PHYSICS Newsletter

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UMassAmherst | Physics

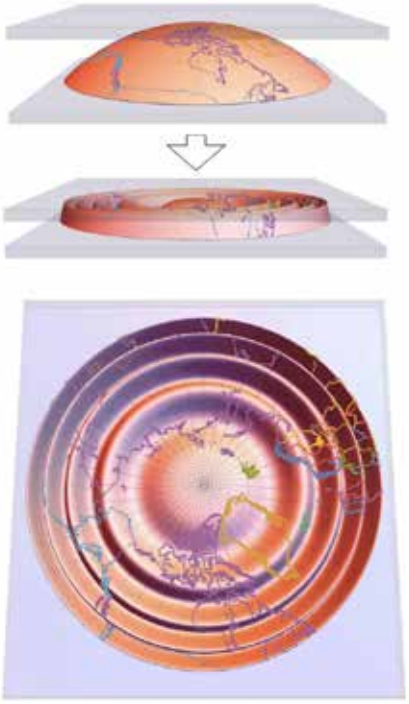
Strain in Thin Sheets

Addressing a physics problem that dates back to Galileo, three UMass Amherst researchers proposed a new approach to the theory of how thin sheets can be forced to conform to "geometrically incompatible" shapes – think gift-wrapping a basketball. Their new approach relies on weaving together two fundamental ideas of geometry and mechanics that were long thought to be irreconcilable.

Theoretical physicist, Prof. Benny Davidovitch, polymer scientist Prof. Gregory Grason and Physics doctoral student Yiwei Sun, writing in Proceedings of the National Academy of Sciences, demonstrate via numerical simulations that naturally flat sheets forced to change their curvature can accommodate geometrically-required strain by developing microscopic wrinkles that bend the sheet instead of stretching it to the breaking point, a solution that furthermore costs less energy.

This advance is important as biotechnologists increasingly attempt to control the level of strain encountered in thin films conforming to complex, curving and 3D shapes of the human body, for example, in flexible and wearable sensors for personalized health monitoring. Many of these devices rely on electrical properties of the film that are shown to be highly vulnerable to stretching but that can tolerate some bending.

According to Benny, nonconformities that come with bending are so small that, in practical terms, they cost almost no energy. "By offering efficient strategies to manage the strain, predict it and control it, we offer a new quantitative tool that is useful for people predicting the forces required to



The figure shows what happens when a curved elastic shell is forced by confinement to change from spherical to flat. If it wrinkles enough, the shell can flatten almost without stretching. Image courtesy of UMass Amherst/G. Grason

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Conference for Undergraduate Women in Physics (CUWiP)

Over the Martin Luther King weekend, the Physics department at the University of Massachusetts, Amherst, (UMass) partnered with Smith, Mt. Holyoke, and Amherst Colleges, to host an American Physical Society-sponsored Conference for Undergraduate Women in Physics (CUWiP). The conference works to support and mentor women, LGBTQ, and minority undergraduate physics students. Since 2006, when the first CUWiP conference took place at the University of Southern California, it has continued to grow and by now thousands of women physicists have attended the annual conferences. This year there were 12 different simultaneous conferences taking place in various locations around the country and Canada over the weekend of 18 - 20 January 2019 with UMass Amherst being one of them.

It was the first time that UMass was host. As the flagship campus of the University of Massachusetts system and the largest public university in the densely-populated Northeast, we were in a unique opportunity to reach out to students of varied socio-economic background, ethnicity and gender. We had 238 undergraduate students in physics registered coming from over 60 institutions ranging from large established research universities to small Community

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Dear alumni and friends of UMass Physics:

One of the great pleasures in serving as department head is that I have many occasions to show off the many achievements of the department. We have several to share with you in this year's offering of the newsletter!

Last fall, the physical landscape of the department has undergone the largest change in the nearly fifty years since Lederle tower opened in the early 1970s. Ten physics research groups have moved into a brand-new research facility in the Physical Sciences Building, which we share with the Chemistry department. The physics labs are in a basement area with high-bay rooms, vibration-isolated floors, clean room spaces and modern infrastructure. This space enables our colleagues in nuclear and high energy physics and in quantum condensed matter to launch ambitious projects that would not have been supportable in their older spaces. The faculty, students and postdocs in these groups are in the adjoining building, the former West Experimental Station. The exterior of the building retains its historic look, while the modern interior preserves details of the original building –wooden doors, a safe, a fireplace. Please do visit us!

We have added three talented young faculty members to the department last fall. They bring in new expertise and vitality to our research portfolio and expanded research opportunities for our undergraduate and graduate students. Jordy de Vries works in nuclear and high-energy theory, seeking physics beyond-the-Standard Model. Ben Heidenreich works in string theory, formal quantum field theory, and quantum gravity. Together, they bring new, complementary skills to the theory group of the ACFI (Amherst Center for Fundamental Interactions). Shuang Zhou is a soft condensed matter experimentalist working in liquid crystal physics, particularly known for his work in using these systems as anisotropic environments for microbial motion.

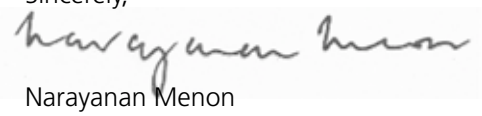
In addition to our youngest faculty colleagues, we also have a new Gluckstern Chair professor who joined our ranks in January: Krishna Kumar, an experimental nuclear physicist, who was once a professor in our department has returned to us after several years away. He plays a leading rule in several experiments hosted at Jefferson labs, and will also complement our colleagues who work in underground experiments searching for dark matter. The Gluckstern professorship is named after Robert Gluckstern, who was instrumental in transforming the department into a modern research department in the mid-to-late 1960s.

Our current faculty colleagues have also not been idle – as you will read elsewhere in this newsletter, their efforts and talents have been recognized by Young Investigator awards, NSF CAREER awards, student achievement awards, APS Fellowship, and Chancellor's Leadership awards. A particularly high point is the recognition of the career achievements of Barry Holstein by his receipt of the 2018 Feshbach Prize, the highest prize of the American Physical Society in theoretical nuclear physics.

Our research centers also have made UMass Physics a destination for research visitors. The ACFI continues to hold focused workshops and schools on forefront topics; the Massachusetts Center for Autonomous Materials and the Center for Biological Physics continue to bring together campus efforts in their research areas. A nascent faculty group in Precision Many-Body Physics hosted an international workshop to promote this new field, in which UMass Physics has a substantial footprint. In a collaborative effort with the other Five College departments, and with the enthusiastic help of several undergrads, graduate students and faculty, we hosted an APS Conference for Undergraduate Women in Physics. It was truly inspiring to see close to 200 enthusiastic and bright young women physicists gathered on our campus, learning new physics, planning their careers, and building social and professional networks.

I opened this note with one of the more pleasurable aspects of serving as department head and I conclude with another: I've had the opportunity over the last year to interact with many alumni when they visit campus. It's very satisfying to learn the depth of connection that you feel with our department and University. Please do visit, and keep in touch, we would appreciate your sharing life experiences, career advice and opportunities with our students.

Sincerely,



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Colleges, but many had to cancel at the last minute because of the season's largest snowstorm that arrived on Saturday the 19th, forcing us to abbreviate the conference and end at 3:30 pm on Saturday instead of 1:30 pm on Sunday. However, the weather did not dampen the spirits of the 190 students who did attend, along with speakers, panelists, and representatives from industry and local Graduate Schools.

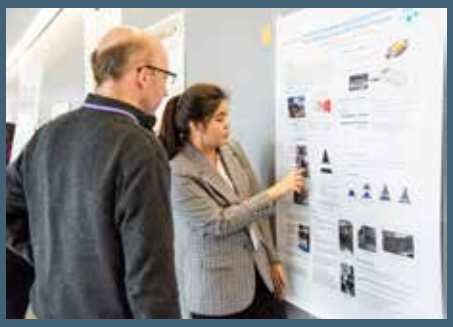
This conference was an opportunity for the students to mingle with physicists in academia, industry, and a variety of other careers with a mix of presentations by women scientists, career and scientific workshops and panel

discussions. Students got to network with other students, had the opportunity to present their research work in poster presentations, and attended a networking fair with visiting companies and graduate schools. The program was designed with the goal of increasing the recruitment and retention of women and other underrepresented minorities in Physics and make them aware of the range of opportunities available to students majoring in this field.

The organizing committee, led by UMass Amherst physics faculty member Shubha Tewari, included faculty from all four partner institutions, as well as graduate and undergraduate students. Support to the conference came from the American Physical Society via NSF and DOE, a variety of offices at UMass including: Departments, the College of Natural Sciences Dean's Office, the graduate school and the Chancellor's office, and our partner institutions Smith, Mt Holyoke and Amherst, as well as corporate donations. Tewari expressed hearing from a number of students over the years about how formative the CUWiPs had been in their career path choices, and felt, as a large campus, that UMass could host this conference and energize our Physics majors and those from all over the Northeast in the process.

The impending winter storm forced the organizers to re-arrange the program on the fly and cut short the conference, nevertheless students got to enjoy most of the program before they had to leave one day in advance.

The conference opened with a recorded welcome message from the Chancellor and a welcome message from Prof. Anna Branch, Associate Chancellor for Equity and Inclusion. It was followed by a plenary talk at dinner time by Prof. Nergis Mavalvala of MIT, who spoke about the instrumentation her group designed for LIGO (Laser Interferometry Gravitational Wave Observatory) that made the impossible possible – the first detection of gravitational waves that produce changes in length of order 10^{-18} m, a thousandth of the size of an atomic nucleus. It was an exciting talk, and the students asked many pertinent and interesting questions. They asked why there was a delay between the detection of gravitational waves from another event captured by LIGO and the corresponding detection of electromagnetic waves: the first neutron star merger. Before and after the talk, undergraduates from Mt Holyoke and UMass led a series of "ice-breaker" activities that got the audience on their feet, laughing and interacting in groups, making the large group feel more intimate.



