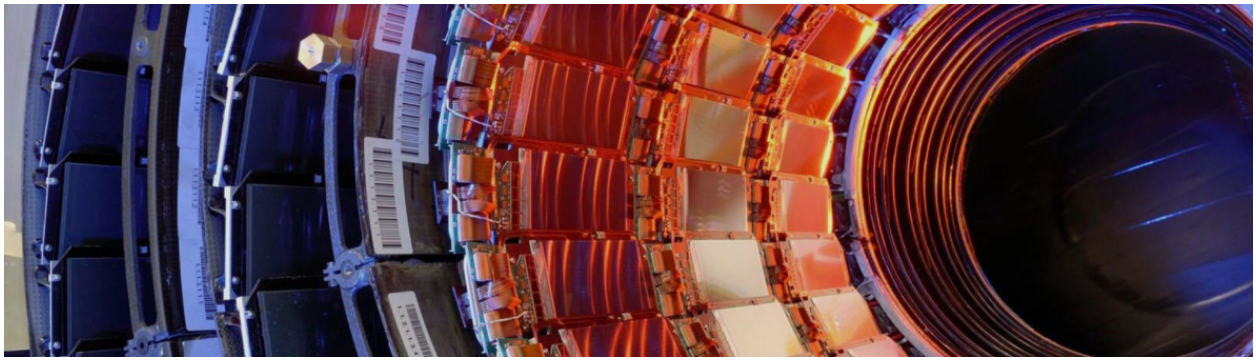


Physical Interactions

News from the UC Davis Department of Physics and Astronomy

Message from Department Chair Rena Zieve

Department Chair Rena Zieve

Greetings from the *Department of Physics and Astronomy*! Our name change culminated several decades of expansion into astronomy. For many years Bob Becker was our sole astronomy faculty member, teaching all of our astronomy classes from lower-level service courses through the graduate level. We then hired several faculty in cosmology, a branch of astronomy with especially close ties to physics. They expanded astronomy course offerings at all levels and developed a new Astrophysics Specialization for the Physics Bachelor's degree. After a recent round of faculty hiring broadened our astronomy research, we proposed the name change. University bureaucracy doesn't move quickly, but we received the final approval in June.

Like the rest of the nation and most of the world, the department has had special challenges this year. People in the United States began to realize the seriousness of COVID-19 in early March 2020, toward the end of winter quarter. The last lecture or two for each course was cancelled or moved online, as were all final exams. That turned out to be just the beginning. Other newsletter items comment on how we've managed classes and research for the past eight months.

Most universities finish their spring terms by mid-May, but with our quarter system, UC Davis ends in mid-June. After the killing of George Floyd on May 25, our students had to get through two more weeks of class and then final exams. Classes or not, many felt the need to add their voices and presence to protests. Meanwhile the isolation imposed by the pandemic made it harder for all of us to process our reactions. Our amazing students found the strength to pull through. Our faculty were spurred to improve our record of training Black physicists. Several, along with an enthusiastic group of graduate students, are looking into changes we can make. Among other efforts, we applied to become an APS Bridge Partnership Institution and are beginning a fellowship drive to support graduate students with background similar to that of Bridge Program students.

A QMAP interaction space awaits interactors

Despite the pandemic, the major renovations in progress were completed: space in the Physics Building for new condensed matter research labs, and the top two floors of the Physical Sciences Library for the Center for Quantum Mathematics and Physics (QMAP).

By the time the space was ready for occupation, COVID-19 had severely limited on-campus presence. Ironically, QMAP theorists who have primarily been working from home have come to campus to move their belongings from one office they haven't been using to another which they won't use any time soon. The various moves will free up some space in the Physics Building. Much of it will be used to add experimental stations for our upper-level lab courses. We look forward to showing you the results when you next visit the campus.

Remote Instruction and Research

Of course, Covid has led to an immense disruption of our activities. Nearly all of us (staff, students, faculty, researchers) through the spring and now fall quarters are working and studying from home.

