2024 Rising Stars in Physics Workshop

Columbia University in the City of New York

Flatiron Institute

The 2024 Rising Stars in Physics Workshop was made possible thanks to the support from the Heising-Simons Foundation and the Flatiron Institute, a division of the Simons Foundation.

HEISING-SIMONS FOUNDATION

FLATIRON INSTITUTE

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COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

Welcome
2024 Rising Stars in Physics Workshop

Dear Rising Stars in Physics Participants,

The Columbia University Department of Physics and the Simons Foundation's Flatiron Institute are excited to welcome you to the 2024 Rising Stars in Physics Workshop, addressing issues relevant to women transitioning to their first faculty position.

We hope and expect that the workshop will facilitate lively and intense conversations and will help to build impactful and lasting connections with peers, mentors and future colleagues. We feel privileged to aid an outstanding group of young scholars navigating the opportunities and choices of their academic careers.

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Enjoy!

Dmitri Basov
Chair, Department of Physics
Higgins Professor of Physics
Columbia University

Pablo Jarillo-Herrero
Workshop Co-Chair
Cecil and Ida Green Professor of Physics
Massachusetts Institute of Technology

Andrew Millis
Co-Director
Center for Computational Quantum Physics
Flatiron Institute

Professor of Physics
Columbia University

Kerstin Perez
Workshop Co-Chair
Lavine Family Associate Professor of Natural Sciences
Columbia University

Welcome

The Rising Stars Workshop Organizing Committee

Columbia University
Department of Physics

Simons Foundation
Flatiron Institute

Sonya Hanson

Research Scientist / Project Leader
Center for Computational Biology &
Center for Computational Mathematics
Flatiron Institute

Chris Hayward

Research Scientist
Center for Computational Astrophysics
Flatiron Institute

James McIver

Assistant Professor of Physics
Columbia University

Keynote Speakers

Pilar Cossio

Research Scientist
Center for Computational Mathematics
Flatiron Institute

Project Leader
Center for Computational Biology
Flatiron Institute

Ingrid Daubechies

James B. Duke Distinguished Professor of
Mathematics and Electrical and
Computer Engineering
Duke University

Angela Olinto

Provost and Professor of
Astronomy and of Physics
Columbia University

Workshop Panelists

Viviana Acquaviva
Professor of Physics
The City University of New York

Timothy Berkelbach
Associate Professor of Chemistry
Columbia University
Co-Director
Initiative for Computational Catalysis
Flatiron Institute

Jasna Brujic
Professor of Physics
New York University

Workshop Panelists

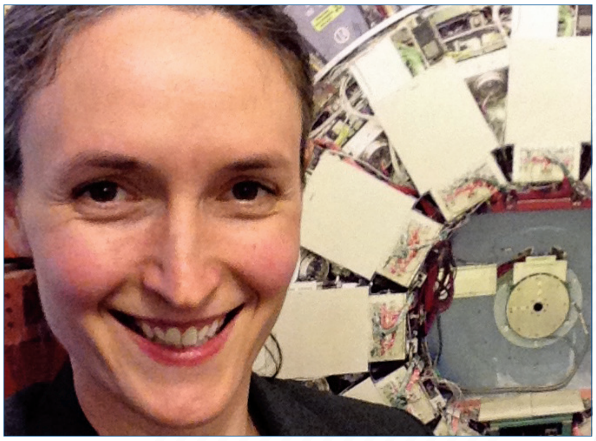
Blakesley Burkhart

Associate Professor of
Physics and Astronomy
Rutgers University

Associate Research Scientist
Center for Computational Astrophysics
Flatiron Institute

Julianne Dalcanton

Director
Center for Computational Astrophysics
Flatiron Institute



Sarah Demers

Professor of Physics
Yale University

Workshop Panelists

J. Colin Hill
Assistant Professor of Physics
Columbia University

Kathryn V. Johnston
Professor of Astronomy
Columbia University

Georgia Karagiorgi
Associate Professor of Physics
Columbia University

Workshop Panelists

Laura Newburgh
Associate Professor on Term of Physics
Yale University

Toyoko Orimoto
Professor of Physics
Northeastern University

Lindley Winslow
Professor of Physics
Massachusetts Institute of Technology

Agenda

TUESDAY, SEPTEMBER 24, 2024

FLATIRON INSTITUTE—INGRID DAUBECHIES AUDITORIUM (IDA), 2ND FLOOR

7:00-9:00pm	**Networking Reception for Workshop Participants**

WEDNESDAY, SEPTEMBER 25, 2024

COLUMBIA UNIVERSITY—555 LERNER HALL

8:30-9:10am	**Breakfast**
9:10-9:25am	**Welcome from Physics Department Chair and Workshop Co-Chairs** Dmitri Basov, Physics Department Chair, Columbia University Pablo Jarillo-Herrero, Workshop Co-Chair, MIT Kerstin Perez, Workshop Co-Chair, Columbia University
9:25-10:30am	**Research Talks by Participants** Moderator: Dmitri Basov, Columbia University
	Array of individually controlled molecules for quantum science Annie Park, Harvard University
	Thermal Hall effect in quantum materials Lu Chen, University of Sherbrooke
	Insight into the strongly correlated electronic system Ling-Fang Lin, University of Tennessee
	Imaging mesoscale electronic phenomena with atomic force microscopy Tatiana Webb, Columbia University
	Ab-initio downfolding for strongly correlated materials Yueqing Chang, Rutgers University
10:30-11:15am	**Group Photo and Coffee Break**
11:15am-12:15pm	**Panel 1: Starting a Research Group** A discussion on how to build a research group, including how to set up a lab and hire/manage members. Moderator: Andrew Millis, Columbia University/Flatiron Institute
Panelists:	Jasna Brujic, New York University Colin Hill, Columbia University Laura Newburgh, Yale University
12:15-1:45pm	**Lunch & Keynote Address** Introduction: Kerstin Perez, Columbia University Keynote Speaker: Angela Olinto, Provost and Professor of Astronomy and of Physics, Columbia University

1:55-3:15pm	**Research Talks by Participants** Moderator: Sonya Hanson, Flatiron Institute
	The GAPS antarctic balloon mission: **A dark matter search with cosmic-ray antinuclei** Field Rogers, UC Berkeley
	Precision neutrino interaction measurements Afroditi Papadopoulou, Argonne National Lab
	The future of collider phyiscs Cari Cesarotti, MIT
	Making light of dark energy with dark energy radiation Kim Berghaus, Caltech
	Searching for axion dark matter with DMRadio-50L Maria Simanovskaia, Stanford University
	Building for the next generation of neutrino discoveries Lauren Yates, Fermilab
3:15-3:45pm	**Coffee Break**
3:45-4:45pm	**Panel 2: Securing Grants** A discussion on how to apply for external funding, interact with program managers, and manage funds. Moderator: Sonya Hanson, Flatiron Institute
Panelists:	Timothy Berkelbach, Columbia University/Flatiron Institute Julianne Dalcanton, Flatiron Institute Lindley Winslow, MIT
4:45-5:30pm	**Walk to Faculty House**

COLUMBIA UNIVERSITY—FACULTY HOUSE

5:30-6:30pm	**Reception**
6:30-8:30pm	**Dinner & Keynote Address** Introduction: Andrew Millis, Columbia University/Flatiron Institute Keynote Speaker: Ingrid Daubechies, James B. Duke Distinguished Professor of Mathematics and Electrical and Computer Engineering, Duke University

