BROWN PHYSICS

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FALL 2023

BROWN

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CELEBRATING OUR GRADUATES!

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Electrons in graphene interacting with photons from microwave radiation
GRAPHIC CREATED BY JIA LI

Back cover:
"Southern Milky Way," Greenbank Observatory, West Virginia.
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GREETINGS FROM THE CHAIR...

Welcome to the Fall 2023 edition of *Imagine* magazine!

I invite you to read about the many topics near to my heart: the varied and astonishing accomplishments of our faculty, students and alumni. Brown Physics continues to thrive and hone our interdisciplinary endeavors through cutting-edge research consisting of diverse fields of physics that will shape our future understanding of matter and ultimately help humanity solve some of the most pressing problems of our time. The astounding research done by our faculty and students has done nothing less than transform our very daily lives.

Our 27 faculty members engage in six different research areas. Our academic programs comprise 179 graduate students, 66 undergraduate physics concentrators (juniors and seniors), 83 Master's students, 96 Ph.D. students, and 20 post-doctoral fellows. I am pleased to present the accomplishments of these outstanding students. As you will read in this issue, our students' achievements span the range of physics awards, from Goldwater Scholarship awardee Lucas Brito, an undergraduate concentrator, to Ph.D. students Danielle Germann, a National Science Foundation (NSF) Fellowship awardee, Rutendo Jakachira, awardee of a Google Fellowship, Ilija Nikolov, University of Bologna Fellowship awardee, and Calvin Bales, awardee of the 2023–2024 Chateaubriand Fellowship awarded by the Office for Science and Technology, Embassy of France in the US. The Department consistently sees the highest caliber of student accomplishment; it is particularly rewarding to see them supported in their pursuit of physics careers by these generous awards.

Continuing the tradition of excellence, our faculty earned some of the highest accolades. For example, Assistant Professor Jia Li, whose research focuses on the quantum properties in 2D materials, received an early-career Sloane Research Fellowship from the Alfred P. Sloane Foundation, Stephon Alexander received the prestigious Isaac Asimov Science Award from the American Humanist Association, and Professor Brad Marston was elected to the presidential line of the American Physical Society (APS) to name just a few. Prof. Marston's honor to lead the APS was awarded for incredible multidisciplinary research achievements and his realization and commitment to promoting the fact that an understanding of physics endows us with critical perspectives to address the global threats of nuclear warfare and climate change and respond to the urgent call for global equity and sustainable sources of energy.

The above successes would be impossible without the support of our wonderful staff and I would personally like to thank them for their continuing efforts to excel our department in education, research and service to our community. In our administrative staff, we are fortunate to have a group of seasoned, talented individuals from across Brown and all walks of life who are collectively leaders in their areas of administrative expertise. In particular, they have my thanks as they manage the components of our department critical to our success: grants management, operations, communications, student affairs, and our department seminars, colloquia and conferences. I would also like to extend my thanks to Professor Gang Xiao for serving as interim chair in the Spring semester.

Vesna Mitrović
PHOTO: V. MITROVIĆ

In closing, I want to acknowledge our late chair, friend and colleague, Meenakshi Narain. Meenakshi's passion was helping women and minorities in physics succeed. Let us not forget that you cannot help others become great scientists without first being an amazing scientist, and Meenakshi was a great scientist in this field that we all love.

I most admired Meenakshi for what was the cornerstone of her passion, for asking the question, "What is the root problem, the biggest obstacle to women and minorities' success in physics?" She sought to answer that question, in part, by fiercely lobbying to bring the Conference for Undergraduate Women in Physics (CUWiP) to Brown, which you can read about on these pages. As chair, I am committed to upholding her vision of a more diverse department and to continuing her legacy as a champion of underrepresented groups and women in physics. Meenakshi's dedication to our students was unparalleled. She was driven to train our students to be better than us. I work daily to ensure that that goal will be realized during my tenure as chair of the Department of Physics.

Vesna Mitrović
Department Chair

CELEBRATING OUR GRADUATES!

PHOTO: COURTESY EAMON HARTIGAN-O'CONNOR

EAMON HARTIGAN-O'CONNOR

Sc.B. Mathematical Physics

Do you have any advice for new physics students?

Make sure to cultivate hobbies and interests outside of physics! As much as I love physics, it is possible to get burned out by a heavy course load. For me, playing soccer and jazz piano helped me to clear my head and keep a good work-life balance.

What was your biggest accomplishment?

My work with the Brown Particle Astrophysics group, leading up to my undergraduate thesis on reflector techniques for LZ calibration. Whether it was learning new simulation techniques, analyzing experimental data or wrangling hardware in a mile-deep research facility in South Dakota, research with that group taught me many practical skills and life lessons. I am very grateful to have had the opportunity to do that research.

NEXT: A PHD IN PLASMA PHYSICS AT PRINCETON!

TAYLOR KNAPP

Sc.B. Astrophysics

What was your favorite physics course and why?

PHYS 2100: General Relativity with Prof. Anastasia Volovich. This course illuminated the elegant interplay between math and physics that is integral to understanding the Universe. The connection between math and physics I found while taking this course paved the way for my curiosity for relativity and gravitational wave astrophysics, which is what I plan to study in graduate school. This course also teaches the mathematical formalism behind black holes, which is just so cool.

What obstacles did you overcome?

Imposter syndrome was a very difficult challenge in my physics studies. As a queer woman from the South, I felt like I came to Brown with vastly less knowledge about how to pursue a STEM degree than some of my peers. Surrounding myself with a supportive physics community and asking for guidance has eased the burden of imposter syndrome. The realizations that physics concentrators all have a common passion for the workings of our Universe, big and small, and each person has their own path through physics helped ease my imposter syndrome as well.

PHOTO: COURTESY TAYLOR KNAPP

PHOTO: COURTESY ISABELLE GOLDSTEIN

ISABELLE GOLDSTEIN

Ph.D. Physics

What awards did you win during your time at Brown?

The Physics Merit Fellowship, Award of Excellence as a Graduate Teaching Assistant (2018, 2021), RI Space Grant Graduate Fellowship, National Science Foundation Graduate Research Fellowship Program Honorable Mention.

Advice for Incoming Students:

Put in the effort to learning strategies for this part of your physics career! The skill set you developed as an undergraduate student is different than the skill set you'll develop as a graduate researcher, and it's important to develop them intentionally.

What obstacles did you overcome?

The isolation and narrowing of my day-to-day world during the COVID lockdown was a huge obstacle. It became even more important to have a work/life balance, and not get discouraged if research slowed during that time.

Is there anyone you would like to thank?

I would like to thank my friends and officemates, for their collaboration and commiseration in equal measure.

RUIJIE SHI

Sc.M. Physics

What was your favorite physics course and why?

PHYS 2140 - Statistical Mechanics because it opened a new window for me to understand physics; also it was vital for my astrophysics concentration.

What advice can you offer incoming physics students?

Actively communicate with all people in the department. For new master's student, it is worth spending some time joining different group meetings and journal clubs, and then determine the most suitable research opportunity for you. Always have great memories with the amazing people in my cohort.

What is your fondest memory of your time at Brown?

All my lovely classmates!

What faculty member had an impact on you and how?

My advisor Prof. Jonathan Pober's continuous teaching, guidance and support impacted me greatly. He is an excellent mentor who opened the door of radio astronomy for me.

PHOTO: COURTESY RUIJIE SHI

"I feel extremely lucky to be part of the Pober Lab."

MICHAEL TOOMEY

Ph.D. Physics

What is the most impactful lesson you learned at Brown?

Actively avoid having blind spots in your research. When you find that you don't understand a derivation or concept, no matter how simple, take note and make sure you figure it out.

What is next for you?

In the fall I will start a postdoc in the Center for Theoretical Physics at MIT.

PHOTO: COURTESY MICHAEL TOOMEY

TSUNG-HAN YANG

Ph.D. Physics

What advice can you offer to incoming physics students?

Trust yourself that you can take on any challenge.

Which faculty member impacted your journey the most?

I learned a lot from Professor Kemp Plumb, especially from his positive attitude in facing difficulties.

What was your biggest accomplishment in your time at Brown?

Setting up a new lab and obtaining the data for our scientific discoveries.

What's next for you?

A postdoctoral position at Oak Ridge Laboratory.

PHOTO: COURTESY TSUN-HAN YANG

ETHAN SWAGEL

Sc.B. Mathmatical Physics

What was your favorite physics course and why?

PHYS 160: Intro to Relativity, Waves, and Quantum, because it opened the world of physics beyond Newtonian mechanics for the first time.

What obstacles did you overcome?

The COVID-19 pandemic.

Is there anyone you would like to thank?

I'd like to thank Professor Brad Marston for two years of mentorship in research and all areas of academics.

What is next for you?

Working at MIT Lincoln Laboratory as a Systems Analyst

PHOTO: COURTESY ETHAN SWAGEL

MARIA TEFU

Ph.D. Physics

What was your favorite course and why?

It was PHYS 2010: Techniques in Experimental Physics because when we did an experiment, we not only improved our experimental skills, but also enriched our theoretical knowledge.

What will you remember most fondly?

When I did my experiments with my lab partner Duoen Shou. We spent hours in the lab, sometimes even on the weekends. We failed many times doing a procedure as the due date approached, but never gave up. We kept trying and that was key for our success.
I send a heartfelt thank you to Shou, the best lab partner.

Is there anyone you would like to thank?

I would like to thank my parents, my sister and especially The Indonesia Endowment Fund for Education (LPDP), who supported me in every way."

"We not only improved our experimental skills, but also enriched our theoretical knowledge."

PHOTO: COURTESY MARIA TEFU

The Class of 2023

BACHELORS

Sebastian Ali
Anvita Kriti Prakash Bhagavathula
Leela S. Canuelas-Puri
Azaar Dubash
Jonah Elias Eick
David Fang
Bibo Feng
Michael Lawrence Foiani
Joseph Benjamin Hall
Eamon Joseph Hartigan-O'Connor
Rachel Elizabeth Hemmer
Selene Rosalyn Hines
Ryan Jones
Esra Revsen Karaalp
Derik J. Kauffman
Dhiraj Khanal
Taylor Ann Knapp
Juliana R. Lederman
Natalie Jiawen Love
Daphne K. Maniatis
Jackson David Moore
Yusra Nadir
Nathaniel James Price
Francesco Serraino
Tej Stead
Ethan Berel Swagel
Zachary Graham Targoff
Martin L. Trouilloud
Jacob Sage Vietorisz
Dingding Wei
Shane Aaron Weiner
Lutong Zhao

STUDENT AWARDS

R. Bruce Lindsay Prize for Excellence in Physics
Joseph Hall and Taylor Knapp

Mildred Widgoff Prize for Excellence in Thesis Preparation
Ethan Swagel and Ding Ding Wei

Smiley Prize for Excellent Contribution to the Astronomy Program
Rachel Hemmer

MASTERS OF SCIENCE

Sarah M. F A. F Alkidim
Rongyu Dong
Junhang Duan
Charles Allen Grimm
Yuqing Gu
Yutian He
Soren Josef Helhoski
Xudong Hu
Renée Alex Kirk
Annalies Kleyheeg
Kyucheol Lee
Youngik Lee
Jeffrey J. Lei
Jianrong Liu
Xinyuan Liu
Chongwen Lu
Taichi Murakami
Jessica Nicole Nelson
Alexis Ortega
Pai Peng
Yi Ren
Trevor Alan James Russell
Pranay Bimal Sampat
Ruijie Shi
Sooyoung Shin
Rahul Arvind Shinde
Duoen Shou
Willow Smith
Jasper Solt
Maria Tefa
Owen William Tower
Yibang Wang
Xuanhao Wu
Xiaozhou Ye
Xue Yu
Ziyang Zhang
Hexiang Zhao

STUDENT AWARDS

Master's Research Excellence
Rongyu Dong, Junhang Duan, Rahul Shinde, Yibang Wang

Outstanding Academic Accomplishment in Master's Program
Youngik Lee, Rahul Shinde, Xudong Hu, Xuanhao Wu

Engaged Citizenship and Community Service to the Physics Department
Sara Alkidim

DOCTOR OF PHILOSOPHY

Jacob Thomas Burba - Adviser: Jonathan Pober
Aleksander Cianciara, Adviser: S. James Gates Jr.
Lijie Ding, Adviser: Robert Pelcovits
Isabelle Goldstein, Adviser: Savvas Koushiappas
Shayan Lame, Adviser: Derek Stein
Ka Tung Lau, Adviser: Greg Landsberg
Luke Lippstreu, Adviser: Marcus Spradlin
Angela Caterina Pizzuto, Adviser: D. Mittleman
Michael Toomey, Adviser: Stephon Alexander
Yiming Xing, Adviser: Humphrey Maris
Tsung-Han Yang, Adviser: Kemp Plumb
Chenyu Zhang, Adviser: J.B. Marston
Yiou Zhang: Adviser: Gang Xiao

STUDENT AWARDS

Galkin Foundation Fellowship Award
Jeanne Bang

Physics Merit Fellowship
Isabelle Goldstein, Ka Tung Lau

Physics Dissertation Fellowship
Luke Lippstreu, Angela Pizzuto, Shayan Lame

Jun Qi and Christine Geng Graduate Fellowship in Condensed Matter Experimental Physics
Michael Discala

COMMENCEMENT 2023

Top: The Brown Physics Sc.M. Class of 2023

Center: Professor Jay Tang congratulates Rahul Shinde with a hearty handshake and the Brown Physics Ph.D. Class of 2023

Bottom: The Brown Physics Bachelors Class of 2023 / James Valles delivers keynote address

Center Top: (L to R) Jim Valles, Bob Pelcovitz, Ian Dell'Antonio

Center Bottom: Matthias Kuehne, Jonathan Pober, Ulrich Heintz and Savvas Koushiappas

Bottom: Interim Chair Gang Xiao applauds the Ph.D. class.

Bottom Center: Candid photo of Jim Valles.

Above Left: Bachelors Award winners (L to R): Dingding Wei, Ethan Swagel, Taylor Knapp, Joseph Hall, Rachel Hemmer

Above Right: Gang Xiao and Jay Tang with Ph.D. graduate Maria Tefu

Below: The Ph.D. Class of 2023

PHOTOS: VALERIE DELACAMARA/BROWN UNIVERSITY

STUDENT STORIES: ANGELA PIZZUTO
PHD

“The majority of success is perseverance.”

PHOTO: COURTESY ANGELA PIZZUTO

ANGELA PIZZUTO
PHOTO: COURTESY ANGELA PIZZUTO

Awards: Excellence as a Graduate Teaching Assistant, Physics Dissertation Fellowship

WHAT ADVICE CAN YOU OFFER INCOMING PHYSICS STUDENTS?

