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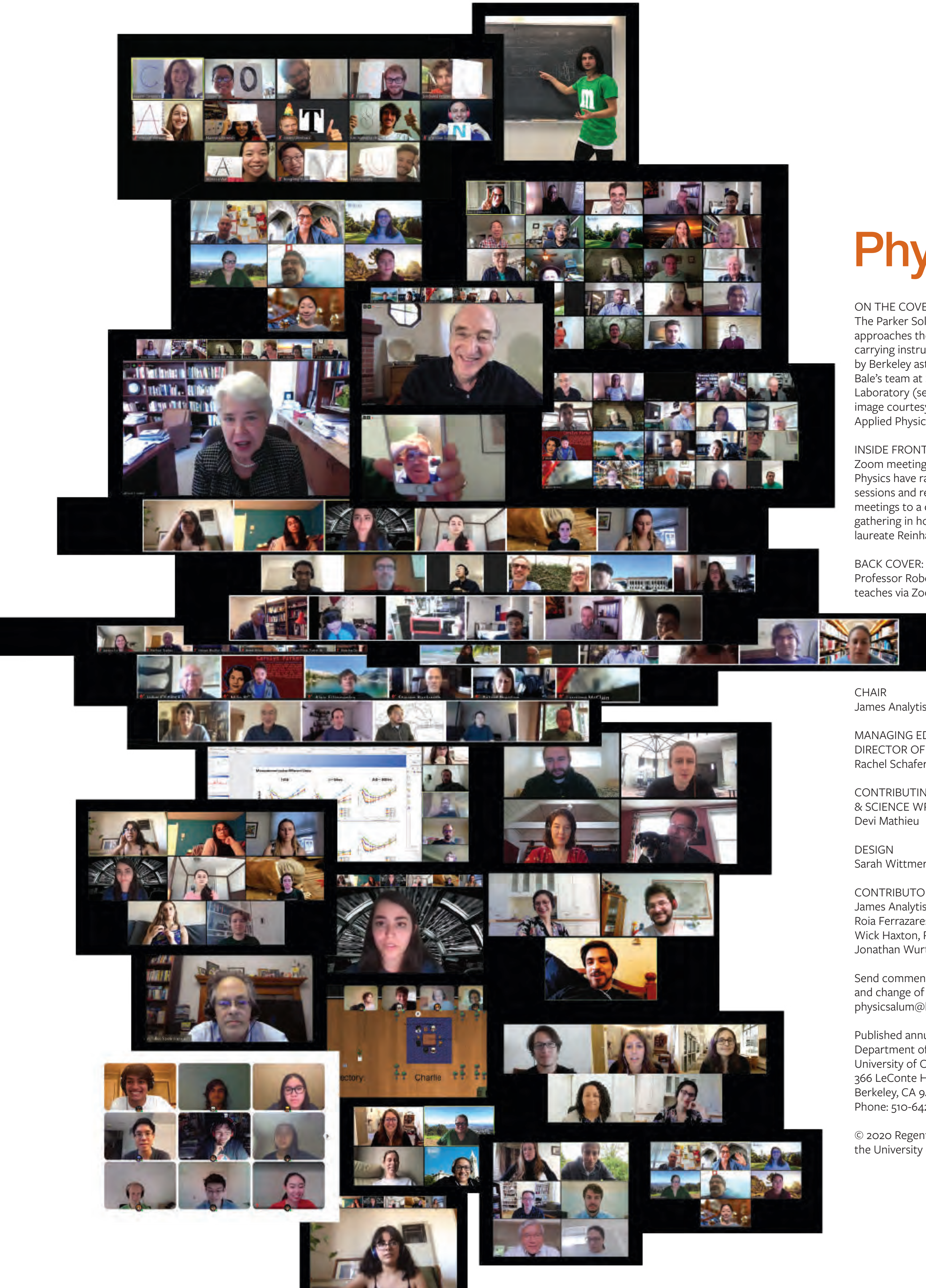
FALL 2020

Diving into the Sun

Astrophysicists from Berkeley's Space Sciences Lab search for the origins of the solar wind



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ON THE COVER:
The Parker Solar Probe approaches the sun's corona, carrying instruments designed by Berkeley astrophysicist Stuart Bale's team at Space Sciences Laboratory (see page 4). Cover image courtesy Johns Hopkins Applied Physics Laboratory

INSIDE FRONT COVER:
Zoom meetings in Berkeley Physics have ranged from teaching sessions and research group meetings to a congratulatory gathering in honor of 2020 Nobel laureate Reinhard Genzel.

BACK COVER:
Professor Robert Birgeneau teaches via Zoom in 1 LeConte Hall.

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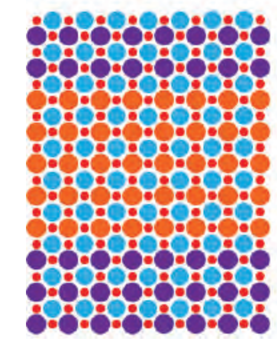
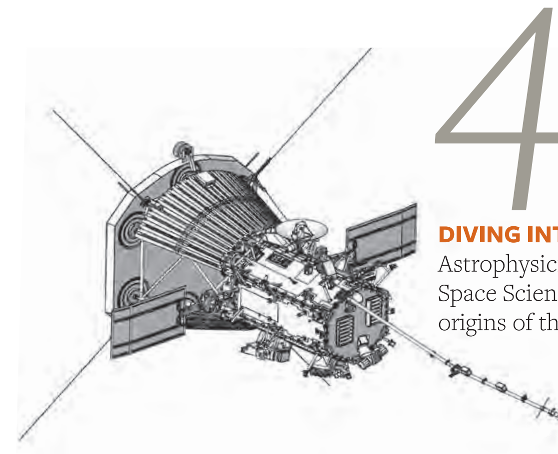
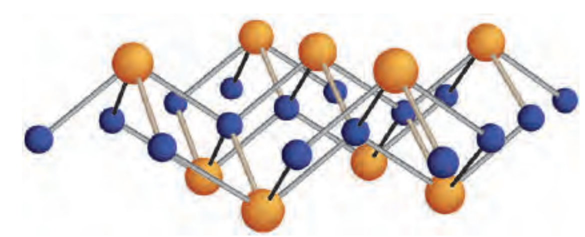






CHAIR'S LETTER

The last eight months have transformed the world, and Berkeley Physics has not been exempt. Each and every one of us played a part in lifting up our community, supporting each other as we went into quarantine, reimagining teaching practices to educate our students, and transforming research procedures so we could safely continue to push the boundaries of knowledge. And we will continue to rely on one another as we face the challenges ahead (see p 14).

Berkeley Physics is answering the call for more diversity within our community, by improving our engagement with underrepresented groups at all academic levels and by creating a welcoming, dynamic environment where everybody is empowered to contribute to the pursuit of knowledge. Science thrives on the diversity of ideas, and together we strive to help every member of our community bring their best ideas to life (see p 11).

Through our collective efforts, Berkeley Physics remains at the global forefront of science. Rankings of physics programs around the world place us in the top three in the US, ahead of some of the nation's best private universities. This has helped us expand our international partnerships, offering our students a world-class education.

For the 2020-2021 academic year we are serving 274 graduate students and more than 320 physics majors, connecting them to a network of the greatest minds in physics. We welcome our new Visiting Miller Professor, Immanuel Bloch from Ludwig-Maximilians University Munich.

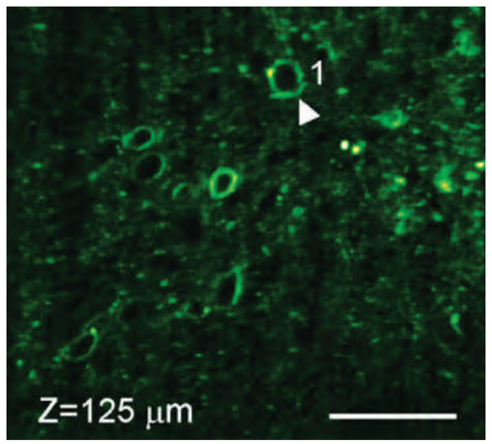
More than 20 of our faculty were recently honored with international awards, including the 2020 Nobel Prize in Physics to Reinhard Genzel, for his pioneering work in the observation of black holes (see p 3). In these footsteps follows Geoff Penington, the youngest addition to our ranks, with his recent award of the 2021 New Horizons Physics Prize for his calculations of the quantum information contained in a black hole and its radiation. Thus continues our long tradition of attracting the most promising young physicists from across the globe to mentor our students and build cutting-edge research programs.

As Chair, I am excited to do my part in bringing us together as a community and optimistic that we will answer the challenges and make the most of the opportunities that lie ahead.

James Analytis, Chair

Research Highlights

High-speed microscope captures fleeting brain signals



CREDIT: NA JI

Electrical and chemical signals flash through our brains constantly as we move through the world, but it would take a high-speed camera and a window into the brain to capture their fleeting paths. Berkeley investigators have now built such a camera: a microscope that can image the brain of an alert mouse 1,000 times a second, recording for the first time the passage of millisecond electrical pulses through neurons.

"This is really exciting, because we are now able to do something that people really weren't able to do before," said lead researcher **Na Ji**, a UC Berkeley associate professor of physics and of molecular and cell biology.

The new imaging technique combines two-photon fluorescence microscopy and all-optical laser scanning in a state-of-the-art microscope that can image a two-dimensional slice through the neocortex of the mouse brain up to 3,000 times per second. That's fast enough to trace electrical signals flowing through brain circuits.

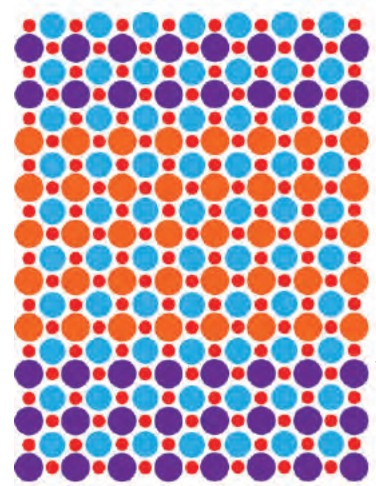
With this technique, neuroscientists like Ji can now clock electrical signals as they propagate through the brain and ultimately look for transmission problems associated with disease.