Some of the highlights of the activities were: a keynote presentation by Dr. Fabiola Gianotti, an internationally recognized particle physicist and

Director-General at CERN, webcast simultaneously to the twelve sister conferences across the US and Canada on Saturday afternoon from CERN. Although she was not able to be physically present at any of the conferences, Dr. Gianotti answered questions in a range of topics from career advice to the future of CERN. Other plenary talks were by Dr. Moureen Kemei from Intel, and Yari Golden-Castaño from MIT Lincoln Laboratory. Dr. Moureen Kemei spoke about how she went from Nairobi, Kenya, to Mt Holyoke College and a PhD at the University of California Santa Barbara, where she won the Dissertation award from the American Physical Society, then onto a postdoctoral fellowship at Caltech and her job at Intel. In her presentation she also told

us in some detail about her work on magnetic storage devices. Yari Golden-Castaño spoke about how, as a young woman straddling the dual worlds and dual languages of Mexico and the US, she found refuge in the universal language of mathematics. She is one of the 100 people shortlisted for the Mars One project and is fully prepared to make the one-way trip to Mars, because, as she told us, she has dedicated her life to Science.

The morning program had two blocks reserved for panels and workshops. Each of them included nine parallel sessions with over 50 panelists. The panels were in varied fields, from career paths in industry and education, to how to apply to internships, to more soft skills regarding work-life balance, mentoring, and diversity and inclusion. The topics of the workshops ranged from Introduction to Arduinos, LHC virtual reality, developing negotiating skills, and preparing CVs. The student poster presentation was held simultaneously with the Networking/Graduate School Fair due to the re-arrangements caused by the weather, but it was still a vibrant scene with representatives from fifteen companies and a comparable number of graduate schools. The poster session prizes for Effective Communication and Visual Impact were presented to four young women by CNS Dean Tricia Serio over lunch on Saturday. Early arrivals were able to tour physics laboratories and core facilities at the UMass Amherst campus. It is our hope that participants left reinvigorated to continue their studies and a sense of belonging to a larger community that is there to support them.

Comments from participants/ panelists (blogs.umass.edu/cuwip):
"... it was very inspiring to hear from so many female physicists about their achievements in their field. As a student in a discipline where women are often underrepresented, I felt encouraged by the success of the speakers and panelists..."

"... I got my first opportunity to be the moderator for a graduate program panel. I look up to these panelists, all amazing physicists I never thought I'd get to meet in-person as an undergrad! I talked for a while with Stevie Bergman, a PhD student at Princeton who works on cutting-edge CMB physics experiments (the field I'm entering graduate school to study) and it turns out she knows my future mentor!"

"We talked about ways members of non-marginalized/minoritized groups need to do the work to create inclusive culture, and how undergrads in particular can elevate issues together, asking their departments to do better by being proactive about inclusivity"

"The thing that I love about CUWiPs: I am reminded how many awesome women work in physics..."

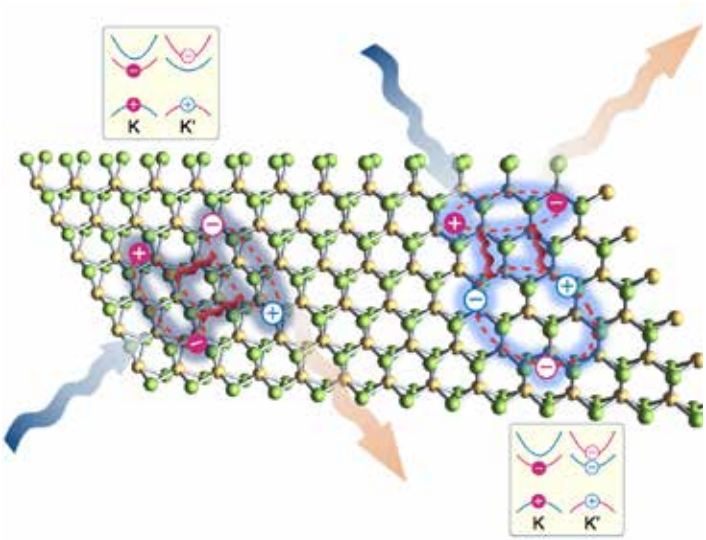
"Wonderful day with so many talented #WomeninPhysics at #UMassCUWiP ! So many great conversations..."

research

EXPLORING VALLEYTRONICS

Jun Yan's group recently investigated how positively and negatively charged particles, when restricted to move in a thin film crystal, interact with each other to form multi-particle complexes. The studied crystal – monolayer tungsten diselenide (WSe_2) - has a thickness of only three atoms, less than a hundred thousandth that of a human hair. Isolating the thin film from the bulk layered parent material increases the interaction strength between its charged particles, making them more likely to bind to each other. When two particles of opposite charge are bound to each other, they form an entity called an exciton, similar to a hydrogen atom (H). The charges can also form three-particle trions and four-particle biexcitons, analogous to H^- ions and H_2 molecules, respectively. In this research, such complexes with up to five charged particles – an exciton-trion – were experimentally identified.

When living in a crystal such as monolayer WSe_2, the charges behave quite differently from those inside a hydrogen atom. The electron and the proton in a hydrogen atom have quantized spins, while in the case of WSe_2, the charges have not only spin, but also a valley quantum number – a degree of freedom similar to spin that is being actively pursued to realize the 'valleytronics' technology. This research discovered that the two excitons in the biexciton have opposite valley quantum number; similarly, the exciton and the trion in the five-particle exciton-trion reside in opposite valleys, i.e., they are 'intervalley' complexes. Further the two excitons in the biexciton have different spins: one has spin zero (known as the 'bright' exciton) and the other has spin one (the 'dark' exciton). These findings are confirmed in parallel by three other research groups at Stanford University, Rensselaer Polytechnic Institute and University of Cambridge, and were featured in a News & Views by Nature Nanotechnology.



Schematic illustration of the four-particle biexciton and the five-particle exciton-trion in a WSe_2 crystal composed of a sub-nanometer thick atomic film. They can be created by light illumination, and their recombination emits light. The biexciton in the figure is due to a 'dark' exciton in valley K bound to a 'bright' exciton in valley K'; similarly, the exciton-trion is composed of a K-valley 'dark' exciton and a K'-valley 'bright' trion.

Understanding the origin and the exact quantum information of these multi-particle bound states provides useful insights for designing and building devices with these crystals. The quantum properties of optical emission from the multi-particle bound states are linked to their quantum configuration, efficient control of which may provide a way to express the spin and valley quantum information in the photons emitted, enabling photon mediated quantum technology.

FLOQUET QUANTUM CRITICALITY

Coherently driving a quantum system with a time-dependent field opens new avenues for non-equilibrium quantum dynamics. From a condensed matter perspective, driving can lead to new kinds of non-equilibrium steady states with no static equilibrium counterpart. From an applied perspective, coherent time dependent quantum control is essential for storing and processing quantum information. Obtaining a general understanding of universal aspects of driven quantum systems is an important outstanding task for theory. In contrast to equilibrium phases of matter, which are largely understood within a well established theoretical framework, the theory of non-equilibrium driven quantum phases is far more preliminary. In a recent work, Romain Vasseur and collaborators studied the rich phase structure that emerges in periodically driven "Floquet" systems. In the presence of quenched disorder, these nonequilibrium systems with time translation symmetry can avoid thermalizing to a bland infinite temperature state through a phenomenon known as many-body localization. The ability of these driven phases to host phenomena forbidden in equilibrium, such as "time crystallinity," has gained widespread interest in recent years. In this work, Romain and collaborators considered the question of the criticality that emerges at the transitions between distinct Floquet phases. By providing a universally applicable picture and applying it to a prototypical driven system, the driven Ising chain, they identified critical points and gave an understanding of Floquet criticality in general. Link: http://www.pnas.org/content/115/38/9491

INTERACTING MATTER

Physical systems can generally be classified as classical or quantum. A defining property of two-dimensional quantum matter in condensed matter physics is its emergent behavior at low temperatures. This happens when a large number of individual particles start to interact with each other actively, resulting in the emergence of distinct collective "quasiparticles." Typical examples of quantum materials are quantum magnets and superconductors.

The defining characteristic of superconductivity is the appearance of electron pairs that are "glued" together by the interactions, resulting in vanishing electrical resistance of the material at low temperatures. In quantum magnets, the magnetic moments, such as the spins of electrons, at low temperatures typically organize a regular pattern with neighboring spins. Such an ordered state of electron spins is similar in its nature to the Bose-Einstein condensate, where many particles fall into the same quantum state due to mutual interactions.

The microscopic description of materials exhibiting quantum magnetism and the description of superconductors have traditionally been entirely different. However, in a recent series of publications, UMass Physics faculty member Tigran Sedrakyan and his international collaborators presented an elegant theoretical method to describe both quantum states within one unified scenario - based on topological field theory. Tigran explains aspects of their theory: "Both states are ordered, and as such, the emergent quasiparticles in these states are very similar."

The progress in this direction will help scientists understand phases of interacting quantum matter and the interplay between them. The work will boost new experiments giving the possibility to model transitions between such phases using ultracold atom setups -- a modern contemporary tool to control interacting quantum matter to high precision. Tigran continues: "Experiments we propose are well within the current capability of experimentalists, and have the potential to open a new era of interdisciplinary research looking at fascinating properties of phases of quantum matter."

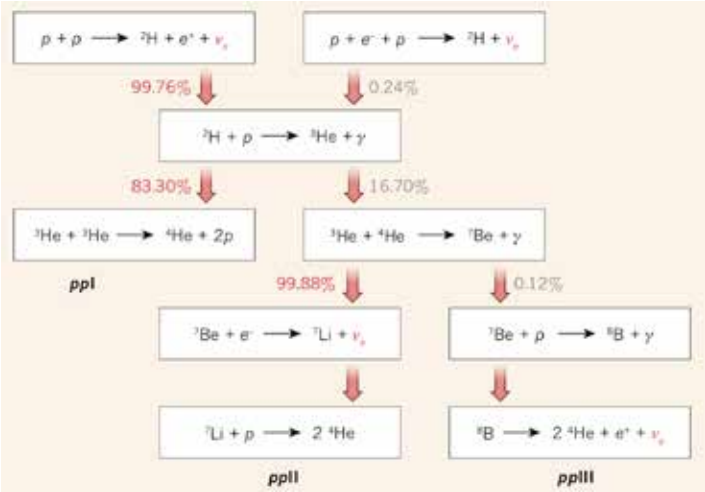
BOREXINO STUDIES ENERGY PRODUCTION IN THE SUN

Before the eighteenth century and the "uniformitarianism" theory of the Scottish geologist James Hutton, the age of the Earth and the Sun was taken to be about 6000 years or so, and the energy emitted by the Sun was assumed to come from a hot mass as it cooled down. However, we now know that the Sun was created about 4.6 billion years ago and has been radiating 4×10^{26} joules per second ever since. The origin of this energy production was identified by Hans Bethe in the late 1930s to be nuclear fusion, primarily via the so-called pp-chain, wherein 4 protons are fused into helium accompanied by the release of 24.7 MeV of energy. Because protons are charged and repel one another, this chain of reactions can only occur in a region such as the solar core where the pressure is intense and the temperature is greater than ~10^7 K or so. Confirming this fusion picture is difficult, because the Sun's surface temperature is only about 3000 K. However, detection of this process is possible because during the fusion chain several neutrinos are emitted, and these very noninteractive particles can travel directly out from the solar interior and then to the Earth, where they can be detected.