Learning physics is confusing, messy, and frustrating. Push through that discomfort, and don't let it discourage you! Commit yourself to being a perpetual student, to admitting when you don't know something, and to asking for help when you need it. It can be really fun if you don't take it all too seriously.

WHAT DO YOU CONSIDER TO BE THE MOST IMPACTFUL LESSON YOU LEARNED DURING YOUR TIME WITH BROWN PHYSICS?

How important mentorship and community is. The worst times of my Ph.D. were when I isolated myself, and the best times were when I leaned on my support network and spent more time with my friends. I realize now that I can't be successful in a vacuum, and taking time to foster positive relationships is just as important as research.

WHAT IS YOUR FONDEST MEMORY?

There are so many. Grueling late-night study sessions in the PhD student offices, board game and pasta nights with my cohort, swimming in Newport during my lab group's annual beach day, traveling all over the world for conferences, the list goes on. I'm grateful for how many fun memories I made in the last few years.

DID ANYONE AT BROWN WHO INSPIRED YOU?

Definitely, the students I TA'd for in PHYS 0070, 0160, and 0500. They had so much dedication and enthusiasm. Working with them inspired me to be a better teacher and a better physicist.

WHAT WAS THE BIGGEST OBSTABLE YOU OVERCAME?

The first two years, and especially the qualifying exam, were pretty tough. I developed some test anxiety early on, dealing with constant impostor syndrome. Passing the exam and all of my classes was such a relief, and I think it gave me the confidence I needed to relax a bit for the rest of my degree.

IS THERE ANYONE YOU WOULD LIKE TO THANK?

My husband for taking care of our lives while I spent long nights in the lab or at my computer writing my thesis. And my lab mates for keeping me sane in the final research stretch. And also my dog for being a very good boy.

WHAT FACULTY MEMBER HAD A BIG IMPACT ON YOUR JOURNEY?

Of course, it's my advisor, Dan Mittleman! I can't say enough good things about him as a mentor, but I particularly remember how much he helped me network at terahertz science conferences worldwide. Going to Delft and Budapest last summer were real highlights.

WHAT DO YOU CONSIDER TO BE YOUR GREATEST ACCOMPLISHMENT DURING YOUR TIME AT BROWN?

I survived doing some cleanroom work with hydrofluoric acid. That data never got published, but I think being alive with intact bones is a big accomplishment.

WHAT IS NEXT FOR YOU?

I'm a sellout, i.e., I've gone to an industry job. Now I'm a Senior Research Scientist at the Raytheon Technologies Research Center, where I get to do a lot of fundamental science research relating to optics, photonics, and integrated circuit design.

LOOKING AHEAD:

2023-2024 Ph.D. Student Award Winners

Galkin Foundation Fellowship Award

Lecheng Ren

Physics Dissertation Fellowship

Zezhu Wei

Physics Merit Fellowship

Erin Morissette, Xianlong Liu

STUDENT STORIES: JOSEPH HALL

Sc.B Mathematical Physics and Contemplative Studies

WHAT ADVICE CAN YOU OFFER INCOMING PHYSICS STUDENTS?

Seek out community or create it if you don't find any. Building relationships and camaraderie in the department is the most sustainable way to succeed and feel happy. Focus on concepts over calculations, process over outcome, and try to find some kind of joy or fascination in the work that you're doing.

WHAT WAS YOUR FAVORITE PHYSICS COURSE?

Not exactly a physics course, but PHYS 1720 with Prof. Volovich was the course that changed me into a real college-level student, and the math we learned is still helpful in my daily work. It doesn't hurt that she's also one of the best professors I've ever had at Brown. I also loved PHYS 1420 and PHYS 1530 with Dimitri Feldman, whose lectures I will never forget, even if I do forget about degenerate perturbation theory.

WHAT WAS THE MOST IMPACTFUL LESSON YOU LEARNED?

You need to learn to trust yourself and own your shortcomings and mistakes. Learning your true worth as a scientist and student can only happen from within. Feeling unsure of yourself for long periods is the price of admission for doing something radically interesting with your life and academic journey, so don't kid yourself into thinking everybody else has it figured out!

WHAT WAS THE BIGGEST OBSTACLE YOU OVERCAME WHILE OBTAINING YOUR DEGREE?

For me, the biggest obstacles were a persistent sense of imposter syndrome and a fear that my degree wasn't going to lead to a career that I'd be happy in. Imposter syndrome got to the point where I would intentionally not do assignments or let myself fail to try and align my work with my negative perception of myself, which sounds very intense but is something I know many people struggle with. I would highly recommend therapy and self-care activities like journaling and meditation to everyone. The workload for any STEM concentration is grueling at times, and it's crucial to maintain your mental health. I have also had many friends in the department who are underrepresented minorities in physics, and I want to emphasize not only how grateful I am for these friendships and how they have inspired me, but also to say how important it is for all of us in Physics to create a more inclusive, loving environment. Please know you're not alone and many people will help you if you ask!

IS THERE ANYONE YOU WOULD LIKE TO THANK?

I'd love to thank my community at Brown, especially my friends in the department, who helped each other survive quarantine and inspired each other to achieve great things. I want to show appreciation to all the faculty, staff and administrators who helped us organize student events and cared about department culture. Finally, I'd love to thank the younger students who took care of the DUG and other physics department traditions after I stepped away; it gives me a lot of hope to see continued engagement, especially coming from such a diverse and brilliant group.

JOSEPH HALL (L) RACHEL HEMMER (R)
PHOTO: VALERIE DELACÁMARA/BROWN UNIVERSITY

WHAT FACULTY MEMBER HAD A BIG IMPACT ON YOUR JOURNEY?

I want to thank Brad Marston for helping me think beyond my classes at Brown and into other fields of physics. We shared similar interests outside of physics, including meditation and environmental stewardship, which really helped me open up and build a relationship with a professor without prior research experience. Last winter, along with Zoe Zhu from Stanford, we traveled to UCLA to conduct a basic plasma science experiment, which challenged and opened up new avenues for both of us.

WHAT IS YOUR FONDEST MEMORY OF YOUR TIME AT BROWN PHYSICS?

Seeing all my classmates present their honors theses and marveling at how far we've come. There are many memories that I'll remember fondly: Crossing a frozen river with my physics friends to reach a natural hot spring in my home state of Idaho; dancing all night at the International Physics Congress Ball in Washington, DC; laughing over Bad Physics Movie Night; attending our regular Zoom; and HEC's (High Energy Chocolate) with the DUG got us through COVID.

WHAT'S NEXT FOR YOU?

"I will pursue a Ph.D. in Nuclear Science and Engineering at MIT under Dr. Pablo Rodriguez-Fernandez, working on high-fidelity physics models of fusion energy devices."

JOSEPH HALL

STUDENT SPOTLIGHT

Danielle Germann

SEVEN QUESTIONS WITH DANIELLE GERMANN, NATIONAL SCIENCE FOUNDATION (NSF) FELLOWSHIP RECIPIENT

PHOTO: COURTESY DANIELLE GERMANN

DANIELLE GERMANN

Physics Ph.D. student Danielle Germann reflects on her journey at Brown that led to an NSF Fellowship. Danielle discusses her motility studies research and contributions to the assembly of the EXCITE telescope, intended to study the atmospheres of exoplanets. Inspired by her mother, a prominent clinical researcher working with HIV populations, Danielle feels supported as a woman in physics by the Brown University Women in Physics (WiP) group and is committed to making diversity and inclusion a primary focus of her career. She feels that Brown is a special place where her program creates community and is like family.

Read on!

What research will you conduct while supported by the NSF grant?

I am fortunate to have wonderful research opportunities in two labs I have worked with during my first year at Brown. Last summer, I worked in Dr. Jay Tang's lab where I performed motility studies on a novel species of gut bacteria (SM3) and started preliminary experiments on their swarming behavior. While I am passionate about biophysics, I also have an underlying interest in astrophysics that led me to Dr. Greg Tucker's research group. Here, I have gotten to contribute toward the assembly of the Exoplanet Climate Infrared Telescope (EXCITE) intended to study the atmospheres of exoplanets. There are exciting opportunities to expand on both of these projects; I will have to decide soon.

What motivated you to apply for the NSF Fellowship and what distinguished you from the many applicants?

I was first encouraged to apply for the NSF GRF by my mentors, both at Brown and from under-grad. As an undergrad, my interest in multi-faceted fields of physics led me to engage in as many research and teaching activities as I could. I was fortunate to work with many research groups specializing in astrophysics, biophysics, and particle physics, and contributing as an author on three publications. In 2021, I graduated Summa Cum Laude from Syracuse University with a B.S. in physics, and spent the next six months at CERN working on the LHCb experiment. Outside of re-search, my time as a student has been spent promoting educational outreach, and I spent many years as a UNICEF volunteer hosting workshops for impoverished children and minorities. I feel that my passion for physics as a whole and drive to share that passion with others is what stood out in my application, and I am incredibly grateful to have been selected.

How have you been supported as a woman in physics at Brown?

As a woman in STEM, I have noticed a wonderful collective effort within the department to promote diversity and inclusion and have been fortunate to engage in that effort. The Brown University Women in Physics (WiP) group has an ongoing mission to provide support within the department and frequently hosts social events to strengthen a sense of community and open up discussions on topics of importance. Overall, there is a delightful sense of support among the faculty and students at Brown and there is always someone to reach out to. To receive the NSF GRF award, in the midst of Women's History Month, is a recognition that women are continuing to make important contributions in the field of science and I am honored to be among them. As a woman pursuing a Ph.D. in physics, I am dedicated to being a voice for this cause and will continue to make diversity and inclusion a primary focus in my career.

Where do you find inspiration?

A large inspiration in my life is a woman who, in the 1980's, pursued a career in science and became a prominent clinical researcher, devoting many years to helping the HIV community and working to find cures for other deadly and infectious diseases. Also finding time to foster special needs animals and volunteer for countless causes, this woman, my mother, placed her career on hold in order to provide the guidance I would need to pursue my dreams. She nurtured my vivid imagination, interests in acting and ballet throughout my childhood, and has encouraged me throughout my journey in becoming a physicist. Her belief in me has carried me far.

What do you feel distinguishes Brown from other programs, and what about Brown is special and critical to your success?

Not only does the Ph.D. program at Brown offer top-notch graduate level academic preparation and incredible research opportunities, but part of what makes Brown so special is the people. The graduate student body in the physics department alone is so diverse and unique, everyone has a captivating story to tell. I admire my peers greatly and am lucky to be among such intelligent young adults.

What does Brown Physics mean to you?

Being enrolled in the Brown Ph.D. physics program is an incredible honor, and my passion for physics has grown stronger since being here. More importantly though, the way the program encourages collaboration and community among the students has made such a positive difference in my experience this first year. We are like a family, and we look out for one another.

Lucas Brito

GOLDWATER SCHOLARSHIP

STUDENT SPOTLIGHT

Goldwater Scholarships are awarded to second or third-year students planning research careers in mathematics, the natural sciences or engineering.

According to the Barry Goldwater Scholarship & Excellence in Education Foundation, Brito is among 413 students named 2023 Goldwater Scholars from more than 5,000 nominations by 427 academic institutions. "The Department of Defense's continued partnership with the Goldwater Foundation ensures we are supporting the development of scientific talent essential to maintaining our Nation's competitive advantage," said Dr. Jagadeesh Pamulapati, Acting Deputy Director of Research, Technology and Laboratories, who oversees the NDEP program, as he explained the partnership.

Professor Brad Marston worked with Lucas on his research last summer, commenting, "Lucas started working on research under my direction as part of our NSF EPSCoR grant led by Prof. Vesna Mitrović. He collaborated closely with our EPSCoR postdoc, Dr. Stephen Carr. Lucas' project seeks to estimate model parameters for quantum matter. Dirac observed in 1929 that all of condensed matter and chemistry may be understood from many-electron quantum theory. On the other hand, theoretical understanding of the emergent properties of condensed matter has benefitted more from models of severely reduced complexity such as the Hubbard model. Simple models of condensed matter suffer, however, from at least two drawbacks. First, very interesting physics occurs in the proximity of transitions between different phases of matter. Second, it is sometimes desirable to create a highly accurate model so that precise experiments can be carried out. Lucas is using multi-point correlations of quantum matter in a virtuous cycle to realize the best features of both idealized and precise but complex models."

Lucas thanked his faculty and peer mentors and detailed the ways in which the Goldwater Scholarship will help to answer the questions that drive his research. Read on!

What brought you to Brown physics, and who has most directly impacted your journey and how?

I was drawn to Brown's physics department by the vast undergraduate research opportunities, the close relationship with the arts maintained by faculty such as Prof. Alexander, and the collaborative student culture. Throughout my time here, I've been met with generosity and intellectual engagement from all faculty members, most notably Profs. Mitrović and Marston and Dr. Carr. I'm also grateful to peer mentors such as alumni Adam Tropper and Alex Jacoby, as well as like-minded members of the class of 2024, Elijah, Gareth and Smita.

How have the Department and the faculty supported you?

I'm immensely grateful to Prof. Mitrović for accepting me into her group in the Fall of 2021 and thus introducing me to research in condensed matter physics, Prof. Marston for overseeing my more recent projects in theoretical many-body physics and entertaining my various questions about all facets of physics, and Profs. Dell'Antonio and Fan for assisting in navigating the department's courses and offering general mentorship. It has also been a privilege to work so closely with Dr. Stephen Carr, whose abundant wisdom and general kindness have been inspirational to me. More generally, I'm thankful for the liberty the department affords students in exploring their interests and challenging themselves through coursework and research; I hope this culture persists long after I graduate.

Please elaborate on what real-world questions drive your research and the ways in which being a Goldwater Scholar will help answer them.

I am broadly interested in the intersection of quantum statistical mechanics, quantum field theory, and quantum information theory; this interest is informed by scientific and technological demands to understand the foundational principles of quantum matter, and more generally by the philosophical puzzles offered by quantum theory. I am especially drawn to work that leverages computational methods to treat and provide intuition for previously intractable problems.

Receiving the Goldwater Scholarship has been a blessing for me and my family. It provides a financial incentive to continue pursuing the questions I have been drawn to, and reaffirms that the nation maintains commitment to the pursuit of scientific knowledge by assisting young scientists in their early careers

"I was drawn to Brown's physics department by the vast undergraduate research opportunities."