The typical method for recording electrical firing in the brain, via electrodes embedded in the tissue, detects only blips from a few neurons as the millisecond voltage changes pass by. The new technique can pinpoint the actual firing neuron and follow the path of the signal, millisecond by millisecond.

Left: Rapid imaging – a thousand times per second – shows spontaneous electrical activity in neurons inside the brain of an alert mouse.

Above right: Diagram of Van Hove singularity (VHS) shown approximately 1 nanometer below the surface of an oxide heterostructure made of atomically thin layers of strontium titanate and samarium titanate. Purple dots represent samarium; orange represents strontium; light blue represents titanium; and small red dots represent oxygen.

Searching for Silicon's Successor in the Race Against Moore's Law



CREDIT: RYO MORI/BERKELEY LAB

Berkeley scientists have developed a technique that could lead to new electronic materials that surpass the limitations imposed by Moore's Law, which predicted in 1975 that the number of transistors packed into a tiny silicon-based computer chip would double every two years.

The technique was developed by a research team led by **Alessandra Lanzara**, Berkeley's Charles Kittel Professor in Physics, a senior scientist at Berkeley Lab, and director of the Center for Sustainable Materials and Innovation. Her team's findings suggest the first system that could serve as a platform for investigating the control of novel electronic phases at the interfaces between atomically thin, two-dimensional (2D) layers.

Lanzara's group directly measured the electronic structure of electrons confined between layers of two insulating materials — a band insulator, strontium titanate, in which the insulating state is driven by electron-ion interactions, and a Mott insulator, samarium titanate, with an insulating state driven by strong electron-electron interactions. The team used a technique called angle-resolved photoemission spectroscopy (ARPES) at Berkeley Lab's Advanced Light Source.

Very little is known about how to control the electronic properties of these 2D structures, because few techniques can probe below the interface. By probing at a depth of approximately 1 nanometer inside the sample, the Berkeley team discovered two unique properties physicists have long considered important features for tuning superconductivity and other exotic states in electronic materials – emergence of a saddle point in the density of states (known as a Van Hove singularity) and an electronic topological transition in momentum space.

Reinhard Genzel Wins Nobel Prize

CREDIT: MATTHIAS BALK/DPA VIA AP

Reinhard Genzel, professor emeritus of physics and astronomy at UC Berkeley and director of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, will share half the 2020 Nobel Prize in Physics with UCLA professor Andrea Ghez "for the discovery of a supermassive compact object at the center of our galaxy."

The other half of the prize goes to United Kingdom theoretical physicist Roger Penrose "for the discovery that black hole formation is a robust prediction of the general theory of relativity."

In 1969, Donald Lynden-Bell and Martin Rees suggested that the Milky Way galaxy might contain a supermassive black hole at its center, but evidence was lacking because the galactic core is obscured by interstellar dust. At the time, Genzel was a postdoctoral fellow at UC Berkeley working with the late Nobel laureate **Charles Townes**.

Genzel credits Townes for initiating the studies that led to the Nobel-winning discovery. "Charlie Townes' dream was to do this experiment we have done, already in the 1970s," Genzel said. "And he, in fact, did these fantastic, pioneering experiments. But (when he saw) the results, he knew he would never get to the galactic center, which was a real disappointment to him."

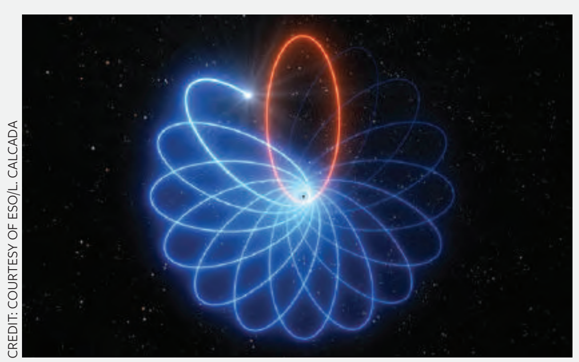
It was up to Genzel to create a team to improve detectors one hundred thousandfold to be able to track stars with such precision that they could essentially measure the concentration of mass in the galactic center. Genzel's team cemented their assertions in 2002.

On October 6, the day of the award announcement, Berkeley Physics hosted a Zoom gathering to enable colleagues and friends in Berkeley to congratulate Genzel, who was in Munich. The conversation was facilitated by Nobel laureate **Saul Perlmutter**, professor of physics at Berkeley, director of the Berkeley Institute for Data Science, and leader of the Supernova Cosmology Project. Speaking to Genzel of his relationship with Townes, Perlmutter said, "The heritage that you have, of following from one Nobel laureate to another at Berkeley, is a great story."

Both Genzel and Ghez use adaptive optics to sharpen telescope images of the galactic center. The two teams ran neck and neck for decades, each spurring the other to greater precision and, eventually, to certainty that the heavy object at the galactic center could be nothing other than a supermassive black hole, some 4 million times more massive than our sun.

"I very much appreciated the competition," Genzel said. "It was initially very much of an advantage." Ghez's team also welcomed the competition, said **Jessica Lu**, a UC Berkeley associate professor of astronomy who has been part of Ghez's team since her days as a UCLA graduate student in 2003."That spirit of competition really led us all to be better."

"Genzel and Ghez have, for years, provided the best – and ever-mounting – evidence for the existence of a supermassive black hole," said **Chung-Pei Ma**, who studies black holes in distant galaxies. Ma is Judy Chandler Webb Professor in the Physical Sciences and UC Berkeley professor of astronomy and physics. "This is a beautiful example of what perseverance, curiosity, and technology can come together to achieve."



CREDIT: COURTESY OF ESO/L. CALCADA

CREDIT: UC BERKELEY

Above: UC Berkeley's Reinhard Genzel, an emeritus physics professor, won the Nobel Prize in Physics for proving that a black hole lurks at the heart of the Milky Way galaxy.

Below, top: Observations by Genzel's team of the stars orbiting the black hole at the center of the Milky Way galaxy confirm predictions of Einstein's general theory of relativity: that the stars' orbits will precess, or follow a rosette pattern instead of an ellipse. This artist's impression exaggerates the precession of a star's orbit for ease of illustration.

Below, bottom: 2020 Nobel laureate Reinhard Genzel, right, posing in 2003 with his mentor, Charles Townes, who won a Nobel Prize in Physics for the invention of the laser. Townes, who passed away in 2015, and Genzel collaborated on some of the first observations of the galactic center, later shown by Genzel and Nobel co-winner Andrea Ghez to host a supermassive black hole.

Parker Solar Probe is a heroic feat of thermal engineering capable of operating in the turbulent inferno of the solar corona, where plasma temperatures can top a million degrees Fahrenheit. The spacecraft is set to make a series of 24 ever-deeper forays into the corona by June of 2025. It will also complete seven separate flybys of Venus to periodically tighten its orbit and pull it progressively closer to the solar surface. Named for astrophysicist Eugene Parker, who predicted and explained the existence of the solar wind in 1958, the probe is the first NASA spacecraft named after a living person.

Diving into the Sun

Astrophysicists from Berkeley's Space Sciences Lab search for the origins of the solar wind

NASA'S PARKER SOLAR PROBE, launched in 2018, is on a historic journey. It's flying closer to the surface of the Sun than any spacecraft before it, and along the way will become the fastest-moving object ever crafted by humans. Over its seven-year mission the probe will make two dozen separate forays into the Sun's corona – the roiling maelstrom of superhot ionized gas that makes up our star's outer atmosphere and streams outward as the solar wind.

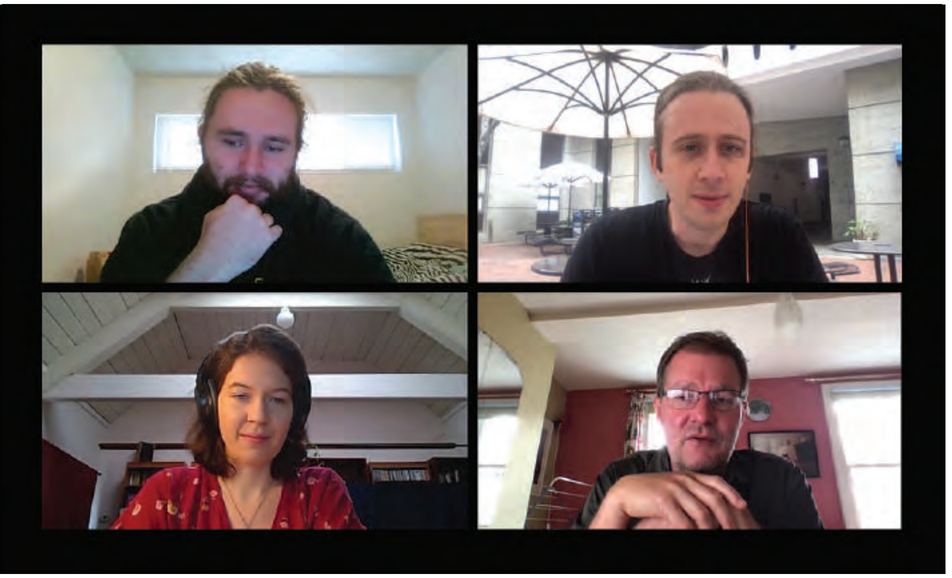
"The streamers of white light you see during an eclipse or with a coronagraph is a projection into the sky of the density of the gas in the corona," says Berkeley physics professor **Stuart D. Bale**, one of four principal investigators for Parker Solar Probe. "We're dipping into these streamers with the spacecraft, flying through them, measuring their structure as it evolves over time and trying to relate that data to the dynamics of the magnetic fields deeper in the corona."

The overall quest is to identify mechanisms responsible for heating the corona to temperatures hundreds of times hotter than the photosphere below it, and to track the energies that generate the solar wind and drive it out beyond the farthest reaches of the solar system.

"We know that something carries mechanical energy out of the photosphere into the corona and dumps it as heat," Bale explains. "That corona then escapes as a wind. The details of how that happens are what we're after. We want to know how the solar wind is created and from what regions of the Sun it emanates. We want to know how it's heated, how it continues to be heated as it flows out from the Sun, how it evolves as it propagates toward Earth and influences the environment of Earth."

