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# Physical Interactions

News from the UC Davis Department of Physics

## Message from Department Chair Rena Zieve

I took over as Physics Department Chair this past summer, from Professor Bob Svoboda. For me the best part of the job has been learning more about the interesting things our faculty and students are doing. Usually this happens because I need to write a letter supporting an activity, recommending an award, etc. Although we won't ask you to write letters, we are reinstating our previous tradition of a department Newsletter so that you too can learn about a small fraction of the research underway, the awards our members and alumni have won, and the outreach and other events that we have organized and hosted.

The department has grown immensely since I arrived here more than 20 years ago. The number of faculty has increased by well over 60%, while our graduate program has doubled and our undergraduate population has tripled! One of my top goals is finding ways to manage our new size, while maintaining opportunities for the sorts of personal interactions that came naturally in our smaller days.



*Department Chair, Professor Rena Zieve*



*Renovations under way for the Center for Quantum Mathematics and Physics in the former Physical Sciences and Engineering Library.*

Not surprisingly, with growth comes construction. The Physical Sciences and Engineering library building has been redesigned to house the Center for Quantum Mathematics and Physics ([QMAP](#)), a joint endeavor of the Math and Physics departments. QMAP faculty, grad students, postdocs and visitors will be located together in the new space, which will feature plenty of places for spontaneous interactions and connections. Construction is well underway, with move-in slated for summer 2020.

The Physics building itself has undergone

major renovations for new condensed matter laboratories which will investigate quantum materials at low temperature. The research will include superconducting and magnetic compounds as well as some with possible applications in quantum information. A new liquefier facility allows recovery and reuse of more than 90% of the helium used as a coolant, an important step given the worldwide helium shortage.

The university's substantial investments in physics recognize our potential for further achievements, in part because our department culture is collegial, adventurous, and ambitious.



*The new Helium laboratory in the basement of the Physics Building*

We are grateful to past department leadership for creating this fertile culture. It was embodied in four of our colleagues who passed away this year: Professors Paul Brady, Tom Cahill, Chuck Fadley and Winston Ko. We comment briefly, albeit inadequately, upon their legacies in the final "In Memoriam" section of this Newsletter.

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## Awards

[Professor Veronika Hubeny was named a Fellow of the International Society on General Relativity and Gravitation.](#) This is a highly exclusive honor as there are only 34 other GRG Fellows, among them Stephen Hawking, Kip Thorne, and Roger Penrose. Adjunct Professor Kai Liu [was elected](#) a Fellow of the American Association for the Advancement of Science. Professors Inna Vishik and Eduardo da Silva Neto both [received Sloan Research Fellowships](#) while Professor Emilija Pantic was selected as a [UC Davis Chancellor's Fellow](#) and Professor Robin Erbacher was elected a [Fellow of the American Physical Society.](#)



*Professor Veronika Hubeny*



*Gong Chen's prize-winning entry in the 2019 LBL Nano-art Image Contest*

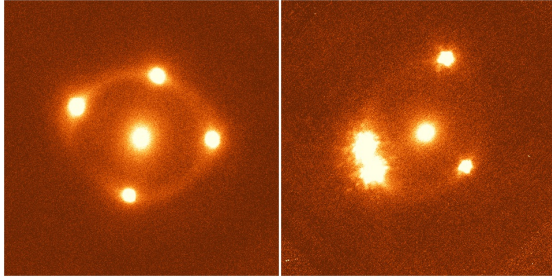
Beyond the faculty, UC Davis alumnus Austin Sendek (B.S. physics, 2012) [was named by Forbes](#) to the 2019 elite list of "the 30 under 30 fueling a more sustainable future." Graduate student Adam Rupe [won the High Performance Computing Innovation Excellence Award.](#) Nick Sherman [won the highly prestigious Leroy Apker Prize](#) from the American Physical Society for outstanding undergraduate research with Professor Rajiv Singh and mathematics Professor Bruno Nachtergaele. We even garnered awards in the performing and visual arts. The undergraduate physics club won a campus award for their [Picnic Day Physics Show](#), and Project Scientist Gong Chen [won first place](#) in Lawrence Berkeley Lab's Nano-art Image Contest.