LUCAS BRITO

David Ferster

FROM PHYSICS TO NEUROBIOLOGY

By Valerie DeLaCámara

ALUMNI SPOTLIGHT

As a junior majoring in physics at Brown in the 1970's, David Ferster had just learned operator notation in a quantum mechanics course when he attended a lecture by Nobel laureate Leon Cooper, then a professor in the Brown Physics Department. Presenting his research to his colleagues, Professor Cooper introduced a model of how the visual cortex might develop to allow neurons to acquire sensitivity to the orientation of visual stimuli; Cooper's model was made using quantum mechanical operator notation. David found the mathematical component of the model to be "quite beautiful." He was intrigued by the idea that biological information processing in the brain could be studied by incorporating math and physics. "I thought it was really spectacular," he says. "It caught me. I later spent a few months working with one of Cooper's postdoctoral fellows in the summer after graduation."

David became driven to learn all he could about neurobiology, first taking a physiological psychology course taught by Professor Mitch Glickstein in the Psychology Department and then completing a paper on the cerebellum for an independent study course. David relates that while researching his paper, he found a reference in a popular book about the brain to one model in particular created by David Marr, but there was no indication of where the paper had been published. A helpful science librarian helped him track down what eventually became a classic paper in theoretical neuroscience. He recalls spending many hours in the library reading the paper simply because he wanted to understand it – it thrilled him in a way few topics had. From that moment on, his academic interests turned from the science of physical systems to the physics of neurobiological systems. "It was like someone flipped a switch," he says.

David observes that there is a long history of people trained in physics who then go on to study the brain and spend their careers doing neurobiological research, including his own thesis advisor. For David, the kernel "started with Leon Cooper. He wasn't applying quantum mechanics; he was applying the formal structure of the math related to quantum mechanics to notate the models he was developing for how the brain might work."

This exposure to a wide range of ideas while in the Physics Department planted the seed of curiosity that led him to apply to graduate school for neurobiology. Although he loved studying, he felt that theoretical physics was "not for me," especially since there weren't many physics jobs available at that time. He applied to and was accepted by several different graduate programs, including MIT and Harvard. He says the "MIT gestalt had always been very interesting to me," but he chose to work with David Hubel and Torsten Wiesel at Harvard, who later went on to win the Nobel Prize in 1981. David reflects with a smile that that decision "was the right one." It was at Harvard that David received training in visual systems neuroscience that laid the foundation for the rest of his career. After a postdoctoral fellowship in Gothenburg, Sweden, he became an assistant professor of Neurobiology at Northwestern University, where he spent his entire academic career, eventually becoming the chair of the department.

David says that once his own independent lab was well underway, it was important for his incoming graduate students to have a quantitative background; the more they had, the more productive they were. He explains that since his experiments were highly quantitative, computer-controlled, and analyzed in real time, "it was a *sine qua non* for them to have a high degree of math and programming abilities. My experimental work and to some extent the theoretical work demanded that graduate students and post-docs in my lab were conversant in both, as well as being good with their hands in the lab. I did admit students with less background in those areas because they were keen on the science and wanted to learn, but it was more of a struggle for them. The best students were those who were quantitatively trained, in math, computer science, engineering, or physics."

David Ferster received an undergraduate degree from Brown's Department of Physics in 1974 and a Ph.D. in Neurobiology from Harvard University in 1980. His research involved neurobiology and the visual cortex. He is a fellow of the American Academy of Arts and Sciences, a Fellow of Alfred P. Sloan Foundation and Professor Emeritus at Northwestern University.

He explains that his area of neurobiological research was tightly linked to his training in physics because he was doing electrophysiology experiments. What he learned as a physics major allowed him to better understand the electrical nature of neurons. Additionally, his physics background allowed him to understand more deeply and intuitively the work he did with electronics, computers and optics. He adds that he and his wife, who is the current chair of the Northwestern Neurobiology Department, wrote a book on some of the foundational early experiments in quantitative neurophysiology which draw heavily on a physics background. While a professor at Northwestern, he also founded a company, Actimetrics, that creates hardware and software for the support of behavioral neuroscience and circadian biology.

Reflecting on his experience as a physics major, David stresses that it was not always easy for him. As an enthusiastic freshman, he went against the advice of a faculty member and used his AP credits to place out of the introductory course and into a more advanced one. When he did not excel in that class, one professor questioned whether he was in the right field. Nevertheless, he forged on and eventually found his footing. By junior year, there were only six students majoring in physics, and while admittedly not the top student, David felt he did well. "The main thing is that I just enjoyed it immensely. I loved the courses. I loved the labs. I loved doing problem sets and spent hours every day working on them. And many of the professors were excellent teachers, something that I appreciate more now as a professor myself."

David wants physics students to know that physics provides an excellent grounding for almost any field of endeavor, perhaps more so than other majors. "No matter what you do in physics, no matter what you do after you major in physics, your experiences as a physics undergraduate will inform and help you. From physics itself, to engineering, to any of the other sciences, hard or soft, computer science, finance, and more. I even know a psychotherapist who majored in physics." David stresses that it is the analytical skills and observational reasoning learned in the study of physics that can be applied to any aspect of the life of the mind. "I'm sure other scientific fields like chemistry or biology can give you a framework for thinking, but because physics gets so deep down into the root causes of things, I would argue that it is unique. I think physics lends itself to that, almost naturally, because it professes to be the study of the processes that make the physical world happen. And while all sciences make use of the interplay between theory and experiment, in physics, that interplay is central. Being deeply imbedded in that mindset, even as an undergraduate, fundamentally changes the way you approach any problem. Having an intuitive, almost instinctual grasp of that process is an invaluable skill."

Recognizing the impact that the department, its faculty and his physics coursework had on the trajectory of his life, in 2021 David made a significant gift to the Physics Chair's Fund. The fund gives the chair of the department flexibility to address emerging priorities in research, education and inclusion. David says of his philanthropy to the department, "The department had such a strong effect on my own development. I wanted to help it do so for other students as well."

David enthusiastically recommends that students attend seminars in person, perhaps because of his early experience with Leon Cooper's lecture. "There's nothing like hearing somebody talk about their work in person. Students, in particular, don't always realize that when you hear a lecture, you engage with the work far more intimately and gain a deeper understanding of it. You see firsthand the relationship between the person and the work they are doing in a way that you can't when you read a paper or watch a YouTube lecture. If you have the opportunity to see someone speak about a topic that inspires you, do it. It could change your life."

2023 GOOGLE FELLOWSHIP

PHYSICS IN HEALTHCARE RESEARCH

Vesna Mitrović

FACULTY RESEARCH

RESEARCHERS DETAIL NEVER-BEFORE-SEEN PROPERTIES IN A FAMILY OF SUPERCONDUCTING KAGOME METALS

By Juan Siliezar

Dramatic advances in quan tum computing, smartphones that only need to be charged once a month, trains that levitate and move at superfast speeds. Technological leaps like these could revolutionize society, but they remain largely out of reach as long as superconductivity — the flow of electricity without resistance or energy waste — isn't fully understood.

One of the major limitations for real-world applications of this technology is that the materials that make superconducting possible typically need to be at extremely cold temperatures to reach that level of electrical efficiency. To get around this limit, researchers need to build a clear picture of what different superconducting materials look like at the atomic scale as they transition through different states of matter to become superconductors.

> **"We know what this is now and our next job is to figure out what is the relationship to other bizarre phases at low temperature — does it help, does it compete, can we control it, can we make it happen at higher temperatures, if it's useful?" Mitrović said. "Next, we keep lowering the temperature and learning more."**

Scholars in a Brown University lab, working with an international team of scientists, have moved a small step closer to cracking this mystery for a recently discovered family of superconducting Kagome metals. In a new study, they used an innovative new strategy combining nuclear magnetic resonance imaging and a quantum modeling theory to describe the microscopic structure of this superconductor at 103 degrees Kelvin, which is equivalent to about 275 degrees below 0 degrees Fahrenheit.

The researchers described the properties of this bizarre state of matter for what's believed to be the first time in Physical Review Research. Ultimately, the findings represent a new achievement in a steady march toward superconductors that operate at higher temperatures. Superconductors that can operate at room temperature (or close to it) are considered the holy grail of condensed-matter physics because of the tremendous technological opportunities they would open in power efficiency, including in electricity transmission, transportation and quantum computing.

"If you are ever going to engineer something and make it commercial, you need to know how to control it," said Brown physics professor Vesna Mitrović, who leads a condensed matter NMR group at the University and is a co-author on the new study. "How do we describe it? How do we tweak it so that we get what we want? Well, the first step in that is you need to know what the states are microscopically. You need to start to build a complete picture of it."

The new study focuses on superconductor RbV3Sb5, which is made of the metals rubidium vanadium and antimony. The material earns its namesake because of its peculiar atomic structure, which resembles a basketweave pattern that features interconnected star-shaped triangles. Kagome materials fascinate researchers because of the insight they provide into quantum phenomena, bridging two of the most fundamental fields of physics — topological quantum physics and condensed matter physics.

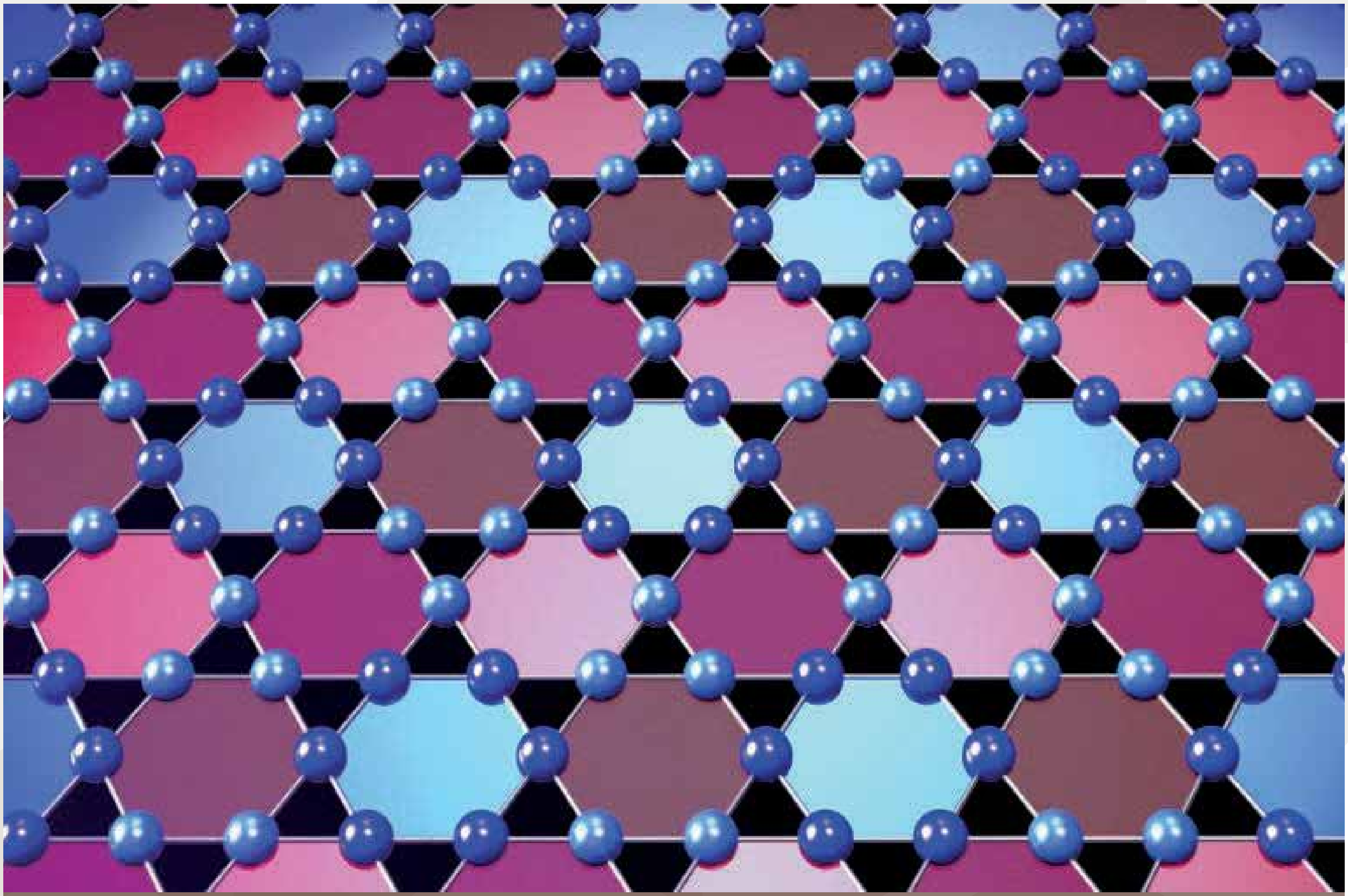
Previous work from different groups established that this material goes through a cascade of different phase transitions when the temperature is lowered, forming different states of matter with different exotic properties. When this material is brought to 103 degrees Kelvin, the structure of lattice changes and the material exhibits what's known as a charge-density wave, where the electrical charge density jumps up and down. Understanding these jumps is important for the development of theories that describe the behavior of electrons in quantum materials like superconductors.

What hadn't been seen before in this type of Kagome metal was what the physical structure of this lattice and charge order looked like at the temperature the researchers were looking at, which is highest temperature state where the metal starts transitioning betwen different states of matter.

Using a new strategy combining NMR measurements and a modeling theory known as density functional theory that's used to simulate the electrical structure and position of atoms, the team was able to describe the new structure the lattice changes into and its charge-density wave.

They showed that the structure moves from a 2x2x1 pattern with a signature Star of David pattern to a 2x2x2 pattern. This happens because the Kagome lattice inverts in on itself when the temperature gets extremely frigid. The new lattice it transitions into is made up largely of separate hexagons and triangles, the research-

Scientists describe the microscopic structure of a recently discovered group of superconductors for the first time, a small step toward paving the way for future advances in superconducting technology.



Brown researchers, working with an international team of scientists, describe the microscopic structure of Kagome superconductor RbV3Sb5 in a new study. Credit: M. Zahid Hasan and Jia-Xin Yin, Princeton University. Courtesy of the National Science Foundation multimedia gallery.
PHOTO: MATTHEW KAPUST/SURF

ers showed. They also showed how this pattern connects when they take one plane of the RbV3Sb5 structure and rotate it, "gazing" into it from a different angle.

"It's as if this one Kagome now becomes these complicated things that split in two," Mitrović said. "It stretches the lattice so that the Kagome becomes this combination of hexagons and triangles in one plane and then in the next plane over, after you rotate it half a circle, it repeats itself."

