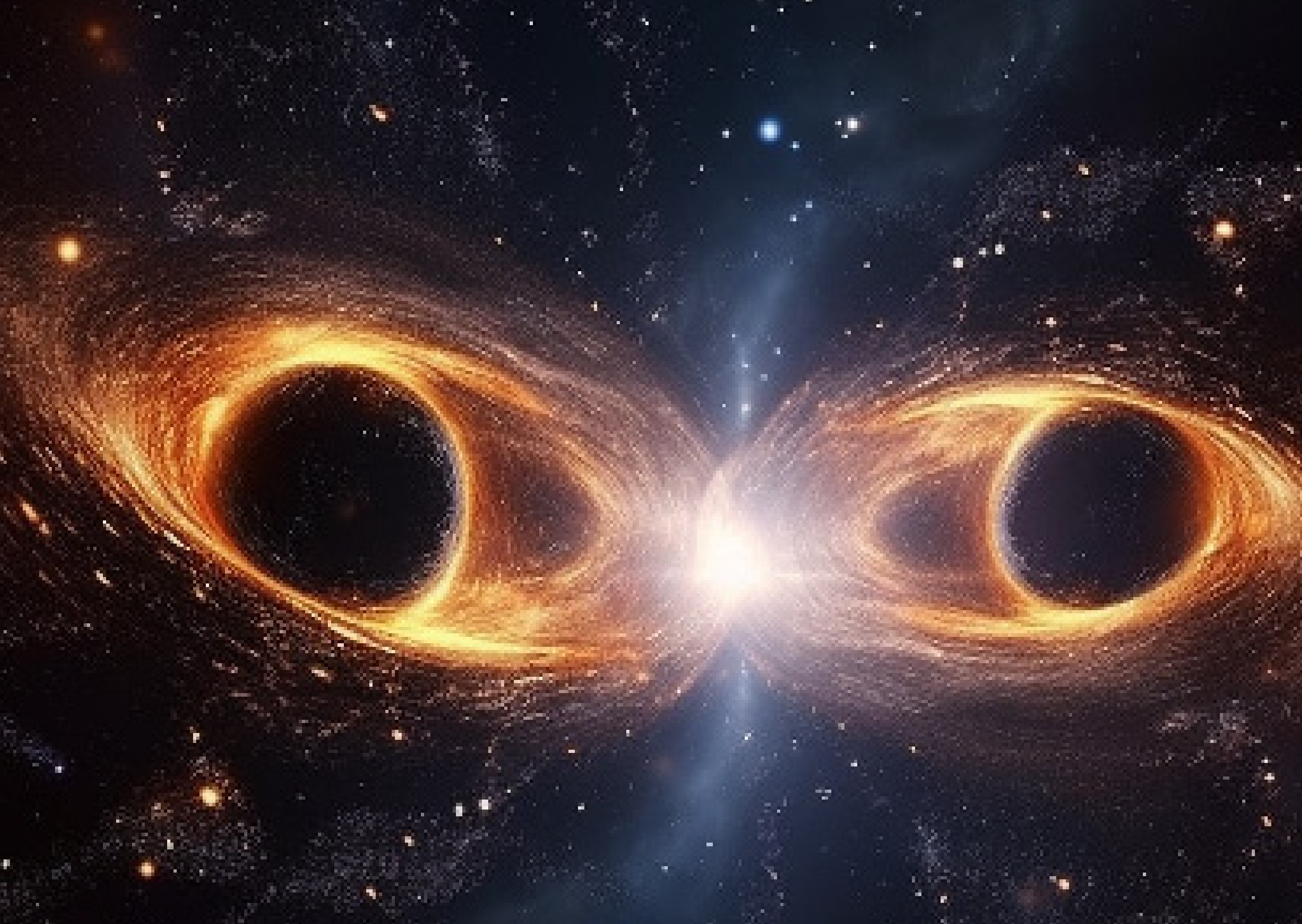
PHYSICS NEWSLETTER

University of California Santa Cruz
Physics Department

Spring 2025



COVER STORY

QUANTUM ERROR CORRECTION AND QUANTUM GRAVITY

UC SANTA CRUZ

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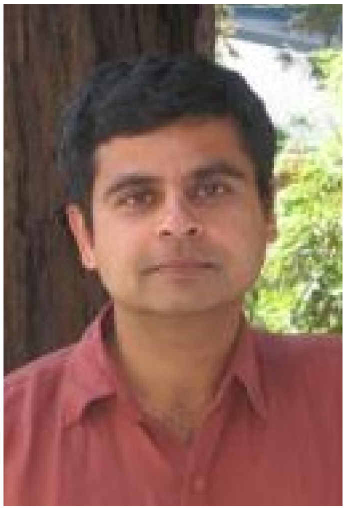


Dr. Onuttom Narayan

Welcome to another edition of the UCSC Physics newsletter! Since the last newsletter a few years ago, the department has seen many changes.

Among the faculty, Ryan Baumbach has joined us as part of the materials science group, with expertise in the synthesis of novel materials. With his arrival, the materials science group has achieved critical strength that is enabling it to apply for large center-level grants. Despite the turbulent situation with funding for scientific research at the national level, we hope that these efforts will be successful in the next few years. We have also welcomed our first Teaching Professor Amy Furniss, who has been pivotal in changing the teaching of the Physics 6 series (which caters to chemistry, biology and earth science majors), with several other instructors of these courses following her example. On the debit side, condensed matter theorist and biophysicist Josh Deutsch retired in 2022, leaving a gap in our research and teaching.

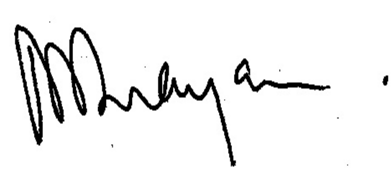
In terms of the curriculum, the interdisciplinary Materials Science MS and PhD programs were launched in Fall 2024, spearheaded by Physics professor David Lederman. Enrollment in these programs is growing, and these students will soon have an impact on the research being done in the Physics Department. The Computational Physics concentration in the Applied Physics major, with an emphasis on computer programming and computational techniques (including an elective on machine learning), was launched in Fall 2023.

Another exciting achievement has been the 2024 launch of the concentration on Quantum Information Science (QIS) in the Physics major, which is one of the strongest undergraduate programs in this extremely fast-growing field. This concentration has entailed setting up a new QIS upper division laboratory course, with novel experiments on quantum optics, Bell's inequality, and Josephson junctions. There is considerable student interest in the program.

In recognition of our efforts, we are delighted to report that we received the 2024 Improving Undergraduate Physics Education (IUPE) Award of the American Physical Society. We continue to look for new opportunities to respond to changing student interests.

