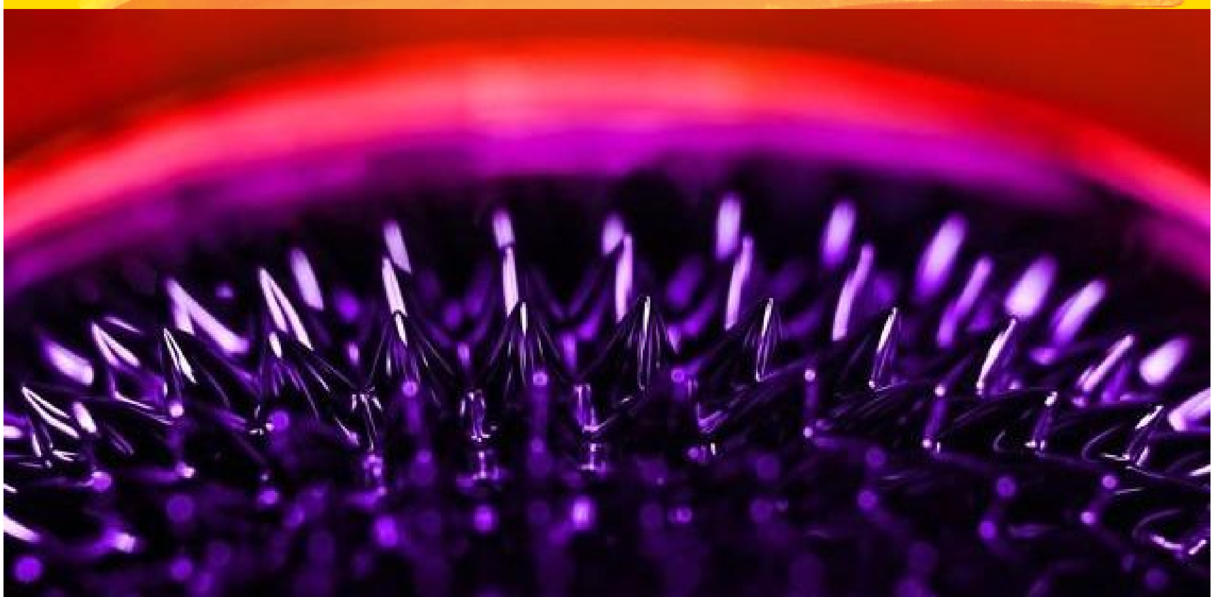
UC DAVIS

COLLEGE OF LETTERS AND SCIENCE

Department of Physics and Astronomy



Alumni Newsletter 2021-22

Physical Interactions

News from the UC Davis Department of Physics and Astronomy

Message from Department Chair Dr. Rena Zieve

Greetings from UC Davis, where we’re thrilled to be back (mostly) on campus. Classes are in-person, albeit masked. Research groups can work together in their laboratories and at blackboards. More lasting changes from the pandemic are the many remote or hybrid meetings and seminars, and many staff working remotely a few days each week.

Our summer Research Experiences for Undergraduates program kicked off the return to in-person status as the first residential program on campus; it served both as a small test of what would happen when students returned, and as a step towards acclimating us to being around other people again. Students performed research on the Mu2e experiment to study conversion of muons to electrons, on Chevrel phase materials exhibiting magnetism and possible superconductivity, on how satellite galaxies evolve, and much more.

Life has also gone on in the more standard ways. Distinguished Professor Warren Pickett retired after more than 20 years at UC Davis. Fortunately he continues to work on the department's behalf, for example organizing the upcoming visit by Sir Michael Berry (discussed below). A new Assistant Professor, Alex Thomson, will arrive in Davis next summer after completing her Sherman Fairchild postdoctoral fellowship at Caltech. Much of her recent work in condensed matter theory is on twisted graphene bilayers. A rotation of a few degrees between the two graphene planes vastly increases the length scale for repetition of spatial structures and gives rise to new electronic properties and means of control.

Check out the rest of this newsletter for recent research, curriculum developments, upcoming events, and more.