Probing this atomic structure is a necessary step to providing a complete portrait of the exotic states of matter this superconducting material transitions into, the researchers said. They believe the findings will lead to further prodding on whether this formation and its properties can help superconductivity or if it's something that should be suppressed to make better superconductors. The new unique technique they used will also allow the researchers to answer a whole new set of questions.

"We know what this is now and our next job is to figure out what is the relationship to other bizarre phases at low temperature — does it help, does it compete, can we control it, can we make it happen at higher temperatures, if it's useful?" Mitrović said. "Next, we keep lowering the temperature and learning more."

The experimental research was led by Jonathan Frassineti, a joint graduate student between Brown and the University of Bologna, Giuseppe Allodi from the University of Parma, and two Brown students: Erick Garcia and Rong Cong. Theoretical work was led by Pietro Bonfà while all the materials were synthesized at the University of California Santa Barbara. This research included funding from the National Science Foundation.

Matthias Kuehne

Q&A WITH OUR NEWEST RESEARCHER

By Valerie DeLaCámara

Anyone wondering what sustains the Physics Department's newest researcher, Assistant Professor Matthias Kuehne through his research can look no further than Seven Stars Bakery in Providence, his favorite East Side haunt. He says that being German, having access to good bread is essential!

Professor Kuehne and his wife met in a tango class and recently welcomed an infant son to their growing family. Coffee and sweets work equally as well as sustenance for late nights with the baby as for long research stretches. New to Providence and a budding foodie, Prof. Kuehne loves Providence's eclectic restaurant scene, with a special nod to Middle Eastern food, his favorite cuisine.

Prof. Kuehne's musings on the future his son may face and supporting his interests – whatever they may be – speak to his kind and supportive approach in the classroom and attitude toward encouraging students to pursue whatever avenues of scientific collaboration excite and interest them. His group investigates fluidic, ionic, and electronic properties of low-dimensional materials and devices, and while not immersed in related research, this tango-dancing foodie can be found on the 7th floor of Barus & Holley.

BROWN PHYSICS: Welcome to Brown! We are very excited to have you here. First of all, congratulations on the birth of your son! How is it being a new parent?

PROF. KUEHNE: It's our first, and it's great. It's a big change, but it's fantastic.

BP: Are you getting much sleep?

PROF. KUEHNE: Yes, he is gaining weight and sleeping longer stretches. I feel like the body gets used to five hours of sleep here and there.

BP: Do you hope for a future in physics for your son?

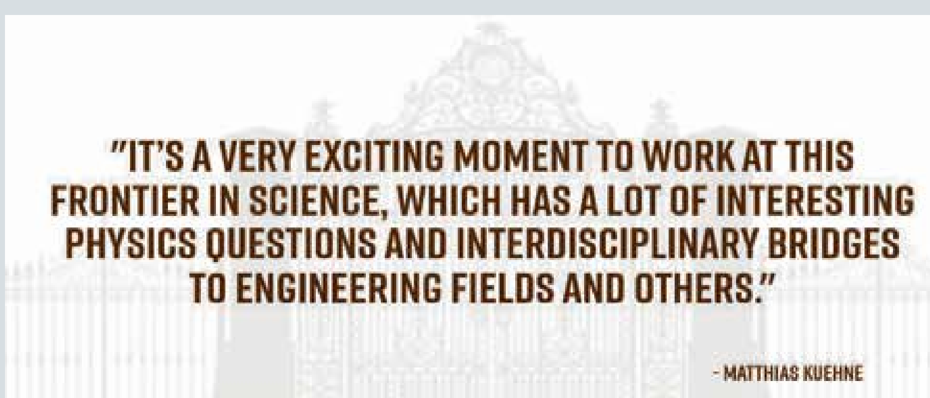
PROF. KUEHNE: Not specifically; whatever he does, as long as he's happy, he should pursue what he is interested in and enthusiastic about. You can pursue many interesting things in your life, and physics is only one. Our children's generation faces so many challenges on the planet we leave them; I think there are many relevant things one could engage in. I will support him in whatever he wishes to pursue.

BP: Your research investigates fluidic, ionic and electronic properties of low-dimensional materials. What type of background would a graduate student need to have to work in your group?

PROF. KUEHNE: I view my group as an experimental group with an interdisciplinary focus. We investigate fluidic and ionic phenomena in low-dimensional solid-state devices. So, regarding the types of backgrounds that a graduate student would need to work with me, the research profile is the big picture because it is somewhat at the interface of physics and chemistry and maybe material science. Tackling problems in this space requires expertise traditionally routed in different disciplines to come together. I hope to build a group that reflects this. So while a solid background in physics is important, a grad student who has had previous exposure or even training in chemistry or material science would be very welcome. I view bringing such different perspectives together an important asset for the group. I have myself done a post-doc in a chemical engineering department, rather than physics, although I am a physicist by training. I believe the exposure has helped broaden my horizons and provided me valuable insights in how people do research in a different environment than the one I was formally trained in.

Some of the experiments we are doing are in some respects similar to what electrophysiologists or electrochemists do or, for example, when it comes to material synthesis, our experiments are similar to what material scientists do. Experience in or exposure to these different things are just examples of what graduate students could bring; there's no strict profile of what I am looking for. Different backgrounds and training can contribute to a research program like mine.

The field has seen significant advances in low-dimensional materials research, some of which have been pioneered in our department, such as by the Li group. There are also groups in engineering and chemistry now that work on low-dimensional materials, and we've seen a surge in what humans can do with them in the last ten to twenty years. These material systems enable a completely new quality of research on nanofluidics and nanoionics programs



Prof. Kuehne joined the Department of Physics at Brown in 2023, following post-doctoral work in the group of Prof. Michael Strano at MIT. His group at Brown investigates fluidic, ionic and electronic properties of low-dimensional materials.

that have been beyond reach ten to twenty years. I think it's a very exciting moment to work at this frontier in science, which has a lot of interesting physics questions and interdisciplinary bridges to engineering fields and others.

BP: Tell us about your work at the Max Planck Institute.

PROF. KUEHNE: The Max Planck Society comprises quite a number of different Max Planck Institutes, each dedicated to a particular research field. I worked at the Max Planck Institute for Solid State Research, one of the biggest Max Planck Institutes (by number of people) due to the non-negligible amount of infrastructure needed to do solid-state research at least 50 years ago when the institute was founded. For example, it houses a central helium liquefication facility and all sorts of workshops for electronics, wood, glass, etc.

The Max Planck Institute for Solid State Research is housed in a big 1960s-era building, not unlike the Barus & Holley building here at Brown; however, it was placed in the forest outside of Stuttgart. It is somewhat like a monastery for physicists and chemists working together on solid-state systems. It's a fun place to be and has made history since its inception in 1969. Klaus von Klitzing, awarded the Nobel Prize for the discovery of the Quantum Hall Effect, has been a director there and just celebrated his 80th birthday. To this day, he is pretty much at the institute every day if not traveling. He is a very enthusiastic and inspiring person.

Other prominent names of directors who served there include Manuel Cardona (semiconductor physics), Ole Krogh Andersen (density functional theory), Bernhard Keimer (solid-state spectroscopy), and Joachim Maier (solid-state chemistry). I was very fortunate to have the opportunity to pursue Ph.D. research at this institute, which I did in the Jurgen Smet group that focused on solid-state nanophysics and was spun out of the Klaus von Klitzing department.

BP: Do you plan to continue that line of research?

PROF. KUEHNE: Yes, to some extent. I hope to bring some of the expertise I gained during my Ph.D., which was two-dimensional materials electrochemistry, and then the expertise I gained in my post-doc, which was more like nanofluidics and 1D systems. I worked on carbon nanotubes especially, which are tubular structures of atomic scale, very tiny hoses to put fluids in. I'm planning to build experimental platforms using both 1D and 2D materials, so low-dimensional materials is the correct label. I consider both types of materials as solids, although you can argue from a chemist's perspective that they are just big molecules, which is also true. There's very good physics that people have established over the last 20 years to describe these systems.

People also have developed tools to actually manipulate these systems in the lab; we know how to integrate them into devices. There's still a lot to be done, but there is significant knowledge to build on. I have those two elements from my background and want to bring them together.

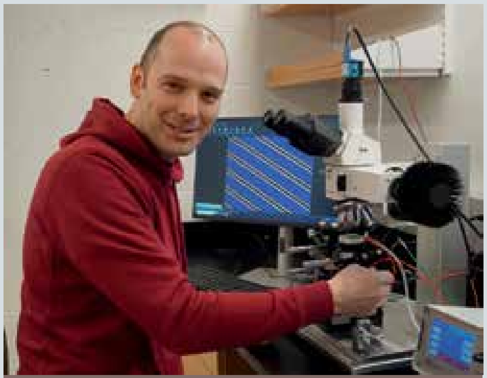
There are cool applications now where people can sequence DNA just by pushing it through a very tiny pore that may be solid-state. Chemical information storage is one area where people want to interface electronics with ionic systems, and you need a very small scale to have the control at the relevant level. Those are some of the directions I hope to explore. Advancing physics in this field has the added benefit that it may inform the engineering of practically relevant devices.

BP: Who influenced you most while you studied physics?

PROF. KUEHNE: I had two very inspiring mentors when I was a master's student, Marek Potemski and Clement Faugeras. They were committed, serious and genuinely interested in Physics. Being part of that was important and very formative for me. I also vividly remember nights spent in the lab in front of a very strong magnet we had only dedicated measurement slots on, when Clement would occasionally play the saxophone to make the time pass.I'm hoping to have a similar impact on my students. Here at Brown I see the opportunity to build strong relationships between advisor and advisee. I want to be the person who will say, "Yes, here are the resources. I want to encourage you to pursue the questions you are passionate about and succeed." I strive to create an environment where people can learn, grow, make mistakes, and persevere.

BP: Now that we've heard about your research, can you tell us where you go to unwind? For example, what is your favorite restaurant?

PROF. KUEHNE: I like Middle Eastern food, but don't have a favorite Middle Eastern restaurant yet. Seven Stars Bakery has become quite essential, which should sustain me through my research!



Matthias Kuehne in his lab.
PHOTO: JESSE TESSIER/BROWN UNIVERSITY

STUDENT AFFAIRS UPDATE

Program Updates by
Jay Tang, Graduate Program Director and
Jim Valles, Ph.D. Program Director

The physics Sc.M. program has seen remarkable growth in recent years. In the fall of 2022, the incoming class size reached nearly 50 students, triggering a departmental assessment to determine whether a size limit should be set to ensure the best educational outcome for our students.

Enrollment for the core courses PHYS 2030, 2040, 2050 & 2060 has increased dramatically, from typically a dozen or so in the past, to 40 or even 50 students, requiring larger classrooms and senior Ph.D. students serving as teaching assistants. Besides the concern regarding the class size of the core graduate physics courses, the department also must ensure that Sc.M. students benefit from mentored research.

The incoming master's class with Graduate Program Director Jay Tang (second from right) and (L to R) Sean Ling and Kemp Plumb.
PHOTO: VALERIE DELACÁMARA/BROWN UNIVERSITY

The administrative demand has also grown with the size of the program. Currently, Prof Jay Tang, a biological physicist, serves as the physics Sc.M. program director.

Recently, the department brought on board two staff members, Elyse Souliere and Jessica Bello, to serve as Student Affairs Managers. With their combined service at Brown of 17 years and counting, Elyse and Jess coordinate affairs of both Sc.M. and Ph.D. students in physics. With student numbers approaching 100 in each cohort, of whom more than half are international students from all over the world, these students bring to the department boundless energy, research interests and skills covering all areas of physics, and from time to time, various administrative challenges. Bound by their shared love of physics, these students have extracurricular interests including music, dance, professional video gaming, etc.

The Sc.M. class of 2023 graduated about 30 degree recipients. More than 50% of the Sc.M. graduates were accepted into competitive Ph.D. programs such as Brown (5 students), Northwestern, UMass, University of Waterloo, just to name a few. In the fall of 2023, with 45 students proceeding to the 2nd year of their Sc.M. program, 42 new master students enrolled in the program.

About 20% of the incoming students are women, a low but typical percentage in physics. The program seeks to improve that percentage by active outreach and community building among women in STEM programs on campus and beyond. Recent Sc.M. graduates Sara Alkidim and Kanchita (Khing) Klangboonkrong have played leadership roles in this important cause. Having continued on with their Ph.D. studies in our department, Sara and Khing seek to continually improve the visibility and success of women in physics at Brown University.

- Jay Tang,
Graduate Program Director

"Khing and Sara have played leadership roles ... and seek to continually improve the visibility and success of women in physics at Brown."
- Jay Tang

Our largest Ph.D. class in recent memory just matriculated this fall. Our 27 students have physics interests that span our department's current research efforts. To give them a broad introduction to physics frontiers and research methods, we initiated a first-year Ph.D. seminar series featuring faculty members. In these talks, faculty members introduce themselves, the broad questions that inspire them and their group's specific activities. Our hope is that they will be energized and feel more broadly informed as they choose research groups in the coming months.

- Jim Valles,
Ph.D. Program Director

Brad Marston elected to presidential line of the American Physical Society

By Juan Siliezar

Brown University physics professor Brad Marston has been elected to the presidential line of the American Physical Society.

The nonprofit professional society represents more than 50,000 physicists in academia, national laboratories and industry in the U.S. and around the globe. Marston will serve as its vice president in 2024, president-elect in 2025 and president in 2026. He will be the second Brown faculty member elected to serve as the society's president in the past five years.

The APS president leads the society's board of directors, which is responsible for its overall management. The society's mission is to advance and diffuse the knowledge of physics through its research journals, scientific meetings, as well as through education, outreach, advocacy and international activities.

Marston says he's honored and excited by the opportunity.

"I look at the list of past presidents of the APS and see the names of some really amazing people who have served," he said. "I can only hope to live up to the high standards that these predecessors have set."

Marston also hopes to help the society continue to engage members of the public and scientists in the field on how physics can impact the world's most pressing problems.

"I want to continue doing what I have been doing with APS in terms of trying to interest a broader range of physicists in thinking about the climate problem, and possible ways to reduce climate change," he said.

Marston joined the Brown physics department in 1991 after earning a Ph.D. from Princeton University and completing postdoctoral research at Cornell University. Originally trained as a condensed matter physicist, Marston has also worked on climate science since 1990. He currently directs the Brown Theoretical Physics Center.

He has been recognized for work including furthering fundamental understanding of quantum systems, such as Mott insulators and quantum spin-liquids, and applying non-equilibrium statistics to the physics of atmospheres and oceans to better understand climate and climate change. Marston has also has garnered attention for work looking at problems in classical physics, like turbulence, and has recently been helping to launch Brown's Initiative for Sustainable Energy.