There has been considerable staff turnover since the last newsletter. Our department manager Cathy Murphy retired and was replaced by Deena Pais for two years before our current manager Theo-Alyce Gordon took over last Fall. The other staff — graduate advisor Jeremy Parker, undergraduate advisor Christian Sanchez, lower division lab manager Kenny Smith, and department assistant Kali Lucas — all joined us in the past few years. As always, the dedication and hard work of our staff is essential for our continued success.

These are challenging budgetary times for universities everywhere, but our physics faculty remain energized by a shared passion for teaching and research, and by the knowledge that there will always be students who share that passion. Fueled by this committment, we continually seek new resources to strengthen our academic programs and research capabilities. We hope that you will support us in this effort by going to https://www.physics.ucsc.edu/support-us/index.html and contributing toward the goals and initiatives that help strengthen our department.



Interview with 2005 Physics PhD alumnus Brandon Allgood

by Arthur Ramirez

Earlier this year I connected with alumnus Brandon Allgood, presently Chief Data Science Office at Parabilis Medicines and Lecturer at UC Berkeley. He discussed his own career path which took unusual turns after his 2005 PhD in theoretical cosmology, turns which may offer a template for future alumni.

You studied at UCSC, receiving a Ph.D. in theoretical cosmology in 2005 and now, in 2025, you are described as a serial entrepreneur with a focus on applying machine learning (ML) aånd other large-scale computational methods in the field of healthcare. Can you tell us how this evolutipomn occurreed?

Sure, I'll go all the way back. Ever since I was a kid, I wanted to be an academic, which was odd, especially since no one in my family had even gone to college. I happened to pick up a book when I was young, probably at a garage sale, on the theory of relativity by Wolfgang Pauli, and attempted to read it many times with little progress, eventually falling back to books like a (Stephen Hawking's) Brief History in Time, which conceptually I understood. That's an example of my early passion and of course students pursuing a Ph.D. in cosmology usually want to be academics – there are no job ads for cosmologists outside academia!

While I was in grad school at UCSC, I saw what the professor's job entails, and as I took stock of the basic math of the number of Ph.D.'s granted each year versus the number of available jobs, I became convinced that I could probably find greater success outside academia. So, out of grad school, I had offers from NASA Ames, Google, and a startup, Pharmix, where some friends from UCSC were working. Pharmix, which I joined, was doing computational chemistry using machine learning. I realized looking at the work they were doing that one can do cutting edge science outside of academia, it had just shifted from the Bell Labs to start-ups. I dove in head first.

That was the seminal event that led you into the healthcare field where, after your stint at Pharmix, you played key roles in two other groundbreaking companies, Valo Health, and Numerate.

Looking back, what would you tell students, and others, who may be trying to chart a course for their career, especially outside of academia and into other disciplines?.

I think the most important things is to be yourself, but also making yourself available to different opportunities, not shying away from some topic you don't know much about. I only knew 10% of what the Pharmix job required, but that was enough to get in.

A little like research, where you never know everything.'

Right. Another piece of advice is to develop a network and keep it active. The network of friends I formed at UCSC is still a big part of my life and, as I mentioned, it was friends working at Pharmix that led to my first job, which was seminal for my career. Nowadays, I continue to foster my network, splitting my time between Seattle and Boston, there are ton of opportunities to engage others in the space, for example at the Allen Institute and University of Washington in Seattle and Harvard and MIT in Boston.

Do you need to be in a place like Seattle or Boston to network in this fashion?

Yes, I would advise people wishing to innovate competitively to move to one of these hubs; Seattle, the Bay Area, Boston, or San Diego for biotech. The problem is that they are expensive to live in, so you'll have to make sacrifices in your personal life. But the main point is to socialize in an innovation hub and while I mentioned the best-known cities, university towns usually have incubator labs and some venture funding base.

But while I mentioned networking, at some point you might want to start your own company, and for that, my words of wisdom would be that no one starts a company by themselves, even Mark Zuckerberg. So, you will also need to find partners, usually just a couple of people, who can complement your skill set - maybe you're the technical person, then you need to partner with a business mind. Most importantly however, you need to surround yourself with people who will push back on your ideas because the more stress-testing you do internally, the fewer mistakes later. I call this psychological safety because you have to be able to tell each other, in brutal terms, what you really think.

You have established a presence in each of three big innovation hub cities, is there a difference among them?

Well, I would say that the Bay area is probably the leader at least in terms of venture capital availability, but Seattle, while overall smaller, is extremely vibrant and culturally similar. On the west coast people work at all hours, show up in shorts, ride bicycles around the office, and have things like unlimited vacation. Boston is different from these places, more formal, and startups in particular are structured more like regular companies, fewer stock options, fixed vacation leave and so forth. But Boston is the innovation leader in the biomedical industry, which is one reason I have an apartment there.

Finally, do you have any immediate advice for a grad student pursuing a degree in, say theoretical cosmology, as they see a small number of academic positions on the one hand and a burgeoning growth in Artificial Intelligence and Machine Learning on the other?

I'm glad that you narrowed it down to my own expertise, theory. I would say to such a student that, while you think your expertise is in physics, from the innovator point of view, you are an embryonic stem cell, able to morph into many different things. To put a finer point on it, your specialty is applied mathematics and abstract problem solving. This skillset is invaluable to companies. For example, now companies using AI and ML need people that can both understand the mathematics behind the model, but can also keep up with fast moving field, and this requires mathematical intuition. For those students wanting to learn more, find the fundamental papers in the AI field and start reading them, just I did Pauli's book. You may not understand them at first, keep at it. Also, as I said earlier, keep yourself open to new ideas and adventures, but realize that physicists are everywhere in the big data, AI, and quantum computing ecosystems. We are everywhere. I network constantly and when I introduce myself as trained in theoretical cosmology not only is this not noteworthy but it's not unusual to hear back "oh I have a degree in astrophysics."

Do you have any parting thoughts?

I think we have touched on the basics of networking and being open. As you grow older, you'll realize that these may be your most valuable, and enjoyable, assets. I would say that for the last 20 years, a large part of my social life has revolved around friendships made at Santa Cruz. These friendships got me my first job, and actually, I just had a group including friends from UCSC up here for my 50th birthday!

My last piece of advice would be to always love what you do, where you do it, and who you do it with. Life is too short otherwise. The more seriously you take this last piece of advice and act on it the sooner you will find joy in your career.