"There's a lot of fundamental plasma astrophysics to learn here," he adds, "including how magnetic fields are generated in plasmas, how they control plasmas near stars and in other regions of space, and how mechanical energy from motion can heat the plasma without collisions."

Findings from the mission will not only broaden understanding of the solar wind and plasma physics. They will also improve the forecasting of 'space weather' – electromagnetic disturbances that can damage electronics and disrupt communications on Earth, interfere with GPS, and endanger astronauts.



Bale and his team, including physics graduate students shown here, receive and analyze new data from Parker Solar Probe via NASA's Deep Space Network. Researchers and engineers at SSL maintain fully functioning versions of the FIELDS and SWEAP instruments and use them to verify alterations in software, configuration, and operational commands before they're sent to the spacecraft. Clockwise from top left: Sam Badman, Brent Page, Stuart Bale, Claire Gasque.

VENUS FLYBYS AND SOLAR ENCOUNTERS

As the Parker probe's mission progresses, the spacecraft will bring its instruments deeper and deeper into the corona, a feat that requires periodic adjustments to the probe's orbital trajectory. It will make a series of seven Venus flybys to gradually shrink its orbit.

"Think of the Sun as a gravitational well," Bale says, "like a funnel. If a ball is rolling around inside a funnel, if there's no friction it'll just keep going around, never falling toward the center. To fall deeper into the gravitational well of the Sun, we need to slow the spacecraft substantially. Each time we fly close to Venus, its gravity slows us down a little bit more, and we can then drop in closer to the Sun. When the probe nears Venus, the FIELDS instrument is turned on and making measurements." The third Venus flyby took place in July, at less than 600 miles from the surface of Venus. The fourth is set for February 2021.

Parker Solar Probe's first three solar encounters took place in 2018 and 2019 and ventured down to 35.7 solar radii, about 15.5 million miles above the Sun's surface. FIELDS recorded a large-scale magnetic structure in the corona, as well as impulsive magnetic events originating at much deeper altitudes that are likely contributors to coronal heating.

"With every solar encounter we see exciting new details," Bale reports. "We can see very small electric and magnetic structures arising in the solar wind, and we're beginning to understand what kinds of magnetic regions on the solar surface are responsible for the origin of the solar wind. We're also beginning to relate the physics of sunspots, as measured from Earth, to magnetic fields in the interplanetary medium as measured by the Parker probe."

This level of detail simply can't be observed from the vicinity of Earth, the vantage point for much of the previous research on the solar wind. "By the time all that structure propagates out and reaches Earth, at 1 AU, more than 90 million miles away," Bale explains, "it's interacted so much with itself that it's evolved into a kind of stable turbulence that flows like a magnetized fluid. You've lost the diagnostic details. It's like trying to understand the source of a waterfall by measuring the water halfway down. It's too turbulent and unstructured to reveal details about its origin."

SWITCHBACKS AND SPACE DUST

Physics graduate student **Sam Badman** used measurements from the Parker Probe's first solar encounter to map magnetic field lines from the spacecraft back towards the Sun, and in this case found the solar wind to be emerging from a small coronal hole near the Sun's equator. Bale and others noticed a surprise superimposed along those field lines: "switchbacks," magnetic fields that make sudden 180-degree reversals in polarity then flip back again in hours or seconds. Bale notes that they are probably associated with plasma jets or large nonlinear waves, and likely to be central to the solar wind heating problem.

Badman extended the magnetic field map all the way out to the region near Earth, matching it up with solar wind measurements made with near-Earth observations. "The large-scale magnetic field measured at the Parker probe maps pretty well out to 1AU,"Bale observes. "You could imagine taking the data from Parker probe and instead of projecting it outward toward Earth, see how it maps back down toward the surface of the Sun. That could correspond to a very simple model of how magnetic fields escape from the Sun's gravity."

"We were also surprised by the ferocity of the dust environment in the heliosphere," Bale reports, "and how much dust science we're able to do with our instruments." Physics graduate student **Brent Page** analyzed millisecond pulses in voltage that occur when fast-moving dust particles collide with the spacecraft. Those data are beginning to give a picture of the cloud of dust that surrounds the Sun and the corona.

> We want to know how the solar wind is created and from what regions of the Sun it emanates.

Opposite: UC Berkeley's Stuart Bale (left) and Keith Goetz of the University of Minnesota in a clean room conducting final checks as they make the FIELDS instruments ready for flight aboard the Parker Solar Probe. The Probe launched in August 2018.

SLOW WIND, FAST WIND

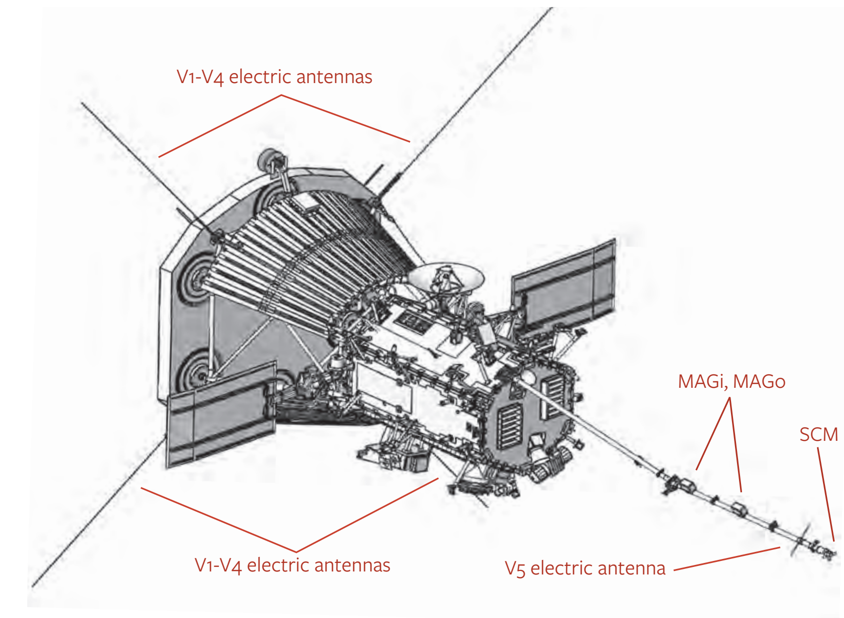
During its very first solar encounter in late 2018, the spacecraft's orbital speed matched and overtook the speed of the Sun's rotation. As a result, most of its time at perihelion was spent hovering in a magnetic field that mapped down to a very small coronal hole close to the photosphere. Coronal holes are cooler, less dense regions associated with so-called 'open magnetic fields' where the solar wind is able to escape the Sun. "We see the wind emerging from this small coronal hole and diverging outward to eventually fill the heliosphere," Bale reports. Data from those observations point to coronal holes near the Sun's equator as likely sources of 'slow' solar winds.

'Fast' solar winds travel at speeds from several hundred to 1000 km/sec. They tend to be steady, smooth, and unstructured, at least during solar minimum, when sunspot activity is low. By contrast, "slow winds are patchy, more structured, less steady, and travel half that speed," Bale explains. "This fast wind/slow wind dichotomy is part of the question of the origins of the solar wind. We think the fast wind emerges mostly from over the poles, with magnetic field lines that are open to the heliosphere. The wind flows out along stream lines, pulling the magnetic field out with it. The slow wind, with all its structure, is not yet well understood."

Solar probe observations also show solar winds being dragged around the Sun as it rotates. "The classical, simple idea is that as the wind forms, it blows out radially from the surface of the Sun. But even now at the altitudes we've reached with the spacecraft, we see the wind being dragged along with the rotation of the Sun. So we're seeing angular momentum transport in action, and it may be telling us something about the global circulation patterns in the corona," Bale observes.

BOUNDARY BETWEEN CORONA AND WIND

During each of its first four solar encounters, the Parker probe's instruments were switched on and taking data for 11 or 12 days surrounding perihelion (the moment of its closest approach to the Sun). Those observations made it clear that important solar



The FIELDS hardware includes two pairs of voltage-sensor antennas that lie in the plane of the Parker Solar Probe's protective heat shield and sit in full sunlight during the craft's solar encounters. Made from C-103 niobium, a reactor grade refractory metal, they can withstand temperatures beyond 1400C. A mere two meters away, the FIELDS magnetometers are positioned on a boom that extends behind the heat shield, aimed away from the Sun. Continuously exposed to the cold darkness of space, they are heated to maintain an operational temperature of -70C.