Marston has earned a number of honors during his academic career including being named an Alfred P. Sloan Fellow, a recipient of a National Young Investigator Award, and a fellow and lifetime member of the American Physical Society. In 2008, Marston was designated a National Science Foundation American Competitiveness and Innovation Fellow.

Marston sees physics as key to advancing humanity — transcending differences of opinion, background and origin — and plans to offer that perspective during his time in the presidential line.

"An understanding of physics endows us with critical perspectives to address the global threats of nuclear warfare and climate change and respond to the urgent call for global equity and sustainable sources of energy," Marston said in his candidacy statement for the APS presidency. "It prepares us to confront emergent challenges such as quantum information and the rapid ascendance of artificial intelligence. In times of political tension, such as during the Cold War, physics brought people together to advance not just our understanding of science but also our mutual empathy and respect."

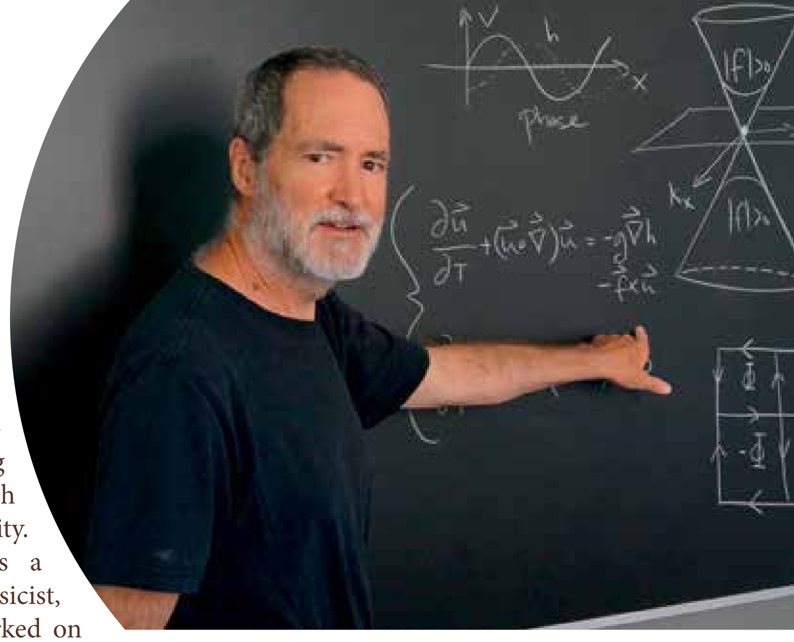


PHOTO CREDIT: ARIEL GREEN/BROWNUNIVERSITY

"I look at the list of past presidents of the APS and ... can only hope to live up to the high standards that these predecessors have set."
BRAD MARSTON

Other Brown faculty members that have served as APS president include Carl Barus, a former dean of Brown's graduate school who served as APS president in 1905 and 1906, and renowned physicist S. James Gates Jr., who was elected to the presidential line in 2018 when he was a physics professor at Brown and served as president in 2021.

Marston is slated to assume the post of vice president on Jan. 1, 2024, and become president in 2026.

FACULTY UPDATES

VESNA MITROVIĆ NAMED CHAIR OF PHYSICS DEPARTMENT, NAMED TO EDITORIAL BOARD OF NEW JOURNAL OF PHYSICS

Vesna Mitrović was named Chair of Brown University's Department of Physics effective July 1, 2023. She was also named a member of the Editorial Board of New Journal of Physics (NJP), on behalf of the Institute of Physics, UK and the Dutsche Physikalische Gesellschaft. NJP is a thriving open-access journal with a mission to serve the whole physics community by publishing free-to-read research articles of excellent scientific quality in all areas of physics.

BRAD MARSTON ELECTED APS PRESIDENT, HONORED WITH KAVLI SYMPOSIUM

Brad Marston was elected to the presidential line of the American Physical Society (APS). According to APS protocol, Brad will be vice-president in 2024, then president-elect (2025), president (2026) and finally past president (2027). The APS has roughly 50k members and a budget of over $100M. Brad joins the small, highly esteemed group of previous Brown faculty who were APS presidents: Carl Barus (1905-1906) and Jim Gates (2021). Prof. Marston was also honored with selection for the Kavli Foundation Special Symposium at the American Physical Society's March Meeting.

STEPHON ALEXANDER RECEIVES THE AHA'S ISAAC ASIMOV SCIENCE AWARD, JOINS BBC SCIENCE FOCUS

Stephon Alexander received the prestigious Isaac Asimov Science Award from the American Humanist Association for outstanding work in the field of cosmology, particle physics, and quantum gravity; explorations of the interconnectedness between music, physics, mathematics, and technology; and advocacy for the importance of greater racial diversity in physics and other sciences. He was also invited to join BBC Science Focus Magazine as a columnist, writing pieces on topics of interest in science and physics to a broad international audience. Professor Alexander joins BBC Science Focus magazine's line-up of six columnists, each doing a column every other issue.

JIA (LEO) LI APPOINTED RICHARD AND EDNA SALOMON ASSISTANT PROFESSOR OF PHYSICS, SELECTED FOR DEPSCOR GRANT

The Physics Department was pleased to congratulate Jia (Leo) Li on his appointment to the Richard and Edna Salomon Assistant Professor of Physics. Prof. Li was also on one of two teams from Brown selected by the U.S. Department of Defense for DEPSCoR grants.

GANG XIAO THANKED BY DEPARTMENT FOR INTERIM CHAIR TENURE

In a festive spring tribute, the Department of Physics gathered to thank Professor Gang Xiao for his service to the department after former chair Meenakshi Narain's passing in January. Interim Provost, Professor of Engineering and the Sorensen Family Dean Emeritus of Engineering Lawrence E. Larson was also on hand to show gratitude and support for Gang's leadership

JONATHAN POBER RECEIVES EARLY CAREER RESEARCH ACHIEVEMENT AWARD

Nominated by his peers and one of nine recipients of the 2023 Research Achievement Awards, Professor Pober will receive a stipend of $5,000 to support his research.

Jia (Leo) Li

FACULTY RESEARCH

U.S. DEPARTMENT OF DEFENSE SELECTS TWO TEAMS FROM BROWN FOR DEPSCOR GRANTS

By Juan Siliezar

As part of its Defense Established Program to Stimulate Competitive Research pro gram, the U.S. Department of Defense has awarded grants to two projects led by Brown University researchers.

Brown faculty members Jia Li and Mauro Rodriguez will serve as principal investigators for the respective projects studying electrons in 2D materials and theoretical modeling on soft materials that may one day be used to better predict the response of the human body to blunt impact.

The grants will provide approximately $600,000 in total for each project over the course of the next three years.

The support comes as part of a Department of Defense effort to bolster science and engineering research in areas important to U.S. defense through a research competition known as DEPSCoR. Established in 1994, the program is designed to strengthen basic research infrastructure at higher education institutions in states or territories that have traditionally been underutilized. This year, the agency awarded $18 million in DEPSCoR awards to 28 academic teams from 15 states. The 28 projects, including the two based at Brown, were selected from 115 white papers that qualified for the competition.

"The idea behind DEPSCoR is for the Department of Defense to cultivate and tap into an ecosystem of researchers found in states eligible for DEPSCoR," said Jill Pipher, Brown's vice president for research and a professor of mathematics. "Brown researchers have a lot to offer the DOD and the nation when it comes to basic research, including where learnings from the work can be applicable and critical to national security. We are grateful to the Department of Defense and especially to U.S. Senator Jack Reed for his continued leadership and support of DEPSCoR."

Reed has represented Rhode Island in the U.S. Senate since 1996 and is chairman of the Armed Services Committee and a senior member of the Senate Appropriations Subcommittee on Defense. The subcommittee secured $20 million for DEPSCoR in 2023's Consolidated Appropriations Act, ensuring that universities in DEPSCoR states like Rhode Island can compete to perform cutting-edge basic research and partner with defense labs.

U.S. Senator Jack Reed speaking at Brown's Veteran's Day Ceremony in 2021. Photo by Nick Dentamaro/Brown University.

"I'm pleased DOD recognizes the breakthrough potential these projects have and is investing in not only Brown University, but the state's research ecosystem," Reed said. "DEPSCoR is a capacity builder that can help create new commercialization and development opportunities right here in Rhode Island."

Li, an assistant professor of physics, will lead work probing and characterizing electron nematicity — a phenomenon in which electrons align themselves in a symmetry-breaking pattern under the influence of a unit of electrical charge called a Coulomb interaction — in the 2D material multilayer graphene. Understanding this interaction can serve as a foundation for future quantum material engineering.

The project, "Probing electron nematicity in multilayer graphene heterostructures," is a collaboration with Brenda Rubenstein, an associate professor of chemistry, who will serve as co-principal investigator. The pair will work together to study the nematicity of the electrons, which is believed to be an important ingredient in unconventional superconductivity. Li will be building a system to physically measure the nematicity through experiments while Rubenstein, a theorist in quantum chemistry, will build a model to simulate the interactions and measurements.

"Through our combined effort, we hope to gain a deeper understanding of how electron interaction gives rise to electronic nematicity, a behavior and arrangement in material that can influence how well an electrical current will be conducted in a material in different directions," Li said. "The general direction that we're going in is to better understand electronics interaction and its influence on other quantum phases of the intriguing material platform of graphene."

Rodriguez, an assistant professor of engineering, is leading the theoretical modeling effort on soft materials. The project, "Theoretical modeling of non-spherical inertial cavitation for anisotropic soft matter rheometry," is a collaboration with David Henann, an associate professor of solid mechanics.

The work aims to advance a method for characterizing how materials, like biological tissue, become deformed when they are hit by blunt objects at high speeds. The technique, which originated at Brown, is called Inertial Microcavitation Rheometry and involves generating a single bubble, in this case using a laser, in a soft gel to measure the properties of the material at high speeds and strains. The researchers will use modern statistical modeling techniques, numerical simulations and theory to determine the properties of different kinds of soft materials and their response to the impact.

"Our ability to characterize response of soft matter at high strain rates is critically important to then begin to predict the sustained damage due to blast loading or blunt impacts," Rodriguez said. "This basic research is at the cross-section between fluid mechanics, solid mechanics, soft matter and biomedical applications which started at Brown, and we now continue that story and aim to further advance this technique and field."

MEENAKSHI NARAIN, 1964-2023

BUILDING A NEW DETECTOR FOR THE LARGE HADRON COLLIDER

By Ulrich Heintz


Meenakshi Narain
PHOTO: COURTESY ULRICH HEINTZ

The Large Hadron Collider has been operating at CERN, the European particle physics laboratory near Geneva, Switzerland, since 2010. The physics output has been nothing short of spectacular. The Compact Muon Solenoid (CMS) experiment alone has published over 1,200 papers in journals, reporting the discovery of the Higgs boson and many other results. Yet, the largest scientific instrument built by humans is nowhere near the end of its useful life. Improvements to the machine will increase the luminosity, a measure of the number of proton-proton collisions per unit time, by a factor of 5 when the so-called high-luminosity (HL) LHC starts operation in 2029. The plan is to increase the total amount of proton-proton collision data from the LHC by an order of magnitude over the following decade.

The CMS experiment sits in the middle of the French countryside. Protons collide about 100 meters below ground and the CMS detector records their signatures in millions of electronic channels. The detector has long exceeded the number of collisions it was designed to record. During the HL-LHC operation, proton beams will cross every 25 ns at the center of CMS. In every crossing, an average of 140-200 proton pairs will collide and spew debris into the detector. In order to extract physics results in this environment, most parts of the detector need to be augmented. The silicon tracker, which sits at the center of the detector and records the trajectories of charged particles emanating from the collisions, will have to be entirely replaced with a more powerful instrument to enable CMS to handle the increased collision rate.

When Professors Ulrich Heintz and Meenakshi Narain joined the Physics Department at Brown about 15 years ago, the design of this replacement had just started and there was the opportunity to make Brown a significant player in the effort to build a new Outer Tracker, the part of the silicon tracker that occupies the cylindrical volume between 20 cm and 120 cm from the beam axis.

A project as large as the CMS experiment can only be realized by an entire community of scientists and engineers working together as a team. “Our collaboration with people from across the globe shows what we can achieve when we are driven by a common goal. Besides the science, this global cooperation has always excited me about particle physics”, says Heintz. Even a subsystem, like the Outer Tracker, is daunting in its scale. It will consist of 26 thousand silicon sensors, comprising a total of some 150 million readout channels. Its novel design will, for the first time at a hadron collider, feed data to the level 1 trigger, a processor that analyzes every beam crossing in real time and decides which is interesting and should be further analyzed. First, silicon sensors had to be designed that are radiation resistant and would be able to operate for 10 years in the radiation environment at the center of the CMS detector. Then the basic elements of the tracker, the modules which consist of sensors and their readout electronics, had to be designed and a construction process developed.

Heintz and Narain set up a lab on the fifth floor of Barus and Holley (B&H), first using equipment that in part dated back to the construction of the silicon tracker for the D0 Experiment at Fermilab in the 1990s. They started building a team and brought in young people. First was postdoc Alexandra Junkes, who recently had received her Ph.D. from Hamburg with a thesis on silicon detectors. She set up the lab to characterize silicon devices. Another early hire was Eric Spencer, who started to experiment with various techniques to assemble modules. The Brown group worked closely with colleagues at CERN, Fermilab and other institutes. Slowly, the group became a key contributor in this Research and Development (R&D) effort.

It was necessary to simulate the radiation environment at the HL-LHC to understand how silicon sensors change when exposed to the LHC environment. Heintz started to collaborate with the Rhode Island Nuclear Science Center (RINSC) to irradiate prototype silicon sensors with neutrons at their research reactor to arrive at a radiation-hard design for the sensors, and Ph.D. student Bjorn Burkle found himself faced with the challenge of understanding the energy spectrum of neutrons from a nuclear reactor.

Brown was among the first CMS institutes to assemble prototype modules to develop a design that could actually be built. The Outer Tracker design requires that each module can send out information about high momentum particles for every beam crossing. The momentum is measured by the radius of curvature of the particle trajectories in the magnetic field of the detector. High momentum particles travel on close to radial lines from the collision point but low momentum particles curl up onto helical trajectories. Individual modules consist of two coplanar silicon sensors, separated by a few mm. A particle from the collision point has to traverse both sensors. The locations where it hits the two sensors can be used to estimate how far the trajectory deviates from radial, which enables the selection of hits from high momentum particles that can be passed to the trigger. This novel feature translates into a challenging design problem for the modules. The two sensors, which measure 5 cm x 10 cm or 10 cm x 10 cm, have to be aligned relative to each other with a precision of 50-100 μm. The whole module has to be mechanically stable under temperature variations between its construction at room temperature and its operation at -30 degrees Celsius.