Agenda

THURSDAY, SEPTEMBER 26, 2024

FLATIRON INSTITUTE—INGRID DAUBECHIES AUDITORIUM (IDA), 2ND FLOOR

8:30-8:55am	**Breakfast**
8:55-9:05am	**Welcome** Andrew Millis, Columbia University/Flatiron Institute
9:05-10:35am	**Research Talks by Participants** Moderator: Chris Hayward, Flatiron Institute
	Gravitational wave paleontology: A new frontier to explore the formation, lives, and deaths of stars across cosmic time Floor Broekgaarden, UC San Diego
	Exploring the origins of fast radio bursts Kenzie Nimmo, MIT
	Resolving galaxies with observations and simulations Rachel Cochrane, University of Edinburgh
	Astrophysical insights from the compact-object mass distribution inferred with gravitational waves Sylvia Biscoveanu, Northwestern University
	Illuminating the Universe's mysteries with quantum optics Haocun Yu, University of Vienna
	From dawn to dusk: Uncovering the evolving relationship between supermassive black holes and their galaxies across cosmic time Erini Lambrides, NASA-Goddard Space Flight Center
	Beyond the observable: AI-driven insights into the large-scale structure of the Universe Carolina Cuesta Lazaro, MIT/Harvard University
10:35-10:55am	**Coffee Break**
10:55-11:55am	**Panel 3: Interview and Negotiation** A discussion on applications, the interview process, and negotiating job offers. Moderator: Chris Hayward
Panelists:	Blakesley Burkhart, Rutgers University/Flatiron Institute Sarah Demers, Yale University Georgia Karagiorgi, Columbia University

11:55am-12:40pm	**Lunch**
12:40pm-1:40pm	**Keynote Address** Introduction: Sonya Hanson, Flatiron Institute Keynote Speaker: Pilar Cossio, Research Scientist, Center for Computational Mathematics, Flatiron Institute Project Leader, Center for Computational Biology, Flatiron Institute
1:40-2:50pm	**Research Talks by Participants** Moderator: Andrew Millis, Columbia University/Flatiron Institute
	A mixing time bound for Gibbs sampling from smooth log-concave distributions Neha Wadia, Flatiron Institute
	Morphodynamics of mixed bacterial communities in three dimensions Meera Ramaswamy, Princeton University
	Cavity electrodynamics of van der Waals heterostructures Hope Bretscher, Max Planck Institute for the Structure and Dynamics of Matter
	A simple and solvable model of non-equilibrium Mott excitons Tessa Cookmeyer, UC Santa Barbara
	Multi-scale models for tunable quantum materials Ziyan (Zoe) Zhu, Stanford University
2:50-3:05pm	**Coffee Break**
3:05-4:05pm	**Panel 4: Balance** A discussion on time management for new faculty, including how to balance research, teaching, service, family and other commitments. Moderator: Rachel Somerville, Flatiron Institute
Panelists:	Viviana Acquaviva, City University of New York Kathryn V. Johnston, Columbia University Toyoko Orimoto, Northeastern University
4:05pm	**Adjourn**

Workshop Participants

Kim Berghaus

Sherman Fairchild Postdoctoral Fellow
California Institute of Technology

TALK TITLE: Making light of dark energy with dark energy radiation

BIO: Kim Berghaus is a theoretical particle physicist and cosmologist, researching dark matter and dark energy. Currently a Sherman Fairchild Postdoctoral Fellow at the California Institute of Technology, she earned her Ph.D. from Johns Hopkins University in 2020. Kim was born and raised near Frankfurt, Germany, and came to the US for her undergraduate studies in physics on a Division I tennis scholarship. She is passionate about science communication and enjoys sharing her enthusiasm for physics by making it accessible.

RESEARCH INTERESTS: My research interests lie on the intersection of particle physics and cosmology. Dark energy, dark matter, and hypothetical dark radiation live beyond the Standard Model of particle physics. My research seeks to illuminate these building blocks of the hidden Universe, by quantifying their properties, and their interactions with one another as well as the visible Universe. In my work, I have studied the first principle production of dark radiation during cosmological periods of accelerated expansion, which has led to new insights in the fields of inflation, dark energy, and the Hubble tension. Moreover, I am interested in utilizing effective quantum field theories to quantify dark matter signatures and backgrounds in new-generation direct-detection experiments with condensed matter targets. Combining cosmological and earth based direct-detection probes, my research aims to identify novel multi-messenger signatures of the dark Universe.

BIO: Sylvia Biscoveanu is a NASA Einstein Postdoctoral Fellow at Northwestern University – CIERA working on using gravitational-wave data to understand the properties of compact-object mergers, their electromagnetic counterparts, and the stochastic gravitational-wave background. A member of the LIGO Scientific Collaboration, she received her PhD in Physics from MIT in June 2023. Sylvia completed her undergraduate studies at the Schreyer Honors College of the Pennsylvania State University, majoring in Physics and Spanish with minors in Mathematics and Violin/Viola performance. Before starting her PhD at MIT, she was a Fulbright Postgraduate Scholar at Monash University in Melbourne, Australia, working on LIGO data analysis. Hailing from Philadelphia, Sylvia is also an avid musician and plays violin in the Chicago Metropolitan Symphony Orchestra.

RESEARCH INTERESTS: My research focuses on applications of Bayesian inference to probe astrophysics and cosmology with ground-based gravitational-wave observations. The growing catalog of gravitational-wave signals from compact object mergers observed by the LIGO-Virgo-Kagra collaboration has allowed us to study the properties of black holes and neutron stars more precisely than ever before. However, the formation channels of these binary systems remain poorly understood. I use population-level studies of compact-object mergers to gain insight into how these systems form and evolve.

In addition to the gravitational waves emitted by compact-object mergers that we can detect individually, I am also interested in accelerated detection strategies for the stochastic gravitational wave background. The gravitational analog of the cosmic microwave background, the stochastic background carries information about early-universe processes that cannot be probed with other means. I am working on a fully Bayesian search to simultaneously detect this primordial stochastic background and as astrophysical foreground, laying the groundwork for the data analysis techniques that will be required for the next generation of ground-based gravitational-wave detectors.

Sylvia Biscoveanu

NASA Einstein Postdoctoral Fellow
Northwestern University

TALK TITLE: Astrophysical insights from the compact-object mass distribution inferred with gravitational waves

Hope Bretscher

Marie-Curie Postdoctoral Fellow
Max Planck Institute for the Structure
and Dynamics of Matter

TALK TITLE: Cavity electrodynamics of van der Waals heterostructures

BIO: Hope Bretscher is a Marie Sklodowska-Curie Postdoctoral Fellow at the Max Planck Institute for the Structure and Dynamics of Matter (MPSD), in Hamburg, Germany, where she investigates the low-energy electrodynamics of 2D materials. Prior to this, she was a Humboldt Postdoctoral Fellow at MPSD. Originally from St. Louis Missouri, Hope received her BA in physics from the University of Chicago and her physics PhD in 2021 from the University of Cambridge. Outside of lab, she can usually be found running, biking, or hiking.

