Miller Institute For Basic Research In Science

Tomales Bay

24th Annual Interdisciplinary Symposium

June 3~5, 2022

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. After its 50+ 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 that time.

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: http://miller.berkeley.edu/

2022 SYMPOSIUM COMMITTEE

Grayson Chadwick, Miller Fellow 2020-2023, MCB

Allie Gaudinier, Miller Fellow 2019-2022, PMB and Statistics

Anna Ho, Miller Fellow 2020-2023, Astronomy

Hilary Jacobsen, Miller Institute Staff

Michael Kim, Miller Fellow 2020-2023, EECS

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

Veronika Sunko, Miller Fellow 2020-2023, Physics

Qiong Zhang, Miller Fellow 2019-2022, Bioeng and PMB

Alfred Zong, Miller Fellow 2020-2023, Chemistry

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Professor Roland Bürgmann
Earth & Planetary Science

Professor Marla Feller
Executive Director, Miller Institute
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Professor Tim Stearns
Biology
Stanford University

Incoming member:
Professor Anna Gilbert
Math, Statistics, Data Science
Yale University

MILLER INSTITUTE
INTERDISCIPLINARY SYMPOSIUM
2022 SPEAKERS

Marla Feller
Molecular & Cell Biology and Neuroscience
UC Berkeley

Venkatesan Guruswami
Computer Science and Mathematics
UC Berkeley

Anette "Peko" Hosoi
Mechanical Engineering and Mathematics
MIT

Chung-Pei Ma
Astronomy and Physics
UC Berkeley

Becca Tarvin
Integrative Biology
UC Berkeley

Tadashi Tokieda
Mathematics
Stanford University

Paul Turner
Ecology and Evolutionary Biology
Yale University

MARLA FELLER
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Dr. Marla Feller is the Paul Licht Distinguished Professor in Biological Sciences in the Department of Molecular and Cell Biology at the University of California, Berkeley, and a member of the Helen Wills Neuroscience Institute. The overarching question at the Feller Lab is the role that spontaneous activity of the developing nervous system plays in establishing and shaping mature circuits. Using immature mouse retina as a model system, her group seeks to elucidate how spontaneous activity in the retina help to wire neurons, with special emphasis on the circuitry that mediates motion-selectivity if retinal neurons.

ABSTRACT: "The role of neural activity in wiring up the brain."

The development of neural circuits is profoundly impacted by both spontaneous and sensory experience. This is perhaps most well studied in the visual system, where disruption of early spontaneous activity called retinal waves prior to eye opening and visual deprivation after eye opening leads to alterations in the response properties and connectivity in several visual centers in the brain. We address this question in the retina, which comprises multiple circuits that encode different features of the visual scene, culminating in over 40 different types of retinal ganglion cells, which are the output cells of the retina that carry all the information of the visual scene to the brain. Direction-selective ganglion cells respond strongly to an image moving in the preferred direction and weakly to an image moving in the opposite, or null, direction and play a key role in image stabilization as we move through the world. I will provide recent progress in the lab that addresses the role of visual experience and spontaneous retinal waves in the establishment of direction selective tuning and direction selectivity maps in the retina.

REPRESENTATIVE ARTICLES:

- https://pubmed.ncbi.nlm.nih.gov/35491255/
- https://pubmed.ncbi.nlm.nih.gov/35395192/
- https://pubmed.ncbi.nlm.nih.gov/35021080/

VENKATESAN GURUSWAMI
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Venkatesan Guruswami is currently a Professor of Computer Science and Mathematics at UC Berkeley and a senior scientist at the Simons Institute for the Theory of Computing. Till 2021, he was a professor in the Computer Science Department at Carnegie Mellon University. Venkat received his Bachelor's degree from IIT Madras, and his Ph.D. from MIT.

Venkat's research interests include error-correcting codes, approximate optimization, and computational complexity. He is currently Editor-in-Chief of the Journal of the ACM. Venkat was a co-winner of the 2012 Presburger Award, and his other honors include a Simons Investigator award, Packard and Sloan Fellowships, the ACM Doctoral Dissertation Award, and an IEEE Information Theory Society Paper Award. He is a fellow of the ACM and the IEEE.