To bid for a part of the construction of the Outer Tracker, a bigger space in a real cleanroom was required. The timing was lucky. When the School of Engineering moved into their new

REALIZING A SHARED VISION


Meenakshi Narain (L) and Ulrich Heintz
PHOTO: COURTESY ULRICH HEINTZ

Research Building, the cleanroom on the seventh floor of B&H was vacated and the University provided it to set up a production facility. The strong support by the Vice President of Research and the Provost made it possible to bring the construction project to Brown.

Today, Brown serves as one of eight CMS institutes in the United States (US), Europe and Asia that conduct quality-control testing of the production silicon sensors manufactured by Hamamatsu in Japan. Brown is also one of ten CMS institutes worldwide that will produce modules for the Outer Tracker. Over a period of two years, in 2025 and 2026, Brown plans to assemble over 2,000 modules. Heintz co-coordinates the CMS module building effort worldwide and is the deputy manager for the Outer Tracker project in the US. The Brown team has slowly grown to six full time lab staff, led by assembly coordinator Nick Hinton.

The total cost of the project at Brown is estimated at around $10M. The work is supported by the US Department of Energy (DOE); Brown has already received over $5M in project funds to support the cost of personnel, building up the infrastructure and procure the required parts. The project benefits Brown by raising the visibility of the Brown Physics Department in the international high energy physics community. It also provides an invaluable training ground for students who learn important job skills for STEM carriers and who are trained to form the next generation of particle physicists who can build even more ambitious detectors in the future. Over 30 undergraduate, Sc.M., Ph.D. students, and postdocs have gained expertise in silicon detectors during various aspects of the R&D process since the beginning of the effort. Farrah Simpson, one of the Ph.D. students, says, "Being involved in the R&D process has allowed me to develop necessary experimental and analytical skills to become a well-rounded scientist. It was one of the pivotal factors that awarded me a fellowship from Fermilab last year. It has also allowed me to be able to understand how a particle detector works on a deeper level."

In collaboration with Prof. Vesna Mitrović at Brown, Dr. Alesandro Tricoli from Brookhaven National Lab and Prof. Isobel Ojalvo at Princeton, Heintz and Narain were able to leverage the detector project to obtain $2M in funding from the DOE for a traineeship program in particle physics instrumentation. As part of this program, graduate students learn about the physics of silicon detectors, the details of tracking detectors, state-of-the-art electronics, and novel quantum detectors. In Mitrović's words "This is a wonderful collaborative effort that provides very unique multidisciplinary training for students—I hope we can carry out this program to live up to Meenakshi's expectations".

The immediate next goal for the project is to get the go-ahead from the DOE to start production, so-called Critical Decision (CD)-3 approval; the reviews will be in fall 2023. Heintz and his team are looking forward to passing this final approval step before construction can start. "My only regret is that Meenakshi will not see her vision for our group realized", says Heintz.

AN UPDATE FROM LADD OBSERVATORY

Another year for Ladd has passed, filled with new and exciting events.

Ladd hosted several labs for Astronomy students, who were enthralled with its beauty and history. As a result, several became a part of the Ladd community, setting up portable telescopes on the deck, introducing the spectroscope to the public that Curator Mike Umbricht had set up in the library, and even working on the historic 12-inch refractor.

The Brown Astronomy Club became more active this year, especially as the "green" comet, C/2022 E3(ZTF), became a part of the sky. Although not visible with the naked eye, the comet could be seen using both Ladd's refractor and the 16-inch telescope atop Barus & Holley. Many students from the Brown community came to view it, which interested many to become a part of the Club. With a growing membership, we'll hear much more about the Brown Astronomy Club in the future!

During one of our open nights, Ken Launie of the Antique Telescope Society brought his wife, first-time visitor Sara Schechner, Curator of the Collection of Historic Scientific Instruments at Harvard. Sara was so taken with Ladd that she asked to bring members of the International Scientific Instrument Society, who would be meeting at Harvard. Thirty members from all over the world came the morning of May 19th. Director Dave Targan and I had them pull the ropes to move the dome, look through the spectroscope in the library, and we even introduced them to horror writer H.P. Lovecraft and his early history as a part of the Ladd community.

The highlight of this year was the introduction of Clear Skies, the online astronomy magazine written by Brown students, faculty and staff. Clear Skies informs the public on topics in all areas of astronomy, from the latest astronomical research to the use of cockroaches in lunar soil determinations. Part of the beauty of the final product lies in the incredible layout and design by students Indigo Mudbhary and Kate Kuli.

All of us at Ladd understand the responsibility of keeping it alive, and as you can see, we're continuing to do so. Onward to next year!

Francine Jackson
Staff Astronomer

STUDENT SPOTLIGHT

PHD STUDENT DANIEL LI WINS BROWN UNIVERSITY STUDENT LEADER OF THE YEAR

By Valerie DeLaCámara

Each year, the Student Activities Office (SAO) honors a Brown student with a Graduate Student Leader of the Year Award. It came as no surprise to anyone in the Physics Department that Ph.D. student Daniel Li was named a 2023 recipient of the award, given to the member of a student group who best demonstrates the qualities of outstanding leadership such as dependability, dedication, trustworthiness, loyalty and helpfulness.

Interim Physics Department Chair Gang Xiao felt strongly that Daniel embodied all of these qualities saying "Daniel was an exceptional leader and organizer of the Conference for Undergraduate Women in Physics (CUWiP) at Brown under the most exceptionally difficult circumstances. He became the chief organizer of this large-scale, three-day event after the conference's faculty leader, Physics Department Chair Meenakshi Narain, passed away three weeks before the conference. Pushing through the emotional strain of losing the faculty advisor with whom he worked closely for four and a half years, Daniel's true leadership shone through the adversity and emotional toll that losing Meenakshi exacted on us all."

CUWiP, a three-day national conference at which Brown hosted groups from 30 national universities, was held January 20 – 22, 2023. Among the attendees were 120 Undergraduates; 40 invited speakers, panelists and workshop facilitators; 40 volunteers; and 40 career fair representatives.

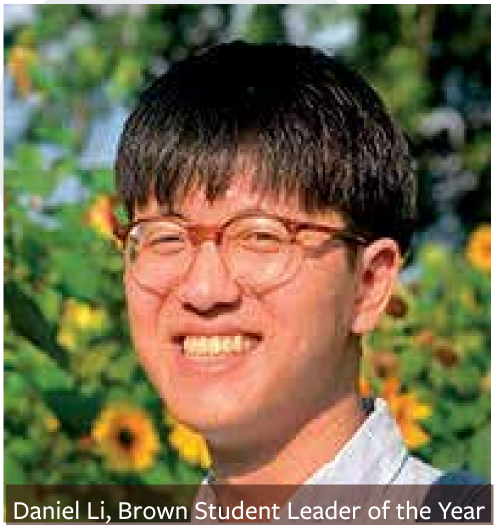
After the passing of the conference's organizer and champion, Daniel moved forward with the myriad aspects of organizing a large-scale event. Professor Xiao and others on the faculty gave Daniel their full support, telling Daniel that given his deep involvement with the project and how closely he worked with Professor Narain, the Department completely trusted his judgment to make decisions that she would have been responsible for. Professor Xiao reflects that Daniel proceeded with confidence and took complete charge of the conference, showing exemplary leadership.

After processing the repercussions of Professor Narain's passing, Daniel related that he recognized how important the conference was to her vision for physics and that he used that conviction to ensure the conference was carried out to the standard she would have expected from him. Knowing that this conference was near to Professor Narain's heart and that she threw all her energy into ensuring that the conference would be held at Brown in her final days, Daniel had an enormous responsibility. He recollects that Professor Narain told him early on that to make the conference succeed he would need to learn to delegate tasks wisely and help others feel ownership over those tasks. He felt that she wanted this to be an opportunity for him to develop as a leader outside of research since she knew of Daniel's tendency to do things independently; she wanted him to learn to trust others in a team environment. Through flawless execution, Daniel showed that he learned Professor Narain's final lessons.

Professor Vesna Mitrović became the CUWiP faculty leader after Professor Narain's passing. She recollects that Daniel ensured that all of the agreed-upon steps were executed to the highest degree of excellence. The result was a seamless conference with many events over three days.

Prof. Mitrović observed that if anyone else was dealing with the emotional strain in addition to overseeing the logistics of this event, the conference simply would not have happened. She remains amazed by his maturity, professionalism and ability to "step up and do it" in the most difficult of times.

Working with Daniel was a true pleasure despite the emotional hurdle they had to overcome and he is proud of Daniel's ability to "get it done" in true leadership form, Professor Xiao reflected. "The impact of Daniel's management of the 2023 CUWiP Conference cannot be overstated. Daniel's leadership elevated Brown University's national profile with the American Physical Society and the many universities that attended this highly successful conference. He was driven to fulfill Professor Narain's vision for a more inclusive and equitable field within physics. Most importantly, in so doing, Daniel cemented Professor Narain's legacy as a champion of women in physics at Brown and beyond."



Daniel Li, Brown Student Leader of the Year
PHOTO: DANIEL LI

"I am forever grateful to my late mentor and role model, Prof. Meenakshi Narain, who demonstrated what it meant to labor wholeheartedly toward your passion."

DANIEL LI

The Physics Department Diversity and Inclusion Action Plan Committee was pleased to host a music event featuring Raga music by Grammy winner Steven Gorn (flute), Nitin Mitta (tabla) and Srinivas Reddy (sitar). It was a first-time collaboration for the the trio, who delighted a crowd of almost fifty people in the ERC on April 3, 2023.

DDIAP SPOTLIGHT: RAGA MUSIC

PHOTOS: JESSE TESSIER/BROWN UNIVERSITY

L to R: Steven Gorn (flute), Nitin Mitta (tabla), Srinivas Reddy (sitar)

L to R: Srinivas Reddy, Steve Gorn, Stephon Alexander, Abhay Ashtekar, Nitin Mitta

THE TENTH NEW ENGLAND STRING MEETING

The Tenth New England String Meeting was held at Brown on Friday, April 28. This series of meetings have been held on a quasi-regular basis at Brown since 2006 and serve the regional formal high energy theory physics community. The meetings consistently attract around 80 external participants for a day of enjoyable and informative lectures and plenty of time for discussion during breaks. Attendance, and anticipation, were high for this year's meeting due to pent-up demand as it was the first one held in person since 2019.

The Tenth Meeting featured talks by Hong Liu (MIT) on "Emergence of space and time in holography," Leonardo Rastelli (Stony Brook) on "Carving out the space of large N confining gauge theories," Andy Strominger (Harvard) on "Cosmic ER=EPR," Kevin Costello (Perimeter Institute) on "Burns space and top-down celestial holography," Geoff Penington (UC Berkeley) on "Algebras and states in JT gravity," and Brian Swingle (Brandeis) on "A holographic model of an accelerating universe."

A group from the Perimeter Institute gathered at a table to enjoy their lunch and said they were drawn by the quality of the speakers and were eagerly anticipating the talks. While they did mention a keen interest in Kevin Costello (Perimeter Institute) and Andrew Strominger (Harvard), all of the attendees at the table overwhelmingly agreed that, without exception, all of the talks looked very compelling.

Richard Nally, a 2015 Brown graduate who went on to get a Ph.D. from Stanford, tries to come back at least once a year to visit his cousin, a Brown undergrad, and to fit in the conference while he is here. "I have more of a reason to come to Providence!" Richard enjoyed his lunch while eagerly awaiting a talk by Brian Swingle (Brandeis). "It's the last one of the day, but worth waiting for," he said.

Support for the meeting is provided by Anastasia Volovich's Simons Investigator Award.

Slides and videos of the talks can be found at https://sites.google.com/brown.edu/strings2023.

THE 2023 ARTIST-IN-RESIDENCE: SYREN MODERN DANCE

THE PHYSICS DEPARTMENT DIAP COMMITTEE'S
ARTIST-IN-RESIDENCE SERIES

By Valerie DeLaCámara

As an academic department devoted to physics research and committed to diversity and inclusion, how does one top an inaugural artist-in-residence program featuring renowned jazz saxophonist and mathematician Marcus Miller? Find a celebrated modern dance company that performs an interpretation of quantum mechanics and bring them to Brown University.

That's exactly what Brown Physics Department Diversity and Inclusion Action Plan (DDIAP) committee chair Professor Ian Dell'Antonio did in April, making the connection through Professor Stephon Alexander to SYREN Modern Dance, a New York City-based dance company whose artists have been named United States Cultural Ambassadors by the Department of State. Professor Alexander instituted the artist-in-residence series in 2022 in furtherance of the DDIAP committee's mission of encouraging inclusion and bringing diverse ideas into the department. Through its innovative interpretations of quantum mechanics concepts, SYREN's one-day residency on April 20th, 2023, showed the physics community new ways to think about physics.

FOSTERING INCLUSION

In SYREN'S piece "Red and Blue, Bitter and Sweet," the disparate worlds of physics and dance collide, creating an unexpected, fascinating synergy. The piece is an exploration of quantum mechanics theories of entanglement, wave/particle duality, uncertainty principle, and superposition. Incoming DDIAP Committee chair Professor Alexander explained why he feels SYREN's piece was ideal for the second installment of the artist-in-residence series, saying, "The piece on quantum entanglement by SYREN went beyond the expectations of the mission of our DIAP. The engagement brought students together to collaborate across departments. The piece reflected the exciting ways modern physics and dance can be intertwined and expand our imagination and knowledge of physics and the arts. It enabled our students and department to forge a more welcoming and inclusive department and community."

SYREN co-artistic directors Kate Sutter and Lynn Peterson founded SYREN Modern Dance in 2003, and, in 20 years, they have yet to experience anything like their day at Brown. They found the Physics Department to be warm and welcoming and were impressed by how well-organized the day was. The company's packed day at Barus & Holley included a tour of physics labs, meetings with Physics Department faculty and a pizza lunch with students. SYREN invited the Physics community to a movement workshop, in which participants were inspired to move their bodies by concepts typically encountered in the classroom, taking them on a journey of discovery and an exploration of new ways to think about physics.

SYREN became interested in the intersection of science and dance in 2015. For both co-artistic directors, the physical expression of quantum mechanics was a natural extension of their curiosity. According to Kate, the company spent much of its organizational journey presenting many themes and points of departure for its work: human experiences, love, the journey of the Sephardic Jewish people, and ancient Egypt.