CREDIT: CHRIS SCHOLZ, SSL

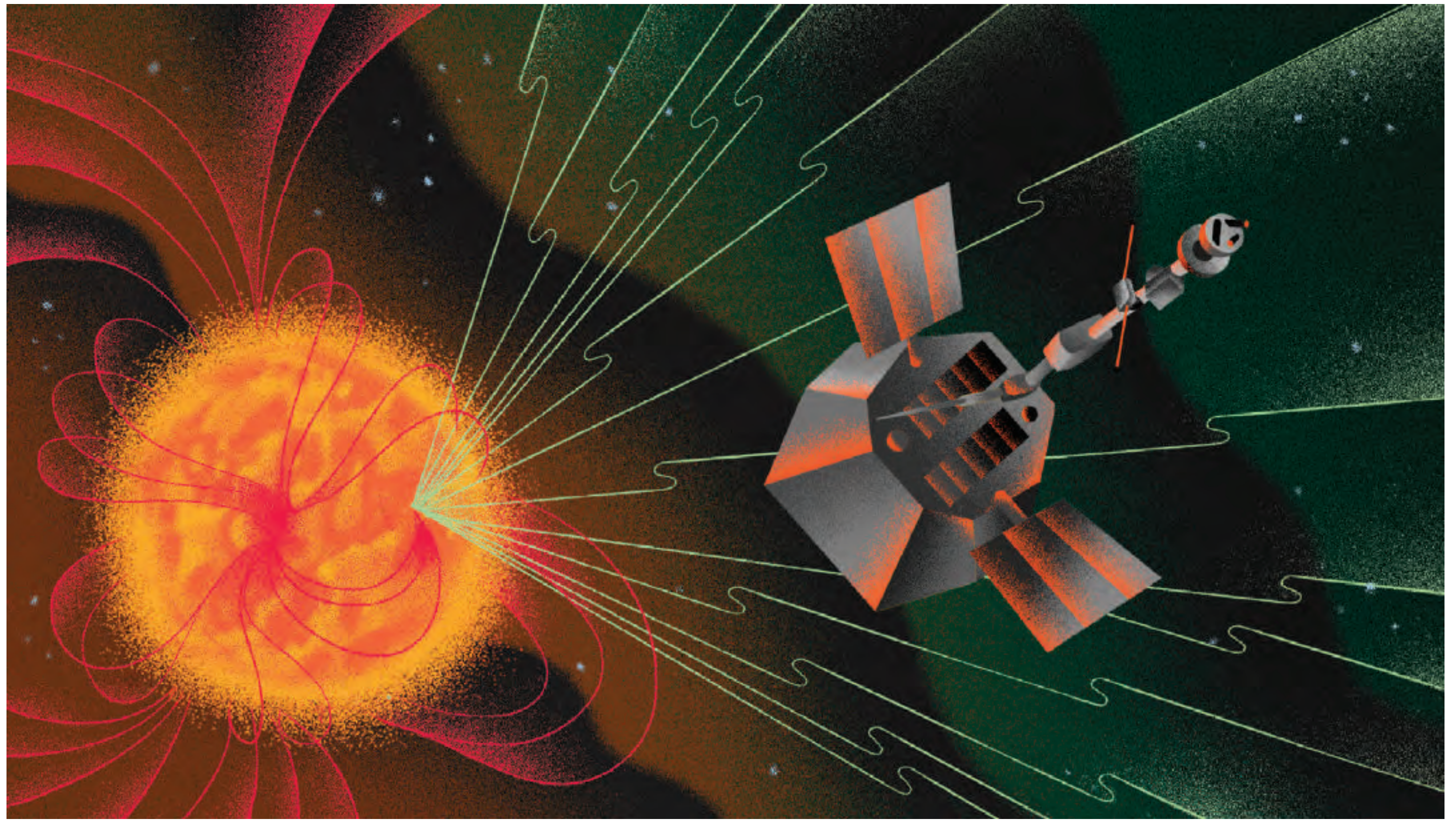
FIELDS and SWEAP

Berkeley's Space Sciences Lab (SSL) has been involved with the Parker Solar Probe since the mission's inception in 2010 and is responsible for much of its instrumentation. Physics professor **Stuart D. Bale**, who directed SSL from 2010-2018, currently leads a research team that operates FIELDS, one of the four suites of instruments on board the probe. He is also a team member on a second instrument, SWEAP.

FIELDS (Fields Experiment) measures electric and magnetic fields in the solar wind, radio emissions related to solar flares and shock events, and plasma waves, which reveal details about instabilities and relative velocities of motion in the plasma.

SWEAP (Solar Wind Electrons Alphas and Protons) counts and measures the properties of the most abundant particles in the solar wind – electrons, protons, and heavy ions.

Both FIELDS and SWEAP were largely designed, integrated, tested, and calibrated at SSL, and are currently being operated from SSL's Science Operations Center. Bale is principal investigator for FIELDS. Justin Kasper of University of Michigan is principal investigator for SWEAP.



CREDIT: ARIEL DAVIS (OPPOSITE) CREDIT: NASA

wind phenomena occur farther away from the Sun than had been expected. So, beginning with the fifth solar encounter, the data collection timeframe was extended from less than two weeks to almost two months, enabling mission scientists to follow more of the solar wind's evolution as it streams outward.

Perihelion for the fourth and fifth encounters took place in January and June and sent the probe 22% closer in to the sun than the first three.

The final solar encounter, scheduled for June 2025, will bring the probe to its closest approach, about four million miles from the center of the Sun. It will fly its fastest then, a record-breaking 200km/sec. "At that altitude we'll be well within the corona," Bale notes. "We'll be in the magnetosphere of the Sun rather than the solar wind." He's referring to the anticipated transition point between the corona itself and the solar wind it generates. "That's where we expect the properties we're measuring to transition from a solar wind to a real corona."

As the spacecraft dips closer and closer to the Sun, the orbits get smaller and the encounters happen more quickly. The first few solar orbits lasted about six months, and now they're down to around four months. "When we get to the lowest altitude orbits," Bale says, "they'll be only 88 days long." That means the work done by operational teams will get increasingly intense as the mission goes on.

This illustration shows an extrapolation of the solar magnetic field during Parker Solar Probe's first dive into the corona. The light green 'open' field lines are seen to converge on a coronal hole, which is the source of the solar wind making its way out to the probe. Switchbacks, or plasma jets observed by the probe, are shown as kinks in the open field lines.

> Each time we fly close to Venus, its gravity slows us down a little bit more, and we can then drop in closer to the Sun.

CONCLUSIONS SO FAR

Bale summarizes findings from solar encounters made thus far by characterizing the solar wind as it emerges from the corona as "a smooth radial flow with highly unstable plasma distributions, punctuated by plasma jets dragging along intense, highly kinked magnetic fields." The solar wind as it arrives at Earth is "very different," he notes, "mixed, homogeneous, and relatively stable."

"Many of the plasma physics processes we see with the Parker probe are well known," he adds. "The question is what are their roles in heating of the corona and the evolution of the gas as it travels from Sun to Earth and beyond. We're really just getting started."

The entire mission is slated to come to a close in 2027. "However," Bale says,"if the probe is still functioning and we're still getting good science from it, there could be an extension. This is a $1.5 billion project, and if NASA can run it for an extra $10 million a year, they might try to do that. You never know what will happen. That's a long time from now."

Opposite: Artist's conception of the LuSEE instrument now being developed as part of NASA's collaboration with commerical partners to launch payloads - and, by 2024, humans - to the moon.

To The MOON

FIELDS and SWEAP are keeping Bale's team at SSL extremely busy, yet they are managing to carve out some time for two other projects. "We're developing an instrument called **LuSEE**, an acronym for Lunar Surface Electromagnetics Experiment," Bale explains. "It's a set of experiments based on the Parker Probe FIELDS instrumentation to be installed on a lunar lander. It's part of NASA's Commercial Lunar Payload Services program. We've learned recently that NASA plans to manifest LuSEE on a mission to the farside South pole of the Moon."

2019-2020 Giving

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LIGHT THE WAY
THE CAMPAIGN FOR BERKELEY

Equity & Inclusion

Berkeley Physics addresses key issues in today's social climate

A STRONG COMMITMENT TO DIVERSITY is central to the mission of Berkeley's Department of Physics and critically important to the health of the department. A diverse physics community fulfills UC Berkeley's pledge to serve all segments of California's citizenry. Here is a brief summary of activities along these lines that are presently underway in the department.

2020 DEPARTMENTAL CLIMATE SURVEY

In April, faculty, staff, students, postdocs, and lecturers received a questionnaire asking for their input on a variety of equity and inclusion issues within the department. A key finding pinpointed the need for stronger inclusion of undergraduate students and postdocs. Acknowledgement of accomplishments, clarity of expectations for success, and support for professional development rated low for both groups. Work is underway to address these issues.

PHOTO: RPR

Left: Physics graduate students Wren Suess and Micah Bush, facilitators for a peer-to-peer workshop on sexual violence and sexual harassment (SVSH) held in August 2019. Targeted for incoming graduate students, the methodology for these groundbreaking workshops was developed by Suess, Bush, and student colleagues and has become a model for similar programs across the Berkeley campus and on college and university campuses nationwide. The sessions grew out of the in-person training program known as Respect is Part of Research, initially established in 2016.

RESPECT IS PART OF RESEARCH (RPR)

In 2016, workshops addressing sexual harassment and sexual violence were developed with the aim of constructing a respectful campus community. Initially designed to educate Berkeley Physics graduate students about expectations for their behavior, the workshops have since been adapted for a variety of groups, from postdocs, faculty, and staff, to other departments on campus and other institutions nationwide.

THE COMPASS PROJECT

COMPASS is a self-formed group of graduate and undergraduate students in the physical sciences seeks to improve undergraduate physics education through mentoring. Compass is responding to a resurgence of interest in students wishing to support populations typically underrepresented in the physical sciences.

EXPANDING RESEARCH OPPORTUNITIES FOR UNDERGRADUATES

A student-led research fair held in September provided a chance for students to talk directly with research faculty and postdocs. Students also had the opportunity to explore work-study arrangements and other means of receiving compensation for research work. Access to paid research opportunities encourages a broader representation of students to choose physics as their major.

SHARED GOVERNANCE

For the 2020-2021 academic year, renewed attention is being given to improving transparency and ensuring that all members of our community – students, faculty, and staff – are recognized as valued contributors.

EQUITY AND INCLUSION SUPPORT FUND

This new fund promotes projects and initiatives that broaden support for the recruitment and retention of underrepresented groups in the field of physics.

SUPPORTING TRANSFER STUDENTS

Berkeley Physics seeks to increase the admission of women and underrepresented groups by encouraging students who are transferring out of community colleges to come to our department. With the new Physics Frontier Center (see p 16), we have joined a network of universities that provides mentorship and an academic year stipend for transfer students.

RESOURCE SHARING WITH COMMUNITY COLLEGES

The COVID-19 pandemic forced us to move online with essentially no notice. That experience made us more cognizant of the impact personal circumstances have on educational opportunity, such as access at home to fast internet or a quiet place to work. We also began sharing online resources with community college faculty, including videos, simulations and, hopefully soon, development of individual lab kits.

CAMPARE AND CAL-BRIDGE

Enhanced collaborations with the CAMPARE and CAL-BRIDGE organizations encourage students from the California State University system to apply for graduate study in physics at Berkeley. Prospective students are invited to participate in summer mentorship and research opportunities that familiarize them with the Berkeley campus.

The Physics of Quantum Materials

Berkeley theorists explore the quantum properties of novel materials

Physics professor Joel Moore (top left) served as founding principal investigator (PI) for the Berkeley Gordon and Betty Moore Foundation Theory Center for Condensed Matter Physics for its first five years. Professor Dung-Hai Lee (bottom left) took over as PI in 2019, when the center was renewed for another five years, with Ehud Altman (top right) as co-PI. Postdoc Zala Lenarčič (bottom right), a member of Altman's research group, studies nonequilibrium dynamics in many-body systems.