RESEARCH INTERESTS: My research centers on investigating and controlling the low-energy electrodynamics of quantum materials using ultrafast optical probes and cavity engineering. In these materials, competition between different microscopic interactions can lead to the emergence of quantum phases that exhibit intriguing and highly tunable properties such as superconductivity, topological edge currents, ferroelectric and magnetic states. Establishing routes to control these phases is important both for advancing our fundamental understanding and delivering novel functionalities for future applications.

During my PhD, I used strong optical pulses to perturb quantum phases out of their ground state and studied their recovery dynamics, providing clues into what governs their emergence. As a postdoc, I developed an on-chip spectroscopic platform to investigate the electrodynamics of 2D materials resonant to the energy scale of their emergent phases (terahertz frequencies). Such resonant probes allow for capturing and controlling the fundamental excitations in materials, such as collective oscillations of the lattice (phonons) or electrons (plasmons), among others, providing a direct window into their underlying microscopic interactions. My particular interest is studying van der Waals (vdW) heterostructures, comprised of stacks of 2D materials, which can be designed to form subwavelength cavities where light and matter interact strongly. Having developed this cavity platform, I am now investigating whether these cavities, which engineer the electrodynamic environment and modify the quantum fluctuation spectrum, can be used to control quantum phases of a vdW heterostructure. I aim to use this light-matter control to answer fundamental questions about the emergence of unconventional superconductivity in vdW heterostructures, and to extend these techniques into the nonlinear regime, to unveil how energy moves coherently throughout a phase.

Workshop Participants

Floor Broekgaarden

Assistant Professor
UC San Diego

TALK TITLE: Gravitational wave paleontology: A new frontier to explore the formation, lives, and deaths of stars across cosmic time

BIO: Floor just started as an assistant Professor in the Astronomy department of UC San Diego working on black holes, stars, and applied statistics. Between 2023 and 2024 Floor was a Junior Fellow in the Simons Society of Fellows, a position that she pursued in New York at Columbia University and the Simons Foundation, and a research Professor at Johns Hopkins University. Floor received her PhD in Astrophysics in 2023 from Harvard University during which she held a NASA FINESST fellowship. Before this, Floor also completed a joint MSc. degree in Astronomy from the University of Amsterdam and the Vrije Universiteit in 2018, and both a Bachelor's degree in Mathematics as well as a Bachelor's degree in Physics & Astronomy at the University of Amsterdam in 2017.

RESEARCH INTERESTS: Floor's research focuses on Gravitational Wave Paleontology: studying massive stars from their remnants as compact object coalescences, with the goal to answer some of the key questions in gravitational-wave astronomy today: How do these gravitational-wave sources form? What can we learn from them about the formation, lives, and explosive deaths of massive stars across cosmic time? How do these sources help to enrich the universe with heavy metals over cosmic time? When pairs of stellar-mass black holes and neutron stars across our vast universe collide, they unleash bursts of gravitational waves that can now be detected on Earth since the first observation of a binary black hole merger in 2015. The detectable properties of these black hole mergers, like their masses, carry valuable information about the physics of black holes and neutron stars and probe the massive stars that once formed them. These detections open this new frontier of gravitational-wave paleontology. Making the most of these gravitational-wave observations requires comparing the observed properties of the black hole and neutron star mergers, such as their rates, masses, and spins, to theoretical models of their formation pathways. Floor's work addresses the key bottleneck in this endeavor: the so-called progenitor Uncertainty Challenge to overcome the issue that uncertainties within the theoretical models are so large, and the models so computationally expensive, that learning about the underlying fundamental physical processes in massive star evolution from gravitational-wave observations is challenging.

Workshop Participants

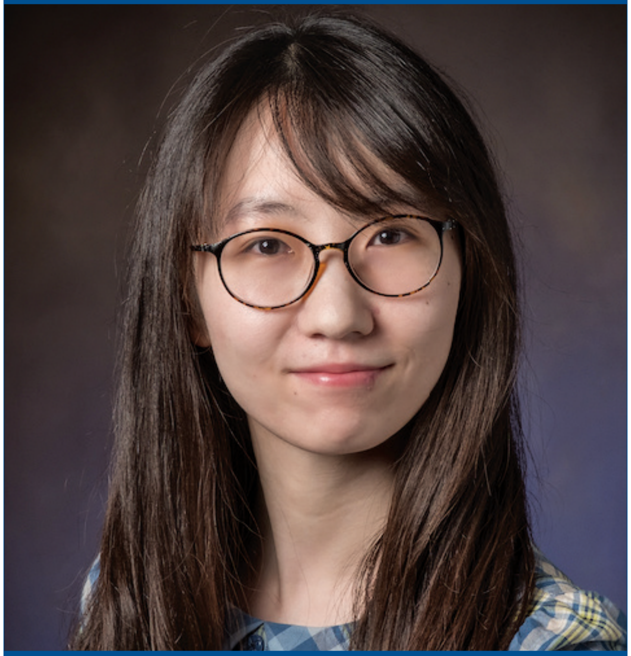
Cari Cesarotti

Postdoctoral Scholar
Massachusetts Institute of Technology

TALK TITLE: The future of collider physics

BIO: Cari Cesarotti is particle theorist working primarily in the realm of BSM at colliders and phenomenology. She started her career in physics as an undergrad at Cornell University, then continued to do a brief fellowship with the NA62 experiment at CERN, looking for signatures of new physics. After this she completed her PhD with Matthew Reece at Harvard University in high energy particle theory. She has since moved to MIT as a postdoc working in the groups of Jesse Thaler and Tracy Slater.

RESEARCH INTERESTS: My research interests are primarily related to beyond the standard model (BSM) searches at colliders and beyond. Given that there is no obvious theoretical model to resolve the various important open questions of particle physics (e.g. the hierarchy problem, dark matter, etc), our approach to finding new physics should be robust. In my research program I therefore strive to develop model-agnostic approaches to finding new physics. This includes looking at the effects of high-energy or weakly-coupled physics on measurements made at colliders, generic DM models and how their signatures might exist in cosmological and terrestrial experiments, or new tools to identify anomalous physics. A large subset of my research program is subsequently dedicated to explore the physics reach of future colliders to inform the discussion of what we do in a post-LHC era.



Yueqing Chang

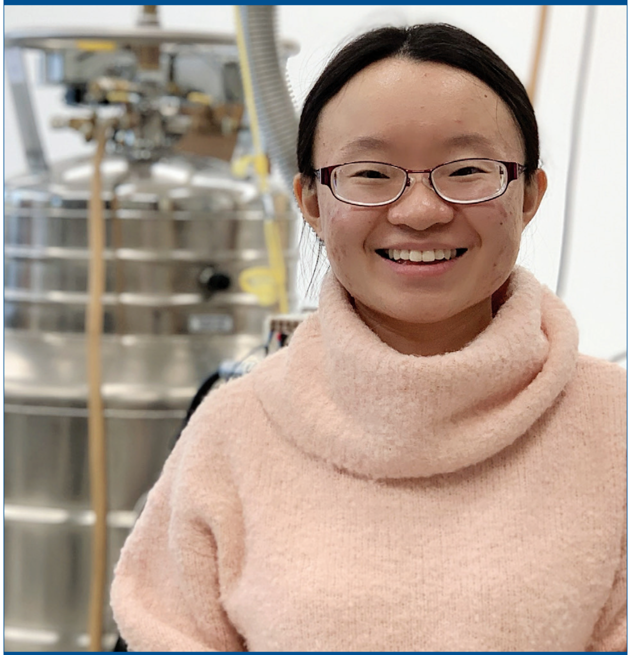
Abrahams Postdoctoral Fellow
Rutgers University

TALK TITLE: Ab-initio downfolding for strongly correlated materials

BIO: Yueqing Chang is an Abrahams Postdoctoral Fellow at Rutgers University, Center for Materials Theory. Her work focuses on understanding and predicting novel properties in quantum materials using numerical simulations. She earned her bachelor's degree in 2016 from Wuhan University, China, and subsequently moved to the United States for her graduate studies at the University of Illinois at Urbana-Champaign. She obtained her PhD in physics in 2022 under the supervision of Prof. Lucas K. Wagner, with a focus on developing systematic ab-initio downfolding frameworks for strongly correlated systems using many-body methods. In her spare time, she enjoys painting, walking her cat, and hiking.

