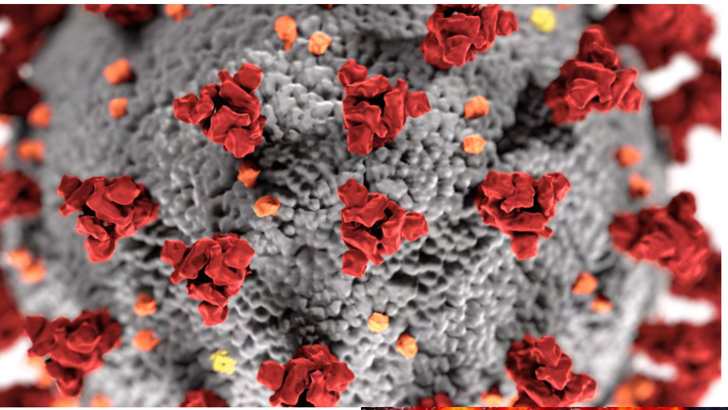
BROWN PHYSICS

imagine

SUMMER 2020

BROWN



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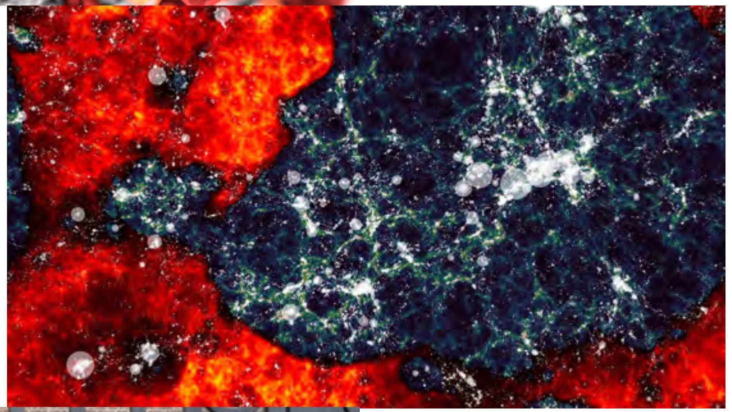

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imagine

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BROWN TOGETHER

FOR ALL DEPARTMENT OF PHYSICS GIFTS AND CONTRIBUTIONS, PLEASE CONTACT RICK MARSHALL '71, P'10, DIRECTOR OF DEVELOPMENT AT 401 863 8977 OR RICHARD_MARSHALL@BROWN.EDU

GREETINGS FROM THE CHAIR...

The last academic year was one of the most challenging times for our department. We began with excitement, welcoming new cohorts of students and receiving increased amounts of research funding in every subdiscipline. We partnered with Sigma Pi Sigma Society of Physics Students to host the 2019 Physics Congress (PhysCon) in November which brought more than 1,500 students, mentors, alumni, and renowned scientists to Providence. Our faculty made presentations at the conference and hundreds of students were invited to visit the department's research labs and participated in various activities. Professor Stephon Alexander organized the National Society of Black Physicists meeting, where nearly four hundred students, professionals, and exhibitors descended on Providence for the annual conference. The theme was "Promoting Professional Connections and Persistence in Physics."

In the spring semester, the COVID-19 pandemic created tremendous disruptions and uncertainties for us. Within a short time, all courses transitioned online and faculty, staff, postdocs, and graduate students began telecommuting. All theory-based research was performed from home, and only some essential experimental research projects were approved to be conducted in Barus & Holley. The members of our department demonstrated resilience, dedication, and collaboration, to complete the semester successfully under the most difficult circumstance. The 2020 graduates received their degrees through a virtual conferral ceremony and we will welcome them back in the spring of 2021 for a commencement celebration. In this issue of our magazine, we will feature some of these students and their experiences at Brown.

Our faculty have remained active in their research, as indicated by the articles in this issue. Many have received prestigious awards including a $4 million grant from the National Science Foundation that will support research aimed at developing a fundamental understanding of quantum systems. They have organized many conferences and outreach activities for both scientists and the public. For the current academic year, we will invite our students back to campus in a three-semester format to de-densify the campus. Courses will be held online or in a hybrid format in the fall, spring and summer. Our department has promoted diversity and inclusion activities on many fronts. Our faculty and students played a key role in a nationwide workshop and a professional event on overcoming racism, held by the physics community.

I am heartened by the continued support of our alumni. They have bestowed gifts that will enable us to broaden our curriculum and research spectrum. I am particularly moved by their generosity during these challenging times. We are committed to actions that will cultivate diversity, equity, inclusion, and promote racial justice for all. I am confident that together, we can build a stronger and more vibrant physics community. Happy reading!

Gang Xiao
Department Chair

AN UPDATE FROM LADD OBSERVATORY

When Brown University's Ladd Observatory was dedicated in 1891, Director Winslow Upton realized the necessity of introducing the sky to the general public. This ideal has been of primary importance to all succeeding directors and Ladd Observatory has been open to the general public as often as possible through the decades. From Ladd Observatory, two amateur astronomy organizations began, including Skyscrapers, Inc., founded by Brown Professor Charles Smiley. Its original purpose, in addition to enjoying the night sky, was to purchase another astronomical facility in North Scituate. Now approaching 90 years in existence, Skyscrapers, Inc. still endures at its Seagrave Observatory.

In 2004, then Director Hendrik Gerritsen proposed a weekly email notice for the public listing possible celestial objects visible at that time, and a bit of astronomical potpourri. Even today these Ladd Notes entertain and inform the public every Tuesday.

With the current health crisis and the need for social distancing, Ladd Observatory is closed to visitors until further notice. Astrophysics Professor Ian Dell'Antonio recently proposed a way to supplement the Ladd Notes by creating videos about the sky. Narrated by Francine Jackson, with images from Robert Horton, and occasional contributions by amateur astronomers, the videos have presented night sky observing through a virtual platform. All are relatively short, just four to six minutes in length, with more planned. The videos will continue, even after Ladd reopens. The public may wish to suggest a program on a particular subject. If so, please go to the Ladd Observatory website, and let us know. We'll be glad to oblige. **--Francine Jackson**

COURTESY SCOTT MACNEILL

CHEERS TO THE GRADUATES!

MATTHEW ISHIMARU

Mathematical Physics

What was the most surprising part about your research experience?

Before Brown, I always imagined research as a very methodical, dry pursuit. I've been most surprised by the immense creativity involved in physics research. You have to be able to make leaps of understanding with limited information. That requires quite a bit of imagination.

ZHENGXUAN WEI

ScM Physics

What was your favorite Physics course?

I would probably choose PHYS 2010. I do hate writing lab reports, however I really learned a lot from this course.

JENNIFER THANH BUI

Engineering Physics

What was your favorite part about being a student in the Physics Department?

The Brown Physics Department is such a warm and close-knit group. From guest lectures to Phys DUG events, I was able to meet brilliant people and peers.

MICHAEL DISCALA

ScM Physics

Why did you decide to pursue a Master's degree in Physics?

After completing my undergraduate degree, I wasn't very confident in my knowledge of physics and was unsure how to proceed in my career. I knew that getting my Master's degree would be the perfect step in getting the expertise I needed to make the next big step in my career. Brown couldn't have been a better choice for this step in my life. Studying at Brown reminded me of the passion I had for physics and presented me with more research opportunities than I could ask for.

KATIE VASQUEZ

Astrophysics

Do you have any advice for new physics students?

Understand that you're all in this together and you are all very smart so support each other and don't feel the need to compete.

RUIXI SEET

Physics

What was the most surprising part about your research experience?

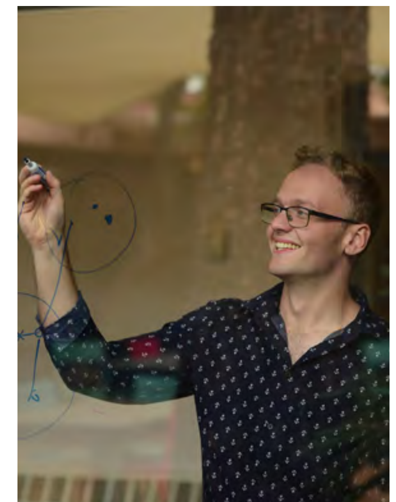
The spirit of collaboration and friendliness in the lab, and how accessible professors and grad students were!

JACOB JACKSON

Mathematical Physics

What was your favorite Physics course?

E&M 2 with Professor Pober was a great course. He was a really great teacher, guiding us through the material with real efforts to train us not just to know the material but to think about it critically as physicists.



SHING CHAU LEUNG

PhD Physics

What research did you work on?

My work focuses on answering questions about dark matter, working with Professor JiJi Fan. Our most recent endeavor is to investigate the relation between dark matter detection and astrophysical structures in the solar neighborhood.

JORGE PALACIOS

Brown-RISD Dual Degree : Astrophysics, Glass

What was your favorite part about being a student at Brown?

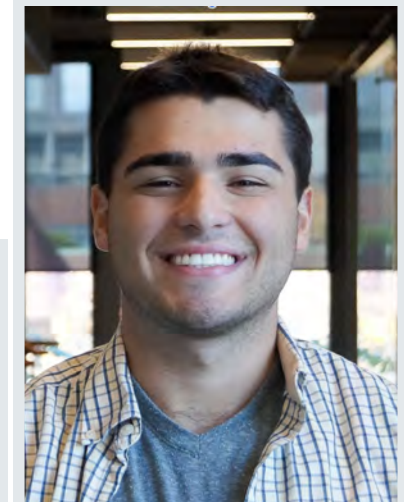
Sending surveys to physics faculty and students on whether studying physics influences their spirituality or views on love. Working at the Ladd Observatory on Tuesday nights was also a lot of fun.

BEN INSLEY

Physics

Do you have any advice for new physics students?

Take as many classes with JiJi Fan as you can. Also take a grad-level class, especially if Brad Marston is teaching it. He runs his classes like he's training you for physics combat. His classes aren't easy, but you really come out of there feeling like you have more skills under your belt.



CLAIRE HAWKINS

Astrophysics

What was your favorite part about being a student in the Physics Department?

I didn't come to Brown knowing I wanted to study physics. But I was drawn in by the sense of community and how much I wanted to take all the courses. I am continuously grateful for the opportunity to work both on problem sets and in the lab with great groups of peers.

BANGGE DING

ScM Physics

What was your favorite Physics course?

For graduate level courses, I enjoyed Quantum Mechanics instructed by Professor Feldman. He gave interesting examples to explain advanced topics like Quantum cryptography and Anyon. I also liked the undergraduate courses taught by Professor Volovich. She engages every student in the class. I would love to audit her String Theory again.

The Class of

2020

MASTERS OF SCIENCE

Atheer Alzahrani
Keyu Cheng
Benjamin Davis
Bangge Ding
Michael DiScala
Yuanzhuo Hong
Yuchen Hua
Fuyang Huang
Haotian Jiang
Zhihao Jiang
Jinglong Liu
Yunzhe Liu
Michael Orlandi
Zehao Song
Dihao Sun
Weilun Tan
Sean Thompson
Zhengxuan Wei
Duo Wen
Zheng Zhang

STUDENT AWARDS

Master's Research Excellence
Michael DiScala

Outstanding Academic Accomplishment in Master's Program
Dihao Sun

Engaged Citizenship and Community Service to the Physics Department
Zhengxuan Wei

BACHELORS

Gabriel Altopp
Jennifer T. Bui
Harry S. Chalfin
Jungho Choi
Nicholas Conroy
Noah F. Fang
James B. Guesman
Galen P. Hall
Gabriel I. Hannon
Kaushik Srinivasan Harith
Claire C. Hawkins
Jonathan M. Hess
Benjamin A. Insley
Matthew A. Ishimaru
Ross P. Kliegman
Conant R. Kumar
Alexander M. Lawson
Ellen H. Ling
Julian Lopez-Uricoechea
Tyco B. Mera Evans
Andrea D. Minot
Jorge A. Palacios
Halle E. Purdom
Ellen C. Royal
Sara Runkle
Devansh Saluja
Ruixi Seet
Jacob G. Stanton
Andrew T. Ton
Katie Vasquez
Benjamin A. Wolcott

STUDENT AWARDS

R. Bruce Lindsay Prize for Excellence in Physics
Adam Tropper

Mildred Widgoff Prize for Excellence in Thesis Preparation
Ross P. Kliegman
Benjamin A. Wolcott

Chair's Award for Excellence in Scholarship & Service to the Physics Department
Jungho Choi
Ellen C. Royal

Smiley Prize for Excellent Contribution to the Astronomy Progam
Claire C. Hawkins
Katie Vasquez

DOCTOR OF PHILOSOPHY

George Barbosa Araujo *Advisor: Jay Tang*

Ansel Lou Blumers *Advisor: George Karniadakis*

Dongqing Huang *Advisor: Richard Gaitskell*

Shao Ran Huang *Advisor: Rashid Zia*

Adam Eudene Lanman *Advisor: Jonathan Pober*

Jangbae Lee *Advisor: Ulrich Heintz*

Shing Chau Leung *Advisor: JiJi Fan*

Wenhao Li *Advisor: Rashid Zia*

Wenyang Li *Advisor: Jonathan Pober*

Binyang Liu *Advisor: Ian Dell'Antonio*

Stefan Stanojevic *Advisor: Marcus Spradlin*

STUDENT AWARDS

Galkin Foundation Fellowship Award 2018-2019
Kwok Wai Ken Ma

Physics Merit Dissertation Fellowship 2018-2019
Lijuan Qian, Stefan Stanojevic

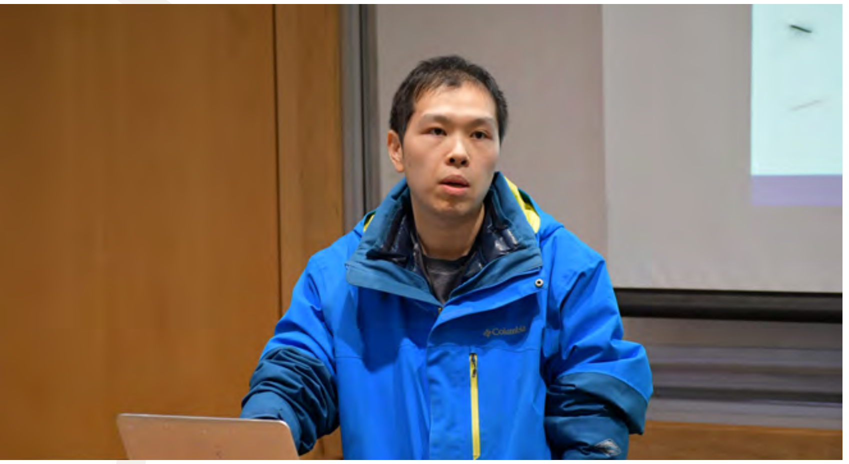
Anthony Houghton Award for Excellence in Theoretical Physics
Kwok Wai Ken Ma

Forrest Award for Excellence in Work Related to Experimental Apparatus
Ka Hei Martin Kwok

Award for Excellence as a Graduate Teaching Assistant
Taeun Kwon, Daniel Li, Nikolas Pervan, Qiaochu Wang, Benjamin Zager

Sigma Xi Award
Kwok Wai Ken Ma

2019 // 2020 GALKIN FELLOWSHIP



KWOK WAI KEN MA

Advisor: Dmitri Feldman

Fractional quantum Hall (FQH) effect demonstrates the novelty of strongly-interacting electrons moving on a two-dimensional flatland. In striking contrast to what we learn from standard quantum mechanics textbooks, quasiparticles in an FQH system are neither bosons nor fermions. They are anyons which possess fractional charges and fractional statistics. Different FQH states are described by topological orders with different anyons. Interestingly, some anyons can show non-Abelian nature and serve as an important building block of topological quantum computation.