QUANTUM MATERIALS is a broad term, coined in recent years to describe matter in which strong electron interactions and quantum-mechanical effects give rise to unexpected properties. New kinds of particles can form. Particles can join in assemblages that behave in ways that are distinct from the expected properties of any constituent particle. In high-temperature superconductors, for example, electrons that ordinarily would repel each other form tightly bound pairs that flow without electrical resistance.

Other examples of quantum materials include graphene, with its many unique physical and electronic properties, and topological insulators, a novel phase of matter that conducts electricity along surfaces but behaves as an insulator in the interior.

The properties and potential uses of quantum materials are so important that they have become a major focus of research among many Berkeley Physics faculty members. Physics professors **Dung-Hai Lee** and **Ehud Altman** are especially active in this area. Both are theoretical physicists currently serving leadership roles in Berkeley's Gordon and Betty Moore Foundation Theory Center for Condensed Matter Physics.

Lee is working to improve our understanding of high-temperature superconductivity and topological phase transitions. Altman studies quantum dynamics – the motion, energy, and momentum exchanges that take place in quantum systems – and quantum information.

HIGH-TEMPERATURE SUPERCONDUCTORS

Superconductivity holds tremendous promise for many uses, from energy transmission and transportation to medicine and basic research. The main barrier to application is the requirement for expensive cryogenics to maintain extremely low temperatures.

A superconductor has a critical temperature (Tc) at which it transitions to a state of zero electrical resistance. The Tc of superconductors in common use today is around 30K. Current research is aimed at finding usable quantum materials with a Tc significantly higher than 77K, the boiling point of nitrogen, and hopefully even room temperature. "If we can find superconductivity at temperatures where cooling is unnecessary or much less expensive, it will change our daily life forever." Lee notes.

The two families of materials known, at least so far, to have Tc values that approach or exceed 77K at ambient pressure are based on copper oxides (CuO_2) and iron selenides (FeSe). Lee's research group has developed a theory that helps explain the high Tc of FeSe-based superconductors. The theory explains results from photoemission experiments showing that a thin atomic layer of FeSe grown on top of a strontium titanate substrate can achieve a Tc as high as 75K. The same experiments also revealed the unusual fact that energy bands within the material are replicated at regular 100meV intervals.

"This is the first time replica bands have been observed in a solid state material," Lee notes. "It requires strong coupling between electrons in the iron selenide and vibrations in strontium titanate. Our theory describes how this coupling boosts Tc; the stronger the coupling, the higher the Tc."

CuO_2 and FeSe based compounds are similar in that both are made of two-dimensional structural motifs. "The excitement," Lee continues, "is that, due to this commonality, we believe that what we have identified in iron-based compounds may also have something to do with high temperature superconductivity in copper oxides." Lee is working with theorists and experimentalists to look for analogous lattice vibrations in CuO_2 materials, and exploring substrates with even stronger coupling to CuO_2 or FeSe films.

SYMMETRY-PROTECTED TOPOLOGICAL PHASES

For more than a century, theorists have described phase transitions between states with different symmetries. For example, at a temperature of about 1000K iron transitions from a state with no magnetism to the ferromagnetic state in which the atomic moments become aligned. Such alignment breaks the rotation symmetry of the atomic moments. "Our understanding of the transitions between phases with different symmetries has led to many revolutions in physics," Lee notes.

He is exploring a type of quantum phase transition that does not involve symmetry breaking. It is known to occur between 'symmetry protected topological states' (SPTs). SPTs, with topological insulators as an example, are new states of matter discovered in the last 15 years.

Lee has developed a 'holographic theory' that describes phase transitions between SPT phases. "The essential idea," he says, "is that the critical point of such a transition is protected by an emergent symmetry and can be realized on the boundary of an SPT living one dimension higher."

"Unlike symmetry breaking phase transitions, the theory of this new type of topological phase transitions is in its infancy," Lee continues. "I envision this research going on for many years."

QUANTUM DYNAMICS AND QUANTUM INFORMATION

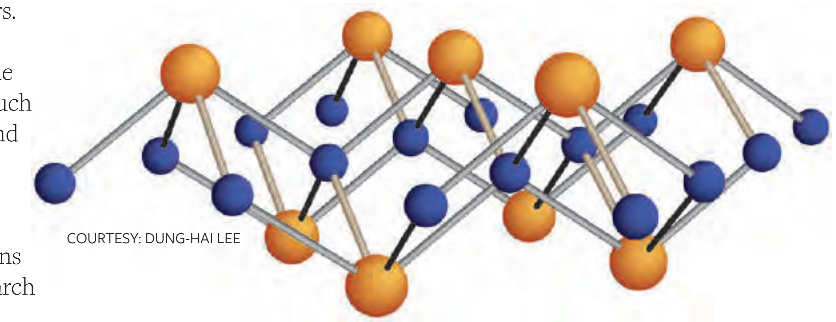
Professor Ehud Altman uses quantum information theory to try and understand the highly complex dynamics of quantum systems. "Most experiments in quantum dynamics look at how the effects of a perturbation propagate in a system," he explains. "The process can be relatively simple if the system consists of quasiparticles, because you can calculate how they evolve." Quasiparticles are among the emergent phenomena that arise from interactions among electrons, atomic nuclei, or other particles in a complex quantum system.

"But strongly correlated quantum systems don't necessarily have obvious quasiparticles," Altman continues. "A simple excitation can become more and more complicated, creating a particle that becomes two, then four, then more entities that are entangled with each other. To predict any properties that emerge, such as conductivity or magnetism, we need to understand the response that gave rise to them. We want to understand the flow of quantum information through the system."

"As the system evolves," he adds, "the information in these particles becomes nonlocal." Nonlocality in quantum mechanics refers to the phenomenon of two or more particles, no matter how widely separated, behaving as though they are a single entity.

Last year, Altman and colleagues presented a method for tracking the flow of quantum information as it evolves from local, observable properties to nonlocal, entangled information. "The growth of a perturbation, such as a change in density, starts small and simple," Altman says. "But as the system evolves, it becomes increasingly complicated as the particles involved in the original perturbation get entangled with other particles and those in turn entangle with more particles. We developed a statistical description of this growing complexity, allowing to us to backtrack how measurable observables, such as the local density of the fluid, behave over time."

"In doing so", he continues, "we established an interesting connection between the observable dynamic response of a system and a more elusive property called quantum chaos, measured by the exponential growth in complexity set off by a small perturbation. This relationship makes possible a tighter bound on how fast quantum chaos can develop."



COURTESY: DUNG-HAI LEE

Above: Copper oxide and iron-based superconductors have similar two-dimensional structural motifs. This diagram shows an iron-selenide structure. Dung-Hai Lee and collaborators are exploring how this commonality could lead to new insights in the search for high-temperature superconductors.

"Quantum chaos is a mechanism that hides quantum correlations between particles by scrambling them into complex, unobservable degrees of freedom," Altman adds, "thus facilitating the transition of a quantum system to behavior that appears classical for practical purposes. We stumbled upon a fundamental point, making a connection between the response of materials, which are easily measured, and showing they can bound something intricate, not easily measured, and related to the flow and complexity of quantum information. This has broad implications for development of quantum computers."

STRENGTH IN COLLABORATION

Berkeley Physics is home to one of eight theory centers nationwide established to explore quantum materials. The Berkeley Gordon and Betty Moore Foundation Theory Center for Condensed Matter Physics is a component of the Moore Foundation's Emergent Phenomena in Quantum Systems (EPiQS) initiative.

As Dung-Hai Lee explains, "The vision of the Berkeley Center is to enable us to synergize expertise from very different areas of study and take a concerted approach to condensed matter physics. This approach is consistent with recent trends in many areas of physics, which seek to combine many disciplines in attacking challenging problems."

Joel Moore, Chern-Simons Professor of Physics at Berkeley, adds, "One of our strengths here at Berkeley is that we have such close ties between theorists and experimentalists. Those ties, along with the combination of private and public support for our research, make Berkeley a unique place to attack deep, long-standing challenges in quantum materials. The Berkeley group has also shown the ability to lead new research directions in this rapidly evolving field."

Resilience

Berkeley Physics Responds to COVID-19

IN EARLY MARCH, with very little warning and within an impossibly short time frame, Berkeley Physics managed to shift almost every department activity off campus and into the homes of faculty, students, and staff.

On March 2, **Amin Jazaeri**, Lecturer and Director of Instructional Support, met with past Physics Chair **Wick Haxton** and Vice Chair **Jonathan Wurtele** to go over the department's contingency plans for remote instruction. "Within hours of that meeting," Jazaeri recalls, "campus activated its Emergency Operation Center, indicating something big was about to happen."

Over the next seven days, Jazaeri and his staff conducted trainings on how to use Zoom. "We also ordered iPads, Microsoft Surface Pros, and tablets to provide faculty, lecturers, and graduate student instructors with hardware to help make remote instruction more effective," he reports. "On March 10, in-person instruction was suspended."

> "I want you to know that despite the virus problem you all are doing an amazing job at coordinating and making arrangements. Thank you! Berkeley is very lucky to have professors and GSIs like you."
>
> ~*Unsolicited accolade from a Berkeley Physics student, Spring 2020*

REMOTE INSTRUCTION

Introductory physics courses ordinarily use live lecture demonstrations to help students understand basic concepts. After the campus closure, Jazaeri says, "we had to switch to pre-recorded video demonstrations, since it was logistically impossible to broadcast them live. For some labs, we created videos so students could observe how an experiment was done to better understand how to treat the data."

Over the summer, Jazaeri and his staff produced additional video demonstrations as well as videos for all the experiments in the Physics 7 and Physics 8 labs. For Physics 5 and 111A labs, kits were put together so students could conduct hands-on experiments at home. "We worked closely with the instructors to help them modify labs and test experiments to make sure they wouldn't become a source of frustration for students."

Jazaeri is developing remote lab experimentation, in which students control a live experiment from home through the internet.