RESEARCH INTERESTS: Effective descriptions of collective matter are central to modern physics. While the high-energy (ab-initio) theory for much of condensed matter physics is known, quantum electrodynamics of electrons and nuclei has historically been considered too difficult to solve directly. As a result, low-energy effective descriptions often rely on phenomenological theories or mean-field calculations that do not fully account for electronic correlations. In strongly correlated systems, where electronic correlations are dominant, these approaches often fail or produce inaccurate interaction terms.

My primary research interest includes using highly accurate many-body wavefunction methods to capture the low-energy physics of quantum materials at the ab-initio level. These ab-initio many-body methods, such as quantum Monte Carlo, aim to solve the high-energy Hamiltonian defined in a huge Hilbert space. While these calculations are systematically improvable and have proven reliable for predicting total energy and other observables in strongly correlated materials, connecting them directly to clear physical pictures remains challenging due to the wavefunctions' high dimensionality. My expertise lies in extracting useful information hidden in these ab-initio results to develop smaller, yet accurate, interacting models, which have demonstrated robustness and transferability across various system sizes. This allows for larger-scale calculations for interacting systems that would otherwise be unattainable. Additionally, I am interested in applying ab-intio methods to provide microscopic explanations of experimental observations and predict novel interaction-driven physics in quantum materials.



Lu Chen

Prize Postdoctoral Fellow
Université de Sherbrooke

TALK TITLE: Thermal Hall effect in quantum materials

BIO: Lu Chen was born and raised in Lanzhou, China. She received her bachelor's degree from the School of Physics at Peking University in 2014. Then she moved to the United States to pursue her graduate study at the University of Michigan, Ann Arbor and got her PhD in 2020. During her PhD, she worked in the lab of Professor Lu Li where she studied the electrical, thermal, and magnetic properties of various quantum materials. Subsequently, she moved to the Institut Quantique at Université de Sherbrooke in Québec, Canada, and worked there as a Prize Postdoctoral Fellow in the lab of Professor Louis Taillefer. During her postdoc, she obtained expertise in conducting thermal Hall effect measurements in novel quantum materials. She will join Professor James Analytis' group at the University of California Berkeley as a postdoc in Fall 2024 and is expected to start her new position as an assistant professor at the Department of Physics at the University of Illinois Urbana-Champaign in Jan 2026.

RESEARCH INTERESTS: My research interests lie in the field of experimental condensed matter physics, more specifically, quantum materials. The development of modern technologies in all fields highly relies on the properties of materials. The vast majority of materials' properties can not be fully understood with only classical physics or a single atom's behavior. Instead, it involves the understanding of collective motions of excitations with strong correlations using quantum physics, which redefines these materials as "quantum materials". I investigate the thermal, electrical, magnetic, and thermoelectric properties of various novel quantum materials, such as unconventional superconductors, quantum spin liquids, and topological materials at extremely low temperatures down to millikelvin and strong magnetic fields up to 100 Tesla. The experimental approaches that I employ are electrical transport, thermal transport, thermoelectric, and torque magnetometry measurements. I am interested in not only understanding fundamental physics phenomena in quantum materials, but also designing new experimental techniques to further advance my research.

Workshop Participants

Rachel Cochrane

Leverhulme Early Career Research Fellow
University of Edinburgh

TALK TITLE: Resolving galaxies with observations and simulations

BIO: Rachel Cochrane is a British astrophysicist studying the evolution of galaxies across cosmic time. She is currently an Leverhulme Early Career Fellow at the University of Edinburgh, where she also completed her PhD in 2019. She was previously a John Harvard Distinguished Science Fellow at the Center for Astrophysics| Harvard and Smithsonian (2019-2021), a Flatiron Research Fellow at the Flatiron Institute (2021-2023), and a postdoctoral research scientist at Columbia University (2023-2024).

RESEARCH INTERESTS: I work at the boundary of theory and observations to address key questions in galaxy evolution: what drives the formation of stars at different cosmic times?; how and when do spiral galaxies like our own Milky Way emerge?; what drives diversity in galaxy sizes and shapes? My approach is based on combining sensitive, high-resolution observations of distant galaxies with computationally-intensive cosmological simulations. I am currently working with data from the new James Webb Space Telescope to identify new populations of galaxies that form within the first billion years after the Big Bang. I am using cosmological simulations to refine the methods used to infer galaxy physical properties from the telescope data.

Workshop Participants

Tessa Cookmeyer

Postdoctoral Scholar
Kavli Institute for Theoretical Physics, UC Santa Barbara

TALK TITLE: A simple and solvable model of non-equilibrium Mott excitons

BIO: Tessa Cookmeyer is a postdoctoral scholar at the Kavli Institute for Theoretical Physics at UC Santa Barbara. She was born and raised in North Carolina until she went to Haverford College where she majored in physics and math. She then moved to UC Berkeley where she was advised by Dr. Joel Moore for her Ph.D. She became interested in physics in high school through Science Olympiad and pop science. When she has free time, she loves to bike, rock climb, play music, hang out with friends, and play ultimate frisbee.

Research Interests: My research is in the area of quantum many-body physics where I use a combination of analytical and numerical techniques to understand the low-temperature phase diagrams of many interacting quantum particles. The broad questions that motivate my research are what are the possible phases of matter that exist in solid state systems, what materials might realize such phases, and how do we detect them. I am particularly interested in quantum magnets and their potential spin-liquid phases, where the spins fail to order at the lowest energies. More recently, I have become interested in the physics of moiré materials, where a small twist is introduced between two single-layer materials, as they exhibit a rich phase diagram to explore and understand.

My dissertation focused on the theoretical understanding of two materials: CeCoIn5 and RuCl3 (and more broadly the Kitaev materials). For CeCoIn5, I developed a model that captures the phenomenology of recent conductivity measurements. Our model suggests that its strange-metal phase is due to a special quantum critical point without symmetry breaking. For the Kitaev materials, I developed a technique to predict the results of inelastic neutron scattering in a putative Kitaev phase for realistic models. My results ultimately disfavor the interpretation of RuCl3 as harboring a special magnetic phase, a Kitaev quantum spin liquid. In my postdoc, I continue to work on the question of how to detect and engineer a spin liquid, and I have begun to think about systems out-of-equilibrium and whether the non-equilibrium effects change or modify the equilibrium phases or phase transitions.