It is believed that non-Abelian anyons exist in FQH state at the filling factor 5/2 (the 5/2 state). The recent experimental observation of a half-integer quantized thermal Hall conductance has provided a strong support to this belief. Different from other filling factors, many possible topological orders have been proposed to describe the 5/2 state. These candidates were introduced from different approaches, such as conformal field theory, trial wave function, particle-hole conjugation, parton construction, etc. It has been a longstanding debate on the nature of the 5/2 state for more than thirty years. The ongoing tension between numerical results and experimental data makes the story even more complicated. On one hand, different experiments seem to support the PH-Pfaffian order. On the other hand, numerical studies point toward either the Pfaffian or anti-Pfaffian order. In fact, different topological orders may exist in different materials even at the same filling factor. Therefore, knowing how to identify all different candidates from experiment is of vital importance.

FQH states at even-denominator filling factors stem from superconducting pairing between composite fermions. We show that different candidates for such paired quantum Hall states can be uniformly described by the Kitaev's Sixteen-fold Way. This description allows us to predict signatures of all candidates in different types of experiments systematically. The result may shed light on future experiment to identify the nature of the 5/2 state and other even-denominator FQH states in different materials. By discovering a close relationship between different candidates, we are also able to generate their wave functions, and effective Hamiltonians.

POSTDOC SPOTLIGHT

Evan McDonough PhD

Postdoctoral Fellow 2017 - 2020

With a PhD in Cosmology and String Theory, I came to Brown to work with Professor Stephon Alexander. These topics were our common ground, but in fact some of our biggest research achievements were in a different topic: dark matter. I had a long-standing interest in dark matter physics, but avoided the topic for fear of getting involved in a mess of model building. Professor Alexander has a refreshing take on dark matter — namely that we really have no clue what it is, so we should try to think outside the box! Together with David Spergel, then professor at Princeton University and now director of the Flatiron Institute Center for Computational Astrophysics, we developed a dark matter model in close analogy with Leon Cooper's (Nobel Prize winning) description of superconductivity as the pairing of electrons to form a bosonic particle. This led us to a model of "superfluid dark matter." We now have a series of papers on dark matter physics which were all really fun.

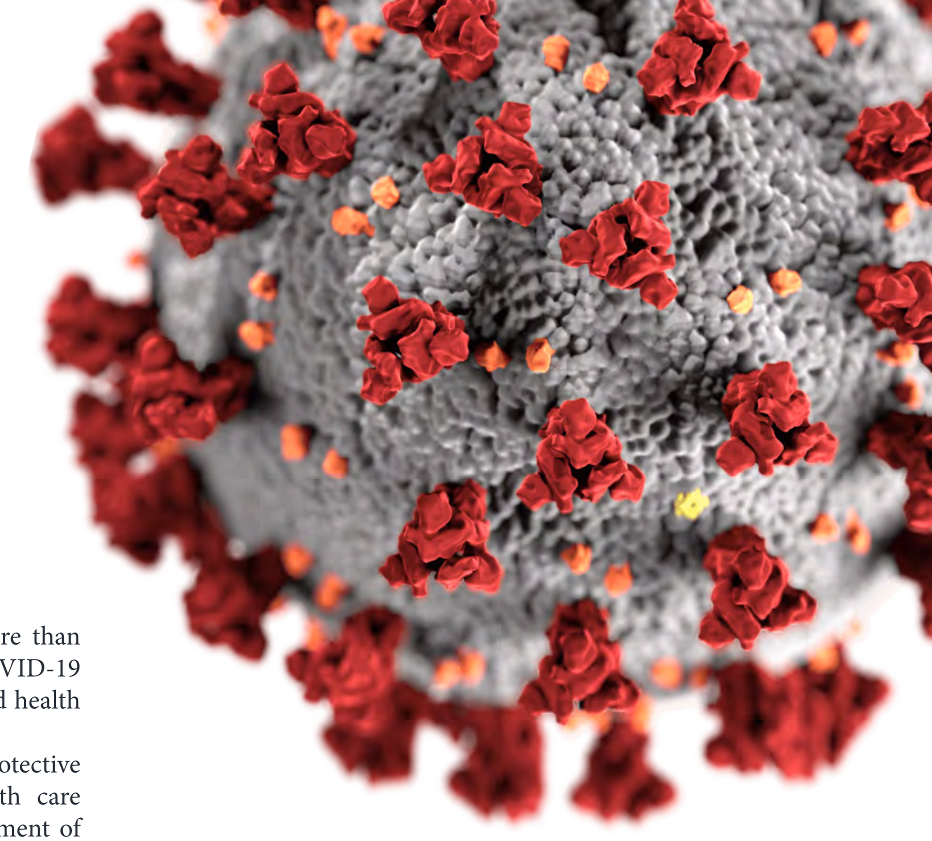
I was the Postdoctoral Research Associate representative on the Physics Department Diversity and Inclusion Action Plan (DIAP) committee. While the life of a postdoc is inherently transient, and for this reason we are often overlooked in discussions of institutional steps towards a more diverse and inclusive campus, many graduate and undergraduate students receive most of their research supervision from a postdoc. My small contribution to the DIAP committee was to advocate for the role of postdocs in creating the type of university that Brown hopes to be.

Evan is currently a Banting Fellow at the MIT Center for Theoretical Physics, working with Profs. Alan Guth and David Kaiser on inflationary cosmology. In fall 2020 he'll be starting a position as an Enrico Fermi Fellow at the University of Chicago Enrico Fermi Institute.

IDALINA ALARCON/BROWN UNIVERSITY (2)

BROWN DONATES LAB SUPPLIES & PROTECTIVE EQUIPMENT IN COVID FIGHT

By Kevin Stacey



An effort by Brown faculty and staff gathered more than 4,000 N95 masks, a critical component in COVID-19 testing and other supplies for donation to Rhode Island health care providers and agencies.

Facing the same acute shortage of personal protective equipment (PPE) and other supplies affecting health care providers across the nation, the Rhode Island Department of Health (RIDOH) and health organizations on the frontlines of the COVID-19 pandemic have issued urgent calls for donations.

At the forefront of that #GetMePPE effort are Brown physician scholars including (to name just two) Dr. Megan Ranney, an emergency physician and Warren Alpert Medical School faculty member, and Dr. Ashish Jha, incoming dean of Brown's School of Public Health.

Now, thanks to a campus-wide effort to locate useful items, the Brown community is helping to answer the call. Over the course of last week, Brown faculty and staff have gathered more than 4,000 critical N95 respirator face masks along with supplies of gloves, gowns, face shields and other items for donation to RIDOH as well as the Lifespan and Care New England hospital systems. And a Brown biomedical lab is producing and donating a component critical in testing for novel coronavirus infections, which will be important in slowing the spread of the virus.

The supplies were sourced from Brown's Environmental Health and Safety (EHS) office as well as laboratories in the Division of Biology and Medicine, chemistry, engineering, physics and even the Brown University Library, where masks are used in work to preserve archives and other historical materials.

To date, Rhode Island has confirmed 488 cases of COVID-19. That number continues to grow daily and with it the need for supplies to help keep health care professionals safe. "Health care professionals here in Rhode Island and across the country are doing heroic work in caring for COVID-19 patients," said Dr. Jack A. Elias, senior vice president for health affairs and dean of medicine and biological sciences at Brown. "We hope that these donations of much-needed testing supplies and personal protective equipment will play a role in helping to keep those frontline personnel safe during the days and weeks ahead. I am very proud of our faculty on the front lines and our faculty and staff for coming together to make this happen. We will continue to work with agencies and providers in the state to make sure we're contributing wherever we can."

Edward Hawrot, a professor of medical science and associate dean of biology who helped to organize the effort, said that the N95 masks address a particular need at this point in time. "What we've been hearing the last few days is that N95 masks are a major need," Hawrot said. "These are the masks that health care workers need to be wearing if they're dealing with a virus, so I'm glad we were able to pitch in." Most of the 4,000 masks Brown donated came from a stock assembled by EHS as part of its routine emergency preparedness planning.

> "My colleagues and I have been very concerned about the lack of medical supplies for health care workers, so we collected what we could." -Gang Xiao

"One of the things we've planned for is a pandemic, and masks are a part of that," said Stephen Morin, Brown's EHS director. "It became obvious that we had masks to spare and our physicians need them urgently, so we looked into how to donate them. I'm happy that we're able to play a role in helping physicians and hospitals in Rhode Island." In all, more than 30 laboratories and offices on campus came together to contribute supplies. EHS officer Stephanie Santucci and safety specialist Ernie Quackenbush oversaw the collection of items and managed a series of deliveries.

"My colleagues and I have been very concerned about the lack of medical supplies for health care workers, so we collected what we could," said Gang Xiao, chair of the physics department, home to materials science labs that made masks, gloves, face shields and other items available for donation. "Every little bit helps and I'm glad we were able to assist, even in small ways, in this important effort."

In a related effort, faculty from the chemistry department are making hand sanitizer. Faculty members Amit Basu, Eunsuk Kim and Matthew Zimmt have made and donated 9.5 gallons so far. All of these donations are just one way in which the Brown community is working to help during the pandemic.

Published April 1, 2020

GET TO KNOW // THE CLASS OF // 2020

ELLEN ROYAL

Physics

What was your favorite part about being a student in the Physics Department?

My favorite part about being a student in Brown's physics department was working in the demonstration room. I learned so much more physics than I would have from just taking classes and I loved feeling like I was giving something back to the department and helping give fellow students the best physics experience they could have.

What was the most surprising part of your research experience?

At the outset of my project, I thought performing the experiment and collecting the data was going to be simple, but I had no idea just how many things could go wrong. The most surprising part of my research experience, though, was how much fun I had fixing all of those things. I had to utilize a whole different type of physics knowledge and creativity from what was required in my classes and it was so much more fun than sitting at a desk reading out of a textbook.

Do you have any advice for new physics students?

Don't compare yourself to other students. Everyone comes in with a different background and everyone gets comfortable with concepts at a different pace. You're not falling behind, you're just on a different path, and that's ok.

What is your signature phrase or quote that you live by?

"Eh, it's probably fine."

JACOB STANTON

Mathematical Physics, Africana Studies

Do you have any advice for new physics students?

Be open to exploring other forms of knowledge and other fields of study. Physics can be a bubble and it's important to sometimes step outside of that bubble to provide context to what you are learning and to make sure that this is actually what you want to study.

Who or what influenced you the most in your life so far?

I can't even answer this question, so many people have influenced me in my life. I think that my parents have shaped my view of the world more than any other people but I feel that this is the same for everyone. If we're considering my time in the Physics department at Brown, it's been Professor Stephon Alexander who has had the greatest influence on me.

What was your favorite part about being a student in the Physics Department?

I'd say my most memorable moments are the Sundays during Junior year that I'd spend working with Gabe Hannon in Barus and Holley room 555 on grad Quantum problem sets. I would get there around noon and sometimes would stay until the point of absolute exhaustion.

ROSS KLIEGMAN

Mathematical Physics

What was your favorite part about being a student at Brown?

It sounds cliché but definitely the people. I'm grateful to have found friends here who I will have with me for the rest of my life. Oh, and the Andrews breakfast burritos. Really gonna miss those.

What was the most surprising part about your research experience?

You don't need a PhD to do meaningful work in research, even in theoretical work. Professors are brilliant and know a lot, but they study questions to which they don't yet have the answers. It wasn't until I began doing research that I saw professors face questions they can't answer because the answers do not yet exist. It turned out I was able to do a lot of productive work in research with just a few math and physics classes under my belt. That felt good.

What are you planning/ looking forward to doing after you graduate?

I will be working for a small company in Maryland that develops detectors that can be used to screen for infectious diseases and other airborne bio-threats. I am looking forward to doing some science outside of academia. Plus, this work seems especially important now more than ever.

ADAM LANMAN

PhD Physics

Advisor: Jonathan Pober

What research did you work on?

Low-frequency radio astronomy, aiming to detect the distribution of neutral hydrogen when the first galaxies formed. My work focused on writing instrument simulation tools for radio interferometers, and using these tools to better understand the effects of observation on measured signals and foreground contaminants.

What are your plans next?

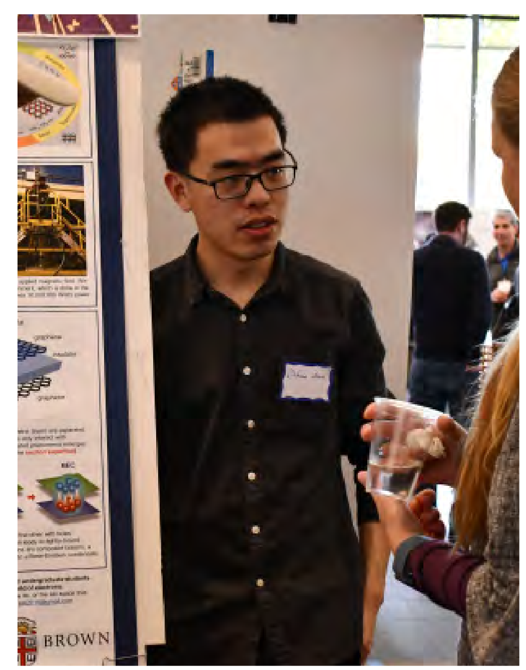
I'm going to McGill University to start a postdoc with the CHIME/FRB experiment. The Canadian Hydrogen Intensity Mapping Experiment (CHIME) is a radio interferometer built in British Columbia to map neutral hydrogen after reionization. It has also become a powerhouse for detecting Fast Radio Bursts (FRBs), mysterious, bright pulses of radio emission coming from intergalactic distances. I will be helping to build outrigger antennas in Green Bank and at the Algonquin Radio Observatory that will improve CHIME's resolution, allowing us to pinpoint the origins of FRBs. I'll also try to learn some French.

Favorite Physics course?

Probably Bob Pelcovitz's Quantum Mechanics course. That was the first time I actually felt somewhat comfortable with QM.

Favorite activity in Providence?

Seeing shows at the Performing Arts Center and Trinity Rep Theatre. Season passes to both are well worth it, though Brown students can get free tickets to Trinity.



DIHAO SUN

ScM Physics

Advisor: Jia (Leo) Li

Why did you decide to get your Master's degree in Physics?

I thought a masters program in physics would be a great opportunity to make more preparation for a PhD program. Specifically, my first goal was to get involved in some real research about experimental condensed matter physics. The second goal was to improve my understanding of fundamental knowledge by learning graduate level courses. Fortunately, the physics ScM program at Brown helped me reach all my goals. I was admitted to the physics PhD program at Columbia University. I will continue my research in condensed matter physics.

What have you enjoyed about studying Physics at Brown?

The poster session in November provides research opportunities to students. In my first year, I got the chance to join Prof. Jia Li's group in the session. It is also a chance for academic training, because I became the speaker for our group the next year. I also love the atmosphere at Brown. Everyone is friendly. We have a lot of pizza or coffee time and many events to bring people together. My favorite one is the Annual Physics Art Show. It is an amazing time to see another aspect of physics.

NATIONAL SOCIETY OF BLACK PHYSICISTS CONFERENCE COMES TO PROVIDENCE

By Kevin Stacey

ALUMNI HONORS

COURTESY JAMI VALENTINE MILLER

Jami Valentine Miller ScM '98

Patent Examiner at U.S. Patent and Trademark Office (USPTO)

Jami Valentine Miller was honored at the 2019 National Society of Black Physicists Conference in Providence, RI. She is known for her pioneering work and mentorship as a female African American Physicist. She engages in many outreach activities, including speaking to young physicists, future scientists and engineers, and those interested in non-academic physics careers, especially intellectual property.

