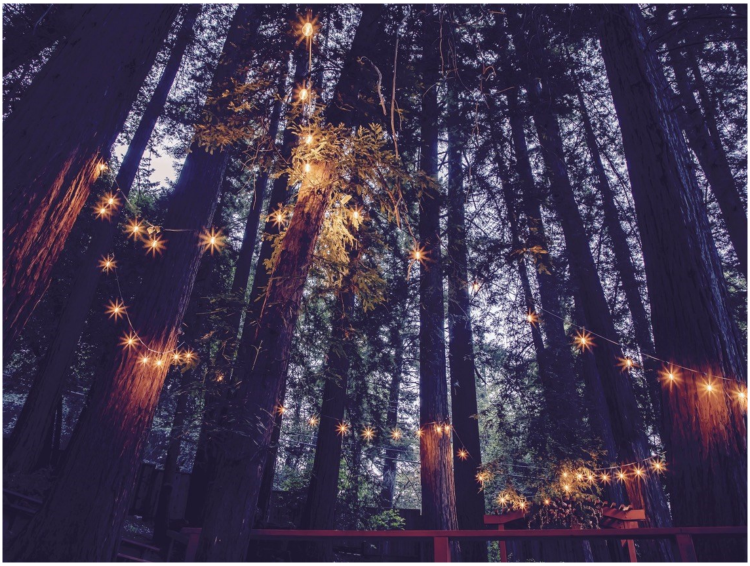
Miller Institute For Basic Research In Science



Santa Cruz Mountains

25th Annual Interdisciplinary Symposium

May 30 ~ June 1, 2023

University of California, Berkeley

THE MILLER INSTITUTE: A BRIEF HISTORY

The Miller Institute was established in 1955 after Adolph C. Miller and his wife, Mary Sprague Miller, donated just over $5 million dollars to the University. It was their wish that the donation be used to establish an institute "dedicated to the encouragement of creative thought and conduct of pure science." The gift was made in 1943 but remained anonymous until after the death of the Millers.

Adolph Miller was born in San Francisco on January 7, 1866. He entered UC in 1883 and was active throughout his CAL years. After graduation he went to Harvard for Graduate School and then for additional study in Paris and Munich. He returned to the United States and taught Economics at Harvard until he was appointed Assistant Professor of Political Science in Berkeley in 1890. After just one year he moved to Cornell. A year later he moved on to Chicago as a full professor of Finance.

He married Mary Sprague in 1885. She was the eldest child of a prosperous Chicago businessman and perhaps the source of much of the Millers' wealth. In 1902 Miller returned to Berkeley as Flood Professor of Economics and Commerce. He established the College of Commerce, which has grown into the Haas School of Business today.

After 11 years at UC, Miller resigned to become the US Assistant Secretary to the Interior. The following year the Federal Reserve system was established and President Wilson appointed Miller to its Board of Governors. He held that position for 22 years under 5 different presidents.

The Miller Institute has sponsored Miller Professors, Visiting Miller Professors and Miller Research Fellows at different times throughout its history. The first appointments of Miller Professors were made in January 1957. Throughout its 60+ year history the Institute has hosted over 1,000 scientists in its programs. For a period of time in the 1980s the Visiting Miller Professorship program did not exist but it resumed in 1985 and has grown considerably since then.

In 2008 the Institute created the Miller Senior Fellowship Program and appointed its first recipient. Miller Senior Fellows serve as mentors to the Miller Fellows by leading discussions and participating in Institute events. They are awarded an annual research grant to use at their discretion in support of their research.

The Institute is governed by the Advisory Board, which is comprised of the Chancellor of the University, four outside members, and the Executive Committee. The Advisory Board meets once a year to assist the Executive Committee in selecting Miller Professors and the Visiting Miller Professors. The Executive Committee alone selects the Miller Fellows and the Miller Senior Fellows.

More at: https://miller.berkeley.edu/

2023 SYMPOSIUM COMMITTEE

Grayson Chadwick, Miller Fellow 2020-2023, MCB

Clara Duman, Miller Institute Staff

Hilary Jacobsen, Miller Institute Staff

Michael Kim, Miller Fellow 2020-2023, EECS

Antoine Koehl, Miller Fellow 2020-2023, Statistics

Michael Manga, Earth & Planetary Science, Chair of Symposium Cmte.

Andrew Rosen, Miller Fellow 2021-2024, Materials Science

Veronika Sunko, Miller Fellow 2020-2023, Physics

Alfred Zong, Miller Fellow 2020-2023, Chemistry

Additional Speaker Liaison: Anna Barth, Miller Fellow 2021-2024, Earth & Planetary Sci.