Professor **Andrea Pocar,** a UMass nuclear experimentalist, is a member of the Borexino Collaboration, which operates a neutrino detector filled with 300 tons of liquid scintillator located in the ~2-mile-long Gran Sasso highway tunnel connecting Rome with the Adriatic Sea. Recently, he discussed the Borexino experiment. "Neutrinos emitted by this chain represent a unique tool for solar and neutrino physics," he explained, "and our new paper in *Nature* (Nature **562**, 496 (2018)) reports on the first complete study of all the components of the *pp*-chain performed by Borexino." These components include not only the *pp* neutrinos, but others called Beryllium-7 (^{7}Be), *pep* and Boron-8 (^{8}B) neutrinos. The *pp* fusion reaction of two protons to produce a deuteron is the first step of the reaction sequence responsible for roughly 99 percent of the Sun's energy output, Pocar says.

He adds, "What's new today is incremental, it's not a leap, but it is the crowning of more than 10 years of data-taking with the experiment to show the full energy spectrum of the Sun at once. Our results reduce uncertainty, which is perhaps not flashy, but it's the type of advance that is often not recognized enough in science, especially when presenting to the general public. The value is that measurements get more precise because with more data and thanks to the work of dedicated young physicists, we have a better understanding of the experimental apparatus."

"Borexino offers the best measurement ever made for the *pp*, ^{7}Be and *pep* neutrinos," he adds. "Other experiments measure the ^{8}B neutrinos more precisely, but our measurement, with a lower threshold, is consistent with them." Further, "Once you have more precise data, you can feed it back into the model of how the Sun is behaving, and then the model can be refined even more. It all leads to understanding the Sun better. Neutrinos have told us how the Sun is burning and, in turn, the



Sun has provided us with a unique source to study how neutrinos behave. Borexino, scheduled to run for another two to three years, has strengthened our understanding of the Sun very profoundly."

For earlier studies, the team had focused on each one of the *pp*, ^{7}B, *pep* and ^{8}B neutrino channels separately in targeted analyses of the collected data in restricted windows of energy, "like trying to characterize a forest by taking one picture each of many individual types of trees," Pocar notes. "Multiple pictures give you an idea of a forest, but it's not the same as the photo of the entire forest."

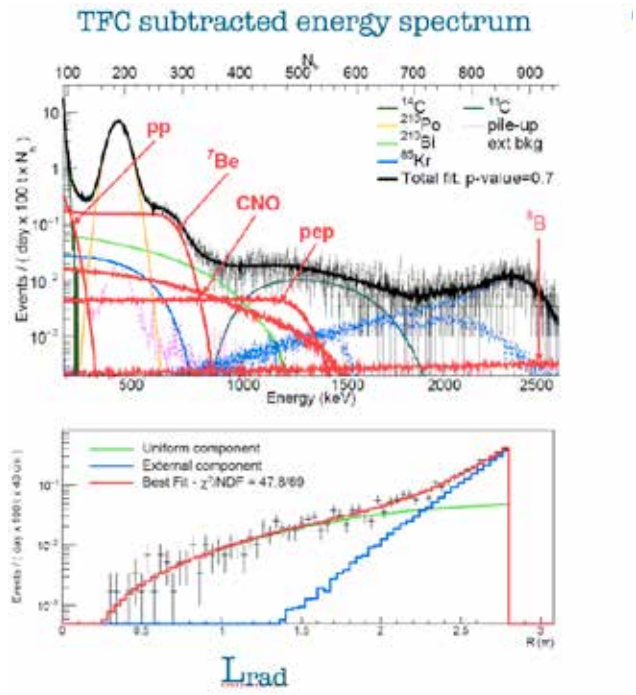
"What we have done now is take a single photograph that reflects the whole forest, the whole spectrum of all the different neutrinos in one. Instead of zooming in to look at little pieces, we see it all at once. We understand our detector so well now, we are comfortable and confident that our one shot is not only valid for the whole spectrum of neutrino energies, but is also the most precise way for us to look at them."

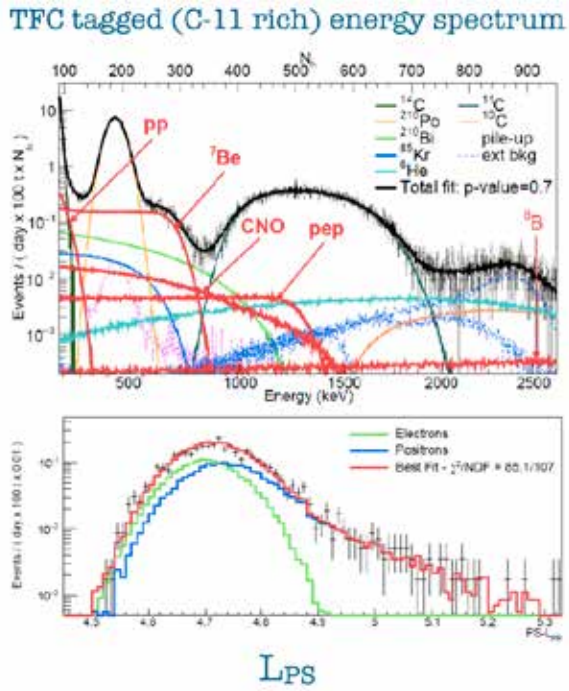
Solar neutrinos stream out of the star at the center of our system at nearly the speed of light, as many as 420 billion hitting every square inch of the Earth's surface per second. But because they only interact through the nuclear weak force, they pass through matter virtually unaffected, which makes them very difficult to detect and distinguish from trace nuclear decays of ordinary materials, Pocar says.

The Borexino instrument detects neutrinos as they interact with the electrons of an ultra-pure organic liquid scintillator at the center of a large sphere surrounded by 1,000 tons of water. Its great depth and many onion-like protective layers maintain the core as the most radiation-free medium on the planet. It is the only detector on Earth capable of observing the entire spectrum of solar neutrino simultaneously, which has now been accomplished, he notes.

The UMass Amherst physicist, one principal investigator on a team of more than 100 scientists, is now particularly interested in turning his focus to measure yet another type of solar neutrino known as CNO (carbon nitrogen oxygen) neutrino, which he hopes will be useful in addressing an important open question in stellar physics, that is the metallicity, or metal content, of the Sun.

"There are two models that predict different levels of elements heavier than helium, which for astronomers are metals, in the Sun: a lower metallicity and a higher metallicity one," he notes. CNO neutrinos are emitted in a cyclic fusion reaction sequence different from the *pp* chain and subdominant in the Sun, but thought to be the





main source of power for heavier stars. The CNO solar neutrino flux is greatly affected by the solar metallicity.

Pocar says, "Our data is possibly showing some slight preference for high metallicity, so we'll be looking into that because neutrinos from the Sun, especially CNO, can help us disentangle this."

Borexino is an international collaboration funded by National Science Foundation in the United States, the Italian National Institute for Nuclear Physics that manages the Gran Sasso labs, and funding agencies in Germany, Russia and Poland.

DARKSIDE-50 SEARCH FOR DARK MATTER

A good deal of past and recent astrophysical and cosmological evidence has indicated that the visible matter that makes up stars, galaxies, and other objects that we have so far detected is only a small fraction of the mass which makes up the universe. A significant component of the remaining "missing" matter is composed of "dark matter", which is unseen by direct methods but whose presence is detected by studying the evolution of galaxies themselves as revealed, for example, by measuring their rotation as a function of distance from the center.

Looking for direct evidence of dark matter by means of terrestrial studies has been underway for many years, but thus far no signal has been observed. Most of these studies have involved a search for "weakly interacting massive particles" (WIMPs) whose presence would be indicated by the detection of a recoiling nucleus in a large volume detector even though there is no incoming man-made beam. Many such studies have used detectors with liquefied noble gases such as argon or xenon. One such effort is the "DarkSide" experiment, of which UMass Professor Andrea Pocar is a member, and which is situated in the Gran Sasso automobile tunnel connecting Rome to the Adriatic. The signal for a dark matter-induced recoil is scintillation light and the very tiny expected signal requires that backgrounds be kept to an absolute minimum. One problem in this regard is the presence of the radioactive isotope ^{39}Ar whose presence can be minimized by use of argon from deep Earth sources rather than extracted from the atmosphere. The first such limit obtained by the collaboration was published in December 2014 using argon harvested from the atmosphere, which was followed in October 2015 by an improved number obtained using the first such search using argon from underground sources.

The present effort, called DarkSide-50, uses an argon mass of 50 kg and employs a detection scheme based on a dual-phase time projection chamber, which is made up of a small layer of gaseous argon above a much larger liquid argon reservoir. This configuration allows a remarkable reduction of possible backgrounds and the collaboration has recently released the results of a 500-day detector exposure and has set the best limit yet obtained for interaction of WIMPs having masses from 2 — 6 GeV.

The future of this effort is the Global Argon Dark Matter Collaboration (GADMC), formed in September 2017, consisting of 300 physicists from 15 countries and 60 institutions which are already involved in first generation dark matter experiments. This collaboration is working on the DarkSide-20 kg detector to accumulate 100 ton-years of data, 250 times the observation exposure from DS-50, and would be followed by a much larger detector to accumulate ten times this signal. The result would be the most complete probe yet for a WIMP dark matter signal.

HAPPY BIRTHDAY, LHC!

Physicists around the world are celebrating the 10th anniversary of the largest particle collider ever built, the Large Hadron Collider (LHC), which occupies a 17-mile ring 300 feet underground in the CERN laboratory, located on the outskirts of Geneva, Switzerland. When the collider is turned on, powerful electromagnetic fields accelerate protons to the highest energies ever produced in a laboratory. Giant particle detectors (called ATLAS, CMS, LHCb, and ALICE) measure the direction and energy of the particles produced in each collision. Since the particle collisions happen 40 million times per second, the amount of information analyzed by each detector makes up the largest dataset ever produced. For particle physicists, it's a dream come true.