ABSTRACT: "When and why do efficient algorithms exist (for constraint satisfaction and beyond)?"

Computational problems exhibit a diverse range of behaviors in terms of how quickly and effectively they can be solved. What underlying mathematical structure (or lack thereof) in a computational problem leads to an efficient algorithm for solving it (or dictates its intractability)? This is a central challenge addressed by research in the theory of computing.

Given the vast landscape of problems and myriad clever algorithms to solve them, it would be simplistic to hope for a universal theory explaining the underpinnings of easiness/hardness. Yet, in the realm of constraint satisfaction problems, the (recently proved) algebraic dichotomy theorem gives a definitive answer: a polynomial time algorithm exists when there are non-trivial local operations called polymorphisms under which the solution space is closed; otherwise the problem is NP-complete. Inspired and emboldened by this, one might speculate that a polymorphic principle might hold in more general contexts, with interesting ways to combine solutions to get more solutions being the genesis of efficient algorithms.

The talk will give a gentle introduction to the classification of computational complexity of problems, which is a core endeavor in theoretical computer science, with particular attention to constraint satisfaction problems and the polymorphic approach to understanding their complexity. We will describe some extensions beyond CSPs where the polymorphic principle seems promising (yet far from understood), point out some of the many challenges that remain, and speculate on broader connections to fine-grained complexity and optimization.

REPRESENATIVE ARTICLES/BACKGROUND READING:

- https://introtcs.org/public/lec_10_efficient_alg.html
- https://en.wikipedia.org/wiki/P_versus_NP_problem
- https://en.wikipedia.org/wiki/Schaefer%27s_dichotomy_theorem
- https://arxiv.org/abs/1907.04383

ANETTE "PEKO" HOSOI
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Anette "Peko" Hosoi is the Neil and Jane Pappalardo Professor of Mechanical Engineering and Professor of Mathematics. Her research contributions lie at the junction of nonlinear hydrodynamics, biomechanics, and bio-inspired design. A common theme in her work is the fundamental study of shape, kinematic, and rheological optimization of biological systems with applications to the emergent field of soft robotics. More recently, she has turned her attention to problems that lie intersection of biomechanics, applied mathematics, and sports. She is the co-founder of the MIT Sports Lab which connects the MIT community with pro-teams and industry partners to address data and engineering challenges that lie within the sports domain.

Peko joined the Department of Mechanical Engineering in 2002 as an assistant professor after receiving an AB in physics from Princeton University and an MA and PhD in physics from the University of Chicago. She has received numerous awards including the APS Stanley Corrsin Award, the Bose Award for Excellence in Teaching, and the Jacob P. Den Hartog Distinguished Educator Award. She is a Fellow of the American Physical Society (APS), a Radcliffe Institute Fellow, and a MacVicar Faculty Fellow.

ABSTRACT: "Sports, probability, and public policy"

In light of recent advances in data collection, sports possess a number of features that make them an ideal testing ground for new analyses and algorithms, and allow them to serve as a controlled microcosm in which to explore broader societal issues. In this talk I will describe two such studies: one related to public health and the pandemic and one related to the role of skill and chance in everyday activities.

In the first, I will discuss what can be learned from the natural experiments that were (fortuitously) run in America football stadiums. During the 2020 National Football League (NFL) season, teams collaborated with local communities to determine whether or not to allow fans in the stadiums during the pandemic. These policy decisions were made based on local guidelines, local prevalence, community risk tolerance, and other localized considerations; some stadiums ultimately decided to allow fans at the games while others remained closed, providing perhaps the first set of natural experiments that can be analyzed to investigate the impact of opening stadiums on public health.