Dr. Brandon Allgood

My Journey from Banana Slugs to Google AI

By Dr. Eddie Santos

Hello everyone! It's Eddie Santos, and I graduated from UCSC in 2015 with a PhD in Physics after six transformative years in Santa Cruz. I have countless special memories and enduring friendships from my time at UCSC. I'll always be forever grateful to Howie Haber, my advisor, for not only imparting to me a level of intellectual rigor that has stuck with me, but most importantly for his friendship and the great times we shared together. Who could forget the legendary reign of our Re-Entry softball team, racking up a 39-1 record and two championships? And also many great memories with Stefano Profumo during the endless hours we spent zooming up and down the Santa Cruz mountains on our bikes. Those were great times!

During my last year at UCSC, I had become intrigued by the booming tech industry on the other side of the hill, and watched curiously as my classmates participated in the Insight Data Science program, a seven week intensive that helped recent PhD graduates, like us, transition to tech careers. I followed suit shortly thereafter to join what felt like a world unknown, and it's been a roller coaster of an adventure ever since.

My first role in tech was at a very successful startup based in downtown Palo Alto that had just been acquired by Salesforce. It was a true culture shock to enter a lavish world where all meals were catered, not to mention the mid-day company beach parties with flowing champagne and overwhelming amounts of lobster to eat. While I was getting used to these new experiences, I couldn't be more pleased that the deep intellectual rigor and problem-solving skills honed during my physics journey transferred wonderfully to solving business problems and building new products. I also enjoyed giving tech talks to coworkers curious about physics news they had heard (e.g. gravitational waves), allowing me to continue sharing my passion for science with a new audience.

From Salesforce, I moved to Airbnb as an early machine learning hire Airbnb during that time was gearing up for a much anticipated IPO, and it was another great experience to witness the opulence of Silicon Valley firsthand. My tenure at Airbnb proved to be brief however, as an irresistible opportunity to join Google and work at the industry epicenter for all things AI over the past few decades.

At Google, I was hired to help modernize the video search experience on Google Search with AI, which resulted in the video key moments product that is still being used by billions of users to this day, a truly incredible opportunity. In further pursuit to be at the forefront

product that is still being used by billions of users to this day, a truly incredible opportunity. In further pursuit to be at the forefront

of AI, I then found myself at Google Brain working on a team that demonstrated the ability for AI to detect breast cancer in mammograms at a super human level of performance. It was fun to be part of the research world once again, where I co-write a few papers in the medical AI space regarding using AI to detect abnormalities in chest x-rays, which proved timely as we were just heading into the pandemic. A desire for new challenges led me to Twitter as an Engineering Lead on their then Responsible AI team. It was incredibly rewarding to help ensure that AI was used ethically and fairly across the platform, particularly given the importance of Twitter as a town hall for the world to discuss everything from entertainment to politics. I was looking forward to Twitter being a long term home for my career until it was announced that the company would be acquired, and I was part of the wild ride that ended with being part of the 90% of the company laid off shortly after the acquisition.

I eventually found myself back at Google, where today, I'm an Engineering Lead for the Gemini Code Assist products. We're at the forefront of developing revolutionary AI tools that empower software developers, and it's incredible to be in this position at a company that's at the very forefront of all things AI. My career has been quite a journey, and I'm grateful for everything I've experienced and the many great folks I've met along the way. It's also been fulfilling to be joined in tech by many ex-physics classmates and colleagues both from UCSC and beyond!

As I reflect on the decade since leaving Santa Cruz, I can confidently say that the rigorous academic environment of the UCSC Physics Department was key in establishing a level of intellectual rigor that has been a constant throughout my professional journey. The ability to dissect and solve complex problems, as well as critically analyze data – skills deeply ingrained during my PhD – have been fundamental to my success and the journey that followed.

To the current PhD students and fellow alumni, I hope my journey illustrates the diverse paths that physics degrees can open. The critical thinking and analytical skills you are developing at UCSC are powerful assets that can be applied to a wide range of fields. Embrace the rigor, cherish the the community, and know that the foundation you are building here will serve you well, wherever your path may lead.

Dr. Eddie Santos

Quantum Error Correction and Quantum Gravity

By Professor Edgar Shaghoulian

Quantum computers are fundamentally concerned with transmitting and manipulating quantum information. But this information can develop errors or be corrupted along the way, since quantum computers are incredibly delicate. In such a situation we would like to reconstruct the original information. What works for classical computers – simply sending many copies of the information, so if some are corrupted it's still clear what the original information was – does not work in quantum mechanics. This is because of the "no-cloning theorem," and it simply says you cannot replicate quantum information. It has the unfortunate consequence that quantum computers which hope to use the magic of quantum mechanics need a new way to protect against errors.

This is where quantum error correction enters the picture. The same profound property of quantum mechanics – quantum entanglement – which is behind the inability to replicate information, is also behind a new scheme to protect information. Instead of simply copying the information we want to send, we can encode it into the entanglement structure of our quantum state. You can then show that the original information can be reconstructed even if some of the information is corrupted, because there is some redundancy in how the information is encoded.

It has come as one of the big surprises in the last decade that the very practical concern of protecting information as it makes its way through a quantum computer has a lot to do with how nature encodes information in and around black holes. Famously, black holes suck in objects and, therefore, information. Stephen Hawking showed in the 1970s that once you introduce quantum mechanics into the mix, black holes also spit out particles and, therefore, information, although the information they spit out seemed uncorrelated with the information that went in. This led to a decades-long puzzle that fueled much of the work in high-energy theoretical physics, since this picture violated a sacrosanct principle of quantum mechanics: conservation of information.

In 2019, my collaborators and I showed that by recasting the question in the language of quantum gravity (more precisely, the quantum gravity path integral), the problem could be geometrized in a surprising way. In this approach, it became clear that certain geometries – wormhole configurations – had been overlooked, and that by including them in the geometric description one is able to see that the information that falls into the black hole also gets out of the black hole. The mathematics of how this information is encoded in the particles that the black hole spits out is precisely the same mathematics of quantum error correction! (Our neighbors over the hill at Stanford University also had this result and published it at the same time – sometimes an idea is just in the air.) While this connection may at first seem quite mysterious, it helps to remember that quantum error correction at its core is concerned with how information is transferred in a quantum-mechanical theory. Quantum gravity is just another quantum-mechanical theory, so it should apply just as well to this context. And there was precedent for this idea, as several years earlier many scientists had developed the concepts of quantum error correction in quantum gravity when black holes were not in the mix.