Stephon Alexander, Brown professor and president-elect of the National Society for Black Physicists, discusses the organization's annual conference, which comes to Providence for the first time this year.

For more than 40 years, the National Society of Black Physicists (NSBP) has provided support and mentorship to African American and black scientists seeking physics careers both in academia and industry. This week, the organization brings its annual conference to Providence for the first time.

The conference, sponsored in part by Brown University, is the largest academic meeting of physicists from historically underrepresented groups in the United States, the organization says. The roughly 400 attendees are a mix of students and professionals from around the country and beyond, coming together for mentorship, networking opportunities and to generate new research collaborations.

For Stephon Alexander, professor of physics at Brown, having the conference in the city where he lives and works is particularly special. Alexander joined NSBP as a young undergraduate and aspiring physicist. Now he's a member of the Brown faculty and president-elect of NSBP. He says it's gratifying to be part of two organizations with the shared goal of making education and research more inclusive endeavors.

Alexander discussed this year's conference, which takes place from Nov. 14 to 17 at the Marriot Downtown Hotel, in an interview.

Q: Can you share an overview on NSBP and its mission?

The goal of the NSBP is to promote the professional well-being and success of African American and black physicists, with an emphasis on fostering excellence and innovation. I think the organization is a good example of how a group of people who, for the love of their field, decided to come together at a time when they were explicitly not welcome in some places. Instead of giving in or giving up, they built this community around their passion and desire to do research and to teach.

Q: Can you describe your experiences at past conferences?

I've been an NSBP member since my freshman year of college, and this conference is where I met many of my mentors, including Jim Gates [a Brown professor and National Medal of Science winner], who will give a keynote talk this year. As an undergraduate, I had a bit of a low opinion of myself in terms of my abilities, and this conference gave me confidence. I remember a moment from one of my first conferences during a lunch break. There was a table of very distinguished black physicists — people from MIT and Duke — and they just called me over to the table like I was their nephew. It was like, 'come join us here,' and it gave me a sense of belonging and that I was being taken seriously. Now 20 or 30 years later, these people are my colleagues. Being the incoming president, if I can contribute to enhancing that type of culture, that would be great.

Q: What are some of the highlights on the schedule?

The leaders of each of our scientific program areas — like astrophysics, condensed matter, quantum mechanics and others — will host programming specific to each of those areas. We'll also have plenary sessions and keynotes for the whole group. I'll be giving a talk. We'll also have James Simons, the mathematician and founder of the Simons Foundation. Jami Valentine Miller, the first African American woman to get a PhD from Johns Hopkins, will speak. Jim Gates will give a keynote, as I mentioned, as will Brian Keating, who led the BICEP cosmic microwave background experiments.

NICK DENTAMARO/BROWN UNIVERSITY

A LEAP TOWARD THE NEXT QUANTUM REVOLUTION

On January 20th researchers from across the U.S. gathered in the Physics Department for a five-day workshop to discuss main ideas behind the envisaged NSF Quantum Leap Challenge Institute on the Identification and Control of Fundamental Properties of Quantum Systems.

Twenty-six presenters from universities and national labs tackled the difficult problem of how to achieve a true quantum leap. Professor Vesna Mitrović led the effort. "It's a really complicated problem and my job here was to get the right people together to address it and in the process to refine the idea for achieving a quantum leap."

Participants presented and discussed topics such as Probes of Topological Order, Quantum Sensing, Resources for Quantum Computation, and Coherent Control of Quantum States. Attendees engaged in extensive discussions to define the scope of work needed to achieve and advance quantum sensing. The different aspects of quantum phenomena that can be utilized for the development of quantum sensing holds the promise of enabling new discoveries in science and finding ways to defy natural limits of precision measurements that would go beyond the standard quantum limit.

Entanglement, which is a unique feature of quantum material and is related to quantum sensing, presents the challenge of being difficult to probe using standard experimental methods. Novel ideas were considered for experimentally probing entanglement. Theoretical physicist, Professor Adrian Del Maestro, from the University of Vermont explains "I am interested in entanglement in many-body systems and how this could potentially be useful as a resource to obtain quantum speedups in information processing. Sensing plays a double role here, both in the ability to validate the suitability of a given phase of quantum matter and in terms of read-out of quantum states. The mix of experimentalists and theorists at this workshop has a high potential of making a significant impact on future quantum technologies."

"I feel confident we will produce great results and make major breakthroughs in quantum science." -Vesna Mitrović

Jill Pipher, Vice President for Research, welcomed researchers to the QLCI Workshop.

PhD student Zekun Zhuang (advisor Professor Brad Marston) presented on "Charge Transport and Control in Topological Materials."

IDALINA ALARCON/BROWN UNIVERSITY (3)

Formulating the next steps after this workshop includes assembling a great team and solidifying that this group of scientists has the capability to reach the next quantum leap. "There's a lot of excitement in the condensed matter community to use this momentum from the ongoing funding surge from NSF to pursue fundamental research connected to quantum physics. NSF discusses the current research developments as a "second quantum revolution" and, from the front lines, it is indeed a really exciting time," said Professor Erik Henriksen, an experimental physicist from Washington University in St. Louis.

When asked what happens next after this workshop, Mitrović stated, "We have a great team with needed complementary expertise to tackle the main ideas of the Challenge Institute. I'm very excited for the possibility to work on these problems and I feel confident we will produce great results and make major breakthroughs in quantum science."

The NSF Quantum Leap Challenge Institute Workshop was funded by the National Science Foundation. The workshop was organized by Professors Vesna Mitrović, Dmitri Feldman, and Brad Marston.

Robert Pelcovits

FACULTY RESEARCH

RESEARCH ON SCIENCE COVER REVEALS COLLECTIVE DYNAMICS OF ACTIVE MATTER SYSTEMS

By Kevin Stacey

COURTESY RAY ADKINS/UC SANTA BARBARA

A study provides new details about the collective motion of individual agents in a liquid-crystal-like system, which could help in better understanding bacterial colonies, structures and systems in the human body, and other forms of active matter. Flocks of starlings that produce dazzling patterns across the sky are natural examples of active matter — groups of individual agents coming together to create collective dynamics. In a study featured on the cover of the March 6 issue of the journal Science, a team of researchers that includes Brown University physicists reveals new insights into what happens inside active matter systems.

The research describes experiments using a three-dimensional active nematic. Nematic describes a state of matter that emerges in the kind of liquid crystals widely used in smartphone and television displays. The cigar-shaped molecules in liquid crystals are able to move as in a liquid, but tend to stay ordered more or less in the same direction, a little like a crystal.

In a normal liquid crystal, the molecules are passive, meaning they don't have the ability to self-propel. But the system involved in this new study replaces those passive molecules with tiny bundles of microtubules, each with the ability to consume fuel and propel themselves. The goal of the research was to study how those active elements affect the order of the system.

"These microtubules tend to align, but also continually destroy their own aligning order with their movement," said study co-author Daniel Beller, an assistant professor of physics at University of California, Merced, who began work on the research while he was a postdoctoral researcher at Brown. "So there are collective motions that create defects in the alignment, and that's what we study here."

As the system evolves, the defects appear to come to life in some sense, creating lines, loops and other structures that meander through the system. The researchers studied the structures using topology, a branch of math concerned with how things deform without breaking.

"If your goal is to understand the dynamics of these systems, then one way to do that is to focus on these emerging topological structures as a way to characterize the dynamics," said Robert Pelcovits, a professor of physics at Brown and a study coauthor. "If we can get guiding principles from this simple system, that might help guide us in understanding more complicated ones."

Beller, Pelcovits and Thomas Powers, a professor of engineering and physics at Brown, led the theoretical work for the study. The experimental work was performed by researchers from Brandeis University and the University of California, Santa Barbara. Researchers from the Max Planck Institute for Dynamics and Self-Organization, the University of Chicago, Brandeis and Eindhoven University of Technology contributed computer modeling expertise.

This kind of work had been done in two-dimensional systems, but this is the first time a 3D system had been studied in this way. The research showed that the dominant topological structures in the system were loop structures that emerge spontaneously, expand and then self-annihilate.

The loops are related to the kinds of defects that emerge in better-studied 2D systems, but they differ in a key way, the researchers say. In 2D, defects arise in pairs of points that have opposing characteristics or "charges," a bit like particles and antiparticles. Once they form, they exist until they eventually run into a defect with the opposite charge, which causes them to annihilate.

The loops that form in 3D, in contrast, have no charge. As a result, they form and annihilate all on their own. They're still related to the 2D defects structures, however. In fact, the 3D loops can be thought of as extensions of 2D point defects. Imagine two point defects sitting on a 2D surface. Now connect those two points with an arc that rises up out of the 2D surface, and a second arc on the underside of the surface. The result is a loop that has both charges of the points, but is itself charge neutral. That enables nucleation and annihilation all on their own.

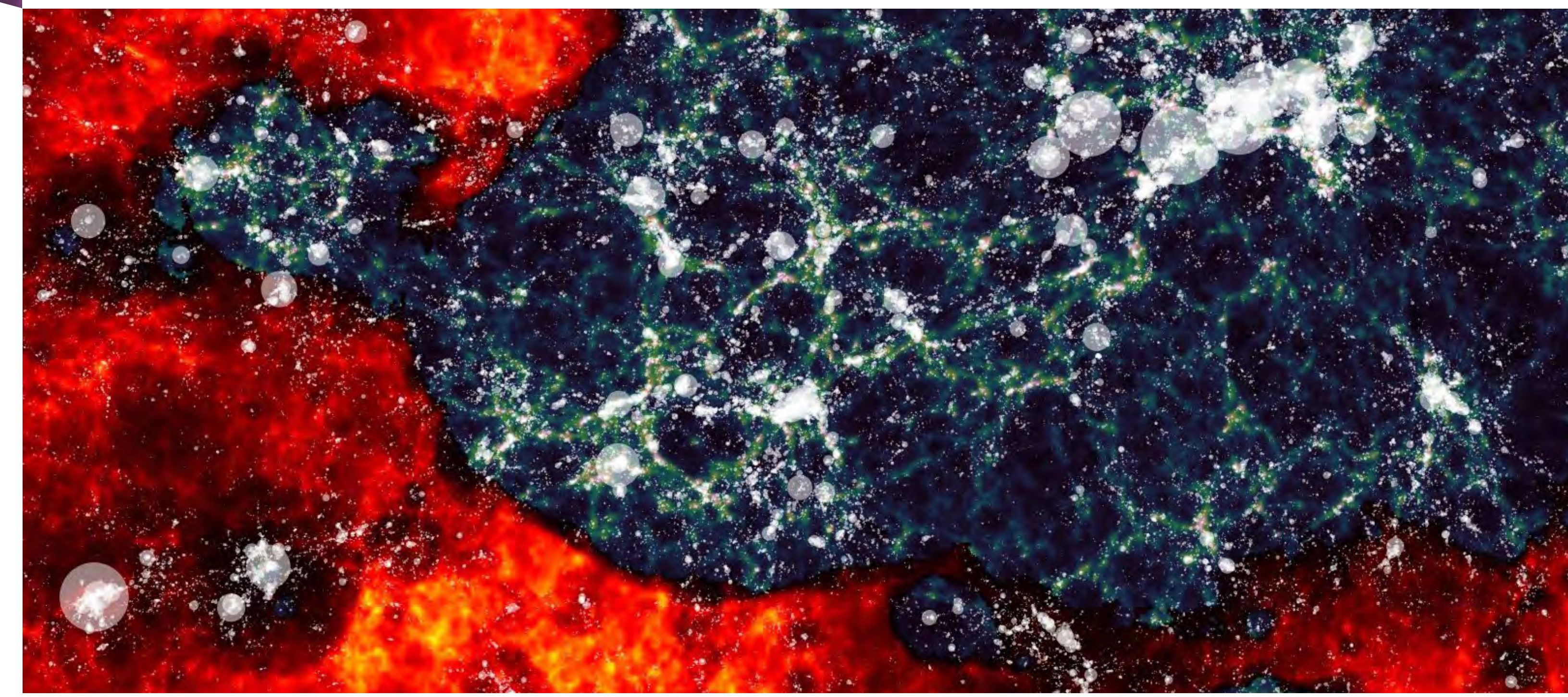
The researchers are hopeful that this new understanding of this system's dynamics will be applicable in real-world systems like bacterial colonies, structures and systems in the human body, or other systems. "What we found here is a quite general set of behaviors that we think will be fully present in similar systems that have this tendency to align, but that are also turning stored energy into motion," Beller said.

Jonathan Pober

FACULTY RESEARCH

AND THEN THERE WAS LIGHT: LOOKING FOR THE FIRST STARS IN THE UNIVERSE

By Kevin Stacey



COURTESY PAUL GEIL & SIMON MUTCH

Researchers hunt for a 12-billion-year-old signal that marks the end of the post Big Bang "dark age."

COURTESY MURCHISON WIDEFIELD ARRAY

Astronomers are closing in on a signal that has been travelling across the Universe for 12 billion years, bringing them nearer to understanding the life and death of the very earliest stars.

In a paper on the preprint site arXiv and soon to be published in the Astrophysical Journal, a team led by Dr. Nichole Barry from Australia's University of Melbourne and the ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D) reports a 10-fold improvement on data gathered by the Murchison Widefield Array (MWA) – a collection of 4096 dipole antennas set in the remote hinterland of Western Australia.

The results published in this paper were the culmination of over five years of work. The data used in the study were collected in 2013 and were first analyzed in a paper published in 2016. The years since saw a concerted effort to develop new techniques for improving the precision of the analysis and better identifying (and excluding) data contaminated by human-generated radio signals.

Brown University researcher Jonathan Pober was a part of this process from the beginning and played a substantial role in vetting the new techniques. Of particular importance was to ensure they would return an accurate and unbiased measurement of any signal present in the data, since techniques to remove contamination from the data can also remove the signal of interest unless the utmost care is taken. Prof. Pober designed a suite of high-precision simulations to validate the entire analysis, while Brown Physics PhD student Wenyang Li conducted a parallel analysis, applying the same techniques to an independent data set to ensure their broader applicability.

This paper is therefore important for two key reasons: it presents the most constraining limit on the EoR signal strength in the literature, but it also represents the highest level of internal validation and scrutiny applied to an analysis in this field and will serve as an exemplar for future such work.

James Valles Jr.

FACULTY RESEARCH

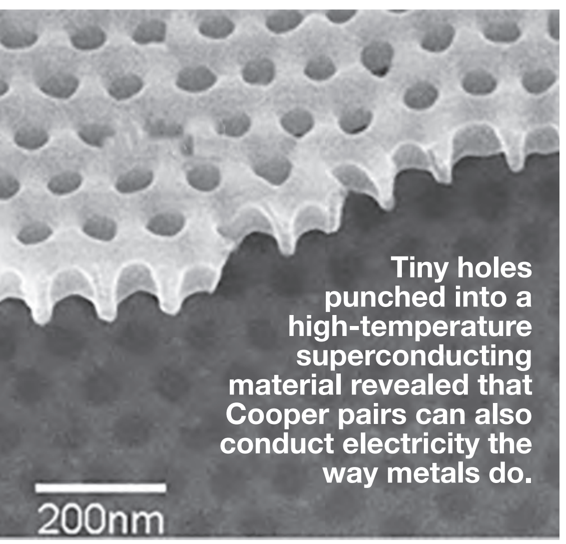
RESEARCH REVEALS NEW STATE OF MATTER: A COOPER PAIR METAL

By Kevin Stacey

In a finding that reveals an entirely new state of matter, research published in the journal Science shows that Cooper pairs, electron duos that enable superconductivity, can also conduct electricity like normal metals do.