Research Some parts of the adjustment were straightforward. Research group meetings and individual meetings with students moved to Zoom. Computational work is done from off campus. The biggest difficulty is for experimental labs. After several weeks of near-complete shutdown of on-campus research, the campus began gradually reopening. For months research groups could do time-sensitive work, but with at most two people per research group in the lab at a time. Masks were required, along with distancing of at least six feet, a minimum space of about 200 square feet per person, and special care to clean shared equipment. From the end of October all research has been allowed, with lab occupancy restricted to 50% of the full level. Masks and social distancing are still needed, but the additional 200 square foot per person requirement is no longer in effect. This allows most groups to function at something approaching a normal level, although with more care than usual for scheduling considerations. Training, which for some tasks is impossible remotely or even at a 6-foot distance, is the biggest remaining issue. We hope to solve this soon through limited exceptions to the distancing rule.

Although research tasks themselves can be carried out, we miss the shared physical presence. Being able to share the excitement of a breakthrough -- or to commiserate when something simply breaks -- is part of the draw of research.

One place researchers are still gathering in small groups is in Professor Jim Crutchfield's 'theoriegarten.' It comes complete with work table, BBQ, whiteboard, pens, wifi, hand sanitizer, and masks (in the lock box at lower left of the whiteboard).

The shutdown had a few shreds of silver lining for research. The initial period with closed labs gave experimental groups time to catch up on data analysis and

Crutchfield's theoriegarten

programming tasks. Even if these hadn't risen to top priority in normal times, their completion will be appreciated going forward. The ease of attending seminars with scientists around the world, now that we are all far too familiar with Zoom, is another plus. Increased use of remote talks and workshops will probably outlive the pandemic, although not to the exclusion of in-person events.

Instruction Coursework in Physics and Astronomy has been entirely remote starting spring quarter. Spring instructors had two weeks' warning, which led to a flurry of experimentation with tablets, webcams, and all manner of software. We cancelled two one-unit courses, the lower-level astronomy lab and the upper-level optics lab. Neither is required for any degree, and the point of both is the hands-on experience. We kept other lab courses to avoid delaying any student's graduation. Advanced Lab instructors provided students with data and focused the course on analysis techniques. For some of the electronics labs, as well as one freshman seminar, students were sent kits with Arduinos, breadboards, and other small items. They could then carry out specially designed activities from home.

At least taking a class photo was easier in 2020

As we learn lessons about how to manage remote instruction, we've made corresponding schedule adjustments. As a general rule, large components like lectures can be scaled up without sacrificing quality, while more interactive activities like discussion sections need to have fewer students than with in-person instruction. We've all but eliminated late-night discussion and lab sections. Never popular, these are even less effective when students attend from home after dinner, and their surroundings tell them their work day is over. Fortunately a remote format removes all constraints from classroom availability.

Both students and instructors vastly prefer in-person classes, and it doesn't look like the internet will make universities obsolete any time soon. Some online elements will stay, like the Gradescope tool for administering and grading work, or recorded lecture snippets to free up class time for other activities. Instructors have also noted that some students feel more comfortable asking questions through Zoom chat than aloud, so they will try to keep such options during in-person instruction.

REU The potential impact of COVID appeared as we were making offers to our annual NSF-sponsored Research Experiences for Undergraduates program, so we kept the size small. Six students participated, as opposed to about 15 in recent years. Three students had originally been offered hands-on projects in condensed matter labs. Those three were all switched to computational work that had some connection to experiment. PhD alum John Mahoney then ran a programming workshop several hours a day during the first four weeks. The workshop ensured that everyone knew the basics of Python, including some data visualization. It also introduced some open-ended physics questions to keep the strongest programmers interested and gave the students an opportunity to interact with each other. We took advantage of the remote structure by having joint final presentations with the UCSB REU, attending a talk by a KITP physicist, and hearing from former REU students in different parts of the country about their career paths.

Alumni Seminar Series We run a seminar series every spring in which our alumni (and others with degrees in physics) come back to campus to tell our current students about life after graduation. This past spring we missed the in-person contact, but at the same time our reliance on Zoom eliminated geographic constraints. We had speakers join us to dispense their wisdom from as far away as Washington (Roderic Vanderscoff), Texas (Rylan Conway), Alaska (Catherine Cahill), and Washington, D.C. (Frederica Darema).