It is important to note that this work about black holes is purely theoretical. We are using mathematically rigorous results from quantum error correction – which are increasingly implemented in quantum computers built in labs around the world – but the results when applied to black holes are not something we can test in the real world. At best, we can hope to simulate such black holes (with quantum computers!), but this is not the same as going out to the black hole at the center of our galaxy and checking whether it implements quantum error correction in the way that we expect.

My focus today is on trying to understand to what extent the lessons learned from black holes and the mathematics of quantum error correction can be applied to puzzles in our expanding universe. Our universe is not only expanding, but it is accelerating as it expands. Similar to how the pull of a black hole is so strong that it leads to an "event horizon," a point of no return, the push of accelerated expansion is so strong that it also leads to an event horizon. In this case, the event horizon surrounds us, and objects which fall past it cannot return. But this seems to lead to the same puzzle as in the case of black holes: is that information really gone? Or is there some way in which that information is still encoded on our side of the horizon? And is the mathematics of quantum error correction important here as well?

While these concerns seem quite highfalutin, we currently have a cosmic event horizon about 16 billion light years away. Most of the galaxies we currently see in our night sky will fall past this event horizon as long as our universe's accelerated expansion continues. Will all the vast richness of our universe be lost beyond this cloak? Or is there some sense in which we will still be able to access that information? My graduate students, postdoctoral scholars, and I are currently trying to puzzle our way through some of these questions.

One of the fundamental difficulties is that, because we are surrounded by a finite-sized (though huge!) horizon, there is a fundamental limitation to how precise a measurement we can do. This is simply because we are cramped by the finite amount of space we have, and we cannot focus energy and resources into an arbitrarily small region since it will become so dense as to form a black hole! While this is clearly not an immediate practical concern, since a sphere with radius 16 billion light years is plenty of space, it informs what a fundamental theory of our universe should look like. In particular, we cannot separate ourselves as scientist/observer from the rest of the system, since we are trapped within the cosmic horizon along with everything else! The theory of our universe should therefore simultaneously incorporate a theory of the observer. While this seems like an added difficulty, there are currently hints from several different directions that this helps simplify some puzzles about our accelerating universe, and may even let us port tools from the black hole context. My hope is that the incorporation of the observer will finally let us crack some of the puzzles that have plagued the development of a quantum theory of an accelerating universe, and that quantum error correction will play an important role in its description.

Professor Edgar Shaghoulian

Frustration of the Magnetic Kind

by Sergey Syzranov

Magnetic materials are quite common in electronic devices, such as audio speakers, electric motors, and MRI scanners. In insulating magnetic materials, i.e. magnetic materials that do not conduct electrical current, magnetism comes from atomic magnetic moments called spins. These magnetic moments normally align in regular patterns (with two examples shown in Figs. 1(a) and (b) at sufficiently low temperatures, often at room temperature and below.

It has been predicted, however, that some magnets will exhibit a distinct state of matter called a quantum spin liquid (QSL). In a QSL, spins would never become ordered but instead exhibit quantum fluctuations, i.e. exist simultaneously in multiple states with random orientations (cf. Fig. 1(c)). A QSL is disordered relative to a usual magnet in the same sense in which a conventional liquid is disordered relative to a crystal, hence the name "spin liquid". Unlike a conventional liquid, however, a quantum spin liquid would not freeze when cooled down to absolute zero.

Apart from fundamental interest, QSLs would hold great potential for applications in quantum information processing. A QSL would be able to store information in the collective quantum state of a huge number of spins in a way that protects information from external perturbations. As a result, many experimental research efforts around the world are directed at finding QSLs in real materials.

Despite those efforts, there is no consensus about the existence of quantum spin liquids in materials studied to date. One of the main obstacles in finding QSLs is quenched disorder, i.e. randomly-located impurities and defects present in all materials. Such imperfections obscure possible experimental signatures of QSLs. Furthermore, below a certain temperature , random imperfections can make the spins freeze in a random configuration (i.e. with spin orientations no longer fluctuating in time but pointing in random directions), which is called the spin-glass state and believed to be incompatible with a QSL state. As a result, researchers invest enormous efforts in purifying magnetic materials, i.e. reducing the number of impurities and defects; pure materials are believed to be more likely to avoid the spin-glass state and host QSLs.

To investigate the possibility of QSLs and gain insight into the nature of magnetic states in candidate materials, the groups of Professors Art Ramirez and Sergey Syzranov at UCSC are exploring the effects of quenched disorder on geometrically frustrated magnets, the largest class of materials in which QSLs are sought.

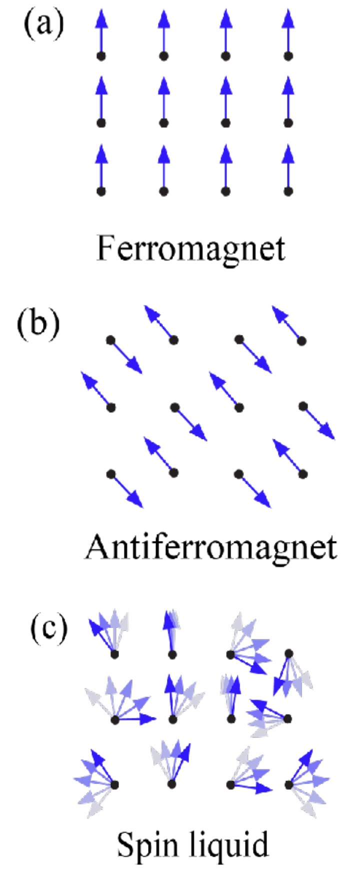


Figure 1 Types of spin ordering in magnetic materials. In a ferromagnet (a) and in an antiferromagnet (b), the spins are ordered in regular patterns. In spin liquids (c), the spins do not form regular patterns but exhibit strong quantum fluctuations.

Vacancy as a magnetic moment. The most common type of quenched disorder in candidate materials for QSLs are randomly located vacancy defects. Vacancy defects, i.e. missing spins in magnetic materials, occur when non-magnetic impurity atoms randomly replace magnetic atoms.

Although these impurity atoms are non-magnetic, the presence of a vacancy affects the orientation of the spins around it, which leads to the emergence of effective magnetization associated with the vacancy. It has been established experimentally that a vacancy defect acts as a free spin, called a quasispin. The magnetic susceptibility of such vacancy quasispins varies as $1/T$ where T is temperature and, thus, can dominate the magnetic response of the material.