Executive Committee

Professor Marla Feller
Executive Director, Miller Institute
Molecular & Cell Biology & Neuroscience

Professor Chung-Pei Ma
Astronomy & Physics

Professor Yun Song
EECS & Statistics

Professor Jeffrey Long
Chemistry

Incoming Members:

Professor Nicole King
Molecular & Cell Biology

Professor Alistair Sinclair
EECS

Advisory Board

Chancellor Carol Christ

Professor Scott Edwards
Evolutionary Biology
Harvard University

Professor Anna Gilbert
Math, Statistics, Data Science
Yale University

Professor Feryal Özel
Astronomy & Physics
Georgia Tech

Professor Tim Stearns
Biology
Rockefeller University

Incoming Member:
Professor Eliot Quataert
Astronomy/Astrophysics
Princeton University

MILLER INSTITUTE
INTERDISCIPLINARY SYMPOSIUM
2023 SPEAKERS

Roger Blandford
Stanford University
Astronomy

Moon Duchin
Tufts University
Mathematics

Julius Lucks
Northwestern University
Chemical and Biological Engineering

Isabel Montañez
UC Davis
Earth and Planetary Sciences

Piali Sengupta
Brandeis University
Biology

Nicola Spaldin
ETH Zurich
Materials Science

William Tarpeh
Stanford University
Chemical Engineering

ROGER BLANDFORD
DEPARTMENT OF ASTRONOMY
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https://profiles.stanford.edu/roger-blandford

Roger Blandford received his BA, MA and PhD degrees from Cambridge University. Following postdoctoral research at Cambridge, Princeton and Berkeley he took up a faculty position at Caltech in 1976 where he was appointed as the Richard Chace Tolman Professor of Theoretical Astrophysics in 1989. In 2003, he moved to Stanford University to become the first Director of the Kavli Institute for Particle Astrophysics and Cosmology and the Luke Blossom Chair in the School of Humanities and Science. His research interests include black hole astrophysics, cosmology, gravitational lensing, cosmic ray physics and compact stars. He is a Fellow of the Royal Society, the American Academy of Arts and Sciences, the American Physical Society and a Member of the National Academy of Sciences. In 2008-2010, he chaired a two year National Academy of Sciences Decadal Survey of Astronomy and Astrophysics. He was awarded the 1998 Dannie Heineman Prize of the American Astronomical Society, the 2013 Gold Medal of the Royal Astronomical Society, the 2016 Crafoord Prize for Astronomy and the 2020 Shaw Prize for Astronomy. He co-authored with Kip Thorne the textbook Modern Classical Physics.

ABSTRACT: "The Unbeatable Rightness of Being: A Cosmic Ray Origin for Biological Homochirality"

The laws of physics were long thought to be unchanged when viewed in a mirror. We have known for over sixty years that they are not. As Sakharov first explained, this asymmetry, in action during the first moments of the universe, may account for the prevalence of matter over antimatter today. Likewise, as Pasteur first showed, the laws of biology are similarly asymmetric, as is exhibited by the structure of DNA. In this talk, a possible causal connection between these two asymmetries, mediated by cosmic rays, will be discussed.

REPRESENTATIVE ARTICLES:

- https://drive.google.com/file/d/1l8CKhx7CPjICY6_ZZZAzGRcCEAUMpDj3/view?usp=sharing
- https://iopscience.iop.org/article/10.3847/1538-4357/abe461/pdf

MOON DUCHIN
DEPARTMENT OF MATHEMATICS
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https://mggg.org/

Moon Duchin is a mathematician who runs a data/ democracy lab at Tufts University. Her lab brings geometry, dynamical systems, and computational modeling into conversation with geography, policy, and law. This year, she's been working as an expert witness in redistricting court cases around the country, and she has a particular interest in the future of the Voting Rights Act.

ABSTRACT: "Modeling civil rights"

Social choice theory is about systems that aggregate public preferences—that is, it's about how we vote and make collective decisions, or the mathematical study of democracy. Classically, the subject has been treated probabilistically, axiomatically, and computationally by turns, but what's arguably been missing is a practical focus on understanding which groups can access effective representation. I will discuss work from the last five years that centers civil rights.

REPRESENATIVE ARTICLES/BACKGROUND READING:

- https://mggg.org/publications/political-geometry/00-Duchin.pdf
- https://dl.acm.org/doi/10.1145/3511265.3550440

JULIUS LUCKS
DEPARTMENT OF CHEMICAL AND BIOLOGICAL ENGINEERING
NORTHWESTERN UNIVERSITY
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https://luckslab.org/

Julius B. Lucks is Professor of Chemical and Biological Engineering and Co-Director of the Center for Synthetic Biology at Northwestern University. Lucks received his PhD in chemical physics from Harvard University and transitioned to synthetic biology as a Miller Fellow at UC Berkeley. He is a leader in RNA research and synthetic biology, focusing on developing technologies that tackle global challenges, most recently in the area of global water insecurity. Professor Lucks has been recognized with a number of awards including a DARPA Young Faculty Award, an Alfred P. Sloan Foundation Research Fellowship, an ONR Young Investigator Award, an NIH New Innovator Award, an NSF CAREER award, the ACS Synthetic Biology Young Investigator Award, a Camille-Dreyfus Teacher Scholar Award, a finalist for the Blavatnik Awards for Young Scientists, and was most recently inducted into the American Institute of Medical and Biomedical Engineers. He also leads the first NSF graduate training program in synthetic biology, is a founding member of the Engineering Biology Research Consortium, and co-founded the Cold Spring Harbor Synthetic Biology Summer Course. He is also a co-founder of Stemloop, Inc. which aims to use cell free biosensing technology to empower people with information about the health of themselves and their environment.