CREDIT: KAREN ZUKOR

Berkeley Physics professor Joel Fajans solders components for kits with microcontrollers, resistors, and other circuit parts for the Physics 111 Advanced Lab. He delivered the kits to students who had scattered over three continents when COVID-19 shut down the campus. From home, students measured one of the fundamental constants of nature.

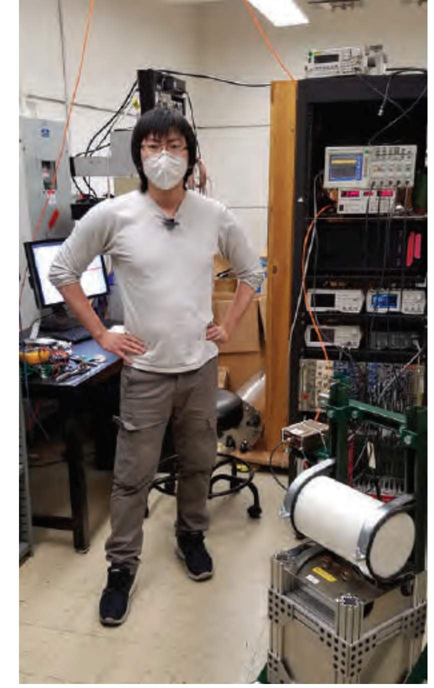
BUILDINGS AND RESEARCH

"Research labs had less than a week, at best, to shut down non-critical experiments," recalls **Anthony Vitan**, Director of Facilities, Division of Mathematics and Physical Sciences. The total shutdown lasted from March 16 through June 26, and during that time only about 10% of researchers were allowed on campus to maintain long-term experiments that had to remain in operation.

On June 25, limited numbers of faculty, instructors, and graduate student instructors were allowed to return to campus to perform teaching duties. On June 26, buildings re-opened for experimental research at 25% occupancy. "That meant most labs were limited to one person at a time," Vitan says, "though very large labs could accommodate three or four, down from the typical 10 or more."

As physics professor **James Analytis** explains, "Grad students and postdocs returned to their projects on a shift-based program, by signing up for an allocated time slot for getting into the lab." Analytis serves as faculty lead for re-occupying research spaces, and became Chair of Berkeley Physics as the fall semester began.

Analytis names Vitan as the hero in all this. "He reviewed the applications, made sure everyone had in place the needed procedures and shift-based protocols." Undergraduates are still not allowed on campus at all, unless they are being paid as research assistants.



Left: Postdoc Junsong Lin maintains social distancing in the lab. Below right: Student Services team members Kathleen Cooney (top center) and Joelle Miles (bottom left) meet with members of the Society of Physics Students via Zoom.

"The situation has been pretty difficult," Analytis notes. "There are fewer boots on the ground and we have to work around the shift schedule. Also, we re-opened for research a bit later than other institutions in the US and Europe. Science moves quickly, and having three months out is a big issue. "

"Postdocs are in an especially tough position," Analytis continues. "They've lost months of work, and need additional time and funding to complete their research. It isn't clear what kinds of positions will be available when they leave and need to find a job."

Analytis also worries about the new crop of graduate students on campus. "It's difficult to find protocols for training them safely while keeping physical distance," he points out. "It's tricky. And everyone is being especially careful to avoid a viral outbreak on campus that could lead to another shutdown."

STUDENT SERVICES AND INSTRUCTIONAL SUPPORT

Serious adjustments to services for enrolled undergraduates and graduate students as well as prospective physics students have also been required. "It was a significant challenge to switch from in-person to remote in all aspects of our work and teaching," recalls Student Services Director **Claudia Trujillo,** "and figure out the best ways to assist students." She and her staff moved all activities to remote operation, from day-to-day operations and regular student events to CalDay, the Graduate Student Open House and Poster Session, and Commencement.

CalDay became CalWeek and accommodated a number of events for prospective freshmen and transfer students. "We held advising office hours and presented a panel via Zoom that welcomed new students to campus and our department," Trujillo says. "It was a fine alternative to CalDay, though in-person is always best."

"With no advance notice at all, and thanks to incredible work by Lead Graduate Advisor **Joelle Miles**, we moved our Graduate Open House to a virtual event," she continues. "Students were still able to attend poster sessions, and prospective graduate students met with physics faculty. It was an incredible amount of work that paid off – we had the same number of graduate student acceptances as we would expect if we had run the event in person. A great success overall."

Trujillo's Student Services Office created a Commencement 2020 Acknowledgement video, with the Dean, the Chair, and the Student Speaker making their contributions remotely. All graduates' names were read, giving families a chance to celebrate.

"We're using our experiences from spring and summer" Trujillo notes, "to ensure continued delivery of workshops, poster sessions, student events, and support for teaching plans and modes in an ever-changing environment. We are in a much better position now, but there is still a lot of work to do."

SILVER LININGS

Some of the department's activities have reaped unexpected benefits from going online. For example, faculty meetings have seen much stronger attendance. "It might make sense to keep some of our meetings on Zoom if that makes it easier for faculty to attend," said Haxton.

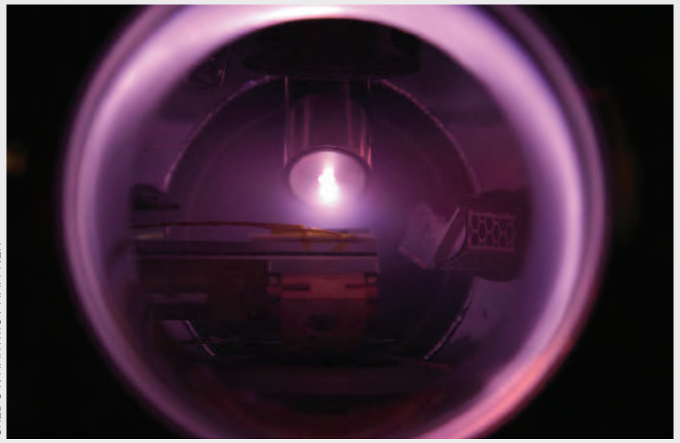
Academic HR analyst **Marissa Dominguez** observed advantages in the search for new faculty. "Despite the initial chaos and stress of abruptly converting in-person faculty interviews and job talks to remote visits via Zoom, several benefits were realized." Competition for classroom and conference room space disappeared, as did the logistics of coordinating room reservations with faculty and candidate availability.

"Attendance at job talks was markedly higher," Dominguez adds, "and several faculty members cited that removing the constraints of physical travel made it much easier to attend. Ultimately, three-fourths of our newly hired faculty during the 'pandemic search cycle' were remotely visiting candidates."

AN IMPRESSIVE RESPONSE

At the end of March, Haxton, who was Department Chair at the time, penned a public statement about the extraordinary situation everyone was facing. "Stress sometimes brings out the best in people," he wrote, "and that certainly has been the case with our students, staff, and faculty. I have never been prouder of Berkeley Physics.... Berkeley resilience is everywhere in evidence. Still, it would be good to get through this. When we do, come visit us – even at distances less than six feet."

UC Berkeley to lead $25 million quantum computing center



CREDOT: HARTMUT HÄFFNER

An argon plasma discharge is used to clean an ion trap to allow for better coherence during quantum information transfer. Trapped ions are one of the most advanced candidates for a scalable quantum processing device. Below right: Expanding debris from a supernova explosion (shown in red) runs over and shreds a nearby star (blue).

The National Science Foundation (NSF) has awarded UC Berkeley $25 million over five years to establish a multi-university institute focused on advancing quantum science and engineering and training a future workforce to build and use quantum computers.

The Berkeley-led center is one of three Quantum Leap Challenge Institutes (QLCI) announced in July. Goals are to improve and determine how best to use today's rudimentary quantum computers and ultimately to make quantum computers as common as mobile phones.

"There is a sense that we are on the precipice of a really big move toward quantum computing," said **Dan Stamper-Kurn**, UC Berkeley professor of physics and director of the new institute. "The development of the quantum computer will be a real scientific revolution, the defining scientific challenge of the moment, especially if you think about the fact that the computer plays a central role in just about everything society does. If you revolutionize what a computer is, then you revolutionize just about everything else."

"This new NSF center builds on a solid foundation of quantum science research at Berkeley Physics," Stamper-Kurn added, "from our world-leading group in atomic, molecular, and optical physics, to condensed-matter physicists who are leaders in development of superconducting quantum information processors, to theorists who have developed quantum information science as a unifying precept."

Situated near the heart of Silicon Valley and at major California universities and national labs, "this center establishes California as the world center for research in quantum computing," Stamper-Kurn said.

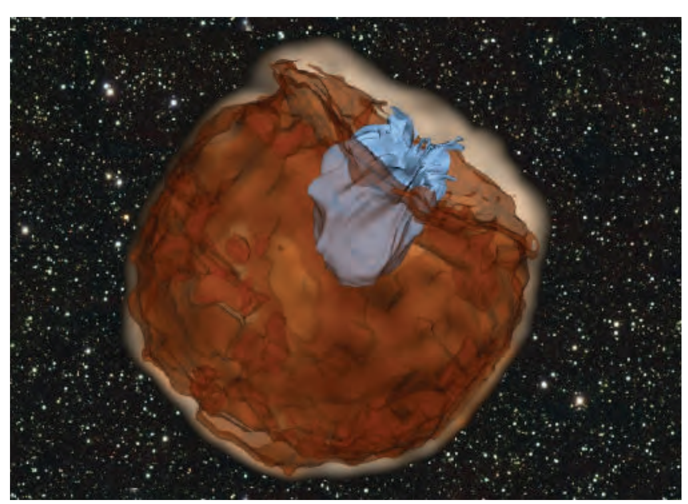
UC Berkeley to Lead New NSF Physics Frontier Center

A new Physics Frontier Center at UC Berkeley, supported by the National Science Foundation (NSF), expands the reach and depth of existing capabilities on campus in modeling cataclysmic events in the cosmos, including supernovae and the mergers of neutron stars and their explosive aftermaths.