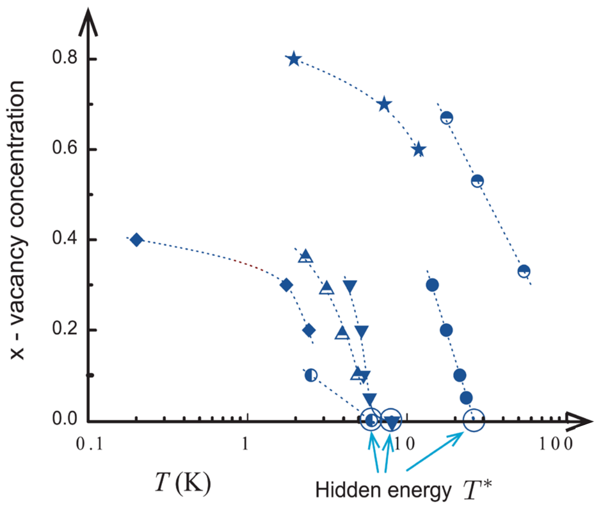


Figure 2 The temperature of the glass-freezing transition as a function of the vacancy concentration for several different magnetic materials. All of the materials for which data exist have a freezing transition that approaches a finite value as the vacancy concentration vanishes, i.e. the material becomes pure,

Graduate student Shijun Sun, Professor Arthur Ramirez and Professor Sergey Syzranov theoretically investigated the conditions necessary for the emergence of quasispins [1] . They found that quasispins emerge in models as simple as the Ising model, i.e. an array of classical spins that can be oriented only parallel or antiparallel to a certain axis and interact with their neighbors. Because realistic models of magnetic materials possess the same ingredients, the emergence of quasispins should generically be expected in magnets that do not develop magnetic order at low temperatures.

With increasing the density of vacancy defects, quasispins can no longer be considered as isolated magnetic moments, and their interactions with each other become essential. A natural and intriguing question that the researchers are currently investigating is the possibility of new magnetic phases that emerge as a result of such quasispin-quasispin interactions.

Low-temperature states and "hidden energy scale". To further explore the effect of quenched disorder on the magnetic materials, Profs. A. Ramirez and S. Syzranov summarized [2] the effect of vacancies on random spin-freezing in the so called geometrically-frustrated magnets (GFMs), the largest class of materials in which QSLs are sought. The analyzed data showed that the freezing temperature in all GFMs grows with decreasing impurity concentration (see Fig. 2).

In other words, contrary to the common intuition, the cleaner the material is, the easier the spins freeze in a random configuration! Furthermore, this analysis suggest that spins will freeze in a random configuration even in a perfect impurity-free system below a certain finite temperature [2] . Such a freezing may prevent the widely sought QSLs in frustrated magnets and will make it impossible to use them for future quantum-communication and computation technology and energy-efficient electronics.

The investigation of the nature of the scale, T*, which the researchers have called "the hidden energy scale" and which is significantly lower than the other temperature scales in magnetic materials, is currently ongoing. According to preliminary results, the system possesses two types of excitations with two very different energy scales. When the material is cooled down to temperatures , the system crosses over to what we call the ``eminuscent phase", in which only the low-energy excitations are important, and the material is very sensitive to the effects of impurities.

The freezing of the spins observed in experiments is thus a consequence of the crossover in the properties of the clean system. Although the spin freezing is caused by a small number of impurities, which are present in all materials, the temperature of that freezing is determined by the onset of the ``eminuscent phase" of the clean medium, as the material in that phase is rather sensitive to the impurities. The word "eminuscence" is Latin for "long range", referring to the existence of spin freezing at very low concentrations, in other words when the vacancies are far apart.

The ongoing research conducted at UCSC will not only advance the understanding of fundamental magnetic phenomena in materials but will also guide global theoretical and experimental efforts in pursuit of quantum spin liquids.

Professor Sergey Syzranov

SCIPP Update

by Jason Nielsen

The Santa Cruz Institute for Particle Physics (SCIPP) is the home of research in particle physics and related areas, including particle astrophysics, cosmology, high-throughput computing, and particle detector development. As an organized research unit, SCIPP has close ties with researchers from several academic departments: Physics, Astronomy & Astrophysics, Computer Science & Engineering, and Electrical & Computer Engineering. Many students from the Physics Department are also engaged in research at SCIPP.

We were pleased to receive overwhelmingly positive feedback during the recent SCIPP external review in 2024-2025. The review committee highlighted the strong sense of community and high impact science at SCIPP. And we were very pleased to welcome Jenna Scarpelli as the new Assistant Director for Administration and Finance.

There are a couple of big events planned at SCIPP for the summer. First, we will celebrate the "first look" of the Vera C. Rubin Observatory as it begins the Legacy Survey of Space and Time. After more than 20 years of development and construction, Rubin made a big splash in late June with its stunning images of the universe. We are looking forward to the science that will be done with this long-awaited groundbreaking instrument. Prof. Steve Ritz was recently named Project Scientist for the Rubin Observatory. Second, UCSC will host the 32nd International Conference on Supersymmetry and Unification of Fundamental Interactions (SUSY 2025) in mid-August, preceded by the pre-SUSY school. Wolfgang Altmanshofer and Howard Haber are leading the organizing committee. This conference brings together particle theorists and experimentalists for all manner of physics in the Standard Model and beyond the Standard Model. It is an outstanding opportunity to welcome the world to the UCSC Physics Department and to SCIPP.

The last few years have seen several new projects launched at SCIPP. The very high-energy gamma-ray astrophysics group is building a new optical alignment system for the Cherenkov Telescope Array Observatory (CTAO). This project, led by Prof. David Williams, represents the first U.S. hardware contributions to the international CTAO installation. The fast sensors group, led by Prof. Bruce Schumm, has developed a high-bandwidth diamond-based sensor that can be used for accelerator physics, bright light-source measurements, or inertial fusion energy diagnostics. This will be part of a fusion energy collaboration with other UC campuses and national laboratories. A new effort in thin-film charged particle detectors, led by Prof. Mike Hance, has been funded by the Department of Energy as a promising technology for future particle physics experiments. This project is notable for collaboration with engineering colleagues at UCSC and at the University of Hawaii. And the SCIPP theory group has ramped up the study of conformal field theories under Prof. Edgar Shaghoulian, attracting postdocs and graduate students to this area of study.

SCIPP continues a strong program of education and outreach activities. The Western Advanced Training in Computational High-Energy Physics (WATCHEP) is a new graduate training program run from UCSC. The trainees follow a skills-based curriculum and complete a research project with a mentor from a national laboratory. This program joins other programs in instrumentation and IC design. SCIPP hosts a number of research intern students each year from Cal-Bridge and from the Science Internship Program. And the outreach calendar is a busy as ever with high school visits, the annual Particle Physics Masterclass, and special hands-on exhibits at the Santa Cruz Museum of Natural History.