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## Research Briefs

**Expanding Mysteries:** One of the hottest topics in cosmology now is a controversy over

discrepant inferences of the current rate of expansion of space. More direct methods indicate that there are about 74 kilometers of new space created in each Megaparsec each second (that is, the Hubble constant is 74 km/s/Mpc), while more model dependent methods favor 67 km/sec/Mpc. The topic is one of great interest because the discrepancy may stem from inadequacies of our cosmological models; i.e., the discrepancy may be pointing us toward a fundamentally important discovery. UC Davis researchers are playing leading roles in the cosmology community's effort to sort this out. You can read more about the controversy, and the contributions of Graduate student Geoff Chen, Professor Chris Fassnacht, and Professor Lloyd Knox in a number of articles in the popular press: in [Scientific American](#), again in [Scientific American](#), in the [New York Times](#), and in [Science News](#). A paper by Chen et al. is covered in astrobit.es [here](#).



*Images made with the W.M. Keck Observatory in Hawaii show how light from two distant galaxies is distorted into multiple images. UC Davis astronomers have made a new estimate of the Hubble Constant, which describes the expansion of the universe, by observing these distorted images. (Chris Fassnacht/UC Davis)*

**New momentum in photovoltaics innovation:** The long-prevailing wisdom in photovoltaics was that the age of innovation is largely passed, crystalline Silicon (cSi) technology has won, beating out all other proposed technologies, and now the only thing remaining is engineering cSi PV cells to lower their cost. This view was based on the record cell efficiency belonging to cSi at about 24.5 % since about 1996. However, in 2016, researchers from Sanyo and Panasonic made the startling discovery that when they deposited an amorphous Silicon (aSi) layer on top of the cSi layer, they were able to break the 20-year-old record, and achieve a record efficiency of 26.7%, rapidly approaching the theoretical maximum of 31%. The main challenge of these new aSi/cSi cells is that their efficiency seems to degrade faster than regular cSi cells. Prof. Gergely Zimanyi started a research program, recently funded by the Department of Energy, to model and measure this fast degradation, in order to discover design and fabrication changes to mitigate the degradation. His results could help to bring the benefits of this record-efficiency PV technology to the market.



*Professor Gergely Zimanyi, 2nd from left, and his research group*

**New Candidate for Dark Matter:** Another cosmological conundrum is the identity of the dark matter. This matter can't be found on the periodic table of elements, and outweighs regular "baryonic" matter by about 5 to 1. A [new theory](#) of the dark matter was recently introduced by UC Davis Physics Professor John Terning and postdoc Christopher Veerharen. In their theory the dark matter is composed of dark magnetic monopoles.

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## Featured Researchers

Professor Eric Prebys came to UC Davis in 2017 after working at the Fermi National Accelerator Laboratory for 16 years in the fields of particle and accelerator physics. Here



he is serving both as Director of the Crocker Nuclear Laboratory and as the leader of a new effort in the High Energy Physics group, [the Mu2e Experiment at Fermilab](#). The Mu2e experiment will search for the conversion to an electron of a muon that has been captured on an atomic nucleus. While effectively forbidden in our Standard Model of particle physics, this reaction is a virtually universal feature of models beyond that. With the goal of increasing the sensitivity of this search by a factor of 10,000 over the previous best measurement, Mu2e is a unique and powerful tool to test such models. His group is primarily

focused on achieving the challenging beam requirements of the experiment, which is expected to take data in the early 2020s.

Crocker Nuclear Lab is home to a 76” cyclotron, which first operated in 1966 and was a crucial step in establishing the Physics Department. In spite of its age, the cyclotron still has the potential to do exciting cutting-edge research. As Director, Prebys has worked to expand the scientific mission of the Lab, while maintaining the historical commitment to the [Eye Therapy Facility](#) and the users of the [Radiation Effects](#) line. He recently received a grant from the Department of Energy to develop the production of  $^{211}\text{At}$  (“Astatine-211”), an alpha-emitting isotope that shows great promise for cancer treatment. Because this isotope can only be produced by bombarding a Bismuth target with alpha particles (Helium nuclei), it cannot be produced at commercial isotope facilities, which have only beams of protons. In addition, he has recently been [awarded a grant](#) as Principal Investigator for an experiment to develop high performance accelerator diagnostics based on diamond detectors, which have fast response, large dynamic range, and are extremely radiation resistant. The cyclotron will serve as a test bed for these detectors, and they will in turn be used to study beam dynamics during acceleration. For this project, UC Davis will serve as the lead institution for a collaboration that includes Los Alamos National Lab, Lawrence Berkeley National Lab, UC Santa Cruz, and UC Santa Barbara.