For years, physicists have assumed that Cooper pairs, the electron duos that enable superconductors to conduct electricity without resistance, were two-trick ponies. The pairs either glide freely, creating a superconducting state, or create an insulating state by jamming up within a material, unable to move at all.

But in a new paper published in Science, a team of researchers has shown that Cooper pairs can also conduct electricity with some amount of resistance, like regular metals do. The findings describe an entirely new state of matter, the researchers say, that will require a new theoretical explanation.



Tiny holes punched into a high-temperature superconducting material revealed that Cooper pairs can also conduct electricity the way metals do.

BROWN UNIVERSITY

"There had been evidence that this metallic state would arise in thin film superconductors as they were cooled down toward their superconducting temperature, but whether or not that state involved Cooper pairs was an open question," said Jim Valles, a professor of physics at Brown University and the study's corresponding author. "We've developed a technique that enables us to test that question and we showed that, indeed, Cooper pairs are responsible for transporting charge in this metallic state. What's interesting is that no one is quite sure at a fundamental level how they do that, so this finding will require some more theoretical and experimental work to understand exactly what's happening."

Cooper pairs are named for Leon Cooper, a physics professor at Brown who won the Nobel Prize in 1972 for describing their role in enabling superconductivity. Resistance is created when electrons rattle around in the atomic lattice of a material as they move. But when electrons join together to become Cooper pairs, they undergo a remarkable transformation. Electrons by themselves are fermions, particles that obey the Pauli exclusion principle, which means each electron tends to keep its own quantum state. Cooper pairs, however, act like bosons, which can happily share the same state. That bosonic behavior allows Cooper pairs to coordinate their movements with other sets of Cooper pairs in a way the reduces resistance to zero.

In 2007, Valles, working with Brown engineering and physics professor Jimmy Xu, showed that Cooper pairs could also produce insulating states as well as superconductivity. In very thin materials, rather than moving in concert, the pairs conspire to stay in place, stranded on tiny islands within a material and unable to jump to the next island.

For this new study, Valles, Xu and colleagues in China looked for Cooper pairs in the non-superconducting metallic state using a technique similar to the one that revealed Cooper pair insulators. The technique involves patterning a thin-film superconductor — in this case a high-temperature superconductor yttrium barium copper oxide (YBCO) — with arrays of tiny holes. When the material has a current running through it and is exposed to a magnetic field, charge carriers in the material will orbit the holes like water circling a drain. "We can measure the frequency at which these charges circle," Valles said. "In this case, we found that the frequency is consistent with there being two electrons going around at a time instead of just one. So we can conclude that the charge carriers in this state are Cooper pairs and not single electrons."

The idea that boson-like Cooper pairs are responsible for this metallic state is something of a surprise, the researchers say, because there are elements of quantum theory that suggest this shouldn't be possible. So understanding just what is happening in this state could lead to some exciting new physics, but more research will be required.

Luckily, the researchers say, the fact that this phenomenon was detected in a high-temperature superconductor will make future research more practical. YBCO starts superconducting at around -181 degrees Celsius, and the metallic phase starts at temperatures just above that. That's pretty cold, but it's much warmer than other superconductors, which are active at just above absolute zero. That higher temperature makes it easier to use spectroscopy and other techniques aimed to better understand what's happening in this metallic phase.

Down the road, the researchers say, it might be possible to harness this bosonic metal state for new types of electronic devices. "The thing about the bosons is that they tend to be in more of a wavelike state than electrons, so we talk about them having a phase and creating interference in much the same way light does," Valles said. "So there might be new modalities for moving charge around in devices by playing with interference between bosons."

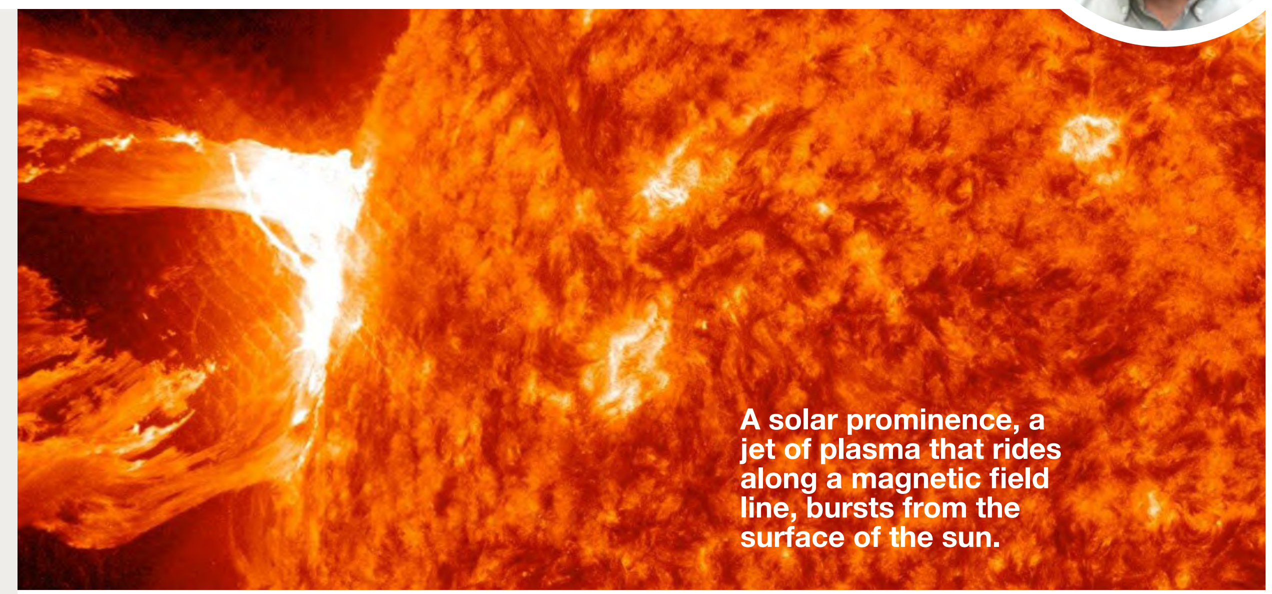
But for now, the researchers are happy to have discovered a new state of matter. "Science is built on discoveries," Xu said, "and it's great to have discovered something completely new."

Brad Marston

FACULTY RESEARCH

TOPOLOGICAL WAVES MAY HELP IN UNDERSTANDING PLASMA SYSTEMS

By Kevin Stacey



A solar prominence, a jet of plasma that rides along a magnetic field line, bursts from the surface of the sun.

COURTESY NASA/SDO

A research team has predicted the presence of "topologically protected" electromagnetic waves that propagate on the surface of plasmas, which may help in designing new plasma systems like fusion reactors.

Nearly 50 years ago, Brown University physicist Michael Kosterlitz and his colleagues used the mathematics of topology — the study of how objects can be deformed by stretching or twisting but not tearing or breaking — to explain puzzling phase changes in certain types of matter. The work won Kosterlitz a share of the 2016 Nobel Prize in Physics and has led to the discovery of topological phenomena in all kinds of systems, from thin films that conduct electricity only around their edges, to strange waves that propagate in the oceans and atmosphere at the Earth's equator.

Now a team of researchers, including another Brown physicist, has added a new topological phenomenon to that ever-growing list. In new theoretical research, the team shows that electromagnetic waves of topological origin should be present on the surface of plasmas — hot soups of ionized gas. If the theory proves true, those waves could provide a new way for scientists to probe the properties of plasmas, which are found in everything from fluorescent lightbulbs to stars.

The research was led by Jeffrey Parker, a research scientist at Lawrence Livermore National Laboratory, in collaboration with Brad Marston, a professor of physics at Brown, and others. The paper is published in Physical Review Letters.

The waves, called gaseous plasmon polaritons, propagate along the interface of a plasma and its surroundings when the system is exposed to a strong magnetic field. Marston says that what's interesting about these waves is that they are "topologically protected," meaning that they're inherently present in the system and are resistant to being scattered by impurities.

"Any time you have a wave that's protected against scattering, it means they can stay intact over a long distance," Marston said. "As a practical matter, we're hoping that these can be used to diagnose plasma states. One of the big problems in plasma physics is to figure out the state of a plasma without disturbing it. If you stick in a probe, you're going to disrupt the system. We might be able to use these waves to discern the state of a plasma without disturbing it."

One way to think about topological protection, Marston says, is something known as the hairy ball theorem. Imagine a ball covered in long hairs. If one were to try to comb those hairs down, there will always be at least one spot on the ball where the hairs won't lie flat.

"This spot will always be there," Marston said. "You can move it around, but the only way to get rid of it is to tear some hair out. But barring something violent like that, if you're just manipulating it continuously without tearing anything, there's always going to be a vortex." The ever-present vortex on the hairy ball is mathematically analogous to the waves on a plasma's surface, Marston says. "In this case, there's always a vortex but it's in the wave-number space, wavelengths of the different waves," he said. "It's a little more abstract than in real space, but the math is largely similar." Having fleshed out the theoretical basis for these waves, the next step is to perform experiments to confirm that they're really there.

Marston and his colleagues recently won a seed grant from Brown to help them do just that. With the help of researchers at UCLA's Basic Plasma Physics Facility, Marston and his colleagues plan to perform experiments to detect these waves.

Ultimately, Marston hopes that the discovery of these waves could be a boon for plasma physics, helping scientists to better understand and control plasma systems. One major area Marston is interested in is plasma fusion reactors. Such reactors could one day harness nuclear fusion to produce an abundance of clean energy, but so far the plasma systems have proven hard to control.

"In the long term, we hope this can make an impact on fusion energy," Marston said. "If we can use these waves to discern the states of plasmas, it might help in designing a fusion reactor that's stable and able to produce energy."

But for now, Marston and his colleagues are looking forward to performing their experiments.

"If we can demonstrate these things experimentally, people in the plasma community will hopefully start paying closer attention to this idea," he said. Other co-authors on the paper were Steven Tobias and Ziyan Zhu.

FACULTY APPOINTMENTS

STEPHON ALEXANDER WILL SERVE AS THE NATIONAL SOCIETY OF BLACK PHYSICISTS PRESIDENT 2020

Professor Stephon Alexander has been elected president of the National Society of Black Physicists (NSBP), the nation's pre-eminent organization devoted to the African American physics community. Alexander joined NSBP 28 years ago as a first-year undergraduate student at Haverford College. Formed in 1977, the organization works to bolster opportunities for African Americans in physics, as well as increasing their representation. NSBP also develops activities and programs that highlight the scientific contributions that African American physicists provide for the international community. Alexander says he hopes to expand NSBP's visibility by working to add chapters in the U.S. and abroad. He also hopes to engage younger members to identify career and education challenges they face, and then engage senior members to help address those challenges through mentorship or other means.

COURTESY STEPHON ALEXANDER

COURTESY MEENAKSHI NARAIN

MEENAKSHI NARAIN APPOINTED CO-CONVENER OF THE ENERGY FRONTIER OF SNOWMASS 2021

Professor Meenakshi Narain has been appointed a co-convener of the Energy Frontier Study Group of the Snowmass 2021 Initiative. Hosted by the American Physical Society (APS) Division of Particles and Fields, the Snowmass studies take place every 5-6 years to help determine particle physics research in the coming decade. Snowmass is an opportunity for the entire HEP community to come together to identify and document a vision for the future of particle physics in the U.S. and with its international partners. The Energy Frontier team is led by three researchers and will engage in a long term planning exercise for particle physics in the US. Narain and her team, will identify the most compelling scientific questions to determine what should be the next generation particle colliders, which are the heart of HEP. During this exercise, the Energy Frontier team will compare the discovery potential of proposed future particle colliders, based on their reach for direct observation of new massive particles, or on the sensitivity of precision measurements of the properties of known particles to the presence of new physics that goes beyond the Standard Model of particle physics.

SYLVESTER JAMES GATES JR. WILL SERVE AS AMERICAN PHYSICAL SOCIETY PRESIDENT 2021

Professor S. James Gates Jr. has been elected to the presidential line of the American Physical Society, a nonprofit that represents more than 55,000 physicists in higher education, national laboratories and industry in the U.S. and across the world. Gates served as the society's vice president in 2019, is currently serving as the president-elect, and will serve as president in 2021. The APS president leads the society's board of directors, which has the ultimate responsibility for the actions of the society. The society's mission is to advance and diffuse the knowledge of physics through its research journals, scientific meetings, education, outreach, advocacy, and international activities.

COURTESY S. JAMES GATES

FACULTY NEWS

APS OUTSTANDING REFEREE

Dmitri Feldman

Professor Dmitri Feldman has been named a 2020 APS Outstanding Referee. Honorees are selected based on the quality, number, and timeliness of their reports. The Outstanding Referee program was instituted in 2008 to recognize scientists who have been exceptionally helpful in assessing manuscripts for publication in the APS journals. The highly selective Outstanding Referee program annually recognizes about 150 of the roughly 71,000 currently active referees.

EXCELLENT RESEARCH AWARD FROM MAGNETO-SCIENCE SOCIETY OF JAPAN

James Valles Jr.

Professor James Valles Jr. was awarded the Excellent Research Award from The Magneto-Science Society of Japan for his work on manipulating biological organisms and materials with intense magnetic fields.

APS FELLOW

Anastasia Volovich

Professor Anastasia Volovich has been named a Fellow of the American Physical Society (APS). Professor Volovich's nomination came from the Division of Particles and Fields (DPF) for introducing original perspectives on quantum field theory calculations and uncovering deep mathematical structures in supersymmetric gauge theories, leading to novel and powerful methods of scattering amplitudes evaluation.

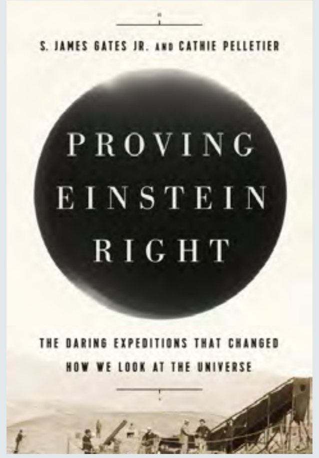
IDALINA ALARCON/BROWN UNIVERSITY (2)

PROVING EINSTEIN RIGHT

S. James Gates Jr. & Cathie Pelletier

Professor S. James Gates Jr. has spent his career pioneering modern physics and diversity in science. His most recent book, written with novelist Cathie Pelletier, is about how scientists proved Albert Einstein's groundbreaking theory of relativity all those years ago.

It's a thrilling adventure story chronicling the perilous journey of the scientists who set out to prove the theory of relativity, the results of which catapulted Einstein to fame and forever changed our understanding of the entire universe. At its heart, this is a story of frustration, faith, and ultimate victory--and of the scientists whose efforts helped build the framework for the big bang theory.