The anniversary also marks a feat of sustained collaboration between thousands of researchers from hundreds of institutions, including our own physics department. The ATLAS group at UMass Amherst includes scientists, engineers and students who analyze some of the data collected in the ATLAS detector and work on the operation, maintenance and upgrade of the experiment. ATLAS is a collaboration of over 3000 scientists from all around the world, and the detector itself (one of four within the jaw-droppingly huge collider), weighs as much as one hundred 747 jets, and houses more than 1,800 miles of cable.

This past decade at the LHC has been filled with excitement, including the discovery of the Higgs boson particle in 2012. As UMass Professor Rafael Coelho Lopes de Sa, physics, relates "the Higgs boson

was predicted theoretically in the 1960s and, later, was understood to be an important part of the Standard Model of Particle Physics. It was the last fundamental particle of the Standard Model to be observed in the laboratory." The UMass ATLAS group has made significant contributions to the experiment, he says, including developing "new algorithms used in several searches for new sub-nuclear particles, even more exotic than Higgs boson."

What's next for the ATLAS detector? Upgrades are in the works, and several new technologies for them are being developed in brand new laboratories opened in the Lederle Graduate Research Tower and the new Physical Sciences Building. Lopes de Sa points out, "UMass scientists, professors, and students will spend the next five years producing new particle detectors and dedicated hardware that selects only the most interesting collisions. These systems will be installed in the ATLAS detector and will be key to understanding the biggest bangs that scientists can produce, giving us clues into why and how the world around us has come to be."

UPDATE ON THE MUON g-2 EXPERIMENT AT FERMILAB

An experiment with significant UMass participation is under way at the Fermi National Accelerator Laboratory. The centerpiece of the experiment is a 650 ton, 14-meter-diameter storage ring magnet used to trap muons. Muons are fundamental particles like electrons, but are 206 times heavier and decay with a lifetime of a few microseconds.

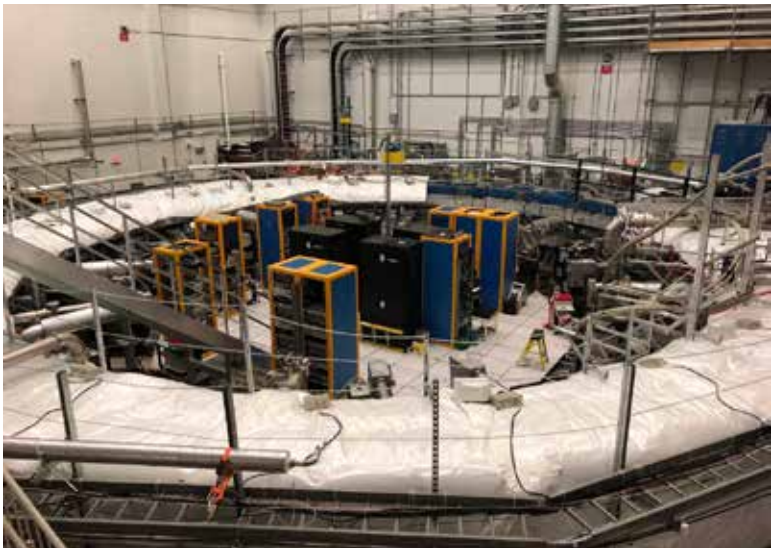
Trapping muons in the storage ring allows a precise measurement of the magnetic properties of the muon. Like electrons, muons have a magnetic moment and behave like a little bar magnet whose strength is characterized by a number, g. Nobel Laureate Paul Dirac predicted in 1927 that g = 2 for fundamental particles like the electron and muon (though the latter had not yet been discovered).

However, precision atomic physics experiments in the late 1940s indicated that $g \approx 2.0024 \pm 0.0001$. The anomalous deviation of g from 2 was a small but important effect. Dirac's theory that predicted g = 2 described a bare particle, but the theory of Quantum Electrodynamics (QED) developed in the 1940s tells us that particles are never bare, even in vacuum. Instead, they are perpetually dressed by virtual particles that appear and disappear out of the vacuum, perturbing the properties of the muon or electron. This leads to a deviation of g from 2 that can be predicted precisely from quantum field theory as long as we include the effects of all the known particles. In fact, the 2018 prediction of g-2 for the electron by Prof. Toichiro Kinoshita at UMass Amherst and collaborators to 13 significant figures *is the most precise prediction in all of physics or any field of human knowledge*. (See Spring 2016 Physics Newsletter)

The *measured* value of g-2 includes the influence not only of all the particles we know about – those included in Prof. Kinoshita's and others' calculations including the famous Higgs boson – but also particles that exist but remain undiscovered. There is interest in the muon g-2 because of a discrepancy between the prediction and value measured previously at Brookhaven National Laboratory, which could indicate the existence of an entirely new class of fundamental particles. Because the difference between the prediction and the measurement at Brookhaven is inconclusive, the muon g-2 experiment is being redone four times better, to a precision of 140 parts per billion at Fermilab, where many more muons are available for greater statistical precision.

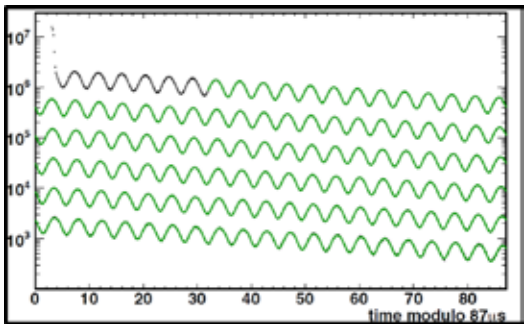
To study muons, we trap them in the magnetic storage ring where they circulate at near the speed of light. When the muons first enter the ring, their magnetic moments are aligned with the muon momentum vector. If g were identically equal to 2, the magnetic moment would remain parallel to the momentum as the muons circle in the storage ring. However, g > 2 and the magnetic moments rotate an extra 12 degrees for each circuit. This extra amount is proportional to the product of g-2 and the magnetic field strength.

The experiment took its first data set in early 2018, when muons were injected and stored in the ring, and calorimeters detected the decay of muons into positrons. The detection rate of the highest-energy positrons oscillates, peaking when the muon spin and magnetic moment point forward, aligned with the momentum, and minimized when the moment points backwards.



The muon g-2 storage ring magnet in September 2018.

The oscillation signal is superimposed on the regular exponential decay curve of the muons, leading to the famous "wiggle" plot in the figure. Precise measurements of the oscillation frequency of the wiggle and the magnetic field determine g-2.



Wiggle plot showing the number of detected positrons versus time. The oscillation frequency is proportional to the product of g-2 and the magnetic field strength.

UMass has significant ties to the new and old experiment. Professor Dave Kawall worked as a postdoc on the Brookhaven experiment, and now works on the team responsible for measuring the storage magnetic field with a precision of 70 parts per billion. Two UMass postdocs, David Flay and Jimin George, lend their talents to this effort, as do graduate students David Kessler and Winnie Wang, and undergraduates Scott Israel, Liam Scanlon, and Anushka Shrivastava.

There are many challenges to making measurements at the 100 parts-per-billion level.

Just to create the muons, we require high-energy protons to hit a target, producing pions, which are captured in a long beamline and decay into muons. These muons are also captured and a tiny subset stored successfully in the ring. For every billion protons hitting the target, we get a single detected positron from muon decay in the experiment. We need about 200 billion detected positrons.

The experiment is poised to take its next data set. Meanwhile, the data set from 2018 is being analyzed and should have a precision comparable to the Brookhaven result. The result, with the future of particle physics at stake, is expected by summer 2019.

THE MULTIVERSE

The term ''multiverse" refers to the idea that there might exist many ''bubbles" of spacetime to which we do not have access and wherein the fundamental constants of nature, such as the cosmological constant or the fine structure constant, are different from ours. Our particular bubble is presumably somewhat unique in these constants having values that enable intelligent life to exist, an idea called the anthropic principle. Because we cannot directly probe other ''universes" and due to the possible association with religious ideas, there are strong opinions as to whether, or not, these ideas really constitute science. One who believes that the multiverse *is* appropriate for scientific study is UMass Emeritus Professor John Donoghue, whose invited article on the subject was recently published in Volume 66 of *Annual Reviews of Nuclear and Particle Science*. John was also interviewed for an article in the digital magazine *Knowable* published by *Annual Reviews,* which is reprinted below. Newsletter readers can make their own decisions as to whether our universe is unique.

JOHN DONOGHUE'S VIEWS ON THE MULTIVERSE

Knowable Magazine quizzed theoretical physicist John Donoghue about the meaning of the multiverse, the issues surrounding anthropic reasoning and the argument that the idea of a multiverse is not scientific. His answers have been edited for brevity and clarity.

Magazine: Can you explain just what you mean by multiverse?

Donoghue: For me, at least, the multiverse is the idea that physically out there, beyond where we can see, there are portions of the universe that have different properties than we see locally. We know the universe is bigger than we can see. We don't know how much bigger. So, the question is: is it the same everywhere as you go out or is it different?

Magazine: If there is a multiverse, is the key point not just the existence of different realms but that they differ in their properties in important ways?

Donoghue: If it's just the same all the way out, then the multiverse is not relevant. The standard expectation is that aside from random details, like "here's a galaxy, there's a galaxy; here's empty space", that it's more or less uniform everywhere in the greater universe. And that would happen if you have a theory like the Standard Model where there's basically just one possible way that the model looks. It looks the same everywhere. It couldn't be different.

Magazine: Isn't that what most physicists would hope for?

Donoghue: Probably literally everyone's hope is that we would someday find a theory and all of a sudden everything would become clear, e.g., there would be one unique possibility, it would be tied up, there would be no choice but this was the theory. Everyone would love that.

Magazine: But the Standard Model does not actually specify all the numbers describing the properties of nature, right?

Donoghue: The structure of the Standard Model is fixed by a symmetry principle. That's the beautiful part. But within that structure there's freedom to choose various quantities like the masses of the particles and the charges, and these are the parameters of the theory. These are numbers that are not predicted by the theory. We've gone out and we've measured them. We would like eventually that those are predicted by some other theory. But that's the question, whether they are predicted or whether they are in some sense random choices in a multiverse.