The second topic I will discuss centers on fantasy sports which have experienced a surge in popularity in recent years. One of the consequences of this recent rapid growth is increased scrutiny surrounding the legal aspects of the games, which typically hinge on the relative roles of skill and chance in the outcome of a competition. While there are many ethical and legal arguments that enter into the debate, the answer to the skill versus chance question is grounded in mathematics. In this talk I will analyze data from daily fantasy competitions and propose a new metric to quantify the relative roles of skill and chance in games and other activities.

REPRESENTATIVE ARTICLE:

- https://www.pnas.org/doi/10.1073/pnas.2114226119

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Chung-Pei Ma is the Judy Chandler Webb Professor in Physical Sciences and a Professor in Astronomy and Physics at UC Berkeley. She is an astrophysicist who enjoys using luminous matter to study dark components in the universe: dark matter, dark energy, and black holes. Her research group uses both theoretical and observational tools to investigate the cosmic assembly of black holes and galaxies.

Chung-Pei was a Miller Professor in 2010 and 2019 and is a member of the Miller Executive Committee. She is a fellow of the American Physical Society, the American Astronomical Society, and the American Association for the Advancement of Science. She is also a member of the American Academy of Arts and Sciences and the National Academy of Sciences.

Chung-Pei is an avid violin player and was a student at the New England Conservatory of Music in Boston while pursuing her undergraduate and PhD studies at MIT.

ABSTRACT: "Black Holes: Singlets and Twins"

Black holes are spectacular end products of the fatal attraction of gravity. "Small" black holes are graveyards of massive stars. Big black holes reside at the centers of galaxies and have masses reaching many billion suns. Moreover, both singlet and twin black holes have been sighted. I will highlight some recent exciting discoveries in black hole research and describe our own effort in uncovering a new population of ultra-massive black holes.

REPRESENTATIVE ARTICLES:

1. Prologue: A Voyage among the Holes (p. 23-58) of "Black Holes and Time Warps" by Kip Thorne
https://www.academia.edu/30472906/BLACK_HOLES_AND_TIME_WARPS_Einstein_Outrageous_Legacy

2. https://www.quantamagazine.org/physics-nobel-awarded-for-black-hole-breakthroughs-20201006/

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Rebecca D. Tarvin obtained her BA in Biology from Boston University in 2010, worked abroad conducting fieldwork in Ecuador and then obtained a PhD in Biological Sciences from the Department of Integrative Biology at the University of Texas at Austin in 2017. After a year-long postdoctoral research position at UT Austin, she conducted another abbreviated postdoctoral scholar position as a Miller Fellow from 2018 to 2019. Rebecca's PhD and postdoctoral work focused on the ecology, evolution, and molecular biology of dendrobatid poison frogs from Ecuador and Colombia. Currently, Rebecca is an Assistant Professor in the Department of Integrative Biology and an Assistant Curator of Herpetology at the Museum of Vertebrate Zoology at the University of California, Berkeley.

<u>ABSTRACT:</u> "Ecology and evolution of toxin resistance in animals"

Toxins are entrenched components of ecosystems. Animals are often faced with the challenge to avoid toxins or adapt to them, and whether they evolve toxin resistance can be a key determinant of their evolutionary trajectory. In this talk I will provide an overview of the diversity of toxin resistance mechanisms present in animals that acquire toxins from their environment. I will then delve into the ecology and evolution of toxin resistance in two major study systems in my lab: field studies of poisonous amphibians and experimental evolution of fruit flies. By studying why animals accumulate toxins and how they deal with the consequences, our research sheds light on the genetics of disease, drug resistance, co-evolutionary dynamics, and protein evolution, from the perspective of wild populations under pressure to survive their natural enemies.

<u>REPRESENTATIVE ARTICLES:</u>

- https://www.sciencedirect.com/science/article/pii/S2590171022000029?via%3Dihub
- https://www.science.org/doi/10.1126/science.aan5061

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Tadashi Tokieda is a professor of mathematics at Stanford University. He grew up as a painter in Japan, became a classical philologist (not to be confused with philosopher) in France and, having earned a PhD in pure mathematics from Princeton, has been an applied mathematician in England and the US. He is also active in outreach in the developing world, especially via the African Institute for Mathematical Sciences. MSRI (Mathematical Sciences Research Institute), Berkeley, funds his videos on the youtube channel Numberphile, featuring a variety of scientifically surprising toys and magic tricks.