COURTESY PUBLIC AFFAIRS BOOKS

EPS HIGH ENERGY AND PARTICLE PHYSICS PRIZE AWARD

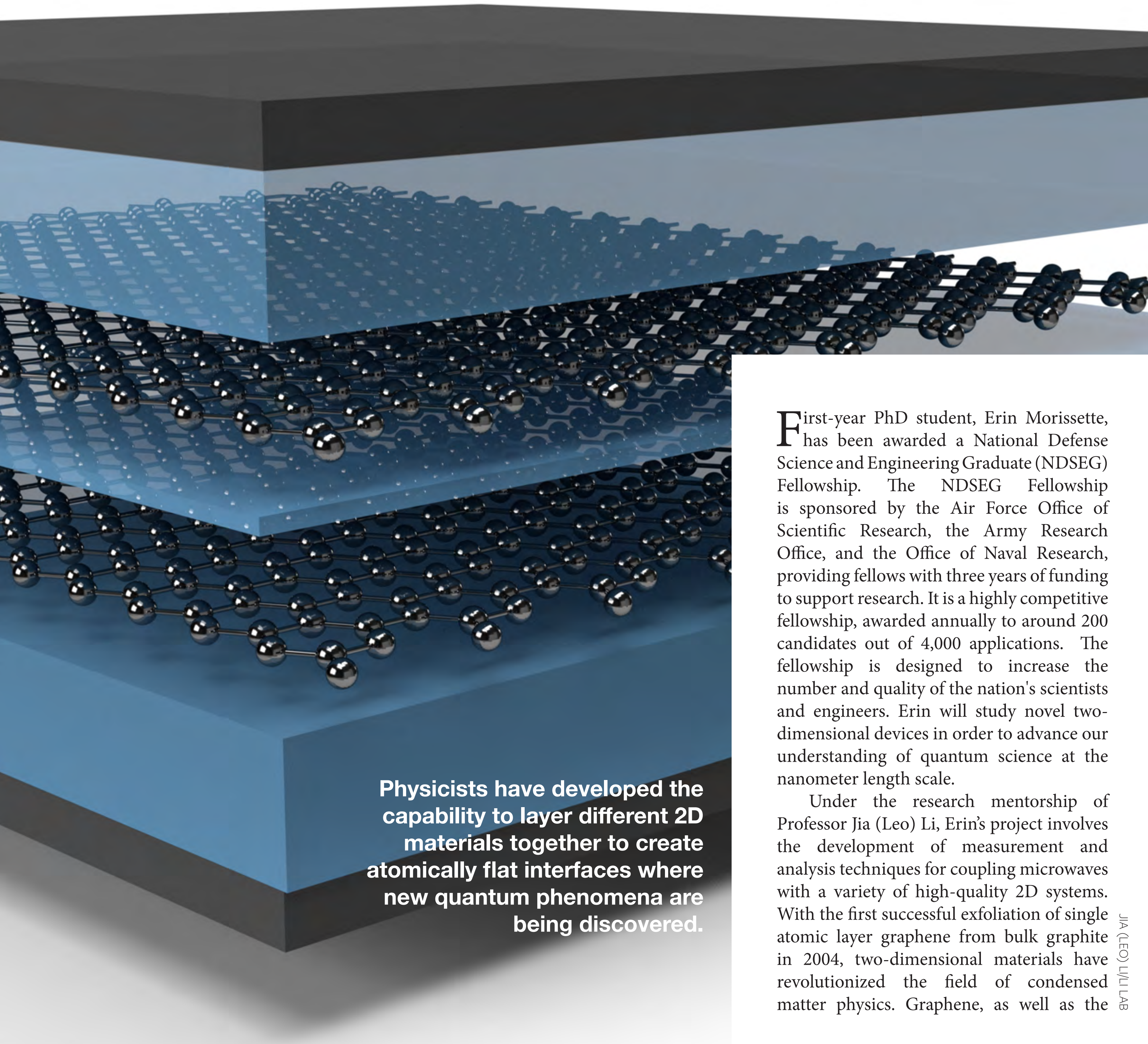
The European Physical Society has announced that the 2019 High Energy and Particle Physics Prize has been awarded to the CDF and D0 collaborations for "the discovery of the top quark and the detailed measurement of its properties." Current Brown Physics Department faculty members David Cutts, Ulrich Heintz, Greg Landsberg, and Meenakshi Narain have been long-time members of the D0 Collaboration. Former faculty members Robert Lanou and Richard Partridge, and many Brown postdocs and students were also members of the D0 collaboration and contributed to its achievements.

EUROPEAN PHYSICAL SOCIETY GIUSEPPE AND VANNA COCCONI PRIZE

The European Physics Society has announced that the 2019 Giuseppe and Vanna Cocconi Prize for an outstanding contribution to Particle Astrophysics and Cosmology has been awarded to the WMAP and Planck Collaborations for "providing high-precision measurements of the cosmic microwave background temperature and polarization anisotropies, leading to detailed information on properties of the universe and tests of cosmological models and fundamental physics." Professor Greg Tucker is a member of the WMAP Science Team and worked on many aspects of the project from design, building, testing and operation of the WMAP instrument to data analysis.

NATIONAL DEFENSE SCIENCE AND ENGINEERING GRADUATE FELLOW

ERIN MORISSETTE



Physicists have developed the capability to layer different 2D materials together to create atomically flat interfaces where new quantum phenomena are being discovered.

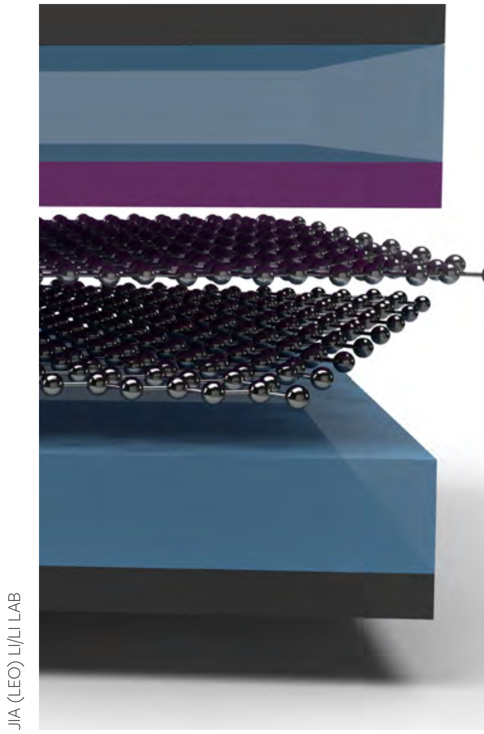
JIA (LEO) LI/LI LAB

First-year PhD student, Erin Morissette, has been awarded a National Defense Science and Engineering Graduate (NDSEG) Fellowship. The NDSEG Fellowship is sponsored by the Air Force Office of Scientific Research, the Army Research Office, and the Office of Naval Research, providing fellows with three years of funding to support research. It is a highly competitive fellowship, awarded annually to around 200 candidates out of 4,000 applications. The fellowship is designed to increase the number and quality of the nation's scientists and engineers. Erin will study novel two-dimensional devices in order to advance our understanding of quantum science at the nanometer length scale.

Under the research mentorship of Professor Jia (Leo) Li, Erin's project involves the development of measurement and analysis techniques for coupling microwaves with a variety of high-quality 2D systems. With the first successful exfoliation of single atomic layer graphene from bulk graphite in 2004, two-dimensional materials have revolutionized the field of condensed matter physics. Graphene, as well as the accompanying family of van der Waals materials, provide the building blocks for custom stacks and fabricated devices. The highly tunable properties of 2D-material devices enable a versatile platform to probe novel quantum phenomena. More specifically, she seeks to develop a spin probe for detecting quantum phenomena in 2D materials by pursuing two parallel efforts: employing resistively detected electron spin resonance and nuclear magnetic resonance for high-quality 2D-material devices, as well as magnetometry of the devices via nitrogen-vacancy centers in diamonds.

Experimental studies of these 2D material structures have relied heavily on quantum transport measurement, the development of a new measurement method based on microwave techniques will be essential to advancing our understanding of quantum science in such low dimensional confinement. In addition, the ability to couple radio frequency fields with the electron spin states in atomically thin layered materials promises to enable a range of future technology and pave the way for innovations in the field of quantum computation.

Erin's research background includes terahertz spectroscopy of thin-film dichalcogenides as a Clare Boothe Luce Research Fellow at Worcester Polytechnic Institute, as well as III-V semiconductor fabrication/testing as a member of the Quantum Information and Integrated Nanosystems Group at MIT Lincoln Laboratories. She spent her first year at Brown as a research assistant in the Li Lab, working on device fabrication and performing preliminary measurements coupling microwave with graphene at Sandia National Laboratory. Erin has greatly enjoyed getting to know her inspiring classmates and looks forward to progressing her research as an active member of the Brown Physics community.



JIA (LEO) LI/LI LAB

DEAN'S FACULTY FELLOW

JATAN BUCH

IDALINA ALARCON/BROWN UNIVERSITY

The Deans' Faculty Fellowship provides an opportunity for senior graduate students to develop and teach their own courses. As a Faculty Fellow for the upcoming academic year, I will tentatively be offering the course Statistical Physics in Inference and (Deep) Learning in Spring 2021.

This course, aimed primarily at undergraduate students, will explore the statistical physics concepts underlying several Bayesian statistical techniques and deep learning architectures widely used today in industry and academia alike. An important focus of the course will be to help students gain hands-on computational experience by applying these techniques to problems in physics, finance, and neuroscience. Since it's unclear whether normal university operations will resume in the upcoming academic year, I will actively work toward creating an accessible and engaging learning environment with an emphasis on collaborative learning rather than the traditional lecture format.

Lastly, any exploration of deep learning, in my opinion, cannot be divorced from its use for objectives that are antithetical to the values of social justice. Accordingly, a part of the course will provide a space for students to interrogate such practices, and reflect on the ethical, political, and policy frameworks that are urgently needed in the age of surveillance.

RESEARCH PROFILE:

I am a fifth year graduate student working with Professor JiJi Fan, and interested, for the most part, in the investigation of dark matter and its phenomenological properties. My research thus far has involved using various data-driven techniques to probe dark matter's particle nature, its interactions with ordinary matter beyond gravity, and its distribution in the Milky Way. More concretely, these searches include inferring the local dark matter density using positions and velocities of stars measured by the Gaia satellite, and studying how astrophysical uncertainties affect the interpretation of DM's particle physics parameters at upcoming direct detection experiments--like the LZ experiment based at Brown--to a family of DM models.

Meanwhile, for my current project, I am collaborating with Professor Savvas Koushiappas to devise statistical searches for dark matter subhalos in the Milky Way using upcoming time series stellar kinematics data at the Vera Rubin Observatory.

BARRY GOLDWATER SCHOLARSHIP

Adam Tropper '21
Mentors: JiJi Fan, Antal Jevicki, Marcus Spradlin

Adam Tropper '21 is one of 396 students across the United States to receive a 2020 Barry Goldwater Scholarship. The Goldwater Scholarship Program, one of the oldest and most prestigious national scholarships in the natural sciences, engineering and mathematics in the United States, seeks to identify and support college sophomores and juniors who show exceptional promise of becoming this Nation's next generation of research leaders in these fields.

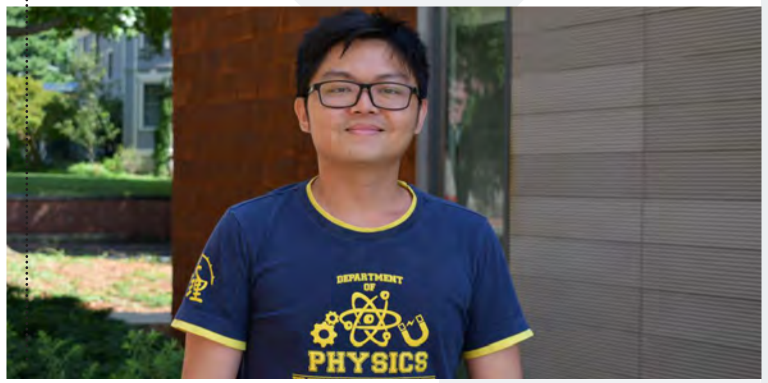
The Barry Goldwater Scholarship and Excellence in Education Foundation was established by Congress in 1986 to serve as a living memorial to honor the lifetime work of Senator Barry Goldwater, who served his country for 56 years as a soldier and statesman, including 30 years in the U.S. Senate.

Adam hopes to pursue a PhD in High Energy Theoretical Physics leading to professorship. His research interests include: particle and string phenomenology, scattering amplitudes, conformal field theory, and dualities. He spent the summer of 2019 performing research with Professor JiJi Fan.

IDALINA ALARCON/BROWN UNIVERSITY (4)

SUMMER RESEARCH

During the summer months students participate in various research opportunities. These opportunities are made possible through the UTRA program, research grants, the SURE exchange program, the Cantabria exchange program and the Summer Student Theoretical Physics Research Session (SSTPRS) hosted by Professor Jim Gates. Students come from across the US and around the world to participate in research study.



Rui Xian Siew *2019 Summer Intern*
The Chinese University of Hong Kong
Advisor: Professor James Gates

Alena Boyko *2019 Summer Intern*
The Chinese University of Hong Kong
Advisor: Professor Gang Xiao

Daniel Sanz Zulet *2019 Summer Intern*
Cantabria University
Advisor: Professor Jia (Leo) Li

Jasper Solt '21 (he/him or they/them)
2019 Summer UTRA Advisor: Professor Jonathan Pober

Can you share about the research you worked on?
Radio astronomy is a powerful tool for observing the universe at the Epoch of Reionization (EoR), a period in the formation of the universe when the radiation from early galaxies began to ionize neutral hydrogen that had until then dominated space. This summer I helped to optimize and test a machine learning algorithm that predicts cosmological values based on data from semi-numerical simulations of the EoR. We trained an algorithm to predict on three different parameters of the simulated data-- the duration of the EoR, the redshift of 50% reionization (midpoint), and the average redshift of reionization. We determined that we could recover the average redshift and redshift midpoint to within +/-3% and the duration to within +/-10% of the true value from the simulations. This research is a precursor to using machine learning algorithms on data from the Hydrogen Epoch of Reionization Array (HERA), a radio telescope array which will, once completed, collect data of unprecedented volume and quality from the EoR. Future work includes testing this algorithm on several different semi-numerical simulation models to see if the predictions agree across all models.

"I got to attend my first ever scientific conference for the Murchison Widefield Array, and had a fascinating experience!" -Jasper Solt

2020 UNDERGRADUATE TEACHING AND RESEARCH AWARDS (UTRA) Aigerim Akhmetzhanova, Ye Won Byun, Adam Furman, Eamon Hartigan-O'Connor, Isabel Horst, Alex Jacoby, Gene Siriviboon, Christopher Turner, Tim Zhao

STUDENT GROUPS

Claire Hawkins '20

Batia Friedman-Shaw '22

Livia Belman-Wells '21

IDALINA ALARCON/BROWN UNIVERSITY (4)

Scialogue
Hosted by DUG & WiSE
The Department Undergraduate Group (DUG) and Physics Women in Science and Engineering (WiSE) hosted a series of "Scialogue" events. Students who have participated in research shared information regarding opportunities available to students during the academic year and summer months.

The BIG BANG SCIENCE FAIR

By Meenakshi Narain and Ulrich Heintz

On Saturday, September 28, the second annual Big Bang Science Fair unfolded on Market Square and in other locations into a smashing success during a full WaterFire lighting dedicated to celebrating educational excellence in Rhode Island.

Coordinated by Physics Professors Meenakshi Narain, and Ulrich Heintz, the event grew relative to its first incarnation in 2018. The event aims to portray scientific ideas in a way that makes them accessible to everyone. It breaks down stereotypical images that depict science as a subject available only to those with an academic degree and presents scientific exploration in a way everyone can relate to, regardless of age, gender, or socioeconomic background. To this end, the organizers reached out to the community to access a larger demographic. Citizens Bank (Geoffery Gunter), Skills for RI's Future (Nina Pande), Microsoft TealsK12 (Andrea Russo), and RI Virtual Reality (Siu-Li Khoe), organized activities geared towards connecting high school students from across Providence with STEAM education.

A program of lectures cycled about 1,000 people through the RISD auditorium between 4 and 10 pm. David Muller from the Youtube channel Veritasium performed a number of physics demos on stage to the theme "How do we find out what is true?" Dr. Rebecca Thompson, head of the Education and Outreach Office at Fermilab, talked about how consistent various aspects of the Game of Thrones TV series are with the laws of physics. And Brown Professor John Donaghue talked about how to use robotics to help people with paralysis carry out simple tasks of everyday life. Dr. Lisa Michaud discussed the challenges of Artifical Intelligence in human language processing. The event started with a demonstration of the musical instrument theremin by Dorit Chrysler and closed with a jazz performance by the group God Particle. In-depth workshops in the big tent on Market Square and in the RISD Conference Room in Market House gave the 300 participants an opportunity to try out a variety of computer programming challenges, build cloud chambers to see the traces of elementary particles, and to learn about the theremin, a musical instrument that is played without being touched.