ABSTRACT: "What is in our water? A journey from basic research to societal scale synthetic biology"

Over two billion people lack access to sufficient clean water for their basic needs. A central challenge in this global water crisis is a lack of information on water quality. While we cannot often see or taste water contaminants, microbes can, creating a profound opportunity to partner with nature to create scalable technologies that could democratize access to water quality information. In this talk I will present an ongoing personal journey that that started at the Miller Institute with a basic biology research question – how do cells sense and 'process' information – and is leading to the development of synthetic biology water quality monitoring technologies that are as simple to use as an at-home COVID test.

REPRESENTATIVE ARTICLES:

- https://www.scientificamerican.com/article/whats-really-in-your-water/
- https://www.nature.com/articles/s41587-020-0571-7

ISABEL MONTAÑEZ
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UNIVERSITY OF CALIFORNIA, DAVIS
ipmontanez@ucdavis.edu
https://en.wikipedia.org/wiki/Isabel_P._Monta%C3%B1ez

Isabel Patricia Montañez holds degrees in geoscience from Bryn Mawr College (B.S., 1981) and Virginia Polytechnic Institute (Ph.D., 1989). She was an assistant and associate professor in the Department of Earth Sciences, UC Riverside before joining the faculty in the Department of Earth and Planetary Sciences at UC Davis in 1998, where she is currently a Distinguished Professor and Chancellor's Leadership Professor. She serves as the Director of the UC Davis Institute of the Environment. Her research focuses on reconstructing past perturbations to global carbon cycling and regional climate change, in particular, during periods of warming and major transitions.

Isabel is a member of the National Academy of Sciences, a fellow of several professional societies (AAAS, AGU, The Geochemical Society, European Soc. of Geochemistry, GSA), a past Fellow of the John Simon Guggenheim Memorial Foundation and a Fellow of the California Academy of Sciences, as well as the recipient of multiple national and international awards and medals. She served as President of The Geological Society of America from 2017 to 2018 and is currently the Chair of the Board of Earth Sciences and Resources, the National Academies of Sciences, Engineering, and Medicine.

<u>ABSTRACT</u>: "The long and short of it: C cycling's role in controlling climate of the past and into our future"

Atmospheric CO_2 and climate are coupled with the strength of this coupling varying through Earth history. In turn, how tightly CO_2 and climate are coupled has important implications for planetary function. Silicate rock weathering on land, through consumption of CO_2, is a primary negative feedback mechanism controlling CO_2 concentrations and in turn, climate. Despite a long history of investigating this feedback and its importance for maintaining Earth's habitability, questions remain about how it functions and the role it plays in determining the strength of CO_2-climate coupling. Laboratory and field studies have provided new insight into the feedback mechanisms, but given the geologic rates of silicate weathering, only studies of the deep time can reveal how and by what mechanism(s) changes in the efficiency of silicate weathering impact the strength of CO_2-coupling. Advancing such studies is dependent on how well we 'know' paleo-CO_2.

In this talk, I will first discuss approaches to reconstructing atmospheric CO_2 concentrations of the past half billion years, the challenges of constraining uncertainty of these estimates, and a new international initiative, CO_2PIP, to advance the reconstruction of paleo-CO_2 through modernization of existing records, quantifying the representation of CO_2 proxy sensitivities to conditions and processes that govern the CO_2 signals, and statistical inversion analysis of simulated and modernized proxy datasets. I will then focus in on a deep-time period, the penultimate icehouse (300 million years ago), and use proxy data-model comparisons to illustrate how major reorganization of the predominant factors influencing silicate weatherability led to large changes in steady state pCO_2 and the strength of CO_2-climate coupling. I will wrap up by discussing how the typically long-term processes of silicate rock weathering can be accelerated in soils of natural and working lands to provide a promising new negative greenhouse-gas emissions pathway capable of sequestering CO_2 from the atmosphere in volumes (millions of tons per year) and at rates relevant to climate change.

<u>REPRESENTATIVE ARTICLES:</u>

- https://drive.google.com/file/d/1Q8c_iwqFhQvQjjqLg2Pu_f2VB6A0OeoJ/view?usp=sharing
- https://drive.google.com/file/d/1dJWz234tdM9IXOE_C9xUyey33kr7rZ8E/view?usp=sharing

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Animals live in extremely complex environments. I have always been fascinated by the question of how animals detect sensory cues, and how they then interpret and translate this information into specific changes in behavior and development. As a PhD student in Biology at MIT, I studied how the baker's yeast *S.* cerevisiae responds to a mating pheromone. As a postdoctoral fellow at UCSF, I moved into sensory neuroscience and explored how the nematode C. elegans responds to environmental chemical cues using its small nervous system. In my own lab at Brandeis University, we have continued to uncover surprises in the mechanisms by which this nematode detects and responds robustly, sensitively, but also flexibly to chemical cues and temperature. We use multiple experimental approaches including genetics, genomics, high-resolution behavioral assays, and live imaging to describe how the nervous system of this animal encodes multiple complex features of the sensory stimuli it encounters. We greatly value and appreciate collaborations, and have worked with and learned from many other biologists, but also physicists and chemists.