SCIPP researchers attended the Coordinating Panel for Advance Detectors Workshop at the Stanford Linear Accelerator Center (SLAC) in November 2023. From left to right: Adam Molnar, Rene Padilla, Jenni Ott, Yuzhan Zhao, Jason Nielsen, Earl Almazan, Tony Affolder. (photo credit: Jason Nielsen).

Materials Program

by David Lederman

The Materials Science & Engineering (MSE) program is now in its second year. With its own curriculum and 37 affiliated faculty from the Departments of Physics, Chemistry & Biochemistry, Electrical and Computer Engineering, Computer Science & Engineering, Biomolecular Engineering, and Earth and Planetary Sciences, the MSE program offers a highly interdisciplinary graduate program. For the Fall 2025 quarter, there will be two PhD and five MS students enrolled. One of the PhD students, Jacob Sands, is working on his research at the Lawrence Berkeley National Lab on three-dimensional topological magnetic structures under the direction of Peter Fischer, Materials Sciences Division Director and Adjunct Professor in the UCSC Physics Department. The second PhD student, Milana Meyer, was awarded a Cota-Robles Fellowship and will be starting her degree in the Fall. In the summer of 2025, 12 undergraduate students, most of them from non-PhD granting institutions, are participating in an NSF-funded Research Experiences for Undergraduates (REU) program where they perform research directed by MSE-affiliated faculty. The MSE program is also pursuing strong ties with industry to provide professional opportunities to its graduates, including summer internships for its MS students. We expect the program to grow in the next few years as MSE faculty continue their growth of interdisciplinary research projects in quantum materials, photonics, photovoltaics, electronics, magnetism and magnetic materials, energy materials, neuromorphic materials, and biomaterials and bioelectronics. For more information, go to https://materials.ucsc.edu/ or contact the Director of the Program, David Lederman, at dlederma@ucsc.edu.

Faculty Recognition

Outside the classroom, physics faculty members continue a tradition of research prominence, as recognized by both national and international awards as well as by formal positions of leadership. Here are some recent examples.

Stefania Gori and **Wolfgang Altmannshofer** were awarded the 2024 Frontiers of Science Award by the International Congress of Basic Science (ICBS) for their 2014 paper "Neutrino Trident Production: A Powerful Probe of New Physics with Neutrino Beams".

Joel Primack was awarded the 2024 American Association for the Advancement of Science (AAAS) Philip Hauge Abelson Prize for his significant contributions to science through his research, policy work, and public service. Joel also gave the Yukawa Memorial Public Lecture at the University of Osaka, Japan on May 25, 2025.

The Vera Rubin Observatory is now producing dazzling images of outerspace using the world's largest camera. UCSC physics professor and former SCIPP director **Steve Ritz** is Project Scientist for the telescope's construction. Also, professor **Tesla Jeltema** is the Deputy Spokesperson of the Rubin LSST Dark Energy Science Collaboration. The project, started in 2007, was originally named the Large Synoptic Survey Telescope (LSST), and renamed in 2019 to honor Rubin, whose work provided the first widely accepted evidence of dark matter.

SCIPP researchers working on experiments at the European Organization for Nuclear Research (CERN) shared the 2025 Breakthrough Prize in Fundamental Physics for data released between 2015 and July 2024. The award money of $3 million will be donated to the CERN & Society Foundation to assist young researchers in future experiments.

SCIPP researcher Dr. **Simon Mazza** was awarded the 2024 Bruno Toushek Award from the Istituto Nazionale di Fisica Nucleare (INFN) for his significant contributions to the devleopment and applications of low-gain avalanche detectors and high-granularity timing detectors in high-energy particle experiments.

An Undergraduate's Perspective

By Klaus Subbotina Stephenson

While at UCSC I benefitted in making contacts that led to two summers of research at Lawrence Livermore National Lab (LLNL). My research at UCSC put me in touch with a former UCSC postdoc working at LLNL, whose team in 2023 was looking for undergraduate interns.

During the first summer I worked in an adaptive optics group where I spent 50% of my time at LLNL on-site in labs and the other 50% at UCSC's Lick Observatory (Mount Hamilton, CA). At Lick Observatory, I worked overnight at the Nickel Telescope, observing with LLAMAS (Low-Latency Adaptive Optical Mirror System). After learning the ropes, my responsibilities involved driving the telescope and customizing Jupyter notebooks for live Python-based data analysis of Laser Guide Star (LGS) and Natural Guide Stars (NGS) data taken with LLAMAS. When in the labs at LLNL, I worked on a variety of tasks, including creating control programs for piezoelectric motors and humidity sensors and using various programming languages to calibrate and align optical components within LLAMAS. My performance over the summer resulted in my being kept on the LLAMAS team during the academic year. I worked part-time while classes were in session, and by the end of my internship, I had gained 60 nights of observational experience.

During the second summer I worked in LLNL's Germanium detector group. I worked primarily with data from the gamma-ray spectrometer aboard NASA's MESSENGER (Mercury Surface, Space Environment, Geochemistry and Ranging) mission (2004) to create a map of Magnesium abundance across Mercury's northern hemisphere. I also had the amazing opportunity to help build and characterize models of the gamma-ray spectrometer for the upcoming NASA/JHU Dragonfly mission, which will fly to Saturn's largest moon, Titan, in 2028. The internship taught me a lot of analysis techniques and hardware skills which have been invaluable for my upper-division laboratory classes at UCSC.

Navigating my first professional experience surrounded by people passionate about science and technology, made LLNL a super welcoming and inspiring place to work. Assigned within the National Ignition Facility (NIF) division, I spent a lot of time collaborating with other research interns and scholars supporting NIF and attended numerous tours and talks. When I started in 2023, the lab was still abuzz with excitement and motivation from December 5th 2022 - which was.

Klaus Stephenson, BS

when NIF achieved fusion ignition for the first time - so it was an exciting time to be at the lab. Despite not supporting NIF directly, my work at Livermore was challenging and invigorating, making me feel like a valuable contributor to lab missions and goals. I was encouraged to ask questions, seek new ideas, and give my input/thoughts on all manners of problems, being not only seen but also heard by all of my mentors and collaborators across LLNL. Getting to work at a national laboratory during my undergraduate education was a great privilege, having left me with valuable technical skills, professional experience, and scientific knowledge, further harboring my curiosity and passion for the physical sciences

Also

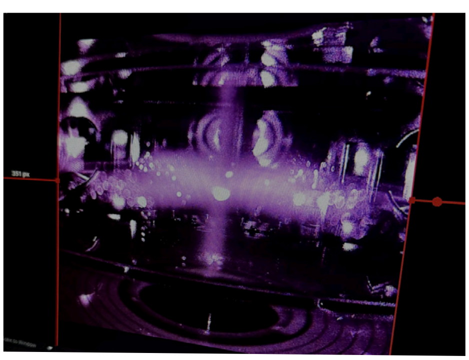
By George Brown

The Physics Department recently took delivery of a Magneto-Optical Trap (MOT), the latest addition to a suite of experiments in the Quantum Information Science Laboratory (Physics 138). The trap was designed and manufactured by OpenQuantum, a small startup company in Cambridge, Massachusetts.