BIO: Carolina Cuesta-Lazaro is a postdoctoral fellow at the NSF Institute for Artificial Intelligence and Fundamental Interactions (IAIFI), focusing on machine learning for astrophysical data analysis. Her research aims to understand the Universe's accelerated expansion and the nature of the elusive dark matter. She earned her Ph.D. in Physics and Data Intensive Science from Durham University's Institute of Computational Cosmology. Carolina has collaborated with the UN Global Pulse and the UK's NHS on epidemiological simulations, and interned with Amazon's Alexa team.

RESEARCH INTERESTS: The upcoming era of cosmological surveys promises an unprecedented wealth of observational data that will transform our understanding of the universe. Surveys such as DESI, Euclid, and the Vera C. Rubin Observatory will provide extremely detailed maps of billions of galaxies that will cover a significant fraction of time evolution in structure formation. These datasets may contain the answer to some of the Universe's biggest mysteries, such as the nature of dark matter and the driving forces behind the Universe's accelerated expansion. Analyzing these massive datasets poses exciting challenges that machine learning is uniquely poised to overcome.

My work focuses on machine learning methods that scale to high-dimensional problems, such as mapping the invisible dark matter from observable light, or reconstructing the early Universe by reversing gravitational collapse. These approaches open new avenues for understanding the formation history of our Universe and the nature of dark matter. Moreover, I work on improving astrophysical simulations by addressing model misspecification and integrating observational data. By developing hybrid models that combine machine learning with differentiable physical simulators, we aim to refine our simulations, revealing new physics and enhancing our cosmological constraints.

Carolina Cuesta Lazaro

IAIFI Fellow
Massachusetts Institute of Technology

TALK TITLE: Beyond the observable: AI-driven insights into the large-scale structure of the Universe

Erini Lambrides

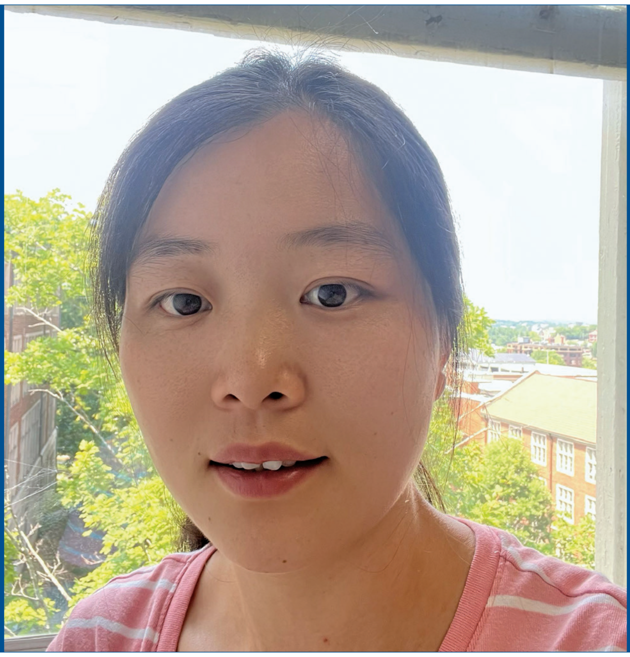
NPP Fellow
NASA-Goddard Space Flight Center

TALK TITLE: From dawn to dusk: Uncovering the evolving relationship between supermassive black holes and their galaxies across cosmic time

BIO: Erini Lambrides grew up in Brooklyn, NY convinced she would become a Broadway star—instead she studies the effects of black holes on the formation of cosmic stars. She transitioned from acting to astrophysics and received her B.S. in Physics at the University of Rochester and her PhD in Astronomy/Astrophysics at Johns Hopkins University. She studies the formation, growth, and impact of supermassive black holes from the dawn of the Universe to the present day. She currently is a prize postdoctoral fellow at NASA-Goddard Space Flight Center and leads several observational campaigns which have enabled new discoveries on the earliest populations of black holes. Outside of research, she cares deeply on how systems enable who gets to study astrophysics and dedicated time throughout her research career to develop pathways for a more inclusive Astronomy. She is currently a founder of NASA-PEER—NASA's first post-baccalaureate research and mentorship program with the goals of aiding largely historically marginalized identities through applying and preparing for graduate study.

RESEARCH INTERESTS: My research is centered on determining what drives the rapid growth of early supermassive black holes (SMBHs) and how this growth impacts the galaxies that harbor them. Every massive galaxy hosts a SMBH in its very center, and there exist empirically-derived relationships that connect the properties of these SMBHs with the galaxies that harbor them. The physical phenomena behind these relationships, in addition to how these relationships evolve over cosmic time, are the subject of the largest, unanswered questions in modern day astrophysics. I lead observational campaigns from state-of-the-art facilities across the entirety of the electro-magnetic spectrum to pioneer new selection techniques and physical paradigms. In particular, I hunt for observationally rare, but demographically plentiful populations of growing SMBHs, such as those that are heavily obscured by the contents of their host galaxies. Some of my work during my postdoctoral career includes finding the earliest samples of obscured SMBHs with relativistic jets to date—shattering expectations on the number density of these sources and developing new models to explain the puzzling properties of these sources and other early Universe SMBHs discovered with the latest flagship space telescope—JWST. My ultimate goal is to leverage high-fidelity observations with cutting-edge simulations to trace the growth and impact of the first black holes to present-day.

Workshop Participants



Ling-Fang Lin

Postdoctoral Researcher
University of Tennessee

TALK TITLE: Insight into the strongly correlated electronic system

BIO: Ling-Fang Lin is a postdoctoral researcher in Physics & Astronomy at the University of Tennessee, in Prof. Elbio Dagotto's group, working on theoretical condensed matter physics. She earned her PhD in physics in 2020 from Southeast University in China under the supervision of Prof. Shuai Dong. In her spare time, she enjoys cooking and baking.

RESEARCH INTERESTS: My research is mainly focusing on first-principles theoretical studies and model simulations of electronic properties, ferroelectricity, magnetism and superconductivity of strongly correlated systems. For example, I have introduced a novel concept, the ferromagnetic half-full mechanism, to explain the origin of the ferromagnetic insulating state in the quasi-one-dimensional strongly correlated electronic system. I am also interested in rich interesting magnetic phase diagrams by including the antiferromagnetic competition, the block magnetic Mott insulating state induced by next-nearest-neighbor hopping, orbital ordering in d2 systems, pairing tendencies in 1D Cu chains, and general picture of oxygen magnetic polarization in transition metal oxides. Now, I am also working on the magnetism and superconductivity of the newly discovered superconducting nickelate systems.

Workshop Participants

Kenzie Nimmo
Kavli Postdoctoral Fellow
Massachusetts Institute of Technology

TALK TITLE: Exploring the origins of fast radio bursts

BIO: Kenzie Nimmo is a postdoctoral research fellow at the Massachusetts Institute of Technology in the Kavli Institute for Astrophysics and Space Research. Born and raised in Scotland, Kenzie obtained her undergraduate and master's degree at the University of Glasgow. She then moved to the Netherlands to pursue a Ph.D. in radio astronomy. In 2022, Kenzie received her Ph.D. cum laude from the University of Amsterdam and ASTRON, the Netherlands Institute for Radio Astronomy. Her thesis work centered on using novel techniques in radio astronomy to explore the origins of Fast Radio Bursts, by zooming in on these mysterious transients in space and time.