Market Square and one end of College Street bustled with 15 tents filled with activities for all age ranges that explored a host of scientific fields, from physics and chemistry, to neuroscience, computer science, medicine, and the science behind cooking. To promote the role of women in STEAM fields, each tent was named after an accomplished female scientist. The ground was again covered with interesting math mazes that challenged visitors' puzzle skills. Canal Walk hosted astronomers from Brown Ladd Observatory with their telescopes which enabled visitors to first observe the sun and later on the night sky. Several thousand people participated in the fun over the course of the event.

> It is hard to capture the excitement, information exchange and learning which happened at the event and the magnitude of effort which led to it.

COURTESY MIKE COHEA (2)

Brown Physicians, Inc. and Alpert Medical School were new participants who introduced medicine to the Big Bang Science Fair. Participants learned how to give CPR to dummies, performed robotic surgery, and inspected specimens under microscopes.


Rebecca Thompson performs a physics demo.

COURTESY MIKE COHEA

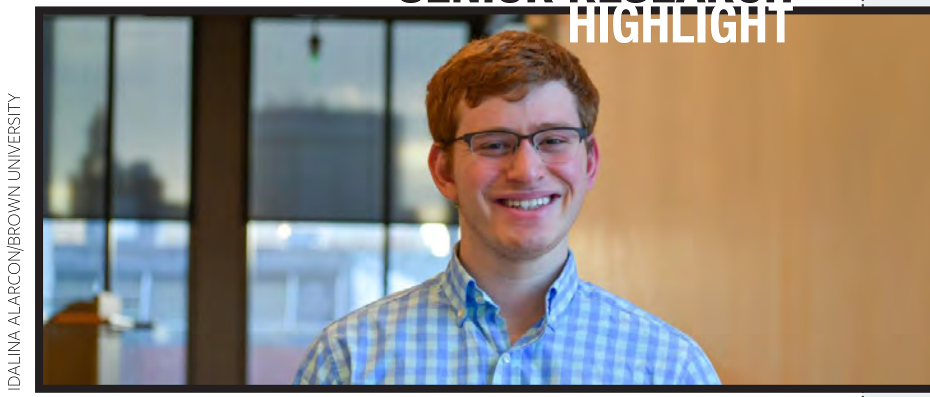
A particular highlight was the living heart virtual reality demonstration by Dassault Systemes. Also a part of the Big Bang Science Fair was a Math Open House at ICERM with exhibitions of mathematical visualizations by in-residence math-artists.

Hack401 organized a hackathon at Skills for RI during which students learned how to produce a podcast and used their skills immediately to interview scientists at the Big Bang Science Fair. Over 30 students attended. Most were from public high schools and they were almost all students of color.

None of this would have been possible without the participation of over 250 volunteers (from Brown University, Lincoln School, Moses Brown, Wheeler School, local communities), nor the generosity of a large number of sponsors. The lead sponsors of the event were Brown University, Citizens Bank, NSF via the USCMS Experiment, and Brown Physicians, Inc.

It is hard to capture the excitement, information exchange and learning which happened at the event and the magnitude of effort which led to it. The activity leaders and core volunteers were students, professionals, scientists, artists and educators, who worked very diligently to bring this event to life.

SENIOR RESEARCH HIGHLIGHT



IDALINA ALARCON/BROWN UNIVERSITY

Harry Chalfin '20

Mathematical Physics

What research areas have you worked in and how has Brown helped prepare you for those experiences?

My physics research experience began after my freshman year at Brown when I worked in Professor Dell'Antonio's group to study dark matter using weak gravitational lensing (an effect of Einstein's theory of relativity). I then moved on to the Collider-Accelerator Department at Brookhaven National Laboratory the following year (for which my group's research was just published), and then to the X Computational Physics Division at Los Alamos National Laboratory this past summer. These experiences required a lot of computer-based calculations and algorithm writing, as well as hands-on laboratory work at Brookhaven specifically. The physics courses at Brown prepared me very well for these research jobs, particularly Professor Stein's "Experiments in Modern Physics" laboratory course and Professor Mitrovic's "Thermodynamics and Statistical Mechanics" course.

More recently, I have been working on a senior thesis project with Professor Jevicki on the AdS/CFT correspondence and holography, the encoding of information in a d-dimensional space to describe a (d+1)-dimensional system. The project has felt quite gratifying thus far, as I have always viewed myself as more of a theoretical physicist. This project is combining a wide range of material which I have studied during my time at Brown. I am very grateful to Professor Volovich for teaching me general relativity and to Professor Tan and Professor Jevicki (with whom I have taken three courses) for teaching me quantum mechanics, as those subject areas are central to my current work. Brown touts its interdisciplinary approach to education, and I can attest that the interrelation between my courses in the Departments of Physics, Math, and Computer Science has been great.

CELEBRATING 20 AND 30 YEARS OF SERVICE

IDALINA ALARCON/BROWN UNIVERSITY

Congratulations to our staff members celebrating 20 and 30 years working at Brown University. Bob Horton (Ladd Observatory Manager), Dean Hudek (Lab Physicist), Kathy Brobisky (Exec. Assistant to the Chair), and Douglas Wilkie (Dept. Manager).

The Brown Theoretical Physics Center

The Brown Theoretical Physics Center (BTPC) is a recent component of the Physics Department that was set up to foster the discovery of new knowledge at the frontiers of physics. The collaborative environment also supports the training of the next generation of theoretical physicists. The BTPC includes two Nobel laureates, a recipient of the National Medal of Science, and experts from other disciplinary subjects that connect to physics such as chemistry, mathematics, biology, and environmental science. Faculty work with undergraduate and graduate students, as well as post-doctoral researchers.

In August 2019 the BTPC expanded into the Barus Building across the street from Barus & Holley. Prior to the construction of Barus & Holley, the Barus Building contained some physics laboratories, including one run by Harrison E. Farnsworth that investigated electron diffraction. Later the building was used by the Department of Education. The 8,410 square foot space currently houses four faculty members, visiting research scientists, postdocs, and graduate students. On the first floor the "Physics Commons" serves as an informal meeting area and the "Physics Forum" located on the second floor holds formal seminars. Several research groups conduct regular meetings in the Barus facility. Nearby Barus & Holley continues to house many BTPC affiliated faculty and students.

During the 2019-20 academic year, the center hosted a variety of speakers for both in-person and virtual seminars. The presenters include Joao Magueijo (Imperial College), Sergej Moroz (TU Munich), Jim Gates (Brown University), Matthew Buican (Queen Mary University of London), Robert Brandenberger (McGill University), Daniel Butter (Mitchell Institute, Texas A&M), and Vincent Rogers (University of Iowa). Due to the COVID-19 pandemic, seminars have been held online since March.

Center postdocs have organized a journal club with speakers from within the Brown physics community. Topics have included *Chaos and Quantum Field Theory, Fluid Waves of Topological Origin*, and more. On Fridays a social hour was organized for all members to meet in a relaxed environment.

This summer, Center Director Jim Gates, Kory Stiffler, and Konstantinos Koutrolikos, along with graduate students Hazel Mak, and Yangrui Hu, hosted the Summer Student Theoretical Physics Research Session (SSTPRS) Streaming on "Aspects of Supersymmetry." Among the undergraduates participating virtually and representing their home institutions included three Brown University students, three at Caltech, one at UC-Davis, one in Abu Dhabi, and a recent mathematics major who just finished a B.S. degree program at Pepperdine University. The remainder of the twenty-two were undergraduates from the University of Maryland. Also one Brown M.S. student and one Ph.D. student participated.

A center coordinator, Victoria Kabakian, recently joined the BTPC. She relaunched the website (btpc.brown.edu), a source for relevant news, updates, and event information. The new website has become the primary resource for information pertaining to the center's past, present, and future. BTPC has also increased its social media presence with a Twitter account (@brown_tpc) that is used to announce events, research breakthroughs, and other pertinent updates.

--Victoria Kabakian

Center Director: S. James Gates
Associate Director: Brad Marston
Affiliated Faculty: Stephon Alexander, JiJi Fan, Dmitri Feldman, Andrey Gromov, Antal Jevicki, J. Michael Kosterlitz, Savvas Koushiappas, David Lowe, Robert Pelcovits, Marcus Spradlin, Chung-I Tan

IDALINA ALARCON/BROWN UNIVERSITY (2)

The Center for the Fundamental Physics of the Universe

While the black-box nature of the techniques in much of machine learning may be considered counter-cultural to traditional physics research analysis, this approach is becoming increasingly effective in finding new and imaginative ways to solve problems. Physicists are notorious for tending to pick systems apart in order to analyze them. However it's in the nature of machine learning that the details of how the algorithms work is often hidden.

The new Center for the Fundamental Physics of the Universe (CFPU) is fostering this strong interest in using machine learning through the Student Machine Learning Initiative. SMLI is led by physics graduate student conveners Bjorn Burkle, Samuel Chan, Michael Toomey, and Austin Vaitkus.

This student-driven group provides a creative environment for undergraduates, graduate students and postdocs alike to gain experience teaching each other about concepts that excite them, which in turn drive them to pursue these areas of research. "Traditionally, a physicist's view on machine learning can be a bit limited in scope," states Vaitkus. "What's really beneficial about SMLI is that it exposes physicists to applications of machine learning outside of the basic concepts. The idea is that people move past preconceived notions to discover that there are more applications than they initially thought."

These peer-guided talks present various uses of machine learning in physics that students can see, test out, and hopefully incorporate into their own research. "One interesting application of machine learning has been to distinguish between different models of dark matter from galaxy-galaxy strong lensing images," adds Toomey. "The extended arcs, known as Einstein rings, are very sensitive to substructure in dark matter halos."

Michael Toomey

IDALINA ALARCON/BROWN UNIVERSITY (2)

Toomey points out that they have used convolutional neural networks to successfully distinguish between simulated strong lensing images with different substructure, showing that this may be a powerful way to potentially identify dark matter. "One way that we are now going further, and doing something really different from what a physicist typically does, is trying to identify dark matter from a theory agnostic perspective. To do this we are now using unsupervised machine learning algorithms to learn the structure present in data without assuming a DM model."

SMLI covers a broad range of physics subfields. "Machine learning has been used in HEP for quite a few years now," says Burkle. "Boosted decision trees were implemented in analysis long before I joined the field, and deep neural networks have become the norm for jet classification. The students in HEP have a lot of machine learning knowledge, and the SMLI is a great way for us to share it with other students. Similarly, I feel like the students from HEP are actively learning about new machine learning techniques from other students at the SMLI workshops as well."

Bjorn Burkle

Undergraduate students are also getting more and more involved in SMLI. Jasper Solt was the first undergrad to present a talk for the group this summer. Solt believes machine learning is the next frontier of data analysis. "I like applying computational methods to physics problems, and trying to extract information from complex, dynamic systems." He adds, "For all the hype they get, machine learning models utilize the same linear algebra physicists use every day. It's a natural fit to use ML in physics research."

In terms of the future of machine learning in physics, Solt adds that as it is increasingly utilized for extracting information from physical data, it will undoubtedly become more and more important that there are physicists who have the computational background to understand the limitations and theory behind it. This group is doing just that by forging an opportunity for forward-thinking students to learn from each other, expanding upon their imaginative ideas to answer unexplained questions.

"We are very excited to be supporting this new initiative for our physics undergraduate, postgraduate and postdoctoral researchers at Brown. They will be better able to accelerate the application of machine learning in their astrophysics, cosmology, and particle physics research at Brown and also in their future endeavors" said Richard Gaitskell, Hazard Professor of Physics and Director of the CFPU.

Information about past and future SMLI presentations is available on the CFPU's new website (cfpu.brown.edu). This includes access to talk files, and videos from virtual events. The website also provides other event information for center-sponsored seminars, group research, and more. SMLI is also working with the Brown Data Science Initiative and the Center for Computation and Visualization to provide further workshop and seminar opportunities for the CFPU students.

--Victoria Kabakian

Center Director: Richard Gaitskell
Affiliated Faculty: Stephon Alexander, David Cutts, Ian Dell'Antonio, JiJi Fan, Ulrich Heintz, Savvas Koushiappas, Greg Landsberg, Jonathan Pober, Greg Tucker

NSF-FUNDED BROWN, DARTMOUTH RESEARCHERS TO EXPLORE MATERIALS, MATTER STATES FOR QUANTUM TECHNOLOGIES

By Kevin Stacey

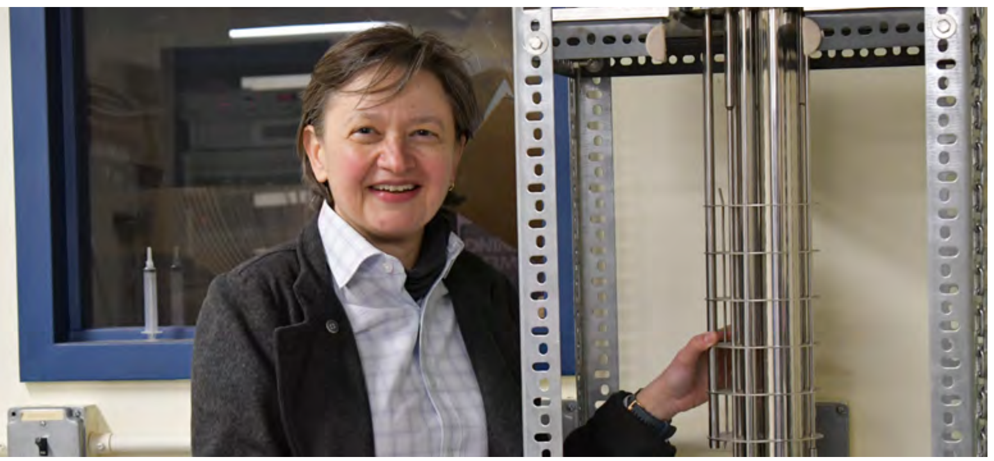
A $4 million grant from the National Science Foundation will support research aimed at developing a fundamental understanding of quantum systems to enable new quantum technologies. Quantum technologies have the potential to spur revolutions in computing, sensing, cryptography and beyond. With a $4 million grant from the National Science Foundation, a team of researchers from Brown University and Dartmouth College will work to better understand the materials and the exotic quantum states that make these technologies possible.

"We're trying to understand these quantum materials and complex quantum states on a fundamental level that enables us to control and manipulate them in useful ways," said Vesna Mitrović, a professor of physics at Brown and principal investigator on the grant. "This new understanding will help us to identify which of these materials or states is useful for which applications, which in turn will help us to move quantum technology forward."

Quantum technologies make use of the often peculiar rules that govern the behavior of individual particles. In the quantum world, particles can behave as if they are in more than one state at a given time, and influence each other's behavior even if they are far away in space. By taking advantage of those properties, quantum computers can process information in new ways, potentially performing calculations far beyond the reach of even the fastest of today's supercomputers. Quantum sensors far more powerful than those used today could be useful in applications ranging from medicine to seismology. And quantum cryptography could lead to intrinsically secure communication.