Postdoctoral Researcher and Hubble Fellow [Sarah Loebman](#) joined Professor Andrew Wetzel’s group at UC Davis in 2017. Her primary research interests are in galaxy evolution, dark matter, and chemo-dynamics in the Local Universe. She uses high-resolution galaxy simulations, survey data, and Big Data tools and techniques to conduct her research. In the Fall of 2020 she will be joining the physics faculty at UC Merced.

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## Outreach

**Secrets of the Universe:** [“Secrets of the Universe”](#) is a sweeping 3D IMAX film about some of the biggest questions in science, with a focus on heavy ion collisions at the Large Hadron Collider. UC Davis plays a prominent role in the film as our very own Professor Manuel Calderón de la Barca Sánchez is the scientific adviser and narrator. Some UC Davis graduate students, such as Santona Tuli, have prominent roles as well. There was an advance screening in Sacramento for educators in November. A special red carpet screening on April 23 with the Chancellor and the Provost has also been scheduled. Stay tuned for information on additional screenings in the Spring.



*Much of the new Imax film, Secrets of the Universe, was filmed at CERN.*

**Astro on Tap:** A monthly set of short, free, public Astronomy-related talks at Sudwerk Brewing is in the middle of its second year of

operation. Every third Thursday we feature two speakers who give short talks with connections to astronomy, play trivia, and give away prizes. We've had talk topics ranging from black holes to climate change to the science of Star Trek. Our next event is January 16th, and more info can be found on our [Facebook page](#).



*Graduate student Pratik Gandhi discusses the physics of Star Trek at Astro on Tap*

### Summer High School Internship

**Program:** Led by Professors Richard Scalettar and Valentin Taufour, the [High School Apprenticeship Program in Materials Science](#) was held at the Department of Physics this past summer. The program was a partnership with River City High School in West Sacramento funded by the Oak Ridge Institute for Science Education. Students built a magnetically levitated train and wrote python codes for simulating magnetic materials.



*Professor Valentin Taufour with high school interns*

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## Major Events

**Conference for Undergraduate Women in Physics:** UC Davis was one of 12 institutions hosting the 3-day [Conference for Undergraduate Women in Physics](#), an annual event coordinated by the American Physical Society. The event had 20 local organizers, and drew on the expertise of more than 50 women who volunteered their time to give talks, lead workshops, and serve on panels. Topics included careers, undergraduate research, graduate school, and ways to increase representation of women in physics, as well as research presentations. The conference drew 142 student attendees to UC Davis, many of whom found it inspirational to participate in such a large gathering of female physicists. One student who attended the conference transferred to UC Davis after the conference, and another participated in our [Research Experiences for Undergraduates](#) program. We hope to see more of the participants at UC Davis in the near future!



Conference for Undergraduate Women in Physics  
January 18-20, 2019



*This coffee break photo shows the level of intellectual excitement at the QI-QG conference. The participants have foregone refreshments in order to gather around a white board for intense discussion.*

### Quantum Information in Quantum Gravity:

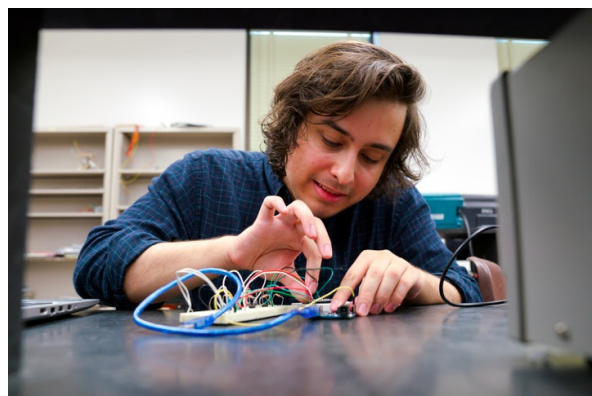
The [Center for Quantum Mathematics and Physics](#) (QMAP) hosted the fifth international conference on [Quantum Information in Quantum Gravity](#). The conference drew about 40 experts from all over the world to discuss the many exciting emerging connections between quantum information and the physics of space and time. This conference is an example of the kinds of connections between different disciplines that QMAP was designed to foster.