Graduation For the first time that any of us can recall, we held a departmental graduation ceremony as a substitute for the spring picnic. We liked it! Although inspired by Covid, we now plan to keep a departmental ceremony during graduation week even once we're back to in-person operations.

Racial Justice

The national focus on race and racism that started with the murder of George Floyd has been a local focus for us as well. We are recognizing that racism is pervasive in our society and are doing our best to be responsible for our teaching and research climate, given that reality.

Creating a more welcoming environment The student group, Diversity and Inclusion in Physics (DIP), has been very active on this front with a number of initiatives to promote diversity and a sense of belonging. These include a workshop on imposter syndrome, an anti-racism reading group, the formation of an APS-IDEA team, fact sheets to faculty about avoiding bias in recommendation letter writing, and preliminary work on the creation of a summer school targeted toward underrepresented minorities (URMs). DIP is working with faculty on efforts to make the teaching assistant training syllabus more inclusive. A letter asking that we make URM faculty hires a priority, signed by half the department's graduate students, has led to serious discussion about the hiring process among faculty. The department has also just launched a climate survey. This survey is fashioned after successful climate surveys at UC Berkeley and was informed by conversations with current and former Diversity, Equity, and Inclusion (DEI) Vice-Chancellors at UCB and UC Davis. It is the first officially-sanctioned climate survey to be initiated by a department at UC Davis. The results of this survey will be used to inform future initiatives to create a more broadly welcoming environment and will ultimately be part of a greater effort by the UCD DEI Office to assess climate campus-wide.

Outreach to Prospective Graduate Students Led by Professor Shirley Chiang, we have applied for membership in the American Physical Society's Bridge Program as a Partnership Institution. The APS Bridge Program is a one to two-year post-baccalaureate program that provides students with research experience, advanced coursework, and coaching to prepare them for a graduate school application. Nineteen of our faculty are

already engaged with this program. If successful in our application we will gain access to the APS Under-represented Minority (URM) applicant database, enabling us to reach out to qualified URM students to encourage them to apply.

Our faculty have also been very active in Cal-Bridge, a program designed to help physics and astronomy students at CSU campuses---the largest and most diverse university system in the US---build their credentials and get into Ph.D. programs. Professor David Wittman helped expand the program from its roots in Southern California and has served on the Northern California steering committee since its expansion, as well as the statewide Graduate Committee which provides feedback to all students navigating the grad school application process. He and six other faculty have mentored Cal-Bridge students. Professor Richard Scalettar has also served on the NorCal steering committee, researcher Brian Lemaux is serving as a graduate student fellowship reviewer and peer mentor leader, and graduate students Patricia Bolan and Ariadna Venegas-Li have recently served as peer mentors.

Recruitment This Fall we are launching Phase I of a campaign to create the Department of Physics and Astronomy Extraordinary Graduate Student Award. This award is intended to support students in their first and second year who have taken a non-traditional path to graduate school. We envision students who show promise as physicists but who may not be fully prepared for the usual PhD program. This can happen for a variety of reasons. For example, students who have significant family responsibilities, or whose finances require them to work long hours during college, cannot spend as much time on coursework and research as their more well-off classmates.

The goal of Phase I is to raise $200,000 in cash and pledges by July of 2021 from within the department. This will set us up for launching Phase II which we intend to bring this award endowment to $1,000,000, sufficient for fully supporting one student each year or partially supporting multiple students. We have already secured over $40,000 in pledges from a few faculty members involved in the early planning.

Awards

Assistant Professor Jaroslav Trnka is the 2021 recipient of the American Physical Society's Henry Primakoff Award for Early Career Particle Physics. His citation reads, "For seminal work on the computation of particle scattering amplitudes, including the development of a new mathematical approach, the amplituhedron." Professor Rajiv Singh was one of three recipients of the 2020 UC Davis Distinguished Teaching Awards in the graduate and professional programs category. Professor Richard Scalettar won the 2020 UC Davis Graduate Program Advising and Mentoring Award.