RESEARCH INTERESTS: Roughly every minute, a bright flash of radio waves reaches Earth from extragalactic space. These fast radio bursts (FRBs) have very short durations of roughly 1 millisecond, comparable to radio emission seen from highly magnetized, dense stars within our own galaxy, known as pulsars. Although their timescales are comparable, FRBs are billions of times more luminous.

To probe the extreme physics behind these mysterious astrophysical transients I use a technique called very long baseline interferometry (VLBI), which uses the delay in the FRB arrival time at radio telescopes separated by over 1000 km to pinpoint where the FRB is coming from. The FRB environment holds valuable clues into their progenitor. Using only a handful of FRB sources during my Ph.D. research, I discovered that they live in a wide range of environments. This could indicate multiple FRB progenitors, or a single progenitor formed in multiple ways. As a postdoctoral fellow I have been playing a leading role in the CHIME Outriggers project: to convert the leading FRB-finding machine, CHIME, into a VLBI network. Soon, for every FRB that CHIME discovers (with a discovery rate of 3 FRBs per day), we will pinpoint them to a host galaxy. This will provide the largest study of FRB environments to use in conjunction with the vast information we glean from the burst properties to learn about the origins of FRBs.

BIO: Afroditi (Papadopoulou) got her undergrad degree at the University of Athens in 2016 while carrying out an analysis using 7 TeV CMS data. She then moved to MIT for her graduate school studies where she worked in collaboration with Prof. Or Hen. Her PhD included analyzing both neutrino data collected by the MicroBooNE detector at Fermilab in Illinois and electron scattering data at Jefferson Lab in Virginia. After her graduation in 2022, she joined Argonne National Lab as a Mayer Fellow where she is continuing her research as a member of the MicroBooNE, SBND, DUNE, and Electrons4Neutrinos collaborations, as well as testing performance of simulation predictions against existing and new neutrino and electron data sets.

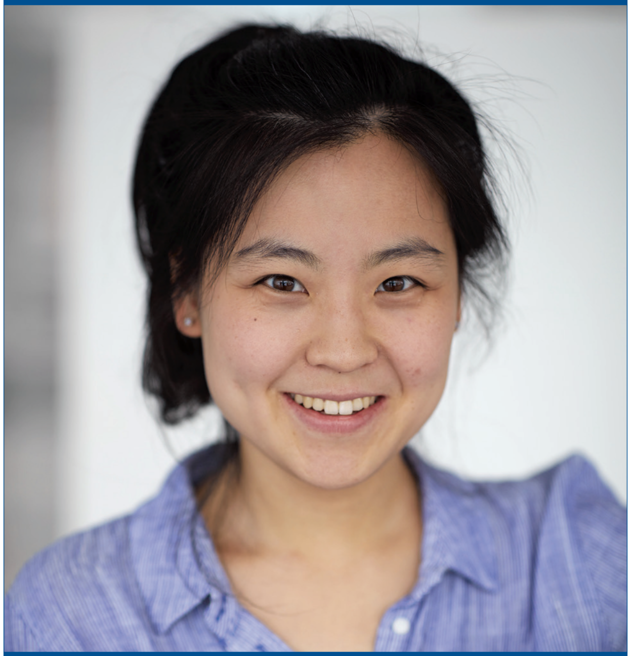
RESEARCH INTERESTS: Neutrino oscillation experiments have the potential to revolutionize our understanding of fundamental physics by offering opportunities to discover charge-parity violation in the lepton sector, determine the neutrino mass ordering, and search for exotic new physics.

The primary goal of my research is to realize these extraordinary measurements, with a particular focus on confronting the neutrino-nucleus modeling precision that threatens to limit the sensitivity of future multi-billion-dollar experiments. These include the US-based Deep Underground Neutrino Experiment (DUNE) and the Japan-based Hyper-Kamiokande (HK) experiment.

Afroditi Papadopoulou

Maria Goeppert Mayer Fellow
Argonne National Laboratory

TALK TITLE: Precision neutrino interaction measurements



Annie Park

Postdoctoral Researcher
Harvard University

TALK TITLE: Array of individually controlled molecules for quantum science

BIO: I am an experimental atomic, molecular, and optical (AMO) physicist. I am currently a postdoctoral researcher at Harvard University. Prior to my postdoc, I received my PhD from Ludwig Maximilian University of Munich (LMU), where most of my research was conducted at the Max Planck Institute of Quantum Optics. I completed my Master's degree at the Institute for Quantum Computing, University of Waterloo.

RESEARCH INTERESTS: My research focuses on achieving precise control over atoms and molecules trapped by laser light, advancing quantum science for applications in metrology, chemistry, simulations, and computation. Throughout my research career, I have acquired state-of-the-art experimental techniques in atomic physics. My specialization includes quantum simulators based on ultracold atoms and polar molecules with the experience of constructing a quantum simulator starting from an empty laboratory. I aim to continue developing next-generation quantum simulators, shedding light on complex quantum many-body phenomena that are currently beyond the reach of classical computers and exploring the prospects of building a quantum computer.

Workshop Participants

Meera Ramaswamy

PCCM Postdoctoral Fellow
Princeton University

TALK TITLE: Morphodynamics of mixed bacterial communities in three dimensions

BIO: Meera Ramaswamy is a Princeton Center for Complex Materials (PCCM) postdoctoral fellow, working in the lab of Professor Sujit Datta in the Department of Chemical Engineering. Her research focuses on the motility and growth of bacteria in complex environments. Meera earned her Ph.D. in Physics from Cornell University and her B.Tech. in Engineering Physics from IIT Bombay, India. In her free time, she enjoys baking, Indian classical dance, and reading outdoors in the sunshine.

RESEARCH INTERESTS: I am broadly interested in soft matter physics and understanding how microscale organization influences macroscale system properties. During my Ph.D., I studied how the microstructure of colloidal suspensions determines their macroscopic rheology. I developed a statistical physics framework to understand shear thickening rheology, which enabled me to design material-agnostic tools for tuning the viscosity of shear thickening suspensions.

As a postdoc, I am using tools from soft matter systems to study the motility and growth of bacteria in complex environments. My primary project focuses on understanding how physical properties, such as initial density and size, can shape the morphology of multispecies bacterial communities in three dimensions. I am also interested in bacterial chemotaxis in heterogeneous environments, whether that heterogeneity arises from environmental changes, such as a transition from liquid to solid, or a patchy distribution of resources. Together, these projects help us understand the motility and growth of bacteria in real-world complex environments.

Workshop Participants

Field Rogers

Postdoctoral Researcher
UC Berkeley

TALK TITLE: The GAPS antarctic balloon mission:
A dark matter search with cosmic-ray antinuclei

BIO: Field Rogers is an experimental particle astrophysicist building high-altitude and space instrumentation to detect dark matter. She is currently a postdoctoral researcher at Space Sciences Laboratory at the University of California, Berkeley. Field received her Ph.D. in physics in 2022 from the Massachusetts Institute of Technology, following undergraduate studies at Yale University. Outside of the lab, she enjoys spending time outdoors, playing the violin, and cooking for people.