ABSTRACT:

Starting from just a sheet of paper, by folding, stacking, crumpling, sometimes tearing, we will explore a diversity of phenomena, from magic tricks and geometry to elasticity and the traditional Japanese art of origami. Much of the lecture consists of table-top demonstrations, which you can try later with friends and family.

So, take a sheet of paper. . .

PREPARATORY VIEWING:

- https://www.youtube.com/playlist?list=PLt5AfwLFPxWI9eDSJREzp1wvOJsjt23H_

PAUL TURNER
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Dr. Paul Turner is the Rachel Carson Professor of Ecology and Evolutionary Biology at Yale University, and Microbiology faculty member at Yale School of Medicine. He obtained a BA in Biology (1988) from University of Rochester, a PhD in Microbial Evolution (1995) from Michigan State University, and did postdocs at National Institutes of Health, University of Valencia in Spain, and University of Maryland-College Park, before joining Yale in 2001. Dr. Turner studies evolutionary genetics of viruses, particularly phages that infect bacterial pathogens and RNA viruses transmitted by arthropods, and researches the use of phages to treat antibiotic-resistant bacterial diseases. He is very active in science-communication outreach to the general public, and is involved in programs where faculty collaborate with K-12 teachers to improve STEMM education in underserved public schools. Dr. Turner's service includes the National Science Foundation's Bio Advisory Committee, and his honors include Fellowship in the National Academy of Science, American Academy of Arts & Sciences, and American Academy of Microbiology.

<u>ABSTRACT:</u> "Leveraging evolutionary trade-offs and phage selection pressure to reduce bacterial pathogenicity."

Increasing prevalence and severity of multi-drug-resistant bacterial infections require novel management strategies. One possible strategy is a renewed approach to 'phage therapy,' where these administered viruses not only kill the target bacteria, but also predictably select for phage resistance that reduces virulence and/or increases antibiotic sensitivity (evolutionary trade-offs). By utilizing virulence factors as receptor binding sites, the phages exert selection for bacteria to evolve phage resistance by modifying (or losing) the virulence factor, potentially reducing bacterial pathogenicity. We present examples of phages that utilize bacterial lipopolysaccharides, efflux-pump proteins, and pili as binding sites, to kill target bacteria while selecting for phage resistance that coincides with useful clinical traits such as antibiotic re-sensitization and reduced tissue inflammation. These in vitro observations are compared to phenotypic, genetic and metagenomics analyses of microbes isolated longitudinally from patient samples before, during and after emergency phage therapy treatments. Throughout, emphasis is placed on the ability to accurately predict how target bacterial pathogens will respond to phages administered either alone, sequentially, or in mixtures (cocktails).

<u>REPRESENTATIVE ARTICLES:</u>

- Kortright et al. 2019 Cell: https://pubmed.ncbi.nlm.nih.gov/30763536/
- Burmeister et al. 2020 PNAS USA: https://www.pnas.org/content/117/21/11207.short

INTRODUCING THE 2022—2025 MILLER RESEARCH FELLOWS

Lijie Chen
EECS
Host: Avishay Tal

Kelian Dascher-Cousineau
Earth & Planetary Science
Host: Roland Burgmann

Boryana Hadzhiysk
Physics
Host: Martin White

Raul Ramos
Kathy Day awardee
Molecular & Cell Biology
Hosts: Ellen Lumpkin, Diana Bautista

Chadi Saad-Roy
Integrative Biology
Host: Michael Boots

Carly Schissel
Chemistry
Host: Alanna Schepartz

Georgios Varnavides
Materials Science and Engineering & Physics
Hosts: Mary Scott, Joel Moore