While Kate's curiosity about cosmology and physics was "always simmering near the surface," she never considered bringing it into her choreographic pursuits, feeling she didn't know enough about it to give it the integrity it deserved in the studio. After some discussion, she and Lynn agreed that to be faithful to the concepts they would learn more so they could express physics through dance. Not having a science background didn't deter Kate, Lynn or their dancers from developing an idea about which they became more passionate the more they learned.

Kate said everything just "ignited" in the studio while working through the ideas with the dancers, who enjoyed the exploration of physics and where that took them creatively. A natural extension of that passion was to develop a piece expressing how they felt about entanglement. Learning about physics gave SYREN a "broad ability to program, create work, do workshops, meet new people, and find new communities," Kate said.

PHYSICS IN MOVEMENT

Lynn described the creative process as a collaboration between the ideas that inspired Kate and the dancers' exploration of those ideas. It wasn't so tightly choreographed that the dancers were constrained; there was room for their journey as dancers in the work to develop their interpretation, making the work more meaningful to each dancer. Lynn explains that she provides the dancers with artistic freedom within the framework of the piece. The dancers' process may allow them to feel, for example, that they don't have to think about uncertainty principal at an exact moment in the piece or at a specific count in the music. They have the freedom to find their journey

SYREN performs "Red and Blue, Bitter and Sweet."
PHOTO: CHRISTOPHER DUGGAN

within, she says, and "maybe at that moment, they won't be thinking about the uncertainty principle; maybe they'll be thinking about their grandmother who passed away. That's where we each can live with it in the universe. Exploration can always play a role in the journey of the dance, so it can be different every time we run it. All of this information about quantum mechanics is in our minds and flows through our bodies, so it's up to each of us as performers to interpret it. Then it is up to the viewer to take from it what they will."

Kate brought books on quantum mechanics into the studio and the company read and discussed the concepts. Then each dancer moved off to translate their ideas into movement, letting their imaginations move their bodies into how they conceptualized quantum entanglement, at times representing "things banging around and colliding," as Kate puts it. As they moved around the studio, Kate saw the beginnings of a performance take shape and began to organize the dancers, having lengthy discussions and individual and collective movement sessions, translating their ideas of physics into movement and form.

Lynn is quick to interject that their goal was not to become physicists. She emphasized that their role as dancers and dance makers is to take a point of departure and inspiration and then bring it into the space they know – the studio – and develop the concept with their bodies. They were moved to learn all they could; that knowledge allowed them to create a beautiful synergy between the worlds of physics and dance. Lynn says, "We were able to create something and then connect it to our experience. So many people are fascinated by physics. It lives inside of us and in the world around us. We all intersect with it daily even though we're not thinking about it. So, it's exciting to remember that we can learn little nuggets of information and then bring them into our world and be surprised by where it takes us."

In the creative process, interpretation is key. It's not so much the exact principle of quantum entanglement as would be encountered in the classroom, but rather the performer's interpretation of what that process entails. Kate explained that when the dancers depict quantum entanglement, their dance represents particles having the same experience but at two different places in the universe. As one dancer performs a movement, another grasps that dancer's shoulder, moving it in a circular motion. At the same time, another dancer mirrors those movements across the stage, their shoulder also manipulated by another dancer. The movements are related but occur simultaneously in different areas of the stage. These visuals came to Kate's mind when she read about quantum entanglement.

She says there are times when audience members pick up on what is being represented on stage but that "certainly in some audiences nobody would ever know that at that moment I am demonstrating this exact thought; I would argue that something is going to resonate with them. They may realize that there's a connection between these two groups of people on stage moving simultaneously and that's enough. Where the audience goes with what that connection means to them is why we're artists. We found one point of departure to demonstrate that, but any given person will respond differently to that, and that's why we do what we do."

BLOWING MINDS EVERYWHERE

According to Lynn, SYREN's whirlwind day at Brown was the exception and not the rule for the company's site visits. She said that the company is often somewhere to perform, teach, or talk, but at Brown, they had the opportunity to do all three with the community.

While those whose studies and research at Brown Physics may take for granted their access to cutting-edge research and facilities, bringing in a fresh perspective about physics reminds one of what a special place Barus & Holley is.

For example, of all the day's activities, Kate's favorite was touring the labs with graduate students and seeing the equipment, such as magnets and microscopes. Explaining her awe, she said it was remarkable how tiny things were. "It was amazing to see how incredibly small the graphene samples were and how precise everything had to be." For Lynn, the labs were "so vastly different from anything I experience on any given day. The entire atmosphere kind of blew my mind." A reminder of how fortunate we are that we get to be in the place where physics happens!

WHERE THE MAGIC HAPPENS

The co-directors agree that at performances of "Red and Blue, Bitter and Sweet," an audience of physics students and faculty is more inquisitive about the artistic process, whereas a general audience is more

SYREN Co-artistic Directors Lynn Peterson (L) and Kate Sutter
PHOTO: VALERIE DELACÁMARA/BROWN UNIVERSITY

fascinated with the representations of scientific aspects of the performance. For this reason, they always have a physicist on hand for the post-performance Q&A to address the more technical questions.

After touring Brown's physics labs, the company is more committed than ever to presenting its interpretation of physics concepts in a consumable format. Lynn has heard from audiences who feel they don't know enough about physics to enjoy the performance, but she insists that isn't the piece's point. She wants people to know they can enjoy the performance without being experts in physics. "We want to present our interpretation without compromising either the integrity of the information or the high level of physical ability that we have to represent the concepts of quantum entanglement. I think the worlds of dance and physics can combine to allow us to be true to the craft while still welcoming audiences to the world of physics. It's a magical combination."

SYREN's Quantum Entanglement
PHOTO: VALERIE DELACÁMARA / BROWN UNIVERSITY

Jia (Leo) Li

With new experimental method, researchers probe spin structure in 2D materials for first time

By Juan Siliezar

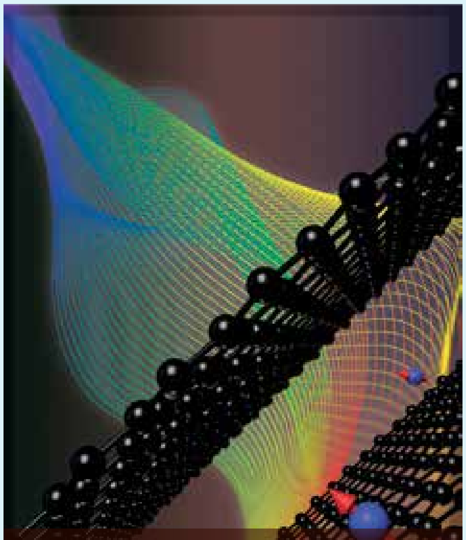
BY OBSERVING SPIN STRUCTURE IN "MAGIC-ANGLE" GRAPHENE, A TEAM OF SCIENTISTS LED BY BROWN UNIVERSITY RESEARCHERS HAVE FOUND A WORKAROUND FOR A LONG-STANDING ROADBLOCK IN THE FIELD OF TWO-DIMENSIONAL ELECTRONICS.

For two decades, physicists have tried to directly manipulate the spin of electrons in 2D materials like graphene. Doing so could spark key advances in the burgeoning world of 2D electronics, a field where super-fast, small and flexible electronic devices carry out computations based on quantum mechanics.

Standing in the way is that the typical way in which scientists measure the spin of electrons — an essential behavior that gives everything in the physical universe its structure — usually doesn't work in 2D materials. This makes it incredibly difficult to fully understand the materials and propel forward technological advances based on them. But a team of scientists led by Brown University researchers believe they now have a way around this longstanding challenge. They describe their solution in a new study published in Nature Physics.

In the study, the team — which also include scientists from the Center for Integrated Nanotechnologies at Sandia National Laboratories, and the University of Innsbruck — describe what they believe to be the first measurement showing direct interaction between electrons spinning in a 2D material and photons coming from microwave radiation. Called a coupling, the absorption of microwave photons by electrons establishes a novel experimental technique for directly studying the properties of how electrons spin in these 2D quantum materials — one that could serve as a foundation for developing computational and communicational technologies based on those materials, according to the researchers.

"Spin structure is the most important part of a quantum phenomenon, but we've never really had a direct probe for it in these 2D materials," said Jia Li, an assistant professor of physics at Brown and senior author of the research. "That challenge has prevented us from theoretically studying spin in these fascinating material for the last two decades. We can now use this method to study a lot of different systems that we could not study before."



In the study, researchers describe what they believe to be the first measurement showing direct interaction between electrons spinning in a 2D material and photons coming from microwave radiation.
GRAPHIC BY JIA LI

The researchers made the measurements on a relatively new 2D material called "magic-angle" twisted bilayer graphene. This graphene-based material is created when two sheets of ultrathin layers of carbon are stacked and twisted to just the right angle, converting the new double-layered structure into a superconductor that allows electricity to flow without resistance or energy waste. Just discovered in 2018, the researchers focused on the material because of the potential and mystery surrounding it.

"A lot of the major questions that were posed in 2018 have still yet to be answered," said Erin Morissette, a graduate student in Li's lab at Brown who led the work.

Physicists usually use nuclear magnetic resonance or NMR to measure the spin of electrons. They do this by exciting the nuclear magnetic properties in a sample material using microwave radiation and then reading the different signatures this radiation causes to measure spin.

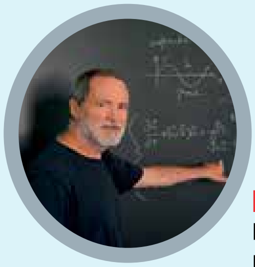
The challenge with 2D materials is that the magnetic signature of electrons in response to the microwave excitation is too small to detect. The research team decided to improvise. Instead of directly detecting the magnetization of the electrons, they measured subtle changes in electronic resistance, which were caused by the changes in magnetization from the radiation using a device fabricated at the Institute for Molecular and Nanoscale Innovation at Brown. These small variations in the flow of the electronic currents allowed the researchers to use the device to detect that the electrons were absorbing the photos from the microwave radiation.

The researchers were able to observe novel information from the experiments. The team noticed, for instance, that interactions between the photons and electrons made electrons in certain sections of the system behave as they would in an anti-ferromagnetic system — meaning the magnetism of some atoms was canceled out by a set of magnetic atoms that are aligned in a reverse direction.

The new method for studying spin in 2D materials and the current findings won't be applicable to technology today, but the research team sees potential applications the method could lead to in the future. They plan to continue to apply their method to twisted bilayer graphene but also expand it to other 2D material.

"It's a really diverse toolset that we can use to access an important part of the electronic order in these strongly correlated systems and in general to understand how electrons can behave in 2D materials," Morissette said.

The experiment was carried out remotely in 2021 at the Center for Integrated Nanotechnologies in New Mexico. Mathias S. Scheurer from University of Innsbruck provided theoretical support for modeling and understanding the result. The work included funding from the National Science Foundation, the U.S. Department of Defense and the U.S. Department of Energy's Office of Science.



UPDATE FROM THE BTPC
(Brown Theoretical Physics Center)

Brad Marston
Director, Brown Theoretical Physics Center

The Brown Theoretical Physics Center (BTPC) continues to grow and evolve. Professor Stephon Alexander is Principal Investigator on a grant from the Simons Foundation that will lead to new interactions with students and faculty at the University of Puerto Rico in San Juan. Working with UPR Professor Carlos Vicente, who received his Ph.D. in physics from Brown under the direction of Brown Emeritus Professor Humphrey Maris, Professor Alexander will lead a group of Brown physics faculty to Puerto Rico in January to teach mini-courses in physics to the students there. Some of these students will then visit Brown next summer to carry out research.

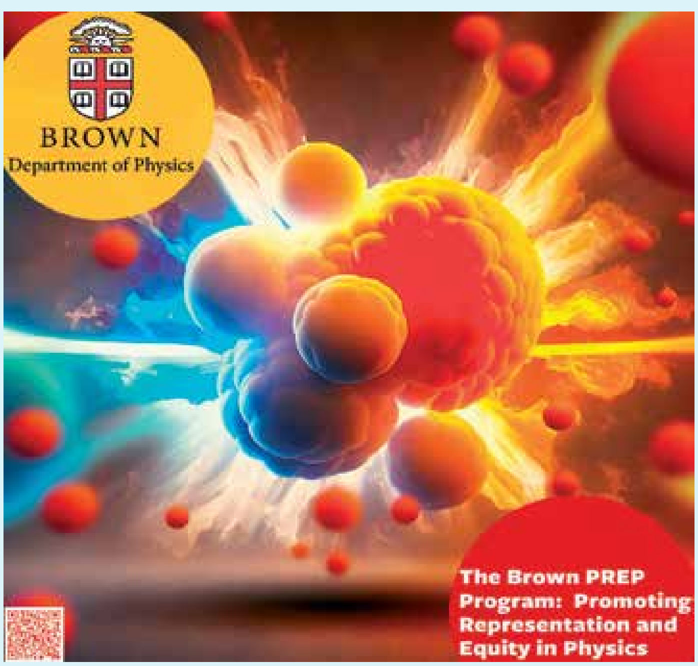
Professor Baylor Fox-Kemper (a BTPC faculty affiliate) and I have received a large grant from the US Department of Energy to model the marine atmospheric boundary layer for the purpose of optimizing the development of floating off-shore wind power. The grant is led by colleagues at the University of New Hampshire and includes Bates College as well; thus the three of the four New England states with coastlines are represented.

The Physics Department is searching for a new faculty member in the field of quantum condensed matter physics. The new faculty member will be a part of the BTPC. Recent postdoc Stephen Carr completed his appointment this past summer and is now a research scientist at HRL Laboratories in Malibu (the lab where the laser was invented). Drs. Humberto Gilmer and Tucker Manton are now in their second year at BTPC and are joined this month by a new postdoc, Dr. Heliudson Bernardo.

The Barus building is seeing strong use by physics undergraduates, and by Sc.M. and Ph.D. students. Many of these students are working with BTPC faculty on research projects. One such project is co-led by BTPC affiliate faculty member Brenda Rubenstein and myself. Our main question is whether or not quantum computers can provide a real advantage over classical computers in the solutions of various problems in the physical sciences.

Quanta Magazine carried an article about work done at the BTPC on waves of topological origin in the stratosphere that was also picked up by Scientific American. Finally, I was elected to the presidential line of the American Physical Society following in the footsteps of Carl Barus and BTPC founding director James S. Gates.

The Brown PREP Program
(Promoting Representation and Equity in Physics)



Physics Chair Vesna Mitrović is pleased to announce the department's continued support for the Brown Physics Promoting Representation and Equity in Physics (PREP) program. The Program seeks to address the lack of diversity in STEM, particularly in physics Ph.D. programs.