The trapping and cooling of ions and atoms have led to multiple Nobel prizes on several occasions over the past century. Our atomic trap utilizes intense solid-state laser beams to suspend and cool a cloud of rubidium atoms within an otherwise ultra-high vacuum chamber, as shown in the photo below. Rubidium is chosen because of its relatively high vapor pressure at room temperature, and because of its well-understood hydrogen-like atomic structure.

The magneto-optical trap is a strong contender as a platform for quantum computation. It is now possible (in a research setting) to suspend an ordered array of of order 100 rubidium atoms in specific quantum levels, while preserving quantum coherence, entanglement, and superposition. With precision lasers, one can then selectively excite two-level atomic transitions. As such, each atom can be regarded as hosting a qubit (quantum binary digit). For an excellent review, please refer to L. Henriet et. al., Atomic Computing with Neutral Atoms, Quantum, 2020.

The magneto-optical trap is the most recent addition to the suite of experiments offered in Physics 138. These include the Josephson effect; quantum optical computing; quantum polarization entanglement (demonstrating the famous Bell Inequality); and photon temporal correlations (including the well-known Hanbury Brown-Twiss experiment). Future plans for Physics 138 include a photon energy entanglement experiment; and possibly high resolution nuclear magnetic resonance.



A typical experiment using a 6-beam optical trap with rubidium vapor, as just acquired by the physics department for undergraduate instruction.

Thank You!

The Physics Department is delighted to announce the establishment of the **Darrell and Elaine Long Professorship in Experimental Physics**. This endowment has been established in honor of Darrell Long and his wife Elaine. Darrell Long is Distinguished Professor Emeritus of Engineering at UC Santa Cruz and the inaugural holder of the Kumar Malavalli Endowed Chair in Storage Systems Research. The chair's initial occupant is Professor Bruce Schumm.

Mrs. Elaine Long and Professor Darrell Long

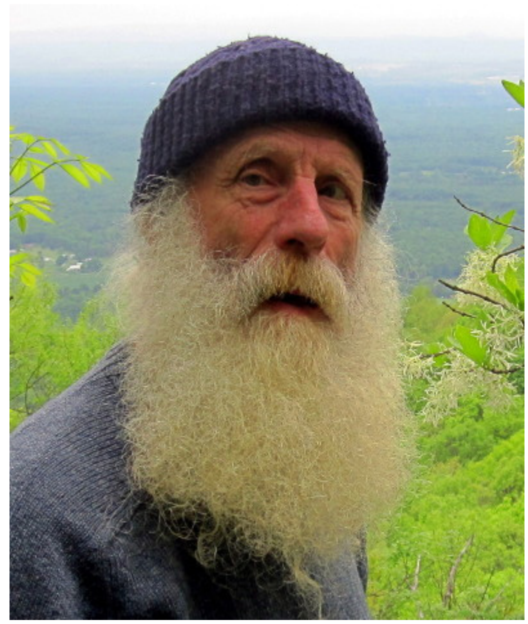
The Physics Department gratefully acknowledges a gift of $25,000 from the estate of **Jerry Swalen and Mary Swalen**. Jerry Swalen was an adjunct professor in the Physics Department, collaborating with Professor Sue Carter. He had a long and distinguished career at IBM, where he was a pioneer in the fields of molecular spectroscopy, lasers and thin films.

Jerry Swalen in an undated photo

The Physics Department is also grateful for a gift of $5,000 from **John Hiser and Ruth Kogan**. John Hiser completed his Ph.D. in the Physics Department under the supervision of Professor Howie Haber, graduating in March 1996.

Obituary for Professor Peter Scott

Peter Scott, a founding member of the physics department, passed away on October 24, 2024, at the age of 91. Peter taught at UCSC from 1966 to 1994, one of an initial group of professors including Ronald H. Ruby, James D. Currin, Bruce Rosenblum, and Michael Nauenberg. In physics research, he was best known for his pioneering work on nonlinear dynamics and in particular, the emergence of chaos that can be witnessed in a leaky faucet – for years his email was drip@ ucsc.edu!


Peter Scott, UCSC Professor of Physics

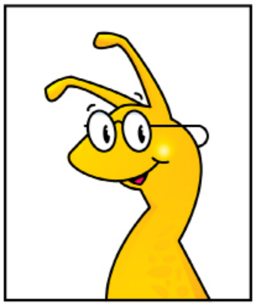
Beyond research, Peter was admired by generations of students for his patience, his mentoring, and his creative approach to teaching. He would embellish his last class each quarter with a banjo performance, performing an original song whose lyrics reflected topics covered in the course.

Peter Scott received his undergraduate degree from UC Berkeley, an M.A. from the University of Michigan, and a Ph.D. in physics from Berkeley Outside of academic work, Peter enjoyed the outdoors, happiest while hiking in the high Sierras. He was also active in community matters such as helping to champion the preservation of the Pogonip, Arana Gulch, the Moore Creek Uplands, and Gray / whale Ranch, as well as the effort to make Wilder Ranch a state park in 1974.

After retiring, Peter was active in campaigns to promote transportation solutions as an alternative to automobiles, as well as a rail connection between Watsonville and Davenport.

(Parts of this article were adapted from the Santa Cruz Sentinel).

Thank You Physics Staff!



Theo-Alyce K. Gordon

Department Manager

Kali Sophia Lucas

Department Administrative Assistant

Christian Ulises Sanchez

Jeremy Ryan Parker

Physics Graduate Coordinator

Kenneth Ray Smith

Lower Division Lab Manager

Undergraduate Award Winners

Deans', Chancellor's, and Steck Undergraduate Awards
- Stuti Garg
- Klaus Subbotina Stephenson
- Noe Gonzalez

Kenneth and Ann Thimann Scholarship: Undergraduate
- Stuti Garg
- Ollie Jackson
- Piramon Kumnurdmanee

URST (Undergraduate Research in Science and Technology) Awards-PBSci Division
- Isabelle Connor
- Liam Murphy
- Ethan Steelberg
- Emerson Tao

Goldwater Scholarship
- Isabelle Connor

Ron Ruby Research Awards
- Aarna Garg
- Shreyanshi Garg
- Arian Moghni
- Quinton Poncelet

APS Far West Division Steven Chu Award
- Filiberto Padilla
- Tyler Morris

Marilyn Stevens Memorial Scholarship
- no award was given for 2024-25.