The example I use in the paper is the distance from the Earth to the Sun. If you were studying the solar system, you'd see various regularities and a symmetry, a spherically symmetrical force. The fact that the force goes like one over the radius squared is a consequence of the underlying theory. So, you might say, well, I want to predict the distance of the Earth from the Sun. Kepler tried to do this and came up with a very nice geometric construction, which almost worked. But now we know that this is not something fundamental; it's an accident of the history. The same laws that give our solar system with one Earth-to-Sun distance will somewhere else give a different solar system with a different distance for the planets. They're not predictable. So, the physics question for us then is, are the parameters like the mass of the electron something that's fundamentally predictable from some more fundamental theory, or is it the accident of history in our patch of the universe?

Magazine: How does the possibility of a multiverse affect how we interpret the numbers in the Standard Model?

Donoghue: We've come to understand how the Standard Model produces the world. So, then you could actually ask the scientific question: What if the numbers in the Standard Model were slightly different? Like the mass of the electron or the charge on the electron. One of the surprises is, if you make very modest changes in these parameters, then the world changes dramatically. Why does the electron have the mass it does? We don't know. If you make it three times bigger, then all the atoms disappear, so the world is a very, very different place. The electrons get captured onto protons and the protons turn into neutrons, and so you end up with a very strange universe that's very different from ours. You would not have any chance of having life in such a universe.

Magazine: Are there other changes in the Standard Model numbers that would have such dramatic effects?

Donoghue: My own contribution here is about the Higgs field [the field that is responsible for the Higgs boson]. It has a much smaller value than its expected range within the Standard Model. But if you change it by a bit, then atoms don't form and nuclei don't form — again, the world changes dramatically. My collaborators and I were the ones that pointed that out.

There's some maybe six or seven of these constraints, i.e., parameters of the Standard Model that have to be just so in order to satisfy the need for atoms, the need for stars, planets, et cetera. So about six combinations of the parameters are constrained anthropically.

Magazine: By "anthropically," you mean that these parameters are constrained to narrow values in order to have a universe where life can exist. That is an old idea known as the anthropic principle has historically been unpopular with many physicists.

Donoghue: Yes, I think almost anybody would prefer to have a well-developed theory that doesn't have to invoke any anthropic reasoning, but nevertheless it's possible that these types of theories occur. To not consider them would also be unscientific. So, you're forced into looking at them because we have examples where it would occur.

Historically there's a lot of resistance to anthropic reasoning, because at least the popular explanations of it seem to get causality backwards. It was sort of saying that we [our existence] determine the parameters of the universe, and that didn't feel right. The modern version of it, with the multiverse, is more physical in the sense that if you do have these differing domains with different parameters, we would only find ourselves in one that allows atoms and nuclei. So, the causality is right. The parameters are such that we can be here. The modern view is more physical.

Magazine: If there is a multiverse, then doesn't that change some of the goals of physics, such as the search for a unified theory of everything, and require some sort of anthropic reasoning?

Donoghue: What we can know may depend on things that may end up being out of our reach to explore. The idea that we should be searching for a unified theory that explains all of nature may in fact be the wrong motivation. It's certainly true that multiverse theories raise the possibility that we will never be able to answer these questions. And that's disturbing.

Magazine: Does that mean the multiverse changes some of the questions that physicists should be asking?

Donoghue: We certainly still should be trying to answer "how" questions about how does the W boson decay or the Higgs boson, how does it decay, to try to get our best description of nature. And we have to realize we may not be able to get the ultimate theory because we may not be able to probe enough of the universe to answer

certain questions. That's a discouraging feature. I have to admit when I first heard of anthropic reasoning in physics, my stomach sank. It kills some of the things that you'd like to do.

Magazine: Don't some people even argue that though a multiverse would seem to justify anthropic reasoning, that approach should still be regarded as not scientific?

Donoghue: It's one of the things that bothers me about the discussion. Just because you feel bad about the multiverse, and just because some aspects of it are beyond reach for testing, doesn't mean that it's wrong. So, if it's worth considering, and looking within the class of multiverse theories to see what it is that we could know, how does it change our motivations? How does it change the questions that we ask? And to say that the multiverse is not science is itself not science. You're not allowing a particular physical type of theory, a possible physical theory, that you're throwing out on nonscientific grounds. But it does raise long-term issues about how much we could understand about the ultimate theory when we can just look locally. It's science, it's sometimes a frustrating bit of science, but we have to see what ideas become fruitful and what happens.

Magazine: An important part of investigating the multiverse is finding a theory that includes multiple "ground states." What does that mean?

Donoghue: The ground state is the state that you get when you take all the energy out of a system. Normally if you take away all the particles, that's your ground state, i.e., all the background fields, the things that permeate space. The ground state is described by the Standard Model. Its ground state tells you exactly what particles will look like when you put them back in; they will have certain masses and certain charges.

You could imagine that there are theories which have more than one ground state, and if you put particles in this state, they look one way and if you put particles in another state, they look another way, e.g., they might have different masses. The multiverse corresponds to the hypothesis that there are very many ground states, lots and lots of them, and in the bigger universe they are realized in different parts of the universe. Kepler's mathematical explanation for the layout of the known solar system involved a series of geometrical solids, including a sphere, cube, pyramid and other shapes.

Magazine: Even if a theory of particles and forces can accommodate multiple ground states, don't you need a method of creating those ground states?

Donoghue: Two features have to happen. You have to have the possibility of multiple ground states, and then you have to have a mechanism to produce them. In our present theories, producing them is easier because inflationary cosmology has the ability to do this. Finding theories that have enough ground states is a more difficult requirement. But that's a science question. Is there one, is there two, is there a lot?

Magazine: Superstring theory encompasses multiple ground states, described as the "string landscape." Is that an example of the kind of theory that might imply a multiverse?

Donoghue: The string landscape is one of the ways we know that this [multiple ground states] is a physical possibility. You can start counting the number of states in string theory, and you get a very enormous number, 10 to the 500. So, we have at least one theory that has this property of having a very large number of ground states. And there could be more. People have tried cooking up other theories that have that possibility also. So, it is a physical possibility.

Magazine: Don't critics say that neither string theory nor inflationary cosmology has been definitely established?

Donoghue: That's true of all theories beyond the Standard Model. None of them are established yet. So, we can't really say with any confidence that there is a multiverse. It's a physical possibility. It may be wrong. But it still may be right.

Interviewer, Tom Siegfried, is a science writer and editor in the Washington, DC, area. He writes the Context blog for Science News and is at work on a book about the history of the multiverse.

FUNDAMENTAL SYMMETRIES AND LOW-ENERGY SEARCHES FOR NEW PHYSICS

Jordy de Vries, who joined the Amherst Center for Fundamental Interactions (ACFI) as Assistant Professor at the beginning of Fall 2018, is active in the search for physics Beyond the Standard Model (BSM). The Standard Model of particle physics is a very successful theory that accurately describes the interactions of fundamental particles. It also explains how these elementary particles combine to form more complex objects such as protons, neutrons, atomic nuclei, and atoms. Despite all its successes, it is widely believed that the Standard Model is not the final theory. For instance, the Standard Model lacks a Dark Matter candidate and does not explain why our universe contains more matter than antimatter. In addition, the Standard Model suffers from theoretical 'fine-tuning problems' as it appears that certain parameters take on very special values. While these values do not necessarily indicate the Standard Model is incomplete, they do beg for a deeper explanation.

The search for BSM physics has grown into a titanic effort. At the forefront is the Large Hadron Collider where high-energy protons are collided. The holy grail of this search is to produce and detect yet unknown particles. At the same time, high-precision experiments aim to test the Standard Model at much lower energies. Here the goal is to look for deviations from Standard Model predictions. Examples of the latter category where ACFI members are involved include high-precision measurement of the muon magnetic moment, searches for electric dipole moments, neutrinoless double beta decay experiments, and Dark Matter direct detection experiments. Professor de Vries is particularly interested in what these different kinds of experiments can tell us about BSM physics. This is not always easy to say, as many of the low-energy experiments involve complicated objects such as hadrons, nuclei, atoms, and even molecules.

One specific class of these experiments aims at detecting charge-parity (CP) violation via electric dipole moments (EDMs). EDMs are (hypothetical) properties of particles and composite objects whose existence would imply CP violation. CP, the symmetry between particles and antiparticles, is broken in the weak interactions of the Standard Model, but this breaking leads to immeasurably small EDMs. As such, the measurements of a nonzero EDM in any of the multitude of ongoing experiments would imply the existence of a new source of CP violation. However, such a signal would not tell us right away what source is responsible nor does it tell us whether this source of CP violation is linked to long-standing problems such as the universal matter/antimatter asymmetry.

The interpretation of the EDM experiments thus requires theoretical input. Such theories are interesting as they cover a large range of physics and associated energy scales. For instance, BSM physics is often associated with new elementary particles that are much heavier than known particles. These particles induce, via quantum effects, CP violation in composite objects such as neutrons and nuclei. Calculating these effects involves particle, hadronic, and nuclear theory. Many experiments even involve atoms and molecules and also require atomic and molecular calculations. Theorists try to capture all these different 'physics scales' into a systematic framework. Such a framework allows us to interpret low-energy experiments in terms of high-energy BSM models. For instance, in recent work with ACFI members Patrick Draper, Kaori Fuyuto, and Johnathan Kozaczuk, and with Dave Sutherland from the University of California Santa Barbara (UCSB), De Vries has investigated whether EDM experiments could provide evidence for the existence of axions, a hypothesized Dark Matter candidate. In other work, he studied how EDMs in combination with LHC measurements can be used to look for signs of a non-SM Higgs sector.

EDMs are just one of many examples of low-energy high-precision experiments that can tell us a lot about possible BSM theories. Other directions he is working on include neutrinoless double beta decay, Dark Matter detection, and neutron-antineutron oscillations. The impressive experimental improvement in these fields should go hand-in-hand with theoretical progress!

A NEW DISCIPLINE

A National Science Foundation (NSF) application, initially supported by the UMass Institute for Applied Life Sciences' Models to Medicine (M2M) Center, seeks to create new areas of study which unite investigators from otherwise distinct research fields. The director, Peter Chien, encourages innovative scientists to collaborate in interdisciplinary teams "to explore bold new directions."

The unification of the expertise of three researchers is directing their efforts toward an entirely new field, that of "touch-based bacterial communication." The team consists of physicist Mark Tuominen, polymer scientist Maria Santore and microbiologist Sloan Siegrist, whose project will receive ~$1M to study soft materials of microbiology, nanoelectronics and electrical signaling. The goal is to explore how bacteria might respond to these signals and how those signals can be used to manipulate bacteria.