The new Network for Neutrinos, Nuclear Astrophysics, and Symmetries (N3AS) Physics Frontier Center is led by Berkeley Physics professor and Berkeley Lab scientist **Wick Haxton**, a theoretical nuclear physicist and astrophysicist. It builds upon an NSF-funded research hub in multi-messenger nuclear astrophysics that was established in 2017, also led by Haxton. In multi-messenger astronomy, researchers gather data from a range of observatories to address longstanding questions in the field. The new N3AS Center, launched September 1, overlaps the hub, which is entering its fifth and final year. Additional Berkeley faculty involved in N3AS include physicists **Daniel Kasen** and **Uros Seljak** and theoretical astronomer **Eliot Quataert**.

The new center continues the hub's theme: using the most extreme environments found in astrophysics – the Big Bang, supernovae, and neutron star and black hole mergers – as laboratories for testing fundamental physics under conditions beyond the reach of Earth-based labs. The NSF commitment to N3AS is $10.9 million over five years. Berkeley Physics, Berkeley Lab, and 12 other institutions are taking part.

"We operate as a single team," Haxton said, "combining our expertise to tackle the complex multi-physics problems that arise in astrophysics – problems that are beyond the capacity of a single investigator.



CREDIT: DANIEL KASEN/BERKELEY LAB, UC BERKELEY

PHOTO: ©PEG SKORPINSKI

Frances Hellman Elected President of APS

In December 2019 the American Physical Society announced the election of Frances Hellman to the APS Presidential Line. Hellman is Berkeley Professor of Physics, Professor of Materials Science & Engineering, Senior Faculty Scientist in Berkeley Lab's Materials Sciences Division, and Dean of the Division of Mathematical and Physical Sciences. She began serving her term as vice president in January this year. She becomes president-elect in 2021, president in 2022, and past-president in 2023.

French Ambassador Visits Berkeley Physics

In January, France's ambassador to the US, Phillippe Étienne, visited campus to celebrate creation of the Centre Pierre Binetruy. Housed at Berkeley Physics, the Centre focuses on a range of topics in cosmology and astrophysics. The Ambassador (second from right) met with the Centre's co-directors, Berkeley physics professor and Nobel laureate **Saul Perlmutter** (second from left) and Radek Stompor (left) of the French National Laboratory CNRS, in the lab of Berkeley physics professor **Adrian Lee** (right). Sylvette Tourmente (center) is from the French Embassy in Washington DC.

PHOTO: SARAH WITTMER

Update: Physics Innovators Initiative (Pi²)

Academic Coordinator Austin Hedeman has taken a leading role in the transition to remote learning by developing online lectures and discussion forums, formulating experiments students can conduct outside the lab, and adding software programming to the problem-solving skills taught to students.

With the Physics Innovators Initiative (Pi²), Berkeley Physics continues to enhance hands-on learning and revamp the curriculum for the Physics 7 undergraduate physics series. Since its launch in 2018, Pi² has hired **Jesse Lopez** as the Instructor and Principle Lab Mechanician for the Student Machine Shop as well as adding new computers, software, and a state-of-the-art laser cutter to the shop's equipment. With support from alumnus Dr. Ernie Malamud (BA 1954), a new CNC (computer numerical control) milling machine has also been installed.

Associate professor **James Analytis** serves as faculty lead for Pi². "Our faculty and staff are finding new paths forward to bring hands-on research to students in these challenging times of remote learning," he says. "This effort includes a combination of online interactive labs and lab-in-a-box educational packs. We purchased nearly 100 such kits and we're trialing them with the Physics 5 Labs. We'll build on that model to apply them to the Physics 7 labs."

"Our new Academic Coordinator **Austin Hedeman** has helped smooth the transition to remote learning," Analytis adds, "by reinventing the lab component of Physics 7 so that students can conduct experiments at home. Coupling electronic sensors for temperature, capacitance, pressure, and acceleration with tablets or phones enables students to gather data and demonstrate basic principles of classical mechanics, electromagnetism, and thermodynamics. This approach is not only appropriate for a world in the middle of a pandemic, but also has taught us more effective and direct ways to engage students beyond the more passive techniques used in the past."

Pi² has also secured funding to kick off Summer Design Fellowships to sponsor eight undergraduates in research over two summers. "It was supposed to start this summer," Analytis reports, "but has been delayed until 2021 because of COVID."

Rachel Cao Schafer, Director of Development and Communications, adds, "Berkeley Physics appreciates the support from alumni and friends whose contributions are enabling Pi² to make great progress toward the goals of modernizing the curriculum and strengthening hands-on learning for Physics 7."

Rhodes Scholar Namrata Ramesh is creator of The STEMinist Chronicles – a student organization that aims to make STEM department climates more inclusive by sharing the stories of women in STEM. www.steministchronicles.com

Namrata Ramesh Selected as 2020 Rhodes Scholar

Namrata Ramesh, a Berkeley Physics international student from India who graduated with honors this spring, was selected as a Rhodes Scholar for 2020. The scholarship is one of the oldest and most prestigious of its kind. Fewer than 100 students are selected each year from eligible regions around the world to attend Oxford University.

Ramesh received a BA in Physics from Berkeley. Her senior thesis, supervised by professor **Naomi Ginsberg**, involved understanding the dynamics of self assembly of gold nanocrystal superlattices using optical and x-ray scattering techniques. She also studied the trajectories of electrons in manganese doped halide perovskites using Monte Carlo simulations. At Oxford, Ramesh hopes to continue investigating the origins of intriguing phenomena in promising photovoltaic materials by working at the interface of experimental and computational physics.

While at Berkeley, she combined her love of multimedia storytelling with her passion for promoting diversity in STEM fields by establishing "The STEMinist Chronicles" – an organization that uses photoessays to tell the stories of women studying and working in STEM.

Ramesh almost did not apply for the Rhodes Scholarship because she did not believe that she fit the mythical archetype of the perfect Rhodes applicant. She says, "I am so grateful for my supportive family and community in Berkeley for helping me believe in myself and encouraging me to apply anyway."

She hopes to pay it forward by inspiring minorities in STEM to believe in themselves and work towards their highest career aspirations. "I am determined to show, throughout my career, that one's race or gender need not be a barrier to becoming a physicist," she asserts, "that the only requirement to be a scientist is a deep love for science."

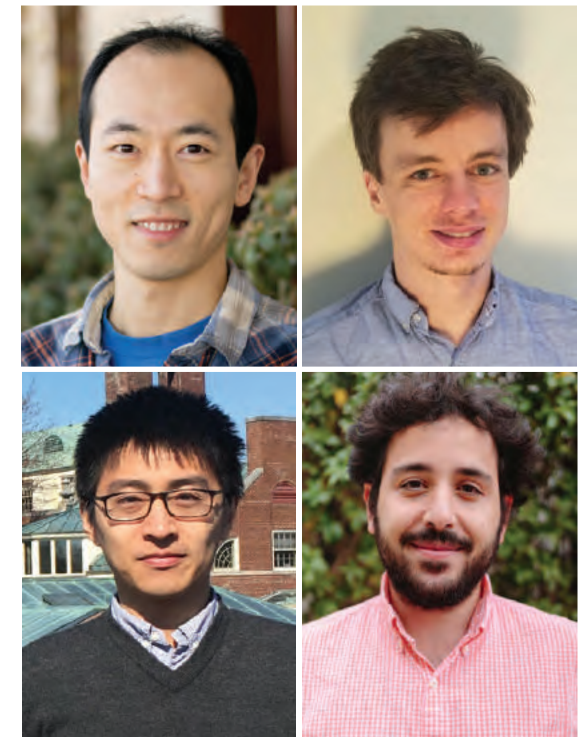
Poster Series Honors Black Physicists

Inspired by the nation's grappling with racism in the wake of George Floyd's death, UC Berkeley physics major and Berkeley Lab student assistant **Ana Lyons** turned to art as a way to contribute to the conversation.

Aware of the scientific community's own self-reflection for its history of racial inequity and discrimination, Lyons found solace and positivity in a poster project honoring the contributions of Black American physicists. The project will feature a series of 12 posters, and she has already completed her first set of six.

Among the physicists featured in her series: Willie Hobbs Moore, the first Black woman to earn a Ph.D. in physics, and Harry Lee Morrison, longtime UC Berkeley professor of theoretical physics and a founding member of the National Society of Black Physicists. Download the first six posters at www.shorturl.at/ahjHY

New Faculty



Eric Yue Ma (upper left) received his BS in Physics from Peking University, and his PhD in Applied Physics from Stanford University. He stayed on at Stanford as a postdoc in Applied Physics and Electrical Engineering. He has also held positions at Apple. Dr. Ma joins Berkeley Physics as assistant professor in July 2021.

Geoff Penington (upper right) received his BA in Mathematics from Cambridge University and his PhD in Physics from Stanford. He applies ideas from the theory behind quantum computers and quantum information to understanding of the quantum mechanics of gravity. Recent work focuses on how information that falls into a black hole ends up being encoded in the Hawking radiation left behind after the black hole evaporates. He joined Berkeley Physics as assistant professor in July.

Liang Dai (lower left) received a BS in Physics from Peking University and a PhD in Physics from Johns Hopkins University, working on theoretical cosmology. He was awarded an NASA Einstein fellowship, was appointed a postdoctoral Member at the Institute for Advanced Study, and is a long-term John Bahcall postdoctoral fellow at the Institute for Advanced Study. He joined Berkeley Physics as assistant professor in July.

Alp Sipahigil (lower right) received his PhD in Physics at Harvard, followed by postdoctoral work at Caltech as an IQIM scholar. He joins Berkeley Physics as assistant professor in January 2021, with joint appointments in the Department of Electrical Engineering and Computer Science and at Lawrence Berkeley National Laboratory.

Staff News

DEPARTURES

Warner Carlisle, Mechanical Shop Manager, retired in July after working in labs all over campus for 27 years. He led the Berkeley Physics R&D shop for the past nine years. Under his leadership, the shop modernized fabrication operations and equipment, developed advanced prototypes to facilitate faculty research, and adopted 3-D technologies.

Kathy Lee, Undergraduate Student Advisor, retired in June after more than 20 years of service in the Department of Physics. She joined the physics staff in 2000. Kathy has helped students, faculty, and staff in many capacities and her professionalism and dedication will be sorely missed.