ABSTRACT: "Shaping Sensory Signaling: How cilia contribute to sensory neuron responses"

Sensory neurons contain structurally diverse 'antennae' called cilia that house signal transduction molecules and play essential roles in olfaction, hearing, and photoreception. Disrupted cilia structure and function lead to sensory disorders including anosmia and blindness. Complex cilia morphologies dictate the concentration and organization of signaling molecules within them, and are thus considered critical for precisely shaping sensory responses. However, the contribution of unique cilia structures to modulating the response profiles of individual sensory neuron types is poorly understood. This talk will discuss how protein trafficking into and out of cilia, and their neuron-specific architectures regulate sensory neuron properties and ultimately direct behavior.

REPRESENTATIVE ARTICLE:

- https://pubmed.ncbi.nlm.nih.gov/28410391/

NICOLA SPALDIN
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ETH Zurich
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https://theory.mat.ethz.ch/

Nicola Spaldin is the Professor of Materials Theory at ETH Zurich. She is best known for her development of the class of materials known as multiferroics, which combine simultaneous ferromagnetism and ferroelectricity. She is a passionate science educator, coordinator of her department's curriculum revision "The Materials Scientist 2030, Who is She?", and holder of the ETH Golden Owl Award for excellence in teaching. When not trying to make a room-temperature superconductor, she can be found playing her clarinet, or skiing or climbing in the Alps.

ABSTRACT: "New Materials for a New Age"

Every advance in human civilization, from the Stone Age to today's Silicon Age, has been driven by a development in materials. I will discuss a new class of materials – multiferroics – that are both a playground for exploring exciting fundamental science, and a potential enabler of transformative beyond-silicon technologies.

REPRESENTATIVE ARTICLES:

- https://www.nature.com/articles/natrevmats201717
- https://www.nature.com/articles/s41563-018-0275-2

WILLIAM TARPEH
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wtarpeh@stanford.edu
https://www.tarpehlab.com/

William Tarpeh is an assistant professor of chemical engineering at Stanford University. The Tarpeh Lab develops and evaluates selective separations in "waste" waters at several synergistic scales: molecular mechanisms of chemical transport and transformation; novel unit processes that increase resource efficiency; and systems-level assessments that identify optimization opportunities. Will completed his B.S. in chemical engineering at Stanford, his M.S. and Ph.D. in environmental engineering at UC Berkeley, and postdoctoral training at the University of Michigan in environmental engineering.

ABSTRACT: "Electrochemical Wastewater Refining for Circular Chemical Manufacturing"

Wastewater is an underleveraged resource; it contains pollutants that can be transformed into valuable high-purity products. Innovations in chemistry and chemical engineering will play critical roles in valorizing wastewater to. Electrochemical wastewater refining, or the use of electricity to drive tunable chemical reactions that recover specific products, can enable circular chemical manufacturing that remediates environmental pollution, provides equitable access to chemical resources and services, and secures critical materials from diminishing feedstock availability. This talk will focus on approaches ranging from electrocatalysis, electrochemical separations, and stoichiometric electrochemical conversions with a focus on nitrogen- and lithium-selective refining. These specific case studies will enable a vision of sustainable manufacturing that uses molecular-scale control over membranes, adsorbents, and catalysts to engineer novel unit processes that make waterborne pollution obsolete.

REPRESENTATIVE ARTICLES:

- https://www.sciencedirect.com/science/article/pii/S2666498421000016
- https://chemrxiv.org/engage/chemrxiv/article-details/642c6a88a029a26b4ce92995

INTRODUCING THE 2023 - 2026 MILLER RESEARCH FELLOWS

Olatubosun Fasipe
Civil & Envir. Engineering
Host: Evan Variano

Rohil Prasad
Mathematics
Host: Michael Hutchings

Augusto Ghiotto
Physics
Host: James Analytis

James Santangelo
Integrative Biology
Host: Rasmus Nielsen

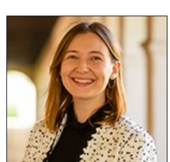
Ioannis (Yanni) Kipouros
Chemistry
Host: Michelle Chang

Ewin Tang
EECS
Host: Umesh Vazirani

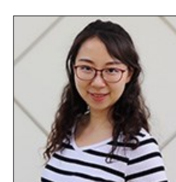
Ethan Lake
Physics
Hosts: Ehud Altman, Mike Zaetel

Yuhan Yao
Astronomy
Hosts: Wenbin Lu, Raffaella Margutti

Molly McFadden
Kathy Day awardee
Chemistry
Host: John Hartwig



Xueyue (Sherry) Zhang
EECS/Physics
Host: Alp Sipahigil



MILLER INSTITUTE SYMPOSIUM
MAY 30 - JUNE 1, 2023
AGENDA

Tuesday, May 30

3 - 6:00 pm Arrival and registration - Welcoming Center

4 - 6:00 Welcome Reception - Outside the Dining Hall

6:00 – 7:30 Dinner & Welcome - Dining Hall

7:30 – 11:00 Miller Fellow Posters/Visual Aids; Stargazing - Assembly Room

Wednesday, May 31

7 - 8:15 am Breakfast - Dining Hall

8:30 - 9:10 JULIUS LUCKS, Northwestern - Assembly Room
"What is in our water? A journey from basic research to societal scale synthetic biology"