The team named their program "Dynamic, touch-based bacteria-device two-way communication." According to them, bacteria change their responses based on the surface of contact, a sense of bacterial touch. The bacteria react to stimuli differently, depending on the type of surface, e.g., contact on a biofilm compared to the open atmosphere in flight.

Mark Tuominen, the physicist, noted that silicon- and metal-based medical devices interact with living tissues via signals dictated by those materials, while living things are accustomed to chemical or biomolecular signals that travel much more slowly. Bacterial cells can respond very quickly, but the idea of interfacing with bacteria is different. "We want to identify broad models that focus on interactions at the faster time scales that bacteria offer.

One goal of our project is to develop bacteria-integrated devices where the cells and the electronics communicate with each other. There is a lot of cool science along the way, in particular how bacterial cells interact with surfaces in their environments." He adds that there has been "a steady evolution of tools in microbiology and nanotechnology that is pushing the frontiers of microbial electronics."

One of the problems is that of scale, because bacteria are so much smaller than mammalian cells, "one-tenth the length, one one-hundredth the surface

area and one one-thousandth the volume." Ergo, a new approach is needed to initialize the program.

The project will provide a new methodology and perhaps instrumentation. An example given was that nanoelectrodes are now a possibility. The microbiologist, Siegrist, will investigate gene expression to mechanically and electronically direct cells to turn on particular genes to read out that gene expression in real time in order to control bacterial behavior. "We think we can tune such variables as the stiffness or flexibility of bacterial cells, their rigidity, for example, by controlling how dense the cell wall mesh is." Siegrist, who sees her challenge as measuring real, reliably reproducible changes in bacteria linked to stimuli, says, "They are so small there is a lot less RNA to work with, their half-life is shorter and chemical structure is different. But it's really fun and exciting to think broadly about how to accomplish this."

The polymer scientist, Maria Santore, will be designing surfaces where the cells stick in exactly the same contact pattern at the same time so that Siegrist can have as many cells as possible with exactly the same surface interaction and timing. "I will engineer surfaces where bacterial cells will respond to an electrical signal. To link the mechanical and electrical response will be interesting. The first step is to observe and later to control. This process has never been done in bacteria."

Besides the research, the team will organize workshops to build a foundation for other investigators to embark on a new sub-discipline, i.e., bio-remediation, pharmaceuticals, engineering proteins or implants that probe muscle cells, and other electronic medical devices.

BIOPHYSICS SLAM

In December of 2017, the Center for Biological Physics held its third Biophysics Slam. A "slam" is an efficient – and exciting – method of sharing ideas and forming connections within a community. The format consisted of 5 minute research talks by faculty followed by a poster session, lunch, and a breakout session on Membrane Biophysics. The 2017 slam hosted 41 scientists, most of whom were from the 5-College area. Based on ideas presented at the slam, a pre-proposal was developed for the NSF Research Advanced by Interdisciplinary Science and Engineering (RAISE) mechanism, "Rules of Life" theme. This year, another slam/workshop on membranes is scheduled for Feb 25, 2019, and a slam/workshop on responsive and nanostructured materials is scheduled for April 10, 2019.

The Center for Biological Physics also sponsors biweekly science presentations by biochemists, biologists, chemists, physicists, and engineers who are interested in biophysics. As with the slam, the goal is to generate new science ideas and create new collaborative teams. For future events, information can be found at www.physics.umass.edu/cbp or by contacting Lori Goldner, the Director of the Center for Biological Physics.

Continued from Cover

STRAIN IN THIN SHEETS

emboss or wrap nanoscopic thin sheets and shells onto substrates of different shapes. Our work shows that by allowing tiny wrinkles in the wrapper, the necessary amount of stretching drops dramatically. For an extremely thin wrapper such as available today in laboratories, the stretching can be eliminated almost entirely."

"Galileo's beam," is a mechanics/physics problem that considers a beam sticking out of a stone wall that will bend or deform when weight is added to it. Predicting the forces and strain on it posed a long-standing puzzle. Galileo (1564 - 1642) did not solve how much the beam will deform nor how to predict that, but this problem related to strain was later explored and defined through new approaches to the geometry of continuous objects by German mathematician and physicist Carl Friedrich Gauss (1777 - 1855). Swiss mathematician Leonhard Euler (1707 - 1783) developed the "*elastica* theory," which argues that confined objects buckle in order to avoid strain, that is, any change in length. Euler showed that a situation in which absolutely no stretching takes place can occur under special circumstances, but not in the general type of confinement defined by Gauss's geometrical constraints.

The UMass Amherst team's new tool shows how to find the optimal physical state or shape when a constraint cannot be perfectly satisfied but is almost satisfied. Benny describes it as "a new branch of variational calculus. All I need to do is minimize the curvature that nearly eliminates all stretching, and it lets me find the one with the smallest possible bending energy."

This new principle, called the *Gauss-Euler elastica*, reconciles the two cornerstones of classical mechanics and geometry defined previously by the works of Euler and Gauss. It invokes a new regime of solutions of the complex morphologies of thin bodies, a problem of intense recent interest in fields ranging from biophysics and materials engineering to applied mathematics. https://www.umass.edu/newsoffice/article/umass-amherst-researchers-offer-new

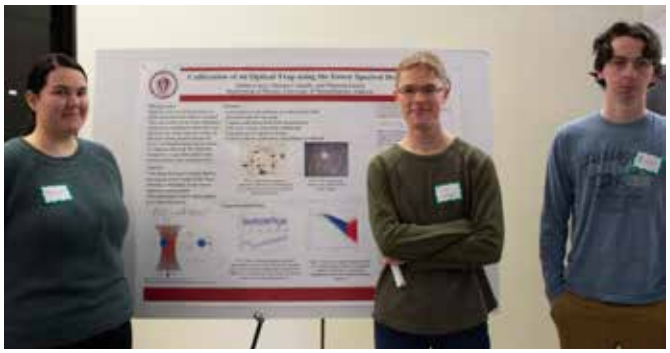
UNDERGRADUATE RESEARCH PROJECTS

Physics students to engage in a wide variety of original, cutting-edge research projects and teaching projects. Here is a list of 48 students working on 47 undergraduate projects that were under way in Fall of 2018-2019.

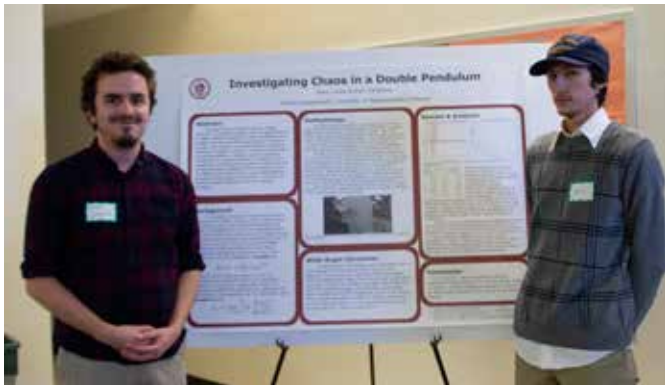
Student	Faculty Advisor	Research Project
Tanios Abi-Saad	Ross	Building a light-sheet microscope.
Ashbell Abraham	Dinsmore	Probing contact-angle hysteresis by measuring slip of a 3-phase contact line.
Brendan Barry	Willocq	Monte Carlo simulation studies of high-momentum Higgs boson tagging for the ATLAS experiment at the Large Hadron Collider.
Anshul Bharghava	Willocq	Studying signal-background discrimination for the di-Higgs high-mass resonance search at the ATLAS detector.
Andrew Brooks	Ross	Learning to engineer new DNA plasmids for protein expression and purification.
Matthew Burke	Martinez Outschoorn	Evaluating a trigger algorithm for the ATLAS muon system.
Jonathan Cali	Menon	Investigating the shapes and volumes when closed polyhedral elastic shells are inflated and deflated.
Thomas Connolly	Wang	Making a non-reciprocal microwave circuit using ferrite-loaded waveguide structures and integration with superconducting qubit/cavities.
Zachary Curtis	Dinsmore	Setting up a microfluidics-fabrication capability for making emulsions.
Thomas Czernik	Santangelo	Developing a mechanical logic system based on soft gels by studying the behavior of mechanical linkages.
Ian Detore	Tewari	Investigating the timbre of musical instruments: why things sound the way they do.
Shivank Doshi	Dinsmore	Computational studies of fluid interfaces using 'Surface Evolver.'
Aaron Fishbein	Willocq	Studying b-tagging performance in di-Higgs Monte Carlo simulations for the ATLAS experiment at the Large Hadron Collider.
Yihan Gao	Martinez Outschoorn	Developing a search at LHC for a dark Higgs boson and a dark photon resulting in a signature of four leptons.
Alex Gekow	Dallapiccola	Assembling and commissioning test stands for use in ATLAS inner detector upgrade studies.
Noah Goldman	Willocq	Studying boson selection in the VH high-mass resonance search at the ATLAS detector.
Matthew Harris	Dallapiccola	Assembling and commissioning test stands for use in ATLAS inner detector upgrade studies.
Scott Israel	Kawall	Developing, calibrating, and analyzing the signals from a sensitive induction coil magnetometer for the Fermilab muon g-2 experiment.
Scott Israel	Sorbo	Selected topics in mathematics with applications to particle physics.
Rucellie Jimenez	Ross	Analyzing mitotic spindle dynamics in cells.
Calvin Johnson	Davidovitch	Studying interfacial energy and elasticity.
Rob Keane	Dinsmore	Measuring adsorption and assembly of nano-sized rods and spheres at fluid interfaces.
Shion Kubota	Willocq	Studying dilepton discovery potential with ATLAS simulated data.
Jeremy Laprade	Dinsmore	Measuring the mechanical properties of charged granular media.
Eric Lyons	Dinsmore	Probing contact-angle hysteresis by measuring slip of a 3-phase contact line.
Bridget Mack	Martinez Outschoorn	Investigating a new algorithm to match precision muon hits with information from the coarse muon detectors at ATLAS.
Mridul Madan	Davidovitch	Studying interfacial energy and elasticity.
Niko Marmanis	Ross	Creating customized flow chambers with semi-permeable membranes for manipulating biological materials.
Neil McCarthy	Tewari	Simulating the flow of a model foam through a widening channel.
Rose McDonald	Toggerson	Revising an online textbook for "Introductory Physics for Life Scientists" with a biological focus.
Jack Mirabito	Dallapiccola	Assembling and commissioning test stands for use in ATLAS inner detector upgrade studies.
Maija Lee Orlovski Nagels	Pocar	Operating a liquid xenon condenser and auxiliary lab activities.
Mackenzie Naseery	Ross	Reading about fluid dynamics and experiments on diffusion.
Trevor Nelson	Martinez Outschoorn	A multijet background estimation for the low mass search for new exotic particles in the Higgs decays.
Linda Oster	Ross	Studying biological physics of microtubules.
Nicholas Popowich	Kastor	Introduction to general relativity through Brian Greene's, "The Elegant Universe."
Alexander Phillips	Traschen	Learning the theory of black holes in cosmology.