FEATURED NEWS

UC Davis Physics Grad Students

Department Climate

Last year, with support from the university's Vice-Chancellor for Diversity, Equity, and Inclusion and the Budget and Institutional Analysis office, we carried out a **departmental Climate Survey**. We are now trying to address some of the "equity gaps," where some groups reported more positive experiences than others. We are targeting more advising and guidance towards transfer students, who have less sense of belonging to the department than those who enter Davis directly from high school. Any former transfer students with ideas on what we can do better should contact **Professor Shirley Chiang**.

Bridge Program

UC Davis became a Partner Institution in the **American Physical Society's Bridge Program**. The program aims to increase the number of students from traditionally underrepresented groups who earn PhDs. It seeks out students who have great potential but were not initially admitted to PhD programs -- because they did not get adequate guidance and encouragement to apply, because they worked their way through college and had no time to explore undergraduate research, etc. UC Davis can now accept Bridge Program applicants into our Masters or PhD programs. In preparation, we are overhauling our first-year graduate advising so that students and advisors develop stronger relationships; the Climate Survey highlighted the need for these changes as well. We have also established an endowed fellowship, discussed below, which will release Bridge students from some teaching duties and make the start of their graduate career less stressful.

New Graduate Fellowship Fundraising Success

On July 14th this past summer, members of the Department of Physics and Astronomy gathered in Central Park in Davis to celebrate a milestone in the establishment of a new graduate fellowship. **The Physics and Astronomy Opportunity Award**, once fully funded, will support graduate students who show great promise as physicists but who have not had the same privileges, in support of their prior preparation, as some of their classmates.

From left to right: Emerita Professor Ling-Lie Chau, graduate students Ben Guthrie, Ben Barton, Sydney Ostrom, Davis Zackaria, and Chair Rena Zieve

Celebrations were in order as we had met our goal of raising over $200K in gifts and pledges from department members, in this first phase of our effort to raise $1M total. Gifts and pledges came from 80% of our faculty members, 44 graduate students, and 12 undergraduates. According to the college's Development Program Manager, KT O'Connor, they have never seen student giving like this before in the College of Letters and Science. We also had gifts from staff, researchers, emeriti, and members of our department's **Advisory Board**. There is clearly broad departmental support for this fellowship!

From left to right: Faculty members Richard Breedon, Lloyd Knox, Eric Prebys, Mani Tripathi, Robin Erbacher, and John Conway

Now is your opportunity to join us! If you would like to do so, please give **HERE**.

The award is a key element of our broader plan to increase participation in our graduate program by members of groups historically underrepresented in physics and astronomy. You can read more about it **here**.

Unprecedented student giving did not happen on its own. The following students spread the word among their peers, encouraging them to join in the effort: Grad students Patty Bolan, Tyler Erjavec, Pratik Gandhi, Julie He, Victoria Norman, Mac

Robertson, Victoria Strait, and Morgan Walker, and undergraduate student Eric Hanaway.

Our campaign was led by department Chair Rena Zieve and Lloyd Knox, together with a committee of faculty members Daniel Cox, Markus Luty, Eric Prebys, Bob Svoboda, Tony Tyson, and Gergely Zimanyi.

Please join us with a gift of whatever size makes sense to you.

Your gift to the **Department of Physics and Astronomy** supports outstanding academic programs, advances the pursuit of new knowledge, and makes innovative research possible.

Click HERE to check out the funds you can support!

Undergraduate Curriculum

We are finishing a major overhaul of our undergraduate curriculum. The new version includes much more computational work, which is also better integrated into the major, rather than appearing in a few isolated classes. This recognizes the importance of computers throughout physics and astronomy, as well as in many of the careers our graduates will follow. A second main goal is to provide more flexibility in the course sequence. This will make it easier for any student who has a "special" situation, from falling ill and withdrawing for a quarter, to participating in study abroad. Third, we are adding discussion sections to key upper-level classes. The extra contact time will be especially helpful as we accommodate an increasing number of physics majors. In concert with the curriculum changes, we also hope to do better at linking our undergraduates to internship opportunities, which are often a stepping stone to a first job. If you think there could be possibilities at your workplace, please contact **Chair Rena Zieve**.