Mengshan Ye
Chemistry
Host: Jeffrey Long

Elena Zavala
Molecular and Cell Biology
Host: Priya Moorjani

Lingfu Zhang
Statistics
Host: Shirshendu Ganguly

MILLER INSTITUTE SYMPOSIUM
JUNE 3-5, 2022
AGENDA

Friday, June 3

3 - 6:00 pm	Arrival and registration - Seagull Check In
4 - 6:00	Informal gathering - Social Time - Buck Hall
6:00 – 7:30	Dinner & Welcome - Redwood Hall Dining Room
7:30 – 11:00	Miller Fellows Posters – Buck Hall

Saturday, June 4 - Buck Hall

7 - 8:30 am	Breakfast - Redwood Hall Dining Room
8:30 - 9:10	**Becca Tarvin, UC Berkeley** **“Ecology and evolution of toxin resistance in animals”**
9:10 - 9:40	Discussion
9:40 - 10:00	Break
10:00 - 10:40	**Peko Hosoi, MIT** **“Sports, probability, and public policy”**
10:40 - 11:10	Discussion
11:10 - 12:45	Group Photo followed by Lunch
1:00 - 1:40	**Chung-Pei Ma, UC Berkeley** **“Black Holes: Singlets and Twins”**
1:40 - 2:10	Discussion
2:10 - 2:40	Break

MILLER INSTITUTE SYMPOSIUM
JUNE 3-5, 2022
AGENDA CONT.

2:40 - 3:20 **Paul Turner, Yale University**
"Leveraging evolutionary trade-offs and phage selection pressure to reduce bacterial pathogenicity."

3:20 - 3:50 Discussion

3:50 - 4:20 Break

4:20 - 5:00 **Marla Feller, UC Berkeley**
"The role of neural activity in wiring up the brain"

5:00 - 5:30 Discussion

5:30 - 7:00 Free time

7:00 – 8:30 Dinner - Redwood Hall Dining Room

8:45 – 11:00pm Movies / Posters / Music and Social Time at Buck Hall

<u>Sunday, June 5 - Buck Hall</u>

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

9:00 - 9:40 **Tadashi Tokieda, Stanford**
"A world from a sheet of paper."

9:40- 10:10 Discussion

10:10 - 10:40 Break

10:40 - 11:20 **Venkat Guruswami, UC Berkeley**
"When and why do efficient algorithms exist (for constraint satisfaction and beyond)?"

11:20 - 11:50 Discussion

12:00 - 1:30 Lunch and close of meeting

Miller Research Fellows

Iwnetim Abate, 2021-2024
MSE and Chem Hosts: Mark Asta, Kwebena Bediako
Ph.D. Institution: Stanford
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Ion-insertion in layered materials has transformed our lives by enabling the invention of Li-ion batteries, which made portable devices and electrification of transportation possible. My research interest lies at the intersection of materials chemistry, surface engineering and electrochemistry to reimagine the physics of ion-insertion towards achieving exquisite atomic level control of material properties and developing novel systems for tunable catalysis, multiplex sensors and quantum information applications.

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

Grayson Chadwick, 2020-2023
MCB Hosts: Dipti Nayak
Ph.D. Institution: CalTech
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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.

Emily Davis, 2020-2023
Physics Hosts: Norman Yao
Ph.D. Institution: Stanford
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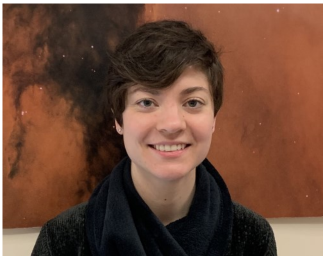

For my doctoral work, I built an experiment to generate and image nonlocal interactions in a cold atomic ensemble trapped in an optical cavity. At Berkeley, I look forward to working in Prof. Norman Yao's group studying many-body physics and high-pressure sensing in nitrogen vacancy centers in diamond.

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. CO_2 capture, purification, electrocrystallization) applications.

Shashank Gandhi, 2021-2024
MCB Hosts: Richard Harland
Ph.D. Institution: CalTech
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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.