Anil Moré retired in December 2019 after a remarkable career spanning 40 years at UC Berkeley and Berkeley Lab. As Director of Administration for Berkeley Physics since 2013, he led the integration and streamlining of Administrative Services across the entire department.

Graduate Advisor **Donna Sakima** has retired from the Physics Department after almost 33 years of service. Her fun spirit and unwavering dedication to students will be greatly missed in the department and the Physics staff wished her all the best with a virtual celebration.

Brian Underwood, who joined Berkeley Physics as Academic Human Resources Manager in 2014 and was promoted to Deputy Director of Administration in 2017, transitioned to the role of Department Manager for Berkeley's Department of Mathematics on February 1.

NEW HIRES

Berkeley Physics welcomed **Roia Ferrazares** as our new Director of Administration in March. She has worked on campus since 2006 in a variety of roles in the Dean's Office of the College of Letters and Science, the Department of Music, and the School of Journalism.

Roia Ferrazares, Director of Administration

Alumni Updates

Gerald Kimble (BA 1949) is a Professor of Mathematics and Computer Science Emeritus at the University of Nevada, Reno. Gerald was an active professor for 23 years and has been retired for 32 years. Previously, he served as the Head of Numerical Analysis at Space Technology Laboratories for four years and has taught at the California State University Long Beach and the University of Montana.

Charles Albert (BA 1984) has been promoted to Chief Operations Officer at ACI Alloys, a PVD materials company. Prior to that, Charles worked in air pollution modeling in Texas and intellectual property law in San Francisco. He also writes science fiction, and a collection of his more recently published stories, A Thousand Ways to Fail, was published in March of 2020.

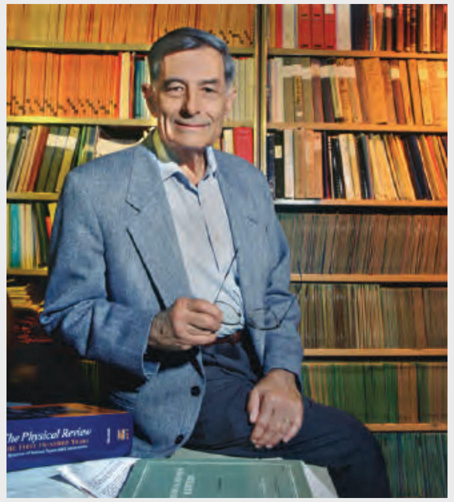
David Strubbe (MA 2007, PhD 2012) was recently named a 2020 Cottrell Scholar, an award from the Research Corporation for Science Advancement to early-career faculty in physics, chemistry, and astronomy. David is one of 25 awardees and received a $100,000 grant for his proposal "Light-induced Structural Dynamics in Materials: New Theoretical Insight into Ultrafast Phenomena." He is currently a professor of physics at the University of California, Merced.

Caroline Sofiatti (MA 2016) is currently a Machine Learning Engineer at Apple and has an algorithms patent. As a graduate student researcher, she worked under Saul Perlmutter and was co-author of three scientific papers, including one on applying Bayesian Statistics frameworks to study supernovae statistical and systematic uncertainties.

Gabe Dunn (PhD 2017) is a Senior Manager at Bain & Company. Gabe completed his PhD in Alex Zettl's condensed matter lab. His thesis was titled "Applications of Nanotechnology to the Life Sciences."

Namrata Ramesh (BA 2020) is currently a Rhodes Scholar in her first year as an MSc(Res) in Materials student at the University of Oxford. Her research involves using first principles computational modelling to understand the reactions occurring at the electrolyte-electrode interface of Li-ion batteries. She also founded and runs the organization "The STEMinist Chronicles," which uses art to tell the stories of women/folx in STEM.

In Memory



George Trilling (1930-2020), passed away April 30. He served on the faculty of Berkeley Physics and as a Berkeley Lab scientist from 1960-1994, continuing his research well after retirement.

Trilling was a particle physicist whose research ranged from the study of K-meson interactions to the discovery of J/psi resonance and measurements of the B meson. He led the Solenoidal Detector Collaboration at the Superconducting Supercollider, and later was instrumental in working to secure US participation at the Large Hadron Collider at CERN. His research at Berkeley Lab continued until 2017. George served as Chair of the UC Berkeley Physics department from 1968-1972, directed the Physics Division at Berkeley Lab from 1984 to 1987, and served as President of the American Physical Society in 2001. He is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and a recipient of the Berkeley Citation.

Robert (Bob) Tripp (1927-2020), Berkeley Physics professor emeritus and retired senior faculty scientist in Berkeley Lab's Physics Division, passed away June 27. He served on the physics faculty from 1960-1991, and continued research at Berkeley Lab after retirement.

As a graduate student at Berkeley, Tripp worked with Emilio Segrè, then as a postdoc with Luis Alvarez. He conducted experiments with the 184-inch synchrocyclotron and the Bevatron. During his career he and colleagues discovered and characterized many of the resonant states that formed the basis of the quark model of Gell-Mann and Zweig. Later interests ranged from neutrinoless double beta decay to luminosity calibrations of distant type 1a supernovae. The latter work led to his co-inventing, with Carl Pennypacker, the FUEGO satellite system to detect fires from geosynchronous orbit.

2020 Berkeley Physics AT A GLANCE

A look at the students and faculty who make up Berkeley Physics

Undergraduate Physics Majors

320 Total # of students

♂ 247 | 73 ♀

137 BAs Awarded 2019-20

40 Transfer Students

Graduate Physics Majors

274 Total # of students

♂ 212 | 58 ♀ | 4 prefer not to say

38 PhDs Awarded 2019-20

25 Countries Students Are From

Physics Faculty

65 Active Faculty

37 Emeritus Faculty

23 Members of the National Academy

4 Active Nobel Laureates

1. George Smoot (Physics 2006)
2. Saul Perlmutter (Physics 2011)
3. Eric Betzig (Chemistry 2014)
4. Reinhard Genzel (Physics 2020)

Berkeley Physics Alumni Nobel Prize Winners

1955: Willis Lamb (BS '34, PhD '38)
1997: Steven Chu (PhD '76)
1998: Robert Laughlin (BA '72)
2000 in Chemistry: Alan J. Heeger (PhD '61)
2004: David Gross (PhD '66)
2006: John C. Mather (PhD '74)
2011: Saul Perlmutter (PhD '86)
2012: David J. Wineland (BA '65)
2017 Barry C. Barish (BA '57, PhD '62)

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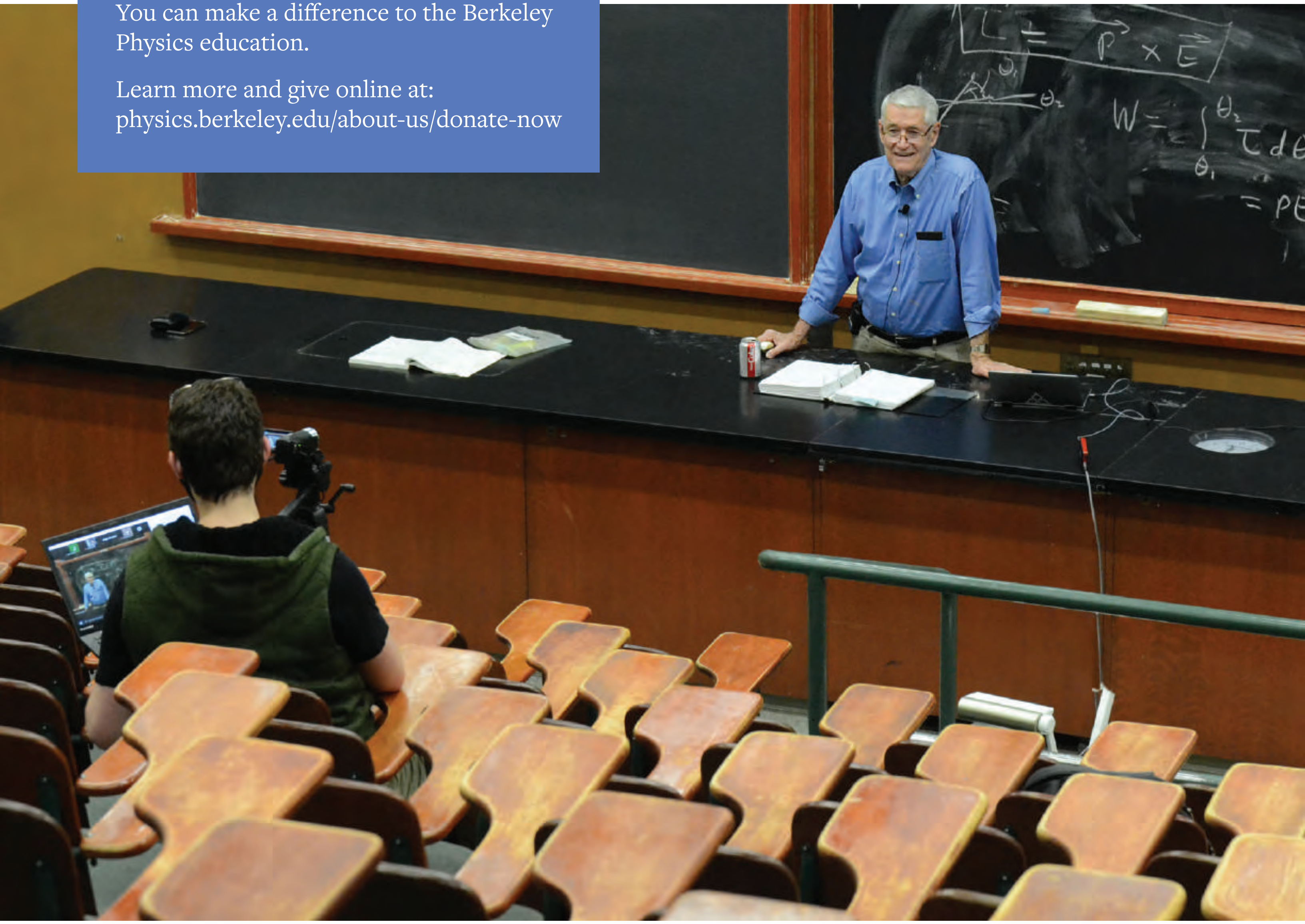

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