Graduate Award Winners

Chancellor's Dissertation-Year Fellowship
- Sri Aditya Gadam

President's Dissertation-Year Fellowship
- Rene Padilla

ARCS Award
- Name

APS Far West Division Margaret Burbidge Award
- Madalyn N. Johnson
- Aidan Lindhe-Johan

Marilyn Stevens Award-Graduate
- No award was given for 2024-25.

Elmer A. Fridley Scholarship in the Physics Sciences
- No award was given for 2024-25.

Long Ph.D. Dissertation Award
- Maverick McLanahan

Congratulations to all award winners!
See the following two pages for descriptions of each award.

Information About Awards

UNDERGRADUATE

Deans', Chancellor's, and Steck Undergraduate Awards

These awards recognize exceptional achievements in research projects or other creative activities, in order to both encourage outstanding scholarship and promote research as an important part of undergraduate education. In the Physical and Biological Sciences, the students submit a completed thesis, usually a senior dissertation.

Undergraduate Research in Science Awards: sponsored by the PBSci Division

These awards recognize undergraduate research in science and technology administered by the Physical and Biological Sciences Division. Multiple awards may be issued ranging from $500 to $2000. There are three sources for the funds behind this call: one is designated for research in coastal sustainability (Gunderson Family Student Research in Coastal Sustainability Award), one is designated for research in Earth and ocean sciences (Kathryn D. Sullivan Award), and the largest is open to projects in any discipline that uses the scientific method (Undergraduate Research in Science and Technology Award).

Koret Scholars Program

The Koret Scholars Program provides funding for a variety of undergraduate research projects and experiences. The program supports scholarships for undergraduate research projects with faculty and graduate student mentors, undergraduate and graduate student research internships with the Student Success Evaluation and Research Center, and expansion of the year-long College Scholars research development program.

Marilyn Stevens Memorial Scholarship

The Marilyn Stevens Memorial Scholarship is an award designed to honor the former Department Manager of Physics, Marilyn Stevens. It is given to a current upper-division physics undergraduate student and a current physics graduate student. Fellow students, faculty, or staff nominates prospective recipients. The award considers academic excellence, community service, service in and out of UCSC, and any outstanding contribution made to the Physics Department.

Ron Ruby Memorial Scholarship

Ron Ruby was a founding faculty member of the Physics Department. A memorial scholarship for undergraduates was set up in his memory. The Ron Ruby Scholarship is intended to reward the most promising young physicists while also honoring Ron's vision of providing greater access to quality college education. Both merit and financial need are considered in making the award. The department considers diversity an important academic value, so the Ron Ruby Scholarship shall be awarded preferentially to one or more students who have demonstrated potential for leadership in promoting cross-cultural understanding and/or those who have an outstanding record of service dedicated toward helping educationally disadvantaged students. However, recipients will be selected without regard to their race, gender, color, ethnicity, or national origin. U.S. citizenship is not required.

Kenneth and Ann Thimann Scholarship

1984 Dr. Kenneth Thimann, founding Dean of the PBSci Division, and his wife, Ann, established this award. Scholarships are awarded at the end of the academic year to a graduating UCSC senior, who has been accepted to graduate school and shows the most promise as a future scientist in one of the disciplines of biology, chemistry, physics, and earth sciences.

Elmer A. Fridley Award

This is a merit-based scholarship and is awarded to a continuing student in the physical sciences (chem, math, physics, astro, etc), either graduate or undergraduate. The winner is selected on academic merit, faculty support and recommendations.

Goldwater Scholars Award

The Goldwater Scholarship is a prestigious national competition for undergraduates in the fields of mathematics, science, and engineering. The scholarships provide up to $7,500 per year for sophomores and juniors from across the country to cover the costs of tuition, fees, books, and other expenses.

GRADUATE

ARCS Award

A national organization, the ARCS (Achievement Rewards for College Scientists) Foundation provides funds for scholarships to deserving graduate students in the fields of natural science, mathematics, medicine, and engineering. Departments submit their single best student for consideration for the 10 awards.

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President's Dissertation-Year Fellowship and Chancellor's Dissertation-Year Fellowship

Dissertation-Year Fellowships (DYFs) are state-funded, merit-based fellowships awarded on a competitive basis to doctoral graduate students who have overcome significant social or educational obstacles to achieve a college education, and whose backgrounds equip them to contribute to intellectual diversity among the graduate student population. The President's and Chancellor's DYFs are quarterly or year-long fellowships that provide a stipend of approximately $21,000 plus payment of resident tuition for the academic year.

Outstanding TA Award

This is the annual award for recognition of their outstanding performance as a Teaching Assistant during the Fall 2019, Winter 2020, and Spring 2020 quarters. Faculty and staff nominate students who are evaluated based upon the faculty endorsement and their teaching evaluations.

Stay Connected

Check out our website at [physics.ucsc.edu.]

Follow us on instagram: @ucscphysics.

Like us on facebook: UCSC Physics Facebook.

Stay updated on our latest department news here: UCSC Physics News.

Finally, the physics faculty would love to hear from you in this survey to help us shape future newsletters and events.

Department Facts & Figures

Undergraduate Students	247 declared
	155 proposed
	11 minors
Graduate Students	73 PhD
	5 BS/MS
Ladder Rank Faculty	22
Adjunct Faculty	10
Lecturers	3
Research Faculty	8
Postdocs	14
Department Staff	5

Giving

Gifts of any size to the physics department are deeply appreciated and can be donated via the department website. These gifts will enable the department to enrich the student experience in a variety of ways such as supporting travel to conferences, hosting more world class researchers for our colloquium series, and supporting student groups. Thank you!

For donors in a position to make a transformational difference, we offer the opportunity to establish named endowments. These endowments will ensure standards of excellence in teaching and research over generations and come in different sizes, from the naming of a colloquium series, to endowed fellowships, to endowed professorships. We are also excited to invite inquiries from donors about opportunities to be recognized through the naming of one of our instructional labs. For more information, please contact the department chair Onuttom Narayan, onarayan@ucsc.edu.

Attribution and Acknowledgments: This newsletter was assembled and designed by student Bhavna Mahi and Professor Arthur P. Ramirez. We would like to thank the Physics Department staff for their assistance, and the students and faculty who contributed articles, photos, and other content.