Allie Gaudinier, 2019-2022
PMB, Stats Hosts: Benjamin Blackman, Haiyan Huang
Ph.D. Institution: UC Davis
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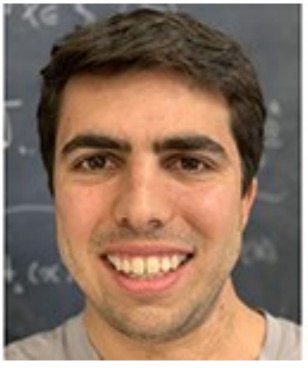
Genetic variation and phenotypic plasticity allow species to adapt to local environments, especially in the face of climate change. My research focuses on exploring local adaptation of monkeyflowers. For plants, the timing of the developmental transition from a vegetative to reproductive life stage is critical for sufficient seed production. Monkeyflower populations from regions of low and high elevations in California and Oregon use critical photoperiod as a cue to regulate flowering time. I am dissecting how changes in regulatory pathways have adapted in these local populations to plants can survive their environments using different genetic mechanisms.

Reza Gheissari, 2019-2022
Stats and EECS Host: Alistair Sinclair
Ph.D. Institution: NYU
gheissari@berkeley.edu



Much of statistical physics is concerned with developing a microscopic justification for emergent phenomena and sharp phase transitions in matter (e.g., crystallization, spontaneous magnetization). I work on mathematical aspects of this theory from a probabilistic point of view, analyzing the equilibrium and off-equilibrium behavior of large, random, systems of interacting particles. I am also interested in relations to the theories of optimization and statistical inference in high dimensions.

Anna Ho, 2020-2023
Astro Hosts: Daniel Kasen, Raffaella Margutti
Ph.D. Institution: CalTech
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The fate of a star - how it lives, how it dies, and the corpse it leaves behind - depends primarily on its mass. High-mass stars explode as supernovae and leave behind a neutron star or a black hole. In rare cases, the corpse acts as an "engine" that launches a relativistic jet. These "engine-driven" explosions are the focus of my research: I use robotic telescopes to discover them as they are happening in the night sky, then use telescopes around the world and in space to watch them unfold.

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

Naomi Latorraca, 2019-2022
MCB Host: Susan Marqusee
Ph.D. Institution: Stanford
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Proteins embedded in cell membranes relay information about the external environment into the cell, allowing the cell to respond by changing gene transcription levels, protein expression, and more. To communicate information across the membrane, these proteins change their shape. Such shape changes or conformational changes might enable the direct movement of nutrients and ions across the membrane or cause the membrane proteins to couple with cytosolic proteins. During my Ph.D., I used computer simulations to reveal what certain membrane proteins look like when they undergo these changes, allowing us to explain cellular level phenomena using atomic-level information. As a Miller Fellow, I hope to combine experimental and computational approaches to better understand how perturbations to protein's structure, including mutations to the protein's primary sequence, alter the dynamics and function of these and other proteins.

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.

Aavishkar Patel, 2019-2022
Physics Host: Ehud Altman
Ph.D. Institution: Harvard
aavishkarpatel@berkeley.edu

I am a theoretical condensed matter physicist interested in strongly interacting many-body quantum systems, which determine the physics of several modern materials. My PhD research was focused on understanding the flows of charge and energy and the dynamics of quantum information in such systems. Taking inspiration from recent and upcoming experiments, I intend to further explore the non-equilibrium properties of these systems.

Ekta Patel, 2019-2022
Astronomy Host: Daniel Weisz
Ph.D. Institution: University of Arizona
ektapatel@berkeley.edu

Tracking the 3-dimensional motions of stars in nearby galaxies is a recent astronomical breakthrough that has substantially increased our knowledge of how galaxies grow, evolve, and interact with each other over cosmic time. My research focuses on using such measurements to understand the history of the Local Group, which is composed of our Milky Way, its twin galaxy, Andromeda, and the dozens of small "satellite" galaxies orbiting around each of them. These dynamical measurements now make it possible to trace the orbital histories of Local Group galaxies to their origins in the early Universe. In my work, I use the combined power of these observational data sets with data from high-resolution simulations of the Universe to uncover the dynamical history and future fate of our galactic neighborhood.