Anthony Raykh	Traschen	Studying the geometry of cosmological black hole spacetimes.
Adam Redfern	Ross	Learning optics by building a light microscope.
Ben Reggio	Tewari	Finding the form of the effective interaction as a function of separation of two dielectric spheres with patchy charge.
Anwesha Saha	Miskimen	Development of audio frequency modulator and demodulator circuitry for IR transmission
Alexander Shilcusky	Wang	Integrating static magnetic field flux tuning into superconducting cavities.
Tom Shneer	Machta	Studying phase transitions in coupled oscillator lattices.
Anushka Shrivastava	Kawall	Applying computer vision techniques to locate the positions of NMR magnetometers in the muon g-2 experiment at Fermilab.
Anushka Shrivastava	Traschen	Studying the thermodynamics of black holes with positive cosmological constant.
Faizah Siddique	Martinez Outschoorn	Investigating a new algorithm for matching precision muon hits to information from the coarse muon detectors for the ATLAS detector.
Isaac Spivack	Santangelo	Studies in geometry of soft material
Ben Strain	Ross	Measuring the behavior of liquid crystalline droplets with novel surfactants.

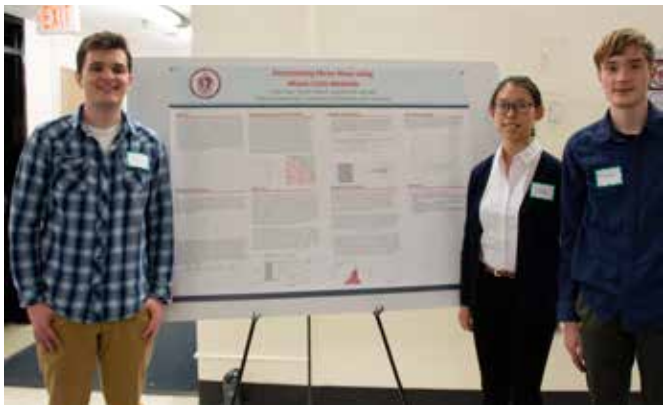
ILAB COURSE WORK POSTER SESSION



Martyna Laszcz, Thomas Connolly, and Joshua Carey "Calibration of an Optical Trap using the Power Spectral



Alex Locke and Alex Hargrove "Investigating Chaos in a Double Pendulum"



Jeremy Laprade, Yihan Gao, and Trevor Nelson "Determining Muon Mass using Monte Carlo Methods"

PUMPKIN CARVING POWWOW

UNDERGRADUATES IN TRASCHEN GROUP

UG students in the Traschen group. Mark Schoen, Bela Nelson, Jennie Traschen, and Jonah Chaban.

teaching

NEW COURSE - INTRO2MEASUREMENT

In Spring, 2018, Tony Dinsmore designed and taught a new course for physics majors called "Physics 192M: An Introduction to Measurement using the Arduino." The idea for the course came from talking with current students and alumni, e.g., such as Michael Buckley, BS '15, who expressed a desire for hands-on technical training in data acquisition early in our program. The Arduino is a powerful and simple-to-use microcontroller, less than 3" across. It is a powerful interface between a laptop computer and a huge variety of detection and measurement devices. During the course, students learn how to set up the Arduino with various sensors, then define their own curiosity-driven question (which is not as simple as it sounds), set up a device to collect data, and answer the question. If you have used an Arduino for data acquisition or control, please tell us about it (email dinsmore@umass.edu).

This course is part of the "skills" section of our undergraduate curriculum. This complements training in fundamental physics, with technical experience with measurement hardware, computational methods, writing resumes and proposals and abstracts, and delivering effective presentations.

OTHER NEW COURSES

Growth in the Physics faculty over the past few years (currently 9 new faculty!) has in turn enabled us to grow our course offerings for both undergraduate and graduate students.

For undergrads (in addition to P192M – Introduction to Measurement), we have a new course P597D – Topics in Statistics in Data Analysis – taught by Prof. Ben Brau. A member of the Department's ATLAS research group, Ben's expertise in data analysis comes from a career working with the large data sets of experimental particle physics. Topics and techniques covered in the course are broadly applicable to numerous real-world data analysis and interpretation applications; such knowledge has become increasingly in demand by employers in the growing information economy.

Also at the undergrad level is a revival of P564 - Introduction to Advanced Quantum Mechanics, which had not been offered in many years. The renewed course is taught by Prof. Guy Blaylock, a specialist in quantum phenomena. In addition to traditional topics, such as the WKB approximation, time dependent perturbation theory and scattering theory, the course explores applications such as quantum cryptography and quantum computing, as well as quantum "paradoxes", including the Einstein-Podolsky-Rosen thought experiment and Bell's inequalities.

For graduate students heading into research in condensed matter physics, we have a cycle of four new courses planned, each to be offered every other year. In Spring 2018, Prof. Romain Vasseur taught P817 - Advanced Statistical Mechanics - another course that had not been offered in many years, which includes the study of phase transitions and critical phenomena. In Fall 2018, Prof. Chris Santangelo offered P797S – Introduction to Soft Matter Physics – which provided an introduction ranging from microscopic to macroscopic phenomena. The course covered basic intermolecular forces, including electrostatics, van der Waals and entropic forces, as well as the basics of polymers, colloids, self-assembly, and fluid membranes. These will be followed in Spring 2019 by Prof. Tigran Sedrakyan teaching P797M – Topics in Many Body Physics – which covers applications of quantum field theory to condensed matter systems, including the quantum Hall effect and topological states of matter. The final course in the sequence will be Continuum Physics, taught by Prof. Benny Davidovitch; then the cycle will repeat.

For graduate students headed into high energy physics, we now offer a second semester of quantum field theory - P890Q - taught by Prof. Michael Ramsey-Musolf, covering topics such as quantum electrodynamics and the renormalization group.

In addition to these courses, we have had a number of recent "special topics" courses offered by new faculty members, aimed at introducing graduate students to their research areas. These have included "Mesoscopic Physics" taught by Prof. Chen Wang; "Underground Physics" taught by Prof. Scott Hertel; "Modern Topics in Quantum Condensed Matter Physics" taught by Prof. Romain Vasseur; and "Topics in String Theory" taught by Prof. Ben Heidenreich.

LAB KITS FOR ONLINE COURSES

The ability to offer online courses in physics has always been hindered by the lab component. Over the past three years, we have developed labs that students are able to perform at home using the IOLab hardware and other materials that we have collected into "kits". This has enabled us to offer, for the first time, a fully online physics course with a lab component.

IOLab is a fairly simple wireless device that contains sensors to measure displacement, velocity, acceleration, force, rotation, pressure, temperature, sound, light, and voltage. The software is free, open source, and easy to work with. By combining this device with other simple materials, we were able to create 9 different labs for Physics 131 (Introductory Physics I) and 9 for Physics 132 (Introductory Physics II). Some of the topics that the labs cover are: friction, torque, momentum, buoyancy, pressure, simple harmonic motion, double slit interference, electric field mapping, magnetic fields in a coil, electromagnetic induction, Lenz's law, and circuits.

All students surveyed at the end of the Spring 2018 semester agreed or strongly agreed that the IOLab device was an effective tool to use for lab experiments and 96% of students agreed or strongly agreed that the labs were appropriately challenging.

96% of students said that they were satisfied or very satisfied with the lab portion of the course. Student satisfaction can also be seen in survey comments: "I liked how you had the option to budget your own time at home to do the take home lab kits." "It was convenient and relatively straight forward." "You could easily do everything at home." "While completing the labs at home I still felt like I received a strong understanding of concepts - perhaps greater because I could spend as much time with the tools as I needed."

NEW QUALIFYING PROCEDURE FOR GRADUATE STUDENTS

After more than 40 years, the graduate qualifying exam is retiring. In the system that has been used until this year, the "quals" consisted of two written exams covering the graduate program of classical and of quantum physics. The exams were administered to students, typically in their second year of graduate study at UMass, in two days during the same week in January. Students that failed at least one of the two exams were allowed a second attempt in April.

The new qualifying procedure is available to graduate students who arrived at UMass in August 2018 or later. There are now two different standard ways to be admitted to PhD candidacy: students can pass the finals of five of the core graduate courses (Classical Mechanics, Electrodynamics, Quantum Mechanics I and II, and Statistical Physics) with sufficiently high grades, or they can have a sufficiently high average grade on the five courses mentioned above, plus Mathematical Methods. An additional provision allows, in exceptional cases, students that miss the criteria listed above (by not too much) to proceed to PhD if they are already very active in research.

The new system has been set up by a "quals task force" that included faculty and graduate students. The goal is to relieve some of the pressure that the old quals were imposing on students: the high anxiety associated with the quals was in several cases influencing the ability of the students to demonstrate their competence. In addition, the final exams of the core graduate courses will be written and graded by a committee, which will maintain the high standards of the old quals. Hopefully, the new system allows students to remove some of the anxiety associated with the old system, so they can devote to research the energy that they previously used to prepare for an especially stressful exam.

SUMMER SCHOOL ON RECENT ADVANCES IN QUANTUM PHENOMENA

Nikolay Prokof'ev and Boris Svistunov, together with Nobel Laureate Frank Wilczek (MIT), Antti Niemi (NORDITA), Egor Babaev (KTH, Stockholm and an adjunct professor at our department), Biao Wu (Peking University), and other colleagues co-organized an international Summer School on Recent Advances in Quantum Phenomena, Sweden, June 13-23, 2018.