9:10 - 9:40 Discussion

9:40 - 10:00 Break

10:00 - 10:40 NICOLA SPALDIN, ETH Zurich - Assembly Room
"New Materials for a New Age"

10:40 - 11:10 Discussion

11:10 - 12:45 Group Photo followed by Lunch - Redwood Amphitheater, Dining Hall

1 - 1:40pm ISABEL MONTAÑEZ, UC Davis - Assembly Room
"The long and short of it: C cycling's role in controlling climate of the past and into our future"

1:40 - 2:10 Discussion

2:10 - 2:40 Break

MILLER INSTITUTE SYMPOSIUM
May 30 - June 1, 2023
AGENDA CONT.

2:40 - 3:20 **MOON DUCHIN, Tufts University - Assembly Room**
"Modeling civil rights"

3:20 - 3:50 Discussion

3:50 - 4:20 Break

4:20 - 5:00 **PIALI SENGUPTA, Brandeis University - Assembly Room**
"Shaping Sensory Signaling: How cilia contribute to sensory neuron responses"

5:00 - 5:30 Discussion

5:30 - 7:00 Free time

7:00 - 8:30 Dinner - Dining Hall

8:45 - 11:00pm Miller Movie night / Social Time and Stargazing - Assembly Room

<u>Thursday, June 1</u>

7:00 - 8:45 am Breakfast - Dining Hall

9:00 - 9:40 **ROGER BLANDFORD, Stanford University - Assembly Room**
"The Unbeatable Rightness of Being: A Cosmic Ray Origin for Biological Homochirality"

9:40 - 10:10 Discussion

10:10 - 10:30 Break

10:30 - 11:10 **WILLIAM TARPEH, Stanford University - Assembly Room**
"Electrochemical Wastewater Refining for Circular Chemical Manufacturing"

11:10 - 11:40 Discussion

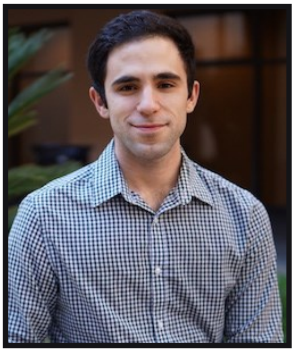
12:00 - 1:30pm Lunch and close of symposium - Dining Hall

Miller Research Fellows

Anna Barth, 2021-2024
EPS   Host: Michael Manga
Ph.D. Institution: Columbia
barthac@berkeley.edu

I study volcanoes and geysers, with a focus on understanding subsurface fluid processes and their relationship to eruption intensity. Since these processes occur deep below the ground, hidden from direct observation, a core aspect of my work is learning how to relate observations at the surface to processes at depth. So far, my approach has involved a range of techniques including field work, laboratory experiments, geochemical analyses, and modeling. Going forwards, I'm excited to extend my observational tools to the vast range of volcano and geyser monitoring data, and to develop ways to represent and integrate these complex and often noisy datasets through methods in data sonification, visualization, and machine learning.

Michael Celentano, 2021-2024
Statistics   Host: Martin Wainwright
Ph.D. Institution: Stanford
mcelentano@berkeley.edu



My research focuses on developing methodology for estimation and inference in high-dimensional regression models. I leverage tools from statistical physics and Gaussian process theory to precisely characterize the behavior of existing methods and to inspire the development of new ones. I am mostly interested in high-dimensional problems which are very noisy and in which signals are structured but relatively weak. In these problems, existing theory often provides limited guidance, and achieving valid, powerful, and computationally tractable inference is difficult but not impossible.

Grayson Chadwick, 2020-2023
MCB   Host: Dipti Nayak
Ph.D. Institution: Caltech
chadwick@berkeley.edu

I am interested in understanding the evolution of energy metabolism in microbes at multiple scales, from the interactions of organisms with their physical environment down to the modifications of individual bioenergetic protein complexes. I focus on organisms that are important sources and sinks of methane on Earth. Much of my previous work was conducted on uncultured organisms in complex environments, allowing us to understand broadly which biogeochemical processes are carried out by which organisms. My work as a Miller Fellow at UC Berkeley will focus on the genetic manipulation of pure cultures to produce more mechanistic understanding of energy metabolism in understudied organisms within the Archaea.

Lijie Chen, 2022-2025
EECS   Host: Avishay Tal
Ph.D. Institution: MIT
wjmzbmr@berkeley.edu

I have a broad interest in theoretical computer science. My current focus is on proving unconditional lower bounds against specific restricted models of computation and studying how to remove randomness in algorithms while paying little overhead.