Visit by Professor Sir Michael Berry

Michael Berry from the University of Bristol, U.K. will visit UC Davis as Distinguished Lecturer in the Department of Physics and Astronomy, hosted by Warren Pickett on behalf of sixteen other faculty in four departments involved in research of joint interest. The visit is being supported by the Department, The College of L&S, APS, and the Moore Foundation.

Michael will provide a colloquium and a public lecture, with topics ranging from the geometric phase (Berry phase) upon which his early career and reputation is based, to everyday phenomena such as the physics of light, touching on the dancing lines of light on the bottom of swimming pools.

ICAM Annual Meeting at UC Davis Jan 10-12th, 2022

The Institute for Complex Adaptive Matter (ICAM) has not held an in person annual meeting since January 2019. To kick start activities in the post-pandemic era, ICAM will hold a largely in person annual meeting at UC Davis this coming January. The meeting will include three Frontiers of Emergence plenary sessions, in our key thrust areas of Soft, Biological and Quantum Matter, round-table discussions and a session devoted to junior scientist presentations. Following tradition, the Annual meeting will be combined with a follow-up workshop on Quantum Matter entitled “New Topological Perspectives on Superconductors and Quantum Magnets”

Lori Lubin selected as Associate Dean of Research and Graduate Studies

Professor Lubin has been a member of the faculty at UC Davis since 2002 and is currently serving as Chancellor’s Leadership Professor of Physics and Astronomy.

She is world-renowned as an observational astronomer whose research focuses on galaxy clusters, which are among the most massive objects in the universe. She received a prestigious Carnegie Fellowship at the Observatories of the Carnegie Institution of Washington, followed by a Hubble Fellowship, often viewed as the top fellowship in astronomy, which she took at Caltech. She has over a hundred refereed articles in premier astronomy and astrophysics journals in addition to substantial funding from NASA and the National Science Foundation.

Professor Lubin is principal investigator of the Observations of Redshift Evolution in Large Scale Environments Survey (ORELSE) and the Charting Cluster Construction with VIMOS Ultra-Deep Survey and ORELSE Survey (C3VO), both comprehensive multi-wavelength surveys of distant galaxy clusters and proto-clusters.

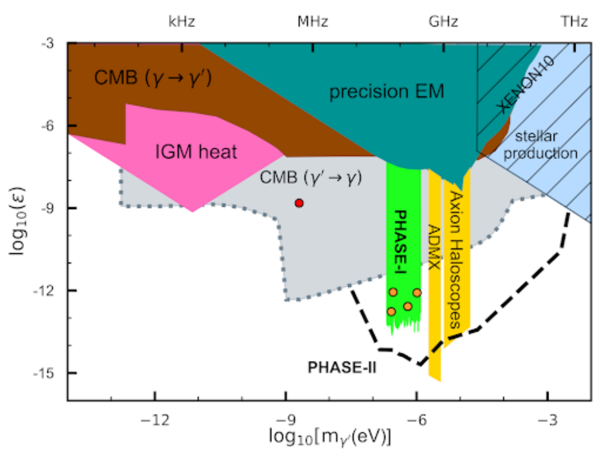
Andrew Wetzel receives CAREER awards

The National Science Foundation (NSF) Faculty Early Career Development (CAREER) program recognizes junior faculty who conduct outstanding research, are excellent educators and include education or community outreach in their work.

Wetzel designs supercomputer simulations that [model how galaxies like the Milky Way form](). The models recreate processes important in galaxy simulation, and also produce synthetic observations for comparison with real-world data. His current interests center on dwarf galaxies outside the Milky Way and star clusters in the Milky Way disk. His new simulations will be able to model the Milky Way's billions of stars down to these tiny dwarf galaxies.

The models Wetzel works on are freely available for public use, and with support from the CAREER grant he plans to develop user-friendly tutorials for anyone interested in analyzing cutting-edge galaxy simulations.