The PREP Program is an initiative conceived of and operationalized in its first year by the late Professor Meenakshi Narain, whose legacy of the PREP Program is now championed by physics Ph.D. student Farrah Simpson. The Program will help students at any school or university from traditionally underrepresented groups prepare their applications to any university for advanced physics studies. Sessions cover the application process, graduate student experience and the Ph.D. admissions program.

Participants can sign up for mentoring via drop-in sessions to help fine-tune their application materials. Applicants to Brown Physics can request an application fee waiver.

Supported by the Physics Department, PREP is funded through the generosity of the Brown University Office of Institutional Equity and Diversity (OIED) and Dr. Sylvia Carey-Butler, OIED Vice President.

THE CONFERENCE FOR UNDERGRADUATE WOMEN IN PHYSICS (CUWiP)

By Valerie DeLaCámara

The Conference for Undergraduate Women in Physics (CUWiP) is a network of three-day regional conferences designed to increase participation and retention of women and underrepresented minorities in physics. The conferences connect undergraduate women in physics with mentors who range in age from graduate students to faculty. Through keynote speakers, workshops and activities, undergraduate women are provided with a unique opportunity to learn all that a future in physics can hold for them. The American Physical Society (APS) is the institutional home of the conferences, which are supported in part by the National Science Foundation and by the Department of Energy. The host sites are chosen through a rigorous selection process, in which the APS expects applications to "demonstrate a clear commitment to the goals of the CUWiP program, both on the part of the institution and members of the local organizing committee," with involvement of both students and faculty.

Brown Physics Professor Meenakshi Narain successfully lobbied for Brown to be named a host site of the January, 2023 CUWiP, at which thirty universities were represented, including Amherst College, Bowling Green State University, Case Western Reserve University, Clarkson University, Hunter College, Miami University, Mount Holyoke College, Oberlin College, , Ohio State University, Ohio University, Ohio Wesleyan University, Providence College, Southern Connecticut State University, University of Cincinnati, University of Connecticut, University of Dayton, University of Massachusetts Amherst, University of Rhode Island, Wesleyan University, Williams College, Wittenberg University, and Yale University.

Prof. Narain reached out to those she considered to be outstanding women in physics and her call was answered resoundingly by some of the most prominent names in the field, including Professors Nandini Trivedi, OSU; Toyoko Orimoto, Northeastern; Jenny Hoffman, Harvard; Beth Parks, Colgate University; Julianne Pollard-Larkin, UT Austin, MD Anderson Cancer Center; Mirna Mihovilovic, Syracuse University and Brown Ph.D. Alumnus; Savannah Thais, Columbia; Sarah Demers, Yale; Jung-Eun Lee, Brown DEEPS; Li-Qiong Wang, Brown Chemistry; Geraldine Cochran, Rutgers; Brown University Vice President for Research Jill Pipher; and Brown University senior administrators Vice President for Institutional Equity and Diversity Dr. Sylvia Carey-Butler and Dean Janet Blume.

Since hosting a CUWiP is an enormous undertaking, the APS provides some logistical assistance for each host site's conference; however, the majority of the work is done by the host site faculty sponsor, along with their team of volunteers. The Brown physics community showed up in numbers, with a group of more than 40 volunteers of physics master's and Ph.D. students, five faculty, two undergraduates and two volunteers from Brown DEEPS.

Upon Prof. Narain's unexpected passing two weeks before the conference, Professor Vesna Mitrović stepped in as the conference faculty lead. Prof. Mitrović relied heavily upon Daniel Li, Prof. Narain's graduate student of almost five years, as he became CUWiP at Brown's chief organizer. Read more about Daniel on page 26.

PHOTO: VALERIE DELACÁMARA/BROWN UNIVERSITY

KANCHITA KLANGBOONKRONG HONORS PROF. NARAIN

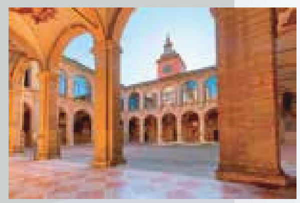
Prof. Mitrović now faced the difficult task of speaking in a timeslot reserved for her late friend. She quietly opened the conference, saying, "I'm unfortunately standing here because our chair – who really organized everything – Professor Meenakshi Narain, left us two weeks ago. I want to dedicate tonight as an homage to her. She was too quiet about all the things she did, but I can't think of any better role model – I know you're going to hear from fantastic speakers tomorrow – but I really cannot think of anybody better that you should aim to be like. My colleague and friend Meenakshi was an amazing physicist, but she also really cared about helping both women and underrepresented groups in physics succeed."

Brown Vice President for Institutional Equity and Diversity Dr. Sylvia Carey-Butler reflected on Prof. Narain's efforts to further opportunities within physics for underrepresented groups, saying, "Losing Meenakshi was a tremendous loss across the university. She played a significant role in helping to advance physics and physics research at Tougaloo College. In fact, in December 2022, Meenakshi received a $1 million dollar grant on behalf of Brown and Tougaloo. We're just so glad she was able to learn about the grant. Meenakshi was also instrumental in the success of the Physics Honors Program Society at Tougaloo College; she was committed to furthering opportunities for women in physics and championing equity and diversity in physics. Her passing was a tremendous loss to students and the faculty at Brown University and on Tougaloo's campus. I considered her a colleague and a friend and will miss her tremendously, but in her name the work will continue and we will honor her legacy.

She was quietly wonderful in all she did, and I am glad I had a chance to work with her."

Photo Credit: CUWIP local organizing committee and volunteers

STUDENT FELLOWSHIP AWARDEE



Ph.D. student Ilija Nikolov won a scholarship grant from the University of Bologna to work in Bologna for two months.

The University of Bologna indicated that Ilija presented an excellent proposal titled "Quantum simulation of magnetic resonance observables and information processing protocols with Nuclear Magnetic and Quadrupole Resonance." Ilija's work in Bologna will be supervised by Professors Mitrović and Samuele Sanna of the University of Bologna.


Ilija Nikolov
PHOTO: DEPARTMENT OF PHYSICS

2023 - 2024 CHATEAUBRIAND FELLOWSHIP AWARDEE

Ph.D. student Calvin Bales was recently awarded a prestigious 2023-2024 STEM Chateaubriand Fellowship.

The Chateaubriand Fellowship is a grant offered by the Embassy of France in the United States. It supports outstanding Ph.D. students from institutions in the United States who wish to conduct part of their doctoral research in France for a period ranging from four to nine months. Chateaubriand fellows are selected through a merit-based competition, with expert evaluation in France and the United States.

The Fellowship is divided into two subprograms, one of which is Science, Technology, Engineering, Math & Health.

The Chateaubriand Fellowship in Science, Technology, Engineering, Mathematics & Biology-Health (STEM) for doctoral students aims to initiate or reinforce collaborations, partnerships or joint projects between French and American research teams. The Office for Science & Technology (OST) of the Embassy of France offers this fellowship in partnership with American universities and French research organizations such as Inserm and Inria. It is a partner of the National Science Foundation's GROW program.

An advisee of Professor Vesna Mitrović, Calvin has officially accepted the offer and will work in LNCMI- Laboratory in Grenoble, France for four months.


Calvin Bales
PHOTO: DEPARTMENT OF PHYSICS

HUMPHREY MARIS RECEIVES INAUGURAL IMPACT AWARD

By Valerie DeLaCámara

On Monday, April 24th, Professor Emeritus of Physics and Professor of Physics (Research) Humphrey J. Maris received the inaugural Brown Technology Innovation Impact Award.

Accompanied by Interim Provost Lawrence Larson and Neil Veloso, Executive Director of Brown Technology Innovations, Vice President for Research Jill Pipher presented the award to Professor Maris' wife, Faye, who accepted the award on his behalf at the 7th annual Celebration of Research Ceremony at Sayles Hall.

Professor Maris is a distinguished physicist and Professor Emeritus of Physics and Professor of Physics (Research) at Brown, where he specializes in low-temperature physics and ultrafast ultrasonics. In 1991, he was appointed the George Chase Professor of Natural Science in recognition of his outstanding contributions to the field. Maris has spearheaded numerous experiments investigating the quantum state of electrons, which have significantly advanced our understanding of quantum mechanics. In 2011, the International Union of Pure and Applied Physics awarded him the prestigious Fritz London Memorial Prize for his exceptional work in low-temperature physics.

Vice President Pipher credits Professor Maris' testing technology with setting the worldwide standard for quality control and manufacturing of computer chips, saying: "Professor Emeritus of Physics, Humphrey J. Maris, is the most successful inventor in Brown University history. Since Prof. Maris came to Brown in 1965, he has been awarded 57 patents, some of which cover the leading method to conduct non-destructive testing of materials. His testing technology has become the worldwide standard for quality control and manufacturing of computer chips. In addition to his prolific inventions, Prof. Maris has advised 50 Ph.D. students in the course of his career."

Professor Maris' groundbreaking work in the field of ultrafast ultrasonics has significantly impacted semiconductor metrology and technology. With his extensive research and numerous contributions, Maris has helped shape the modern understanding of semiconductor materials and their behavior at the nanoscale.

Maris' pioneering work on ultrafast ultrasonics began with his innovative approach to generating and detecting ultrasonic waves with picosecond and femtosecond time resolution. His research utilized ultra-short laser pulses to generate and measure ultrasonic waves, which allowed for the exploration of phenomena occurring on an incredibly small-time scale. This work laid the foundation for a deeper understanding of the fundamental properties of materials and the mechanisms behind acoustic wave propagation.

The impact of Maris' work on semiconductor metrology and technology is profound. Ultrafast ultrasonics has become an essential tool for characterizing and measuring various properties of semiconductor materials, such as their elastic constants, thermal conductivity, and electronic transport properties. These insights have facilitated the development of new materials with tailored properties, leading to improvements in the performance of semiconductor devices and integrated circuits.

One of the most significant applications of Maris' work is in the field of nondestructive evaluation (NDE) of semiconductor materials and devices. Ultrafast ultrasonics has provided a powerful technique for detecting defects and characterizing strain in semiconductor materials with unprecedented precision. This has allowed researchers and manufacturers to identify and address potential issues in the fabrication process, ultimately enhancing the reliability and efficiency of semiconductor devices.

Maris' contributions to ultrafast ultrasonics have also played a crucial role in advancing the understanding of how heat is transported in semiconductors, which is vital for managing thermal management in modern electronics. By investigating phonon dynamics and interactions, Maris' work has enabled researchers to develop new strategies for controlling heat flow in semiconductors, making them more efficient and reliable.

Maris' groundbreaking work on ultrafast ultrasonics has had a transformative impact on semiconductor metrology and technology. His innovative approach to generating and detecting ultrasonic waves has opened new avenues for the study of material properties and device performance, ultimately leading to improvements in the performance, reliability, and efficient manufacturing of semiconductor technologies. As a pioneer in the field, Maris' legacy will continue to influence future research and development in semiconductor science for years to come.

In his remarks at the Celebration of Research, Neil Veloso, Executive Director of Industrial Engagement & Corporate Ventures in the Office of the Vice President of Research emphasized the profundity of Professor Maris' impact on his field, the nation and the world. "The impact of this work is profound. The field of non-destructive evaluation utilizes Dr. Maris' research in ultrafast ultrasonics in the development and fabrication of semiconductor materials. This understanding around material properties gives insight into the transport of heat in semiconductors, and by extension, thermal management of electronic devices. Dr. Maris has 25 invention disclosures and 57 issued patents. The licensing of his work to one of the world's leading semiconductor metrology companies has amplified the impact of this research beyond the university to (in the words of Brown's mission) "serve the nation and the world."

Faye Maris receives the Impact Award for Humphrey Maris.
PHOTO: BROWN UNIVERSITY

The DPF Meenakshi Narain Mentoring Award

The Physics Department is pleased to announce the funding of the Division of Particles and Fields (DPF) Meenakshi Narain Mentoring Award in honor of former Department Chair Meenakshi Narain. The Heising-Simons Foundation has granted $105K, which, along with other contributions, will fully fund the award.

BROWN
Department of Physics

"THIS WILL BE A FITTING MEMORIAL OF HER LEGACY AS A MENTOR AND HOPEFULLY ENCOURAGE MANY OTHERS TO FOLLOW THE PATH SHE SHOWED US."

- PROFESSOR ULRICH HEINTZ

R. Sekhar Chivukula, Distinguished Professor of Physics at UC San Diego and the chair of the Executive Committee of the Division of Particles and Fields (DPF) at the American Physical Society (APS), recently announced the funding of the Division of Particles and Fields (DPF) Meenakshi Narain Mentoring Award in honor of former Department Chair Meenakshi Narain. Professor Chivukula said that the "strong show of support for the endowment from friends and colleagues helped to demonstrate that Meenakshi's scientific and mentoring contributions have had a lasting impact on our community that is worthy of recognition. Meenakshi is very much missed. Through this award, her memory and legacy will continue to be remembered in the years to come."

Professor Narain's husband and research collaborator, Professor Ulrich Heintz, reflected on the spirit of mentoring being a subject close to Meenakshi's heart, saying, "Since Meenakshi's passing, many young colleagues have told me that Meenakshi helped them in one way or another achieve success in their careers. Mentoring her students and postdocs had always been central to Meenakshi's work as a scientist.

But when she was elected chair of the US Compact Muon Solenoid (USCMS) institution board with the charge to represent the interests of the US members of the CMS Collaboration, one of her main responsibilities was to participate in the search committee that discusses assignments of positions of responsibility in the collaboration. She made it her mission to argue for a more equitable process that focuses on the qualifications of the candidates. She especially promoted younger scientists in this process, to the benefit of all her young colleagues, not just those from the US.

Many of these colleagues told me they regretted not having the chance to thank her in person for her role due to travel limitations in the last few years because of the pandemic and Meenakshi's health. I am grateful that Professor Chivukula proposed to name the DPF mentoring award after Meenakshi and that many family members, friends, colleagues, and former students, as well as the Heising-Simons Foundation, collected a big enough endowment to make it a full APS-level ward. This will be a fitting memorial of her legacy as a mentor and hopefully encourage many others to follow the path she showed us."

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PHOTO: BOB HORTO/BROWN UNIVERSITY

Ladd Observatory Manager Bob Horton took this image of the Southern Milky Way from the dark skies at Greenbank Observatory, West Virginia. The camera used was a Canon Ra with a 50mm lens, mounted on a tracking platform, with an exposure of 60 seconds. A diffusion filter was used to accentuate the brighter stars and their colors in the constellations Scorpius and Sagittarius. Numerous star clusters and nebulae can be seen within this area of the sky.

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For all Department of Physics gifts and contributions, please contact

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