Kelian Dascher-Cousineau, 2022-2025
EPS   Host: Roland Burgmann
Ph.D Institution: UCSC
kdascher@berkeley.edu

I study earthquakes physics and tectonic geomorphology. As a primary tool, I leverage the statistical laws and patterns of seismicity to diagnose the physical processes that control nucleation and interactions. This research aims to reveal how stresses in the earth's crust evolve over time and, in some cases, culminate in catastrophic earthquakes. I also study the lasting influence of earthquakes in the landscape. Over thousands of years, the faults that host earthquakes leave a geomorphic imprint. This interplay is a natural laboratory to better understand the earthquake cycle and landscape evolution over tens of thousands of years.

Emily Davis, 2020-2023
Physics Host: Norman Yao
Ph.D. Institution: Stanford
edavis@berkeley.edu

For my doctoral work, I built an experiment to generate and image nonlocal interactions in a cold atomic ensemble trapped in an optical cavity. At Berkeley, I look forward to working in Prof. Norman Yao's group studying many-body physics and high-pressure sensing in nitrogen vacancy centers in diamond.

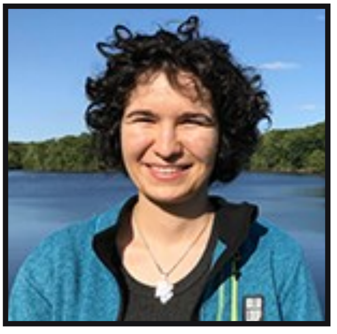
Dimitrios Fraggedakis, 2021-2024
CBE   Hosts: Bryan McCloskey, Kranthi K. Mandadapu
Ph.D. Institution: MIT
dfrag@berkeley.edu

Most biological and electrochemical systems are characterized by disorder at multiple scales, and understanding its influence on electrochemistry and transport is essential to both engineering applications and biological sciences. Disorder is known to give rise to exotic phenomena (e.g. metal-to-insulator transition, superconductivity); however, its effect on electrochemical systems is mostly unexplored. As a Miller Fellow, my goal is to understand the fundamentals and impact of topological, structural and chemical disorder on electrochemistry and transport. By combining my expertise on theoretical electrochemistry and transport phenomena with simulations and experiments, I plan to develop our fundamental understanding on the effects of disorder in the context of important biological (e.g. signaling, membrane formation) and electrochemical (e.g. CO2 capture, purification, electrocrystallization) applications.

Shashank Gandhi, 2021-2024
MCB   Hosts: Richard Harland, Megan Martik
Ph.D. Institution: Caltech
shashank.gandhi@berkeley.edu

In humans, the heart is the first functional organ to form, beginning as a tube that beats and circulates blood, followed by rearrangements that transform the single-chambered tube into a four-chambered organ. Genetic errors in this intricate process can lead to severe congenital heart defects, which are the most common birth defects in humans. Several of these defects result from abnormalities in an embryonic stem cell population called the neural crest. During my Ph.D. studies at Caltech in Dr. Marianne Bronner's lab, I developed and used cutting-edge genomic tools to investigate the mechanisms driving neural crest formation in the vertebrate embryo. As a Miller Fellow, I will employ a multi-modal approach towards uncovering the genetic circuitry that controls neural crest differentiation into muscular tissue of the heart, focusing on the evolution, septation, and morphogenesis of the outflow tract.

Boryana Hadzhiyska, 2022-2025
Physics   Host: Martin White
Ph.D. Institution: Harvard
boryanah@berkeley.edu



My work blends the distinct fields of cosmology, galaxy formation, particle physics, and statistics to probe some of the most puzzling enigmas of our Universe: dark matter, dark energy, and neutrinos. In particular, I compare predictions from powerful numerical simulations with observations from cutting-edge galaxy experiments, jointly analyze early Universe probes and galaxy observations, and develop analytical approaches, in an effort to provide competitive constraints on galaxy formation and cosmology.

Aaron Joiner, 2021-2024
MCB Hosts: James Hurley, Roberto Zoncu
Ph.D. Institution: Cornell
amj85@berkeley.edu

My research interests lie at the intersection of cell homeostasis, membrane biology, and the regulation of cellular trafficking events, with particular focus on the structure and function of key protein components at membrane surfaces. During my PHD, I used X-ray crystallography and cryo-electron microscopy to study two small GTPases and their activators in the early secretory pathway. As a postdoc at UC-Berkeley, I will employ cryoEM and other functional approaches to understand the regulation of another small GTPase and its inactivator at the lysosome.

Michael Kim, 2020-2023
EECS Host: Shafi Goldwasser
Ph.D. Institution: Stanford
mpkim@berkeley.edu

I am a theoretical computer scientist studying the mathematical foundations of responsible machine learning. Much of this work aims to identify ways in which machine learning systems can exhibit problematic behavior (e.g., unfair discrimination) and to develop algorithmic tools that provably mitigate such behaviors. More broadly, I am interested in how the theory of computation can help tackle emerging societal and scientific challenges.

Antoine Koehl, 2020-2023
Statistics Host: Yun Song
Ph.D. Institution: Stanford
akoehl@berkeley.edu

In the post-genome era, we continue to identify new proteins based on their sequence alone, but often struggle to identify their precise biological function. My research seeks to use recent advances in statistical and machine learning techniques to provide better functional predictions to these so-called "orphan" proteins. In particular, my work will focus on the G protein coupled receptor superfamily- despite its central role in human physiology, there remain ~80 "orphan" receptors whose biological role is unknown.