### Multi-Hazard Data Science Workshop:

Hosted in the Physics building by Professor John Rundle, and in conjunction with the Association of Pacific Rim Universities Multi-hazards Hub at Tohoku University in Sendai, Japan, [this workshop](#) in June explored applications of new techniques in data science to inform decision making at various stages of response to natural disasters.

## New Class

**Next-level Legos:** A new class called [Join the Maker Revolution](#) was designed and taught by Professor [Shirley Chiang](#) as a [first-year seminar](#), open to students from across the university. She used her experience building instruments for physics experiments to teach a class where students design and create their own do-it-yourself projects. Students got hands-on experience with soldering irons, 3D printers, and open-source electronic hardware, while developing their skills at problem-solving, communication, and collaboration. The course drew students with a wide variety of majors; they created projects ranging from mechanical flowers to moon clocks.

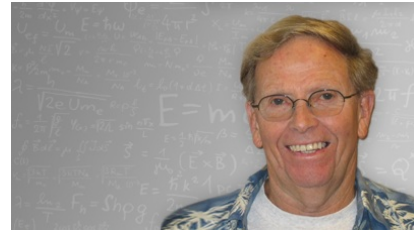


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## In Memoriam

This year we bore heavy losses with the passing of Professors Paul Brady, Tom Cahill, Chuck Fadley and Winston Ko. We mourn these losses, and we are grateful for the many ways they enriched our lives.

Although all were retired at the time of their passing, they were still very active in their support of the department and remarkable for their philanthropy. Paul Brady established the [Paul Brady Award](#) and Paul Brady graduate student fellowships. This kind of support improves our ability to compete for the best prospective students, and gives students the ability to start their PhD research sooner than would be otherwise possible.



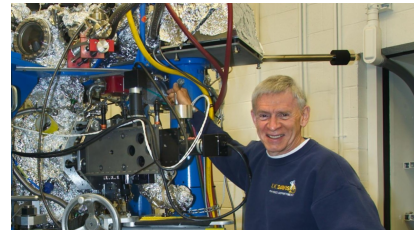
Professor Paul Brady

Tom Cahill and his wife Virginia Cahill established the [Cahill Applications of Physics to Environmental Research Fund](#) to encourage faculty and graduate students in the Department of Physics to conduct research that will address important environmental challenges. These funds supported development of new filters for reduction of air pollution, and the launching of the [Pathways to Climate Neutrality in California initiative](#).



Professor Tom Cahill

Earlier this year Chuck Fadley was still active in training students and carrying out his research program. "Chuck took great pride in his students and their successes," said physics department chair Rena Zieve. "He remained active in research until the last few weeks of his life, and made sure that his current students would be taken care of after his passing. He will be remembered and missed by students and colleagues alike." Years earlier, he created the Katherine Fadley Pusateri Memorial Fund to honor his mother. It funds conference travel awards for graduate students in Physics and in Music.



Professor Chuck Fadley

Winston Ko was chair of the department of physics and then Dean of the Division of Mathematics and Physical Sciences until his "permanent sabbatical" (as he referred to retirement) in 2013. During this sabbatical he and his wife Katy Ko established an endowment to fund the *Winston Ko Professorship in Science Leadership* and a public lecture series in the College of Letters and Science.



Dean Winston Ko

All leave behind significant legacies from their teaching, mentoring, research, and leadership. We have not done justice to those legacies here. Paul Brady's obituary can be read [here](#), Tom Cahill's [here](#), and Chuck Fadley's [here](#). [Memorial gifts](#) for Chuck Fadley may be made to UC Davis in support of the Katherine Fadley Pusateri Memorial Fund in Physics. For Winston Ko there is a [memorial website](#) and the [Winston Ko memorial fund](#).

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STAY CONNECTED