> "This new understanding will help us to identify which of these materials or states is useful for which applications, which in turn will help us to move quantum technology forward."
> -Vesna Mitrovic

For all the promise, however, there are obstacles to overcome before these quantum technologies deliver their full potential. One problem is that quantum states are extremely fragile — the slightest disturbance can destroy them. And scientists still don't fully understand how to model the complex correlations between particles in quantum systems. Those microscopic correlations are critically important, because they ultimately determine the properties of a material at the macroscopic scale. Under this grant, the Brown-Dartmouth team will use a novel approach in which today's small quantum computers are combined with large-scale classical computing resources to study quantum materials and complex quantum states in microscopic detail. Experimental studies of existing materials will be combined with machine learning and artificial intelligence tools to inform the design of new materials, whose properties depend on correlated quantum states that are not so fragile. "The ability to measure these correlations gives us the ability to better understand and control these quantum states," Mitrović said. "That could enable the design of new technologies including error-tolerant quantum computers, for example."



Mitrović is an expert in using a technique known as nuclear magnetic resonance to probe quantum states of materials. For the grant, she'll work with fellow Brown theorists and professors Dima Feldman and Brad Marston. The Dartmouth team is led by experimentalist Chandrasekhar Ramanathan and theorist James Whitfield. The team also includes experts in computer science and quantum physics. "By leveraging their complementary expertise — quantum materials at Brown and quantum information science at Dartmouth — the grant will enable the creation of a New England center of excellence at the nexus of quantum and data sciences, both areas of national priority for science and technology development," Ramanathan said. "This collaboration will allow us to tackle some of the hard problems that stand in the way of deploying quantum technologies."

The combination of quantum information science and data science developed by this research could have broad impacts that benefit society, the researchers believe. And Mitrović said she's excited to work with this group of colleagues on this project. "If you asked me to assemble the dream team of researchers to approach this problem, this would be the exact group I'd put together," she said. "It's exciting because I think we can make genuine progress on this."

The grant is part of NSF's Established Program to Stimulate Competitive Research (EPSCoR) designed to promote scientific progress nationwide (Grant No. 1921199). The grant will fund efforts in Rhode Island and New Hampshire to attract investment, cultivate research talent and create new data science training programs.

KEMP PLUMB EARNS PRESTIGIOUS EARLY CAREER GRANT FROM U.S. DEPARTMENT OF ENERGY

By Kevin Stacey

The five-year, $750,000 award will help Kemp Plumb study exotic states of matter that emerge in certain magnetic materials. Kemp Plumb, an assistant professor of physics at Brown University, is one of just 76 scientists nationwide selected to receive a 2020 Early Career Award from the U.S. Department of Energy (DOE).

The awards, which provide $750,000 over five years, aim to "bolster the nation's scientific workforce by providing support to exceptional researchers during crucial early career years, when many scientists do their most formative work," according to a June 23 announcement of the recipients from DOE.

In his lab at Brown, Plumb and his students study exotic states of matter that emerge in magnetic materials. In particular, he's interested in a theoretical state known as a quantum spin liquid, which is formed by the peculiar interactions between electrons in certain materials.

Every electron has a tiny magnetic moment that points in a particular direction, a property known as spin. In a quantum spin liquid, these spins remain "fluid" — able to fluctuate — even down to temperatures near absolute zero. In addition, the spins of all the electrons are highly correlated to each other throughout the material. These complex spin interactions can give rise to all sorts of strange physics, including quasi-particles that behave as if they were a fraction of an electron.

IDALINA ALARCON/BROWN UNIVERSITY

IDALINA ALARCON/BROWN UNIVERSITY

There is hope that quantum spin liquids may one day be used in quantum computing or other information technologies, but much more work is required first to better understand their fundamental properties. Plumb will use his Early Career Grant to work on just that. The funding will help Plumb and his students produce materials that are considered to be good candidates for quantum spin liquids, as well as to travel to the U.S. National Laboratories that have the specialized equipment used to study them.

"One of the exciting things about studying these exotic states is that they become little universes of their own, where you can explore the implications of this many-body entanglement," Plumb said. "By supporting us to make these materials and study them in state-of-the-art labs, this grant gives us the opportunity to do the long-term fundamental science involved in understanding these materials."

$2 MILLION GRANT WILL SUPPORT DEVELOPMENT OF 'MAGNETIC CAMERA'

By Kevin Stacey

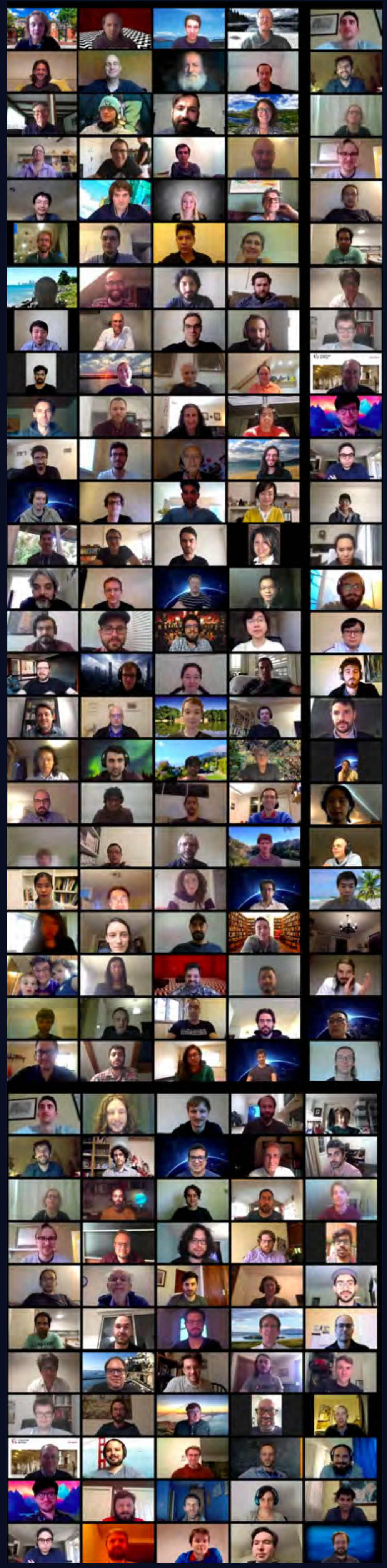
A team of Brown University researchers will use a $2 million grant from the National Science Foundation to build a quantum mechanical magnetic camera, which will take snapshots of weak magnetic fields emanating from quantum materials. The camera will help researchers to understand the exotic materials that may one day be used in quantum computers and other quantum devices.

"Just as the camera on your phone has an array of photosensors that register light and create an image, our device will use magnetic sensors that can 'see' magnetic fields and make images or movies of magnetic patterns," said Gang Xiao, chair of the physics department at Brown and principal investigator on the new grant. "We can learn a lot about quantum materials by observing in great detail the magnetic fields they produce, and that's what this device will let us do."

Quantum technologies make use of the often-peculiar behavior of individual subatomic particles. Harnessing that behavior could create computers than can perform calculations far beyond the reach of even the fastest of today's supercomputers, sensors far more powerful than those used currently and potentially unbreakable encryption modes. Making these quantum tools work depends on a deeper understanding of how particles in quantum systems interact. Magnetic fields offer a window into those interactions, and the magnetic camera could potentially reveal the intricacies of those fields.

The challenge is making the device sensitive enough to register the ultra-weak magnetic signals generated by many quantum materials. To do that, the researchers will have to improve magnetic tunnel junctions (MJTs), tiny quantum mechanical sensors currently used to read information from computer hard disks. Xiao, who has studied MTJs and related nanoscale magnetic phenomena for years, will lead the team in investigating new materials for assembling MJTs and work with electronics experts to build specialized circuitry around them.

Joining Xiao on the team are three experts in quantum materials and phenomena: Vesna Mitrovic, Brad Marston and Kemp Plumb from Brown's physics faculty. They'll work with Professor of Engineering Alexander Zaslavsky and Senior Research Engineer William Patterson, both microelectronics experts.



GOING VIRTUAL :
THE 9TH N.E. STRINGS MEETING // // ZOOMPLITUDES 2020

By Anastasia Volovich

Among the many sudden changes necessitated by the COVID-19 pandemic was that of changing the format of conferences and workshops to allow for fruitful exchange and discussion of scientific ideas while maintaining social distancing. Two physics conferences held at Brown this spring charted new waters in this regard, and introduced new ideas that subsequently influenced conferences organized elsewhere.

THE 9TH N.E. STRINGS MEETING

The first of these was the Ninth New England String Meeting on April 24. This series of meetings has been held at Brown on a quasi-regular basis since 2006 and serves the regional theoretical physics community. The meetings consistently attract around 75 participants for a day of enjoyable and informative lectures. Originally scheduled to be an in-person event as usual, the meeting was moved online via Zoom, and also live-streamed on YouTube. The online format allowed the conference to reach a much wider audience than it would have otherwise, with a peak attendance of around 425 on Zoom, and over 700 unique participants connecting for at least part of the day.

This year's meeting featured talks by Juan Maldacena (IAS) on "Comments on Magnetic Black Holes," Mirjam Cvetic (University of Pennsylvania) on "Constraints on Standard Models in F-theory," Netta Engelhardt (MIT) on "Models of Black Hole Evaporation," Herman Verlinde (Princeton University) on "ER=EPR, Replica Wormholes and a New Holographic Conjecture," Matthew Headrick (Brandeis University) on "Bit threads for Multiple Regions," Xi Yin (Harvard University) on "D-instantons and the Non-perturbative Completion of c=1 String Theory," and Davide Gaiotto (Perimeter Institute) on "Twisted M-theory and Holography."

One topic that elicited considerable attention in several talks and subsequent discussions was the black hole information paradox. This problem has seen progress in the past couple of years, with recently developed methods for computing the von Neumann entropy of gravitational systems showing that the entropy of Hawking radiation of a black hole does decrease to zero as the black hole evaporates, as would be expected from unitary evolution in quantum mechanics. Slides and videos of all the talks can be found online at bit.ly/NEString2020.

ZOOMPLITUDES 2020

The second high energy theory conference hosted by Brown was Amplitudes 2020, held during the week of May 11-15. This was the 12th in a series of annual meetings that bring together a community of physicists and mathematicians to showcase the most recent developments in expanding our understanding of formal and phenomenological aspects of scattering amplitudes in quantum field theory. When the conference, originally scheduled to be held in person at the University of Michigan, was canceled due to COVID-19, Professor Anastasia Volovich stepped up to the plate, volunteering as "Zoomganizer" to bring the conference, re-dubbed Zoomplitudes 2020, online through Brown.

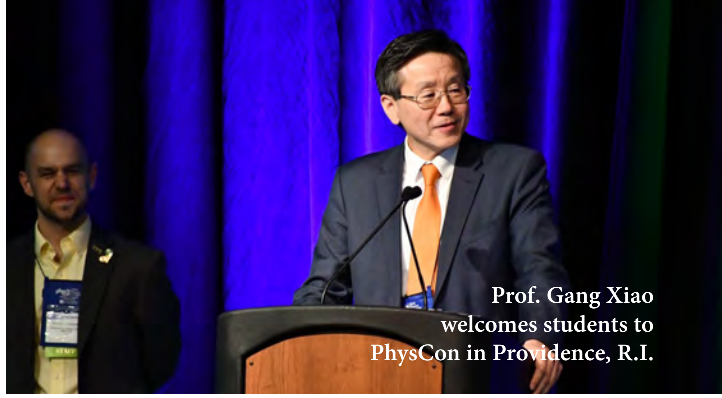
The conference opened on May 8 with special guest speaker Nima Arkani-Hamed (IAS) leading a 14-hour lecture series "Master Class: Spacetime and Quantum Mechanics, Positive Geometries and Cluster Algebras" via Zoom. Professor Arkani-Hamed certified it as the longest continuous lecture series he has given (though not by a wide margin).

Zoomplitudes proper featured 49 talks by speakers from around the world spaced out over a five-day period. The talks covered a wide range of subjects, from the LHC to LIGO to mathematical aspects of amplitudes. It attracted an audience of up to 600 unique Zoom participants per day, and up to 300 additional viewers of the YouTube livestream arranged by graduate student Anders Schreiber. Conference participants were able to discuss the talks in real time using the Zoom chat. In addition, a Slack workspace dedicated to the conference allowed for in-depth on-line discussion of many topics raised at the conference. With luck, the Amplitudes series will continue in-person at the Niels Bohr Institute in Copenhagen in August 2021. Slides and videos of all the talks can be found online at bit.ly/ZOOMPLITUDES.

The 9th N.E. String Meeting was organized by Professors Marcus Spradlin and Anastasia Volovich, and graduate student Anders Schreiber. Zoomplitudes 2020 was organized by Professor Anastasia Volovich.

COURTESY ANASTASIA VOLOVICH

2019 PHYSCON



Prof. Gang Xiao welcomes students to PhysCon in Providence, R.I.

Dame Susan Jocelyn Bell Burnell

IDALINA ALARCON/BROWN UNIVERSITY (4)

"I am always excited to see the young people at PhysCon and the things they are working on. They are awesome and inspiring." -S. James Gates

Sigma Pi Sigma, the physics honor society, brought together physics and astronomy students, alumni, and faculty to Providence for the 2019 Physics Congress (PhysCon).

The three day meeting included panel discussions, interactive demonstrations, tours, career development workshops, and networking opportunities. PhysCon is the largest gathering of undergraduate students in the world.

According to S. James Gates, Ford Foundation Professor of Physics, this year's forum provided a unique opportunity for Brown Physics to demonstrate its many strengths to the larger physics community. "I am always excited to see the young people at PhysCon and the things they are working on. They are awesome and inspiring. I am so happy the event was in Providence this past year and Brown was able to be part of the program so they could see all the amazing things we are doing here."

Plenary speakers included Professor Gates, Dame Susan Jocelyn Bell Burnell who is credited with first discovering pulsars, Sandeep Giri (Google X Manager), John C. Mather (2006 Nobel Laureate), William D. Phillips (1997 Nobel Laureate) and Professor Ellen D. Williams (Distinguished University Professor, University of Maryland). Jami Valentine Miller ScM '98 (Primary Examiner, United States Patent and Trademark Office) who was the first African American female graduate student in the Physics Department also spoke. Dean Hudek, Brown's Director of Instructional Laboratories, and Dr. Phillips hosted two physics demo shows on campus.

Students participated in a wide variety of breakout sessions including workshops on science policy, inclusivity, climate change, mentoring, and careers in physics. Professor Stephon Alexander also led a workshop on the physics of jazz, in which he explained how John Coltrane was inspired by Albert Einstein's general theory of relativity to put physics and geometry at the core of his music. Alexander focused on a mysterious mandala drawn by Coltrane. "What the Coltrane mandala made me realize was that improvisation is a characteristic of both music and physics. Much like Einstein working with his gedankenexperiments (thought experiments), many jazz improvisers construct mental patterns and shapes when they solo. I suspect that this was true of Coltrane."

PhysCon 2019 was attended by nearly 1,500 students from around the world.

--Willis Peter Bilderback

STUDENT SPOTLIGHT

Natalie Rugg '21
DUG Coordinator

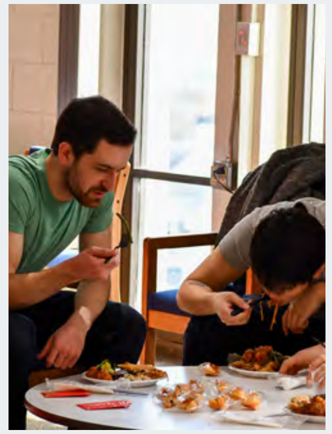
Is this an experience you would recommend to your peers?
Absolutely. I learned so much about the possible pathways through physics. Coming from a first-gen background, the concept of attending graduate school was completely alien to me. I learned so much from the graduate school panel, such as the application process, the day-to-day life of a grad student, and the reasons one might want to attend grad school.