Vayu Maini Rekdal, 2020-2023
IB, PMB, BioEng Hosts: Jay Keasling, Britt Koskella
Ph.D. Institution: Harvard
vayu.mr@berkeley.edu

Much of food processing is not performed by humans alone, but by microorganisms living outside and inside the body. I explore molecular interactions between these microbes and food components in fermented foods and the gut microbiota. This understanding will enable engineering of microbial chemistry to improve human food consumption and production and ultimately address challenges in sustainability, nutrition, and gastronomy.

Raul Ramos
Kathryn A. Day Miller Postdoctoral Fellow, 2022-2025
MCB Hosts: Ellen Lumpkin, Diana Bautista
Ph.D. Institution: Brandeis University
rramos@berkeley.edu

My long-term research goal is to uncover novel molecular, cellular, and circuit mechanisms underlying sensory processing disorders (SPD's). I am especially interested in identifying the cellular underpinnings of tactile hypersensitivity and ways to treat this SPD. My research as a Miller Fellow will explore the therapeutic potential of psychedelics in the context of tactile hypersensitivity and the peripheral nervous system function.

Nayeli Rodriguez Briones, 2020-2023
Chemistry Host: K. Birgitta Whaley
Ph.D. Institution: University of Waterloo
nayelongue@berkeley.edu

Quantum information science gives us an effective language to ponder and understand our universe by describing the laws of nature in terms of the evolution of information. In this context, the question at the heart of my research is how quantum information science can be used to explore and discover new phenomena in the quantum regime and to deepen our understanding in several areas of science, such as quantum many-body theory, thermodynamics/statistical mechanics, and even biology and quantum gravity. In recent years I have been exploring several directions for applying the tools of quantum information science to cool quantum systems in an algorithmic way. These algorithmic cooling techniques are not only of theoretical interest for quantum physics, but they are also at the core of the practical applications in quantum technologies --from the preparation of pure states for quantum computation to the supply of reliable ancilla qubits in quantum error correction.

Andrew Rosen, 2021-2024
MSE Host: Kristin Persson
Ph.D. Institution: Northwestern University
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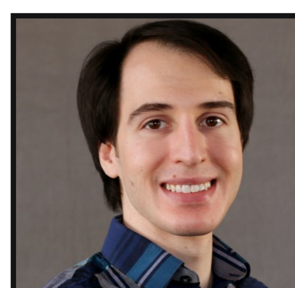

The conventional approach to discovering new materials has largely relied on intuition combined with trial-and-error experimental testing; however, many of the most pressing energy-related problems facing society remain unsolved precisely because they rely on discoveries beyond the boundaries of our current scientific understanding. My research is primarily focused on the use of quantum-chemical simulations and machine learning to transform what has historically been an empirical approach to materials design into one of automated, computationally driven discovery. By bringing recent advances in theoretical chemistry and data science to the intersection of chemical engineering, materials science, and inorganic chemistry, my research aims to accelerate the discovery of novel materials that can address longstanding global challenges in clean energy and sustainability.

Carly Schissel, 2022-2025
Chemistry   Host: Alanna Schepartz
Ph.D. Institution: MIT
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Nature is an expert in synthesizing biopolymers with defined sequences and structures using a defined pool of monomers. However, the ability to expand the chemical and structural possibilities of these biopolymers would have a great impact on materials and medicines. My PhD research focused on the design and chemical synthesis of unnatural peptides that are able to deliver macromolecular cargo to a cell's nucleus. My postdoctoral work will shift towards new methods to synthesize unnatural peptides and proteins using nature's machinery. Specifically, I aim to engineer a recently discovered tailoring enzyme to modify the amide backbone of ribosomally-synthesized proteins in order to change their physical properties.

Veronika Sunko, 2020-2023
Physics   Host: Joseph Orenstein
Ph.D. Institution: University of St. Andrews
vsunko@berkeley.edu

I am interested in understanding how observable properties of solid-state materials arise as a consequence of their structure and constituent elements. It is a question of both practical and fundamental interest; the former because such materials are critical for the development of novel technologies, and the latter because they represent an accessible window onto the underlying quantum many-body problem. As a Miller Fellow I will combine bespoke and sensitive spatially resolved optical probes of symmetry with external tuning parameters to investigate how symmetry and topology collaborate to yield material properties as we know them, both at microscopic and macroscopic length scales. I will do this on a range of promising new quantum materials, which I intend to synthetize, therefore creating novel quantum playgrounds.