RESEARCH INTERESTS: My research uses the Galaxy as a laboratory to reveal the fundamental nature of the dark matter. Recent years have seen several claims of possible dark matter signatures from space, but all are vulnerable to uncertainties in the astrophysical backgrounds. I collaborate on two upcoming NASA instruments which will provide unique probes of the nature of the dark matter. The General Antiparticle Spectrometer (GAPS) is an Antarctic balloon mission to detect cosmic-ray antideuterons. These particles are predicted from dark matter but not from standard astrophysical processes, so detection by GAPS would indicate new particle physics. I direct the integration of the balloon payload and coordinate data taking operations—and I'm eagerly anticipating our Antarctic launch later this year! Meanwhile, the Compton Spectrometer and Imager (COSI) is a satellite gamma-ray telescope expected to launch in 2027. COSI will provide unprecedented sensitivity to the MeV sky, which has been historically under-explored due to the technical challenges of the Compton scattering regime. I am performing the 3D position calibration of the COSI Germanium detectors, which allows for reconstruction of Compton events. I also develop data analysis tools to enable dark matter searches in the energy range that COSI will reveal.

BIO: Maria Simanovskaia is a postdoctoral scholar at Stanford University in Kent Irwin's group. She came to Stanford in 2020 after completing her PhD in nuclear engineering at UC Berkeley and before that, a BA physics and applied mathematics also at UC Berkeley.

RESEARCH INTERESTS: I am interested in designing and building detectors to search for axion dark matter. My interest in axion dark matter searches began in graduate school, where I designed and tested optimized resonant microwave cavities for HAYSTAC to reach higher frequencies than previously achievable in axion searches. HAYSTAC was the first cavity experiment to use a dilution refrigerator and commission a squeezed state receiver to circumvent the Standard Quantum Limit. Resonant microwave cavity experiments can achieve good sensitivity over a limited frequency range, but new technologies are necessary for probing the full parameter space in a reasonable amount of time. In my postdoctoral work, I am leading the design and construction of the resonant lumped-element axion dark matter detector DMRadio-50L that searches for axions below 1 uW; axions that would have been generated before the inflationary expansion of the universe. DMRadio-50L will be the most sensitive experiment in this lower mass range of axion parameter space.

Maria Simanovskaia

Postdoctoral Scholar
Stanford University

TALK TITLE: Searching for axion dark matter with DMRadio-50L

Neha Wadia

Postdoctoral Fellow
Center for Computational Mathematics,
Flatiron Institute

TALK TITLE: A mixing time bound for Gibbs sampling from smooth log-concave distributions

BIO: Neha Wadia is a postdoctoral fellow at the Center for Computational Mathematics of the Flatiron Institute. She holds undergraduate and masters degrees in physics from Amherst College and the Perimeter Institute, respectively, and a PhD in biophysics from the University of California, Berkeley, where she was partially supported by a Google PhD Fellowship. Neha has a varied background, having done experimental work in physics and biology, purely computational work in machine learning, and theoretical work in physics and machine learning. She is interested in algorithmic problems that arise at the intersection of statistical mechanics, machine learning, and neuroscience. Outside of research, Neha spends a lot of time thinking about, reading about, and in pursuit of good food; she also loves spending time outdoors.

RESEARCH INTERESTS: My research is currently driven by the following simple question: how hard is it to sample a natural image? Modern image generation techniques offer proof by existence that the answer to this question is "not impossible" but no further details. A good toy model of natural images—that is, images commonly encountered by humans of the world around us—is a variant of an Ising model where each spin is a pixel. Characterizing the computational complexity of sampling natural images therefore maps to the problem of understanding how to sample Ising models. To address this problem, I study how the mixing time of the Gibbs sampler, which is a natural choice of sampling algorithm for an Ising model, depends on the geometry of the interaction potential governing neighborhoods of pixels. Having recently completed a proof of a mixing time bound for the simplest geometry, where the interaction potential is a convex function (the harmonic potential is a canonical example), I am preparing to move on to more complicated geometries with the goal of eventually describing a model that produces realistic images.

In addition to the potential value of this research to statistical mechanics and computer science, I believe that making progress on understanding the relationship between the statistics of natural images and sampling will help us make guarantees on the accuracy of scientific results that rely on image sampling methods. I am very curious to learn more about the various ways in which physicists are using these methods to address their own research in problems ranging from astrophysics to condensed matter.

Workshop Participants

Tatiana Webb

Postdoctoral Research Scientist
Columbia University

TALK TITLE: Imaging mesoscale electronic phenomena with atomic force microscopy

BIO: Tatiana Webb is an experimental condensed matter physicist at Columbia University using scanning probe microscopy to study electronic phenomena from atomic to mesoscopic scales. Tatiana spent two years in industry after receiving her PhD from Harvard in 2019. She completed her bachelor's and master's degrees at McGill University in Montréal, Canada, and is originally from Berkeley, California.

RESEARCH INTERESTS: My work focuses on understanding and manipulating novel electronic phenomena. I employ a variety of scanning probe techniques to measure electronic, structural and magnetic properties from the atomic scale through mesoscales. A central theme is to use inhomogeneity as a tool both to explore the complex phase diagrams of materials in which electrons interact strongly and to manipulate functional properties of electronic devices.
My interests include both equilibrium phases as well as phenomena that arise out of equilibrium when charge carriers are flowing.

Workshop Participants

Lauren Yates

Postdoctoral Research Associate
Fermilab

TALK TITLE: Building for the next generation of neutrino discoveries

BIO: Lauren Yates (they/she) joined Fermilab as a Postdoctoral Research Associate in 2022, where they work in experimental particle physics studying neutrino properties as a member of the Short-Baseline Near Detector (SBND) collaboration. Their postdoctoral research focuses on commissioning the SBND detector and its initial neutrino data-taking. Before joining SBND, they completed their PhD in physics at MIT, working on the MicroBooNE experiment. Their graduate work focused on searching for an anomalous appearance of electron-flavor neutrinos in a muon neutrino beam. They are interested in building experiments that leverage precise detection technologies and cutting-edge analysis techniques to probe the nature of fundamental particles.

RESEARCH INTERESTS: My research centers on the nature of neutrinos, which are the most elusive constituents of the Standard Model of particle physics. I have been focused on the liquid argon time projection chamber (LArTPC) detector technology that underpins many current and future neutrino experiments. During my PhD, I focused on the evaluation of systematic uncertainties for my analysis using this detector technology, a critical component as we enter the era of precision measurements in neutrino physics. Now on the SBND experiment, I am building a deeper understanding of LArTPCs through the effort to commission the detector.

SBND will enable a generational advance in the understanding of neutrinos through increased statistical power and improved analysis techniques. We are poised to address fundamental questions about the number of neutrino species and the nature of neutrino interactions with nuclei, and we have exciting opportunities to probe other physics beyond the Standard Model as well. SBND is also laying the groundwork for the next-generation Deep Underground Neutrino Experiment (DUNE), which will be the largest particle physics experiment built in the US in several decades.

BIO: Haocun Yu is a Marie-Curie Postdoctoral Fellow at the University of Vienna, where she works with Prof. Philip Walther and the Research Network Quantum Aspects of Spacetime. She completed her Ph.D. in physics at MIT in the LIGO group, working with Prof. Nergis Mavalvala on quantum enhancement for gravitational-wave detectors. She earned her undergraduate degree from Imperial College London. Her work has received several honors, including the MIT Martin Deutsch Student Award, the APS Carl E. Anderson DLS Dissertation Award, and the Boeing Quantum Creators Prize.