Research Briefs



Laboratory Search for Dark Photon Dark Matter

Many types of astronomical observations show decisively that most of the mass in the Universe is of an unknown form, unlike ordinary matter. This "dark matter" fills the universe and clumps over cosmic time under its own gravitational self attraction. Our current understanding of physics cannot explain dark matter; its existence is evidence for new physics! Its physical nature is a central unanswered question in science. Sensitive searches for weakly interacting massive particles in the GeV range have found nothing. Other possibilities for dark matter, such as the ultra-low mass nano eV to milli eV regime remain unexplored. A natural candidate for vector dark matter is the hidden photon, which can couple to electromagnetism. A group at UC Davis led by Tony Tyson are working on an extremely sensitive laboratory experiment: "Dark E-field Radio" which leverages cryogenic microwave detectors and FPGA technology in a GHz wide real-time spectral analysis. The result will be a 10,000-fold improvement over current astrophysical limits in dark matter detection searches in this vast unexplored ultra-low mass regime. To date, they have carried out a pilot experiment which has demonstrated feasibility. The research is supported by the DOE, the Brinson Foundation, and the Nokia Foundation.

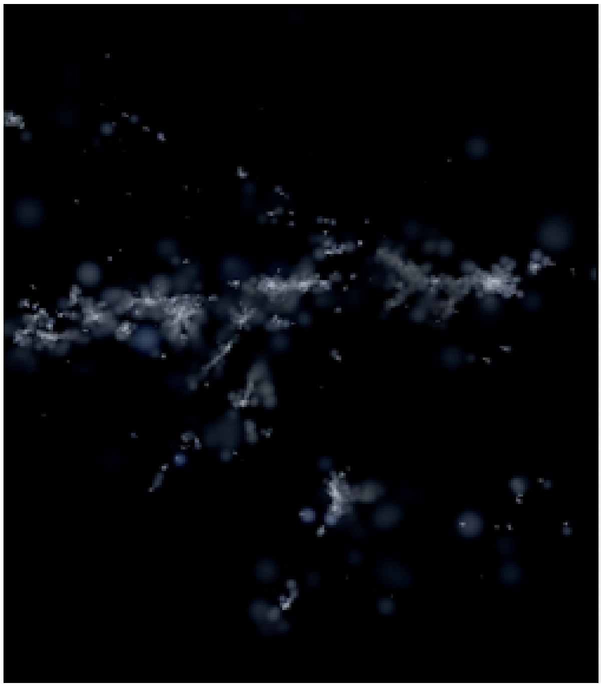
Projected reach of the Dark E-Field Radio experiment at UC Davis. The weak kinetic mixing factor is plotted vs dark photon mass. Regions excluded by astrophysics are shown. Planned ADMX axion and hodoscope searches are shown in yellow. The orange points show calibrated exclusion regions at 4 spot frequencies at 5 sigma measured using the current pilot experiment. The red dot shows the point exclusion limit measured by Phipps et al. (2019). Phase-1 shows extrapolated limits using current setup after 1-year of real-time data acquisition. Phase-2 are cryogenic experiments covering the entire range 10 MHz -- 20 GHz, ultimately to THz.