Jaroslav Trnka

Beyond the faculty, postdoc Ryan Sanders won a Hubble Fellowship, among the most prestigious of postdoctoral fellowships in the field of astrophysics. Graduate students

Victoria Norman, physics graduate student and member of the winning quantum hackathon team

Ben Cohen-Stead and Luke McClintock both won research awards that will take them to Los Alamos National Laboratory to continue their PhD work. Ben won the UC Laboratory Fees Research Program Award and Luke a DOE Office of Science Graduate Student Research Award. A team of students from the laboratory of UC Davis Professor Marina Radulaski won the California division of the Qiskit Summer Jam Hackathon with their project "QUantum Information Demonstrations PROmoting QUantum Optics (Quid Pro Quo). Graduate student Azalee Bostroem won a UC President's Pre-Professoriate Fellowship to support her in the final year of her dissertation work connecting supernovae to their progenitors.

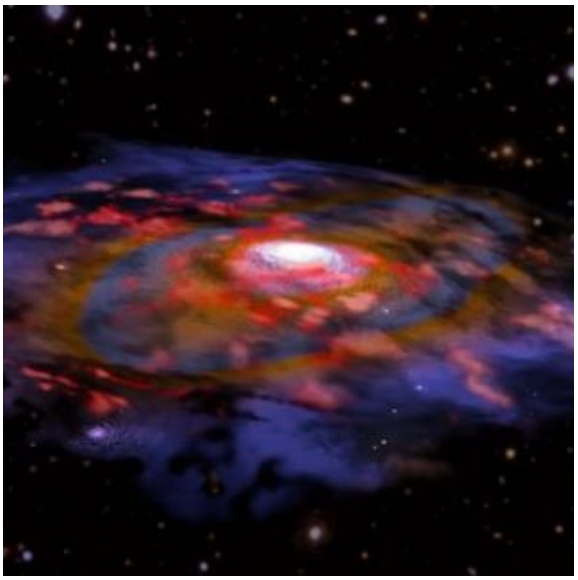
Our alumni continue to win awards as well. Professor Gilbert received a PhD from UC Davis in 2014 working with advisor Kai Liu, and this year won a DOE Career award. Alumnus Vladimir Iglovikov is noted in the AI Time Journal as one of 25 Autonomous Vehicles Influencers to Follow by 2020. Recent graduate Daine Danielson (BS 2017) has been awarded a Hertz Foundation Graduate Fellowship, one of only 16 awards this year nationwide across science, mathematics, and engineering.

Alumnus Dustin Gilbert

Please let us know of any awards our alumni have received by emailing lknox@ucdavis.edu with 'Alum Award' in the subject line.

Research Briefs

Galaxies grow up faster than expected
Physics & Astronomy Professor Lori Lubin and researcher Brian Lemaux are part of an international team of astronomers (ALPINE) studying the maturity of galaxies in the distant universe using a large array of radio telescopes in the high Atacama desert in Chile. Recent results published

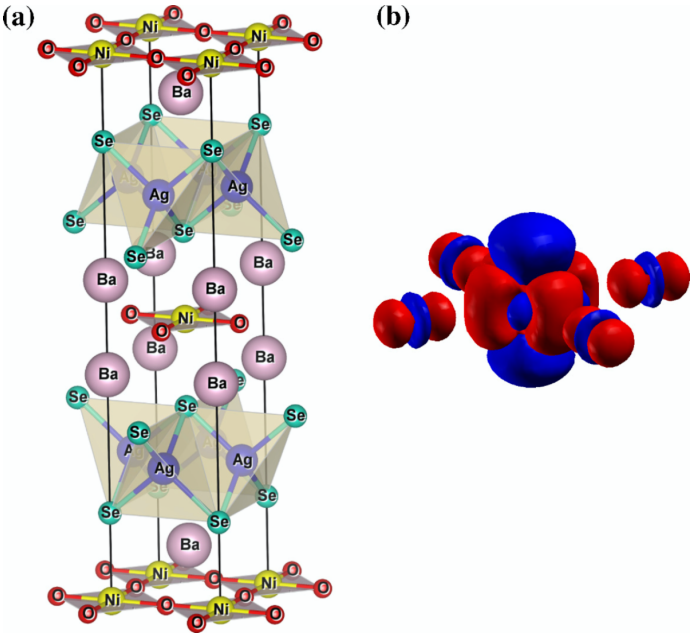


Artist's illustration of a galaxy in the early universe that is very dusty and shows the first signs of a rotationally supported disk. (B. Saxton NRAO/AUI/NSF, ESO, NASA/STScI; NAOJ/Subaru)