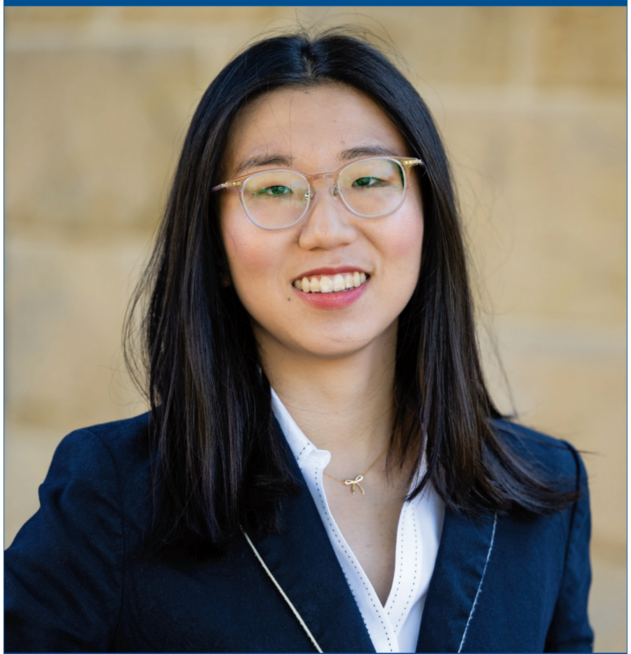
RESEARCH INTERESTS: My research interests lie in using various quantum techniques and precision sensing methods for fundamental physics. During my Ph.D., I implemented quantum squeezing techniques into kilometer-scale detectors, directly observing quantum correlations and surpassing the standard quantum limit with LIGO detectors for the first time. These achievements led to quantum-enhanced interferometry for gravitational-wave astronomy.

In Vienna, I am working towards the convergence of quantum mechanics and gravity. By using photon entanglement, I set a new record for measuring the Earth's rotation rate with a large fiber quantum interferometer, laying the foundation for investigating the gravitational influence on quantum light properties. Additionally, I am developing photon counting methods for axion searches. Moving forward, I am enthusiastic about continuing interdisciplinary work that advances quantum technologies and addresses intriguing fundamental questions about our world.

Haocun Yu

Marie-Curie Postdoctoral Fellow
University of Vienna

TALK TITLE: Illuminating the Universe's mysteries with quantum optics



Ziyan (Zoe) Zhu

Stanford Science Fellow
Stanford University

TALK TITLE: Multi-scale models for tunable quantum materials

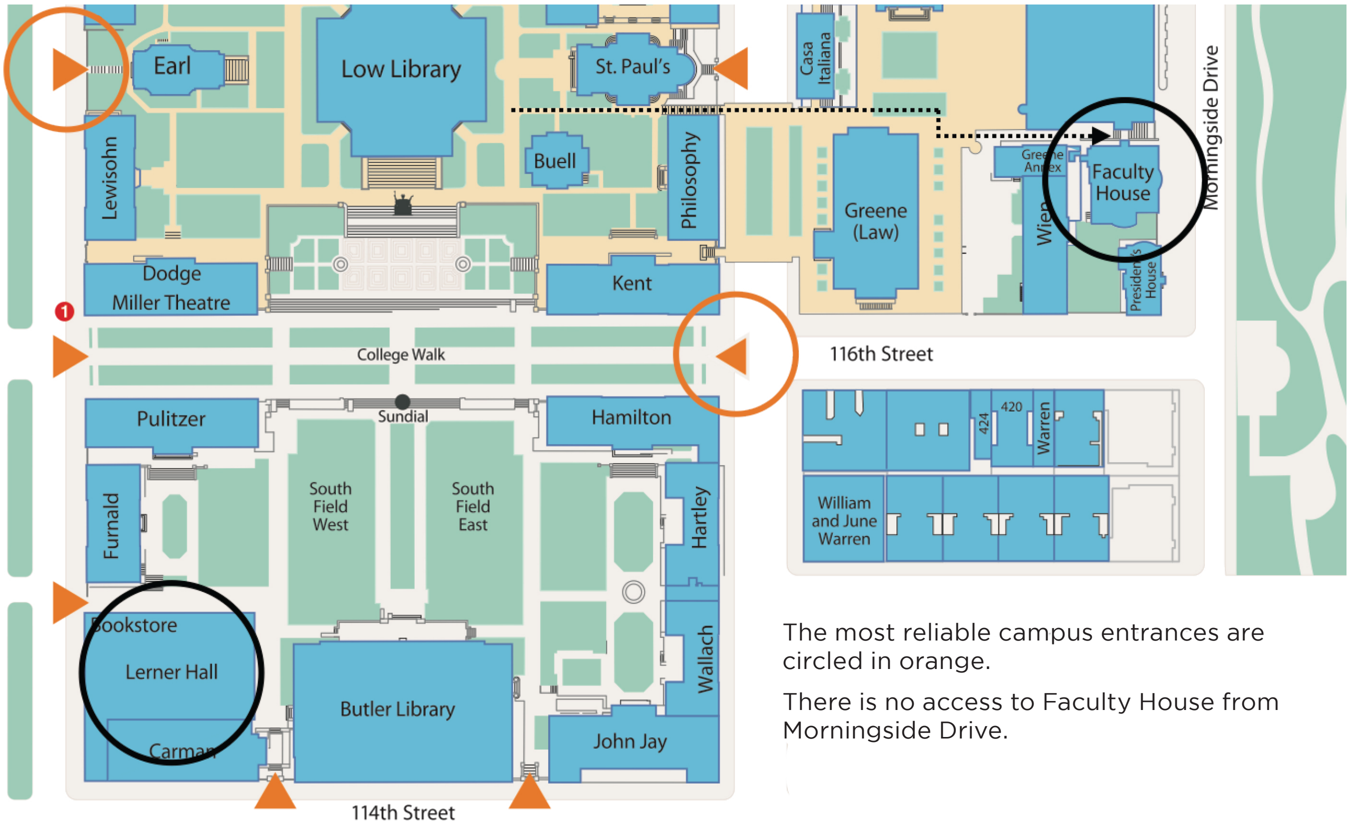
BIO: Zoe is a computational condensed matter physicist. She is currently a Stanford Science Fellow in the group of Prof. Thomas P. Devereaux, primarily focusing on developing multi-scale models of two-dimensional (2D) moiré materials. She obtained her undergraduate degrees in physics and applied mathematics from UCLA with a minor in art history. At UCLA, she worked on plasma physics and fusion. She then moved to Harvard University for her Ph.D. in physics, where she first studied black holes as a part of the Event Horizon Telescope collaboration and eventually joined the group of Prof. Efthimios Kaxiras to study two-dimensional materials.

RESEARCH INTERESTS: The central theme of my research is the design and understanding of the properties of large and complex physical systems across a range of scales, from atomistic to mesoscopic to macroscopic. I specialize in 2D quantum materials without periodicity, particularly multi-layered moiré materials. I study their electronic and mechanical properties using a hierarchy of numerical models that include first-principles density functional theory, low-energy continuum models, many-body models, and machine learning. The goal is to engineer composite materials with desired properties and discover new phases of matter.

I am also interested in applying concepts from condensed matter physics, such as topology and band theory, to phenomena in the ocean and fusion plasmas. I recently conducted an experiment to search for the first experimental signature of topological waves in fusion plasmas.

Location Maps

Columbia University



The most reliable campus entrances are circled in orange.

There is no access to Faculty House from Morningside Drive.

Flatiron Institute

Notes

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