Georgios Varnavides, 2022-2025
Materials Science   Hosts: Mary Scott, Joel Moore
Ph.D. Institution: MIT
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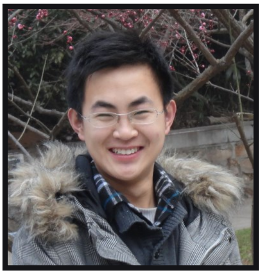
Recent advances in transport measurements have revealed that electrons in materials can flow collectively, exhibiting fluid phenomena such as vortices. Unlike everyday fluids however, preferred directions in crystals imply electron fluids exhibit anisotropic and non-dissipative viscous contributions, giving rise to novel phenomena. As a Miller Fellow, I will image these anisotropic electron fluids with high spatial resolution (<5 nm) using a transmission electron microscopy computational imaging technique. Correlating non-uniform current densities with the underlying structure would open the door to investigating the role of structure and defects in designing near-dissipation-less electronics, inviting questions like "does current flow around defects in materials similar to how rivers flow past pebbles? If so, can we engineer them to minimize thermal dissipation?"

Yao Yang, 2021-2024
Chemistry Host: Peidong Yang
Ph.D. Institution: Cornell
yaoyang1@berkeley.edu



Electrochemistry lies at the interface between chemistry and physics and represents one of the most promising approaches for enhancing energy efficiency, mitigating environmental impacts and carbon emissions, and enabling renewable energy technologies, such as fuel cells, CO2 and N2 reduction, water splitting and secondary batteries. One of the key challenges in electrochemistry is understanding how to achieve and sustain electrocatalytic activity, under operating conditions, for extended time periods and with optimal activity and selectivity, which calls for the use of operando/in situ methods. During my PhD at Cornell, I worked with Profs. Hector Abruna, David Muller and Francis DiSalvo in the design of precious-metal-free electrocatalysts for alkaline fuel cells and the characterization and understanding of their reaction mechanisms employing operando transmission electron microscopy (TEM) and X-ray methods. As a Miller fellow, I work with Prof. Peidong Yang to tackle the fundamental challenges in CO2 reduction to liquid fuels at gas-solid-liquid interfaces in an effort to provide an atomic/molecular-level picture of dynamic electrocatalytic processes with advanced TEM at the LBNL and synchrotron X-ray at the ALS.

Mengshan Ye, 2022-2025
Chemistry Host: Jeffrey Long
Ph.D. Institution: MIT
msye@berkeley.edu

Quantum information science and technologies have brought advances in computing, sensing and communication. In particular, optically addressable quantum sensors harness sensitivities to external disturbances to accurately trace environmental fluctuations. At Berkeley, I will develop atomically tailorable, spatially accessible, and optically active molecular qubits and illustrate their advantages in magnetic field sensing.

Elena Zavala, 2022-2025
MCB Host: Priya Moorjani
Ph.D. Institution: University of Leipzig, Germany
ezavala9@berkeley.edu

My interests are centered on method development for working with low amounts of degraded DNA for applications in both ancient DNA and forensic genetics. During my PhD I utilized ancient DNA methods to reconstruct human and faunal occupational histories from Pleistocene sediment DNA and demonstrated that the integration of these methods into forensic workflows increases success rates for DNA profiling of unidentified historical remains. My research will focus on the development of new workflows for individualizing unidentified forensic and historical remains and increasing our understanding of the accuracy of genealogical searching methods for highly degraded samples.

Lingfu Zhang, 2022-2025
Statistics   Host: Shirshendu Ganguly
Ph.D. Institution: Princeton
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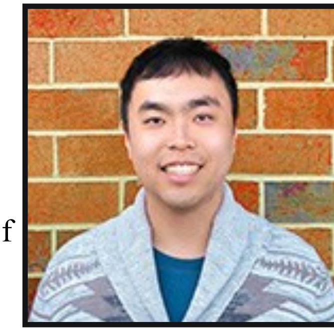

I study probability theory and use it to mathematically analyze real-world problems in theoretical physics, computer science, and statistics. Examples of specific topics include localization of waves in a disordered medium, random processes on large social networks, and random growth modeling bacterial colonies or molecular condensation. A central objective is to understand universality, the phenomenon where different random systems produce the same big-scale behavior, regardless of the microscopic structures.

Yi Zhang, 2021-2024
EPS   Host: Bill Boos
Ph.D. Institution: Princeton
y-zhang@berkeley.edu

I am interested in how the Earth's climate system works with a focus on the dynamics of the tropical atmosphere. I seek to explain the patterns of convection, rainfall, radiative fluxes using a combination of theory, modeling, and observations. I am also interested in how these processes would evolve in response to climate change.

Alfred Zong, 2020-2023
Chemistry   Host: Michael Zuerch
Ph.D. Institution: MIT
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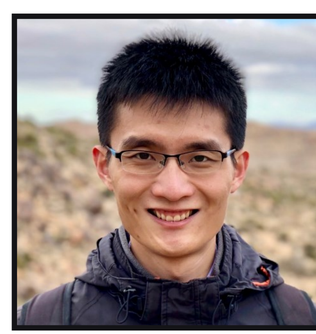

Order formation is typically defined in thermal equilibrium, yet new states of matter are found to emerge in many out-of-equilibrium contexts. I am interested in creating and studying non-equilibrium phases that are otherwise impossible to realize. Using attosecond spectroscopy and diffraction, I hope to understand how microscopic interactions govern phase transitions at the fundamental timescale of electrons, spins, and lattice. The goal is to achieve better control over ordering dynamics even in strongly correlated systems.

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