Nayeli Rodriguez Briones, 2020-2023
Chemistry Host: K. Birgitta Whaley
Ph.D. Institution: University of Waterloo
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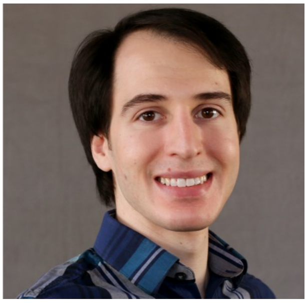
Quantum information science gives us an effective language to ponder and understand our universe by describing the laws of nature in terms of the evolution of information. In this context, the question at the heart of my research is how quantum information science can be used to explore and discover 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
E-mail: arosen@berkeley.edu



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.

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.

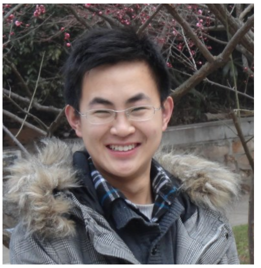
Ellen Vitercik, 2021-2024
EECS Hosts: Michael Jordan, Jennifer Chayes
Ph.D. Institution: Carnegie Mellon University
vitercik@berkeley.edu

My research lies at the intersection of artificial intelligence, algorithm design, and economics, with a particular focus on the theoretical underpinnings of these subjects. I am interested in how machine learning can transform the way we design algorithms in computer science and mechanisms in economics, as well as the broader societal impacts of using machine learning in the context of economics.

Danqing Wang, 2019-2022
MSE Host: Junqiao Wu
Ph.D. Institution: Northwestern University
danqing.wang@berkeley.edu

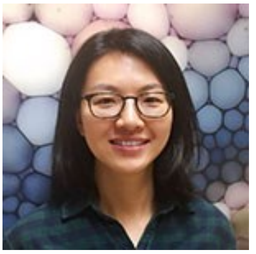
The rapid development in nanoscience not only enables access to physical sizes at a smaller scale, but also triggers fundamental breakthroughs in such as optics, electronics and energy. My Ph.D. research focused on structural engineering of photonic nanocavities for tunable nanoscale lasing, and the light-matter interactions with different gain materials. As a Miller Fellow, I plan to exploit materials development and structural designs for engineering optical behaviors at the nanoscale. I will aim at reconfigurable and tunable nanophotonics by utilizing phase-change materials and two-dimensional materials as new optical elements that are responsive to external stimulus. Also, I will expand my research scope to thermal and electronic properties of nanomaterials, and explore interactions at the quantum level.

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



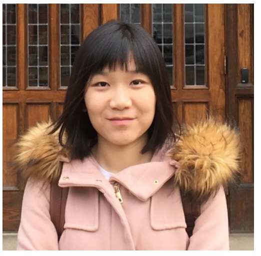
Electrochemistry lies at the interface between chemistry and physics and represents one of the most promising approaches for enhancing energy efficiency, mitigating environmental impacts and carbon emissions, and enabling renewable energy technologies, such as fuel cells, CO2 and N2 reduction, water 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.

Qiong Zhang, 2019-2022
BioEng & PMB Hosts: John Dueber, Brian Staskawicz
Ph.D. Institution: Univ. of Maryland qiongzh@berkeley.edu



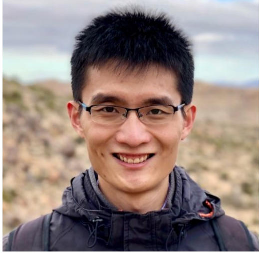
I am a plant biologist aiming to evolve better crops through molecular breeding facilitated by genome editing tools (such as CRISPR). I studied plant innate immunity during my PhD and as a Miller Fellow, I'm developing CRISPR tools to engineer crops with durable resistance against plant pathogens. Eventually, I hope to extend these methods to the improvement of other important agronomical traits.

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 Hosts: Michael Zuerch
Ph.D. Institution: MIT alfredz@berkeley.edu



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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