from these observations revealed a surprising number of galaxies in the early universe that were much more mature than previously expected, primarily indicated by the amount of dust and heavy elements created by these galaxies in a relatively short time (artist's rendition to the left). These mature galaxies also appeared to prefer overdense regions in the distant universe, and Lubin and Lemaux are currently harnessing the power of the twin Keck 10-m telescopes on Mauna Kea in Hawai'i as part of an astronomical survey named C3VO to more fully understand how a galaxy's environment helps it grow up. For more, see press releases from UC Davis, Keck, and the National Radio Astronomy Observatory.

Cox and Collaborator Try to Catch Coronavirus No, they are not trying to get infected. Physics Professor Daniel Cox and Chemistry Professor Michael Toney are adapting technology to make self-assembling protein scaffolds to combat coronavirus. Read the full story at UC Davis News.

Nickel oxide superconductivity: experiment supports theory 15 years later Both old and new theoretical work at UC Davis may clarify decades-old questions about the origin of superconductivity, as described in a 2020 Nature Reviews Physics 'Yearly Highlights' commentary by Professor Warren Pickett. After the initial 1986 discovery of high-temperature superconductivity in copper oxides, attention soon turned to sister compounds that might behave similarly, with nickel oxides chief among them. In 2004, Pickett and then-student Kwan-woo Lee pointed out an important difference between the copper and nickel oxides: the compound $NdNiO_2$ has an active additional 'frontier atomic orbital.' Fifteen years later superconductivity was finally observed in this compound, after careful preparation. The experimental results from last year are best understood in light of the 2004 theoretical discovery, and have provided more clues that Lee and Pickett pursue in three 2020 Physical Review papers.

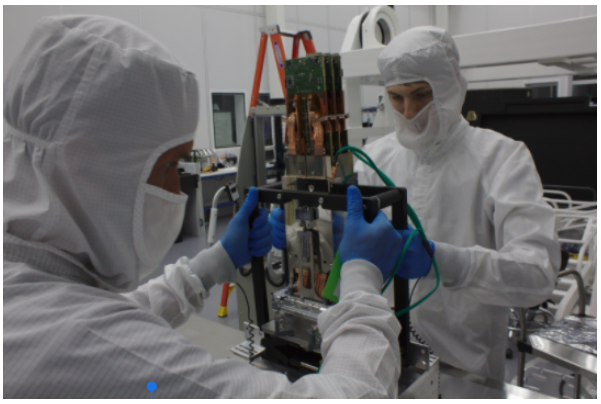


Left: crystal structure of Ba2NiO2Ag2Se2. The bottom, middle, and top layers are the active, two dimension NiO2 layers. Applied magnetic fields provide indications of both magnetic and non-magnetic behavior.

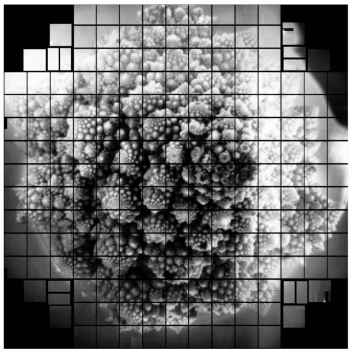
Right: an isosurface plot of the electron (spin) magnetization density. Red and blue parts are spin-up and spin-down respectively, and cancel to zero over the central nickel ion, resulting in an ``off-diagonal singlet'' magnetic unit.