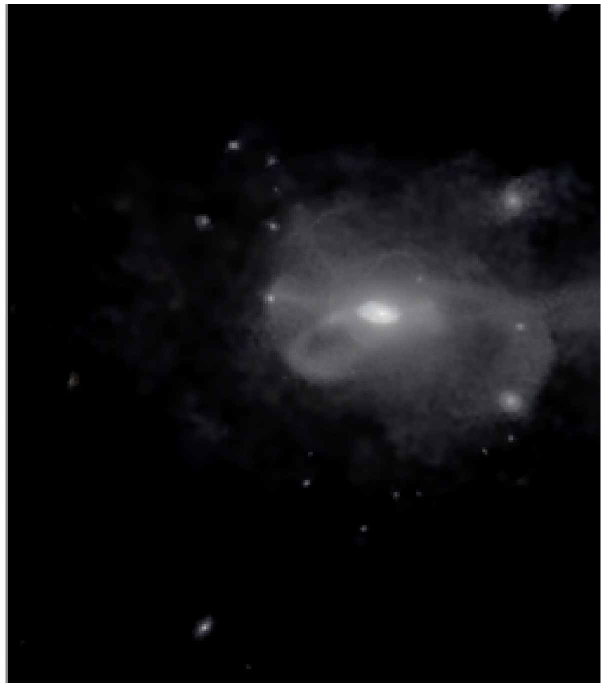
A new type of superconductor

The phenomenon of superconductivity continues to challenge our understanding of materials. In all superconductors, materials that can carry electricity without any resistance, the charge carrier unit is a pair of electrons called a Cooper pair. Below the superconducting transition temperature, Tc, they enter a coherent ground state called a "condensate". In unconventional superconductors, these condensates typically have lower symmetries than in conventional superconductors. These symmetries resemble the ones of atomic orbitals, and give rise to the classification of superconductors as s-wave, p-wave, d-wave, f-wave. Because of a quantum property of electrons which have half-integer spin, the Cooper pairs must be antisymmetric under exchange of electrons. This rule constrains the symmetry of the spin: s-wave and d-wave superconductors are in a so-called spin-singlet state, whereas p-wave and f-wave superconductors are in a spin-triplet state. A team of three faculty groups in the Department of Physics and Astronomy joined their expertise to study a new type of superconductor in which the Cooper pairs have a s-wave spin-triplet symmetry. This weird combination is enabled because the Cooper pairs are formed from a special type of electrons, called Dirac fermions. These Dirac fermions have a linear dependence of their energy with respect to momentum: they behave as if they have no mass.

The UC Davis team found this property in the material LaNiGa2. Graduate student Jackson Badger in the group of Prof. Taufour developed a technique to grow single crystals of this material for the first time. They were able to identify a very peculiar crystal structure with a particular type of symmetry, known as a two-fold screw axis. Such symmetry imposes weird degeneracies ("band touching") for the wave functions of the electrons, known as Dirac points.

They joined their effort with the group of Warren Pickett to calculate the electronic structure of LaNiGa2 and find the momentum of the Dirac electrons. To confirm their calculations, they worked with the group of Prof. Inna Vishik who specializes in measuring the energy versus momentum (dispersion) relations of electrons in materials. Their experimental results were in excellent agreement with the calculations. LaNiGa2 provides the first example of a topology induced s-wave spin-triplet superconductor. These findings will enable future discoveries of additional topological superconductors, which may one day have applications in fault-tolerant quantum computing.





Galaxy simulations from FIRE-2

Simulations Reveal Signs of Galaxy Mergers in Milky Way Disk

Some of the Milky Way’s oldest stars have been spotted in a surprising place — the disk the youngest region of the galaxy. Computer simulations of their orbits suggest these "metal-poor" stars came from a smaller galaxy that slammed into the Milky Way more than 7 billion years ago. Isaiah Santistevan, a doctoral candidate in our department is the lead author of a new study examining the simulation results, which is available on arXiv.org.

The oldest stars in the Milky Way are "metal-poor", with low amounts of carbon, oxygen, iron and other elements heavier than helium that only form in stars. That’s why astronomers think "metal-poor" stars are some of the first stars born after the Big Bang, at least 11 billion years ago, long before our sun formed about 4.5 to 5 billion years ago.

Most of the "metal-poor" stars in the Milky Way cluster in the galaxy’s oldest region, the outer halo. But a few travel an almost circular path in the flat plane that is the Milky Way's disk, following an orbit similar to the sun’s.

To figure out how these stellar artifacts ended up in the disk, Santistevan and his collaborators analyzed realistic simulations of galaxies from the FIRE-2 (**Feedback In Realistic Environments**) project. The simulations include everything scientists know about how galaxies form and evolve.

According to the simulations, the majority of "metal-poor" stars in the disk formed in a different, much smaller galaxy that later merged with the Milky Way. The galactic collision not only left stellar artifacts scattered in the disk, it also brought in younger stars and dust that helped form the disk itself, Santistevan found.

Got news? Send us an update.

We welcome you to contact us at lsdevelopment@ucdavis.edu

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