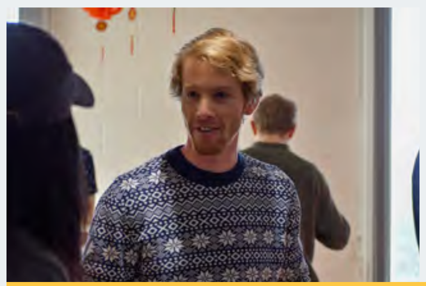
What was it like to meet influential physicists?
When I heard Dame Jocelyn Bell Burnell was a plenary at PhysCon, I knew I had to attend. She was someone I'd read about in textbooks and whose research won a Nobel Prize. I was so excited to volunteer with her in the days leading up to PhysCon. She was kind and witty, and it was unexpected how down-to-earth she was even with being so influential in modern astrophysics.

CONFERENCES & EVENTS

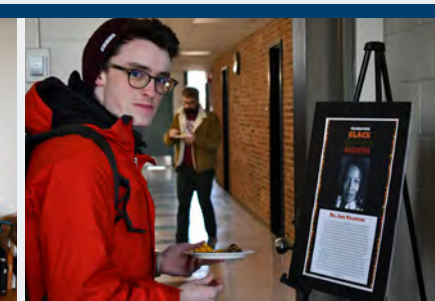
Lunar New Year Celebration

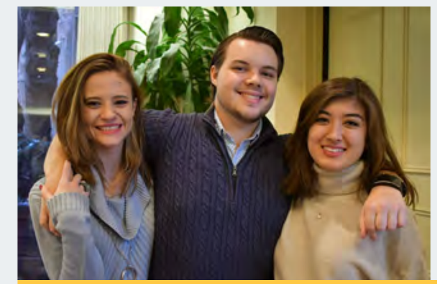






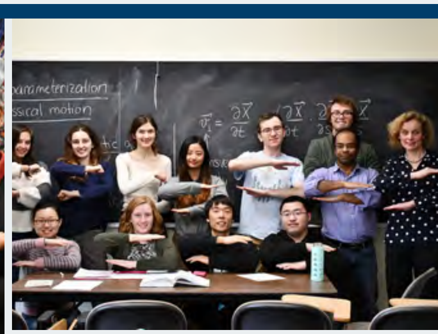
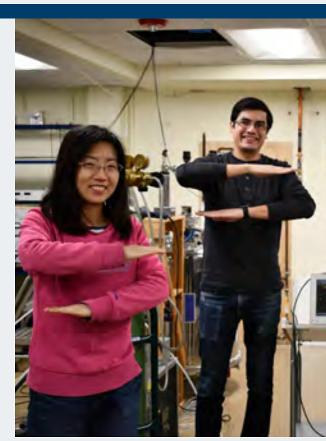
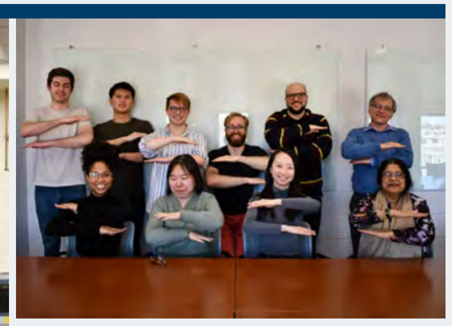
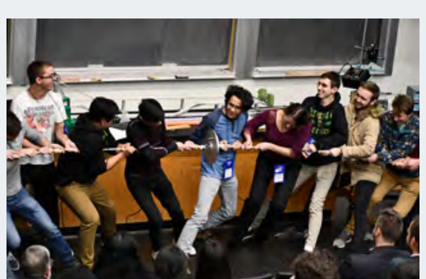
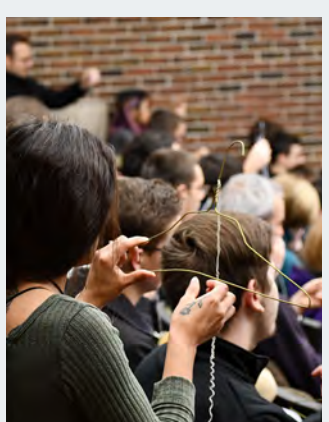
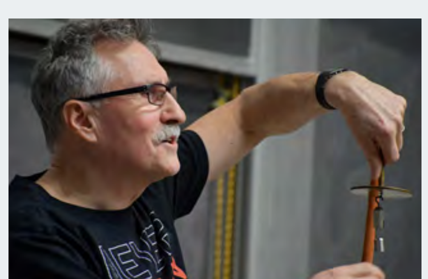
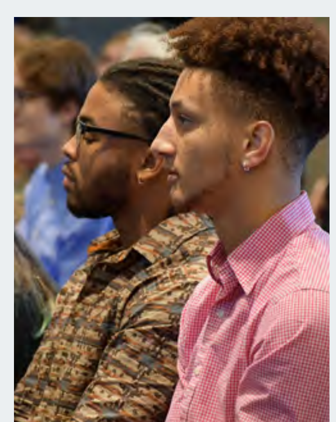

Black History Month Celebration


Holiday Party

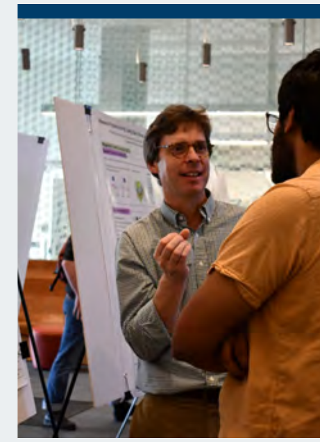
International Women's Day

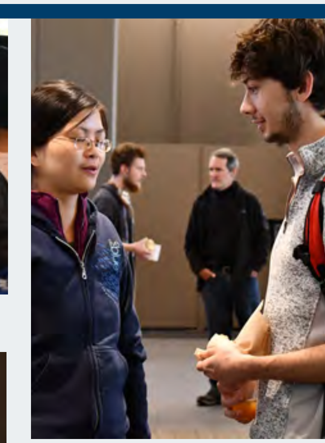









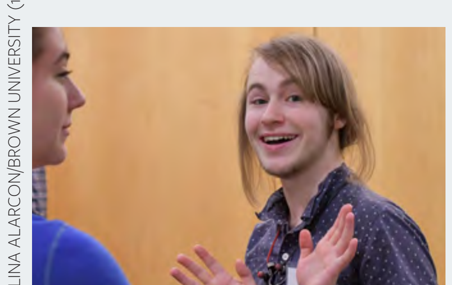
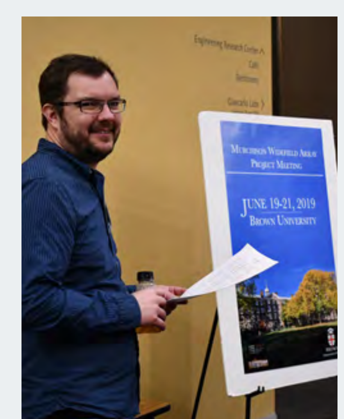
PhysCon

IDALINA ALARCON/BROWN UNIVERSITY (16)

Poster Session





MWA Conference

IDALINA ALARCON/BROWN UNIVERSITY (16)

ALUMNI HIGHLIGHTS

COURTESY NATALIE RUGG

COURTESY GANG XIAO

Jami Valentine Miller ScM '98

Jami Valentine Miller was born in Philadelphia, PA. She earned a bachelor's degree in physics from Florida A & M University and a master's degree in physics from Brown University, working in Professor Jim Valles' lab. In 2006 Jami became the first African American woman to earn a PhD from the Department of Physics and Astronomy at the Johns Hopkins University. Her dissertation research was on the "Spin Polarization Measurements of c-Axis Epitaxial Rare Earth Thin Films."

While she was a graduate student in the department at Hopkins, she realized that there were very few professors who looked like her. When she learned that only fewer than 100 African American women had ever earned a PhD in physics, she began to keep track of them. This was the beginning of what would eventually become AAWIP.com, a website dedicated to celebrating African American women in physics. The goal of the website is to honor the women who paved the way, to inspire future physicists and to connect with people interested in promoting diversity in physics and other STEM fields.

Dr. Valentine Miller joined the U.S. Patent and Trademark Office in July 2006 as an electrical engineer. She examines semiconductor patent applications related to phase-change memory, nanosacale memory and spintronic memory devices.

Charles Kocher '19

Charles Kocher graduated in 2019 with a degree in Mathematical Physics. He is currently a PhD student at Stony Brook University.

While at Brown, why did you choose to concentrate in Physics?

The thing I like most about physics is that, starting from a few general ideas about how the universe should work and what the laws of nature might look like, you can get quantitatively correct descriptions of a wide range of phenomena. My professors at Brown really emphasized this process of modeling the complexities of reality using simple physical models, making my time in the Physics Department a very rewarding intellectual experience. It was a bonus that all of my professors were so passionate about teaching the subject.

What research areas have you worked in and how has Brown helped prepare you for those experiences?

While still at Brown, I worked on dark matter direct detection with Professor Rick Gaitskell and quantum chaos with Professor Antal Jevicki. During my research I was able to develop the necessary computing skills to get a SULI internship at Brookhaven National Lab during the summer between my junior and senior years. Throughout my time at Brown, I was able to acquire the various skills necessary for research, like coding and preparing talks, that you cannot really learn in the classroom. Combined with the solid training in foundational physics that I received in my classes, I feel like I will be able to transition smoothly to research when I finish graduate classes and begin working with a research group.

Can you share about the research you have been working on?

My work with Michael McGuigan focused on using IBM's currently available quantum computer to simulate various physical systems. Ordinary computers perform operations and store information using strings of bits, which are binary numbers that can either be 0 or 1. A quantum computer replaces each bit with a two-state quantum system, known as a qubit. Each qubit can be in the state 0 or in the state 1 like a bit, but since it is a quantum system it can also be in some superposition of the two states. Calculations are done by performing experiments on these qubits and measuring the outcomes. The superposition feature of qubits, which is a purely quantum effect, allows quantum computers to be much more potent than conventional supercomputers. We cannot currently make quantum computers big enough to actually be faster than the best supercomputers we have now, but there is a growing community of scientists working toward this goal. IBM is one of the major groups spearheading quantum computing research. At the time of my internship at Brookhaven, IBM had a few quantum computers of up to 50 qubits in size available for researchers to use. We wrote some programs for these computers that ran the variational method, a standard approximation tool in quantum mechanics, to find ground state energies for some traditionally studied quantum mechanical systems. It turns out that these systems are mathematically similar to some systems that you get from the Wheeler-DeWitt equation of quantum cosmology, which is one attempt at unifying quantum mechanics and general relativity. So, our research culminated in using a handful of very tiny quantum mechanical systems to study the dynamics of the whole universe, which is pretty cool to think about.

ALUMNI NEWS

COURTESY GREG LANDSBERG

THE BROWN CLUB OF SWITZERLAND AT CERN

Professor Greg Landsberg led a tour of the CMS detector site for twelve Brown Alumni in Geneva, Switzerland. The tour ended with a lecture on "Large Hadron Collider: Past, Present, and Future."

WELL WISHES FOR THE *Class of 2020*

Congratulations to you all! Times may be tough, but you are the future of physics, and we are all cheering for you.
Michael Ogilvie PhD '80

I know this probably wasn't the senior spring you expected, but congratulations! Welcome to the Brown Physics alumni!
Miriam Klein '09

A good job requires the right and proper tools. You have acquired the highest quality means of following your intended profession through your Brown education. Congratulations! Go get 'em, Bruins!
Bob Burnham '56

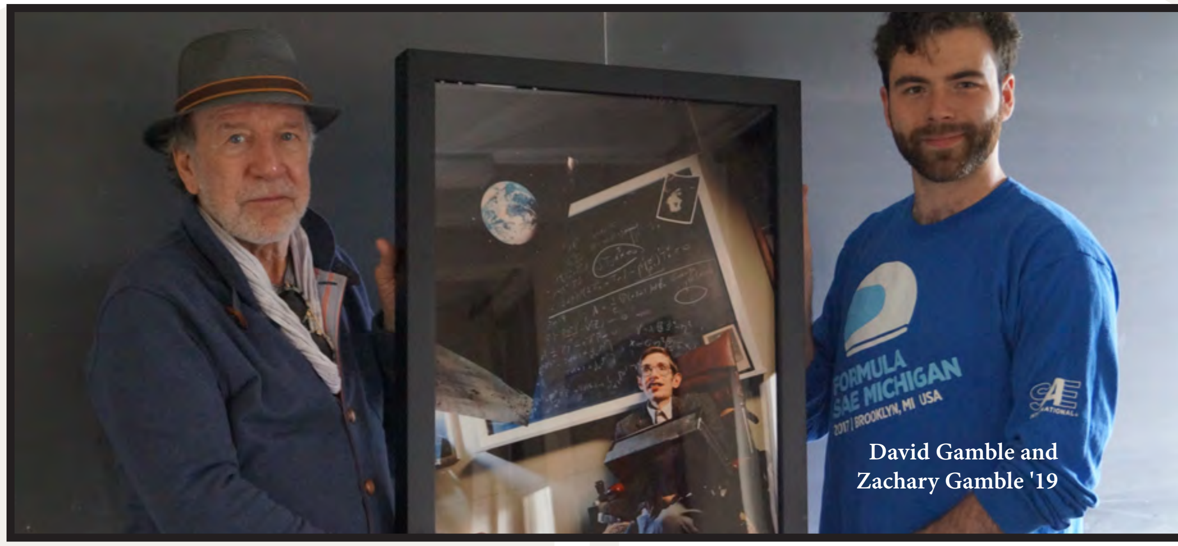
Congratulations class of 2020! Greetings from Munich, Germany.
Alex Loosley '15

Congratulations! Best of wishes on what's next, I hope you find your physics education to be fruitful in many different ways as I have!
David Turbay '13

Congratulations on your hard work and getting through a challenging finish to your years at Brown. I graduated more than 50 years ago and went on to earn M.A. and Ph.D degrees from the University of Virginia. My career took directions I could not have foreseen half a century ago and I have witnessed amazing advances in science and technology. As you go through your careers you may be on the cutting edge of similar remarkable achievements which will change the world. Best wishes and good luck.
Charles Smith '67

STEPHEN HAWKING PRINT DONATION

Artist David Gamble
In Memory of David Fox



David Gamble and Zachary Gamble '19

JESSICA PONTARELLI/BROWN UNIVERSITY

The Physics Department is honored to recieve an original Stephen Hawking print by artist David Gamble, donated in memory of his father David Fox. Fox was a good friend of Professor Leon Cooper and attended several astronomy courses in the department. He and his grandson Zachary Gamble '19 frequently visited Ladd Observatory for stargazing nights, often bringing their own telescope to view the night sky. In 2017 Fox organized a group trip, which hosted several Ladd staff members and physics faculty, to view the eclipse. Over the course of his life he traveled around the world to view over seventeen eclipses. The print will hang in the entry hall of Ladd and visitors are welcome to stop by on a Tuesday night when the facility reopens to view this generous gift.

David Gamble is a multidisciplinary artist from London, now based in New Orleans, LA. His body of work consists of paintings, works on paper, and photographs, all of which have been exhibited globally. Over his decades-long career spanning the commercial, journalistic, and fine art realms, Gamble has photographed such illustrious figures as Stephen Hawking, Margaret Thatcher and the Dalai Lama. In 1987, Gamble won the Kodak Award for Best Photographer in Europe as well as a World Press Photo Award in 1988 for his portrait of Stephen Hawking, which was used as the notable cover of Hawking's "A Brief History of Time." He continues to pursue both photographic and painting projects.

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Comet Neowise. Photo taken on July 15, 2020 from Shippee Sawmill Pond in Foster, RI. ROBERT HORTON/BROWN UNIVERSITY