Featured Faculty: The Vera Rubin Observatory

The Vera Rubin Observatory (VRO), a major new astronomical facility decades in the making, is scheduled to begin conducting its Legacy Survey of Space and Time (LSST) in early 2023. UC Davis has been a leading institution in this project ever since our 2004 recruitment of Tony Tyson to our faculty. Professor Tyson is the Chief Scientist of the VRO, named in January of this year to honor pioneering American astronomer Vera Rubin. **Camera sensors for the LSSTCam take first pictures.** The Tyson group at UC Davis has special responsibility for testing components of the 3.2 Gigapixel camera, the world's largest digital camera. It just took its first pictures in September.



Graduate student Daniel Polin (face toward us) working on camera raft construction.



First picture from the sensors of the LSSTCam. Display at full resolution would require 378 4K ultra-high-definition TV screens

Dark skies and bright satellites Recently Professor Tyson has been confronting a threat to the LSST and observational astronomy more generally: the planned deployment of tens of thousands of communication satellites in low-earth orbit. He has been working with SpaceX, who have launched the most of these satellites so far, and the astronomical community, to find mitigation strategies such as adjusting satellite orientation, darkening the satellite surfaces, and shielding them from the Sun. He co-authored, with Joel Parriott of the American Astronomical Society, a brief description of the problem and the efforts to create environmental protections for a precious natural resource: the night sky.

Secrets of the Universe

On location at CERN

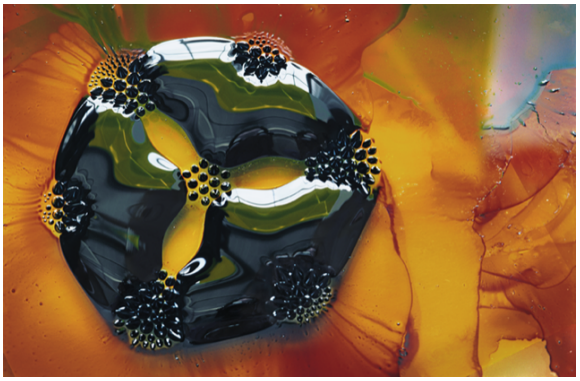
The red-carpet premiere of “Secrets of the Universe”, the Giant Screen film about the Physics of the Large Hadron Collider starring Prof. Manuel Calderón de la Barca and his UC Davis graduate students, was postponed due to COVID-19. While we await safe conditions to reopen theaters, Prof. Calderón de la Barca and the film production team have been avidly promoting the film via online webinars hosted by museums of science and technology, planetariums, and aquariums. These institutions have been eager to engage their audiences online since they are also facing the challenges of closures due to the pandemic. They include institutes in California, such as the California Academy of Sciences, and the Tech Interactive (San José), out-of-state institutes like the Pacific Science Center (Seattle, WA), and the Emera Astronomy Center and Jordan Planetarium of the University of Maine, as well as international venues such as the Armagh Planetarium in Ireland.

We look forward to the time when we will be able to host a screening of “Secrets of the Universe” close to home at the Sacramento Esquire IMAX, as seeing the enormous Compact Muon Solenoid detector on the Giant Screen is the next best thing to being at CERN. We anticipate inviting the UC Davis Physics community, including our Alumni, to join us for that event once conditions permit it.

A New Class on the Art of Science Communication

As part of the Science, Humanities and Arts: Process and Engagement (SHAPE) program a new course will be offered this winter: *Creative Visualizations of Science*, co-taught by Art Professor Darrin Martin and Physics and Astronomy Professor John Terning.
This course explores scientific discovery in visual terms as well as how science can be creatively communicated to non-experts. In a rapidly changing world, citizens need to be adequately informed about science in order to make educated choices. However, few people have sufficient time to keep up with the wide variety of developments. A further problem is that when scientists try to communicate with the public they typically fail to make a human/emotional connection hoping that "the facts will speak for themselves."

Psychological research shows that emotional engagement precedes cognitive engagement.



A ferrofluid, photo by Felice Frankel

Visual representation can convey a great deal of information, but without the emotional component that art has the potential to evoke, it will always fall short. The students will produce their own imaginative videos expressing responses to a specific scientific topic as a final project while linking scientific ideas and data with innovative visual analogies and personal narratives.

Consider making a gift today to help the UC Davis Department of Physics and Astronomy

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