The School was co-sponsored by Stockholm University and NORDITA, together with the TD Lee Institute and the Wilczek Quantum Center at Shanghai Jiao Tong University. It took take place at Högberga Gård resort on Lidingö in the Stockholm Archipelago. The School provided short courses covering hot topics of modern quantum physics, ranging from quantum chaos and disordered systems to topological matter, entanglement and quantum information. There were also extended discussion sessions: about one hour each day. At the School, Nikolay and Boris taught a course on the Worm algorithm and Diagrammatic Monte Carlo.

Workshop on Precision Many Body physics

Nikolay Prokof'ev and Boris Svistunov, together with Antoine Georges (Center for Computational Quantum

Physics Flatiron Institute and Collège de France in Paris), Nobel Laureate Wolfgang Ketterle (MIT), Andy Millis (CCQ Flatiron Institute and Columbia University), and Christophe Salomon (ENS, Paris) organized the Workshop on Precision Many Body Physics, October 20-22, 2018.

The workshop brought together the world's leading theorists and experimentalists developing and applying controlled approaches to quantum matter. It was the inaugural event for the future Center for Precision Many Body Physics being created at UMass by Nikolay and Boris together with Bob Hallock, Romain Vasseur and Tigran Sedrakyan.

The workshop was co-sponsored by UMass Amherst and the Center for Computational Quantum Physics (CCQ). CCQ is part of the recently created Flatiron Institute of the Simons Foundation, which focuses on advancing research through computational methods in different fields of fundamental science. A second workshop was held in Shanghai, China, October 30–November 5 2018, co-organized by Igor Tupitsyn (Senior Research Fellow in our department). Nikolay and Boris gave invited keynote presentations.

"COSMOLOGY AND GRAVITATIONAL PHYSICS WITH LAMBDA" WORKSHOP

Prof. Jennie Traschen was a lead organizer for the 3 week workshop held at the Nordic Institute for Theoretical Physics (NORDITA) in Stockholm, Sweden, in August, 2018. The workshop, hosting 35-40 participants each week, was organized with the goal of having at least one third of the participants be women - which was achieved. The workshop offered a forum for lively and in-depth discussion of current research and open questions in theoretical classical and quantum gravity, which fruitfully crossed and re-crossed boundaries.

Almost a century ago Einstein proposed a game changing addition to his theory of general relativity: Lambda (Λ), the cosmological constant. Today, understanding the role of Λ is one of the deepest open problems in theoretical physics and cosmology. Due to the remarkable cosmological precision data gathered during the last two decades, which indicates possibly two epochs in the history of our universe with a positive Λ, and to the successes of the gauge/gravity correspondence in string theory with a negative Λ, the cosmological constant has gone from a theoretical sideline to a central feature of research.

Each week of the workshop started with participants talking about goals for the program. Day #1 commenced with the challenging and repeated statement that the highly successful ΛCDM (Λ-cold dark matter) paradigm is at the edge of cracking. This set the stage for presentations and critiques of DE (dark energy) particle and gravitational explanations, challenges for inflation, and the stability of spaces with positive Λ. Roughly speaking, the sign of Λ changed from positive to negative as the 3 weeks progressed, and subsequent subjects included black holes with both signs of Λ; the "everpresent" and sign-fluctuating Λ of causal set quantum gravity; and new developments in holographic approaches to horizon dynamics, to cosmology, and to condensed matter theory. These topics have significant technical and conceptual overlap, which was brought out in useful ways by the mix of participants. The program format also allowed significant time for participants' other favorite activities - informal discussions, developing collaborations, and finishing papers.

In addition to the scientific richness of the program, it demonstrated that workshops in theoretical physics can include a significant representation of women, and that this contributed to a friendly, open-minded atmosphere. Participants, both male and female, expressed appreciation for "*…this great workshop and bringing such a diverse community together for far reaching discussions. It was great.*"

SUMMER TEACHING CONFERENCE

Brokk Toggerson, Chris Ertl, David Nguyen, and Jake Shechter presented contributions to the 2018 AAPT meeting in Washington DC. Chris Ertl presented on the take-home labs he has been developing for the online versions of Physics 131 and 132. Brokk Toggerson presented a poster on Physics 131 - Introductory Physics for Life Sciences I: Forces, Energy, Entropy, as well as a poster on his efforts to convert Physics 132 - Introductory Physics for Life Sciences II: What is Light? What is an Electron, and gave a presentation on P390T - Introduction to the Principles of Active Learning to Physics Education. Meanwhile, graduate student Jake Shechter presented his work on developing Physics 691G - Graduate TA Training and Professionalization. Upon returning to UMass, Toggerson, Ertl, Nguyen, and Shechter presented to the faculty at a teaching lunch some of their key take-aways from the other presentations including notes from talks on: improving diversity and equity, integration of computation into the undergraduate curriculum, development of effective undergraduate labs, and other topics. All of their posters and presentations, as well as the slides from their report to the faculty and further information on their work can be found at their website. http://physedgroup.umasscreate.net

MORE 2018 WORKSHOPS, CONFERENCES, AND SCHOOLS ORGANIZED BY UMASS PHYSICS FACULTY

"Testing CP-Violation for Baryogenesis" (Amherst Center for Fundamental Interactions, UMass, March 29 - 31, 2018) co-organized by Prof. Michael Ramsey-Musolf and postdoctoral researcher Kaori Fuyuto. Explaining the cosmic matter-antimatter asymmetry requires CP-violation beyond that of the Standard Model. Electric dipole moment searches and measurements of CP-violating observables in heavy quark systems place tight constraints on new CP-violation at and below the weak scale. Next generation Electron Dipole Moment searches and heavy flavor probes, together with prospective collider tests, will have considerably greater sensitivities. This workshop will explore how these future probes of CP-violation may provide tests of scenarios proposed to explain the matter-antimatter asymmetry. https://www.physics.umass.edu/acfi/node/902

"2018 Summer School on Soft Solids and Complex Fluids" (UMass, Amherst, May 27 - May 31, 2018) co-organized by Profs. Don Candela, Benny Davidovitch, Narayanan Menon, Jenny Ross, and Chris Santangelo. For more than 10 years, the annual summer school has helped fill the need for graduate level instruction in basic techniques common to research areas in soft matter physics; including liquid crystals, granular matter, solid mechanics, polymeric and colloidal physics and micro-fluidics, as well as biophysics. The 2018 school included lecture series devoted to "The Physics of Lipid Membranes" (Markus Deserno, CMU), "Physical Networks" (Eleni Katifori, UPenn), "Critical Soft Matter" (Leo Radzihovsky, UColorado), "Colloids and Emulsions" (Tony Dinsmore, UMass). http://blogs.umass.edu/softmatter/program-2018/

"Dynamics of Quantum Information" (Kavli Institute for Theoretical Physics, Santa Barbara, August 6 - November 12, 2018) co-organized by Prof. Romain Vasseur. The workshop promoted the development of new inter-disciplinary techniques to understand the dynamics of quantum information in many-body quantum systems, by gathering together very different communities ranging from condensed matter physics or quantum information to string theory. This workshop also had an associated conference on "Novel approaches to quantum dynamics" https://www.kitp.ucsb.edu/activities/dynq18

Dark Interactions: Perspectives from Theory and Experiment (Brookhaven National Laboratory, October 2 - 5, 2018) co-organized by Prof. Stephane Willocq. The purpose of this 3rd biennial workshop was to review and discuss the status and future of the searches for dark sector states, their implications for the mystery of Dark Matter, and new associated theoretical developments. Session topics included; theoretical motivation for dark sectors; experimental constraints from high energy colliders; constraints from non-collider experiments, cosmological constraints; implications for dark matter; prospects for LHC and future intensity frontier experiments. https://www.bnl.gov/di2018/

"Work from Noise: Harnessing Fluctuations to Manipulate Matter" (Massachusetts Center for Autonomous Materials, UMass, Amherst, October 26 - 28, 2018) organized by Profs. Tony Dinsmore, Jenny Ross, Jon Machta, Don Candela and Thai Thayumanavan (Chemistry). The workshop focused on new methods to extract useful action or work from systems that are driven far from equilibrium. Twenty-five invited leaders in the field from physics, chemistry, biology and materials science, coming from both academia and industry, gathered to exchange ideas and ambitions on the general theme of rectifying and channeling non-equilibrium noise in mechanical, electrical, fluid, granular, or living systems to achieve useful, controlled work. http://blogs.umass.edu/masscam/

"Beta Decay as a Probe of New Physics" (Amherst Center for Fundamental Interactions, UMass, November 1 - 3, 2018) co-organized by Prof. Michael Ramsey-Musolf. The workshop addressed questions such as: which experimental approaches provide the most promising probes for new physics via neutron and nuclear beta decays? What theoretical input is required to ensure experiments achieve optimal sensitivity? We hope to provide a road-map for progress on the theory of nuclear decays and the beyond standard model scenarios they test to ensure the maximum impact for ongoing and planned experiments. https://www.physics.umass.edu/acfi/node/955

"Theoretical Issues and Experimental Opportunities in Searches for Time Reversal Invariance Violation using Neutrons" (Amherst Center for Fundamental Interactions, UMass, December 6 - 8, 2018). This workshop focused on theoretical issues relevant for experimental searches for time reversal violation using slow neutrons. Presentations covered the current and projected reach of a range of experimental approaches and explored the interrelationships of the sensitivity to different types of T violation. Experimental strategies discussed included searches for neutron electric dipole moments, searches for T-odd correlations in neutron decay experiments, searches for T-odd effects using polarized neutron dynamical diffraction in non-centrosymmetric perfect crystals, and T-odd effects in forward transmission in polarized neutron optics. https://www.physics.umass.edu/acfi/node/963

NEW SI UNITS

Widely agreed-upon units are necessary for modern civilization. For example, commerce needs agreed upon units for at least mass and length, in addition to currency. Such units go back into the distant past, with mention in the Bible. That is also true of science, which requires many units in addition those just noted. In the 1800s, there were attempts to standardize the definitions of units, especially those used in science, under the International System of Units, **SI** (from the French *Système international d'unités*). Until recently, these basic units were defined using measurements which were not always as precise as might be wished. For example, the kilogram was defined as the mass of a platinum-iridium bar housed in a vault in Paris. Unfortunately, the mass of that bar changed ever so slightly when it was handled, however carefully.

Recently, a new definition of units derived from a set of fundamental **constants**, which have well defined values that can be measured anywhere with suitable apparatus, has been proposed. From these constants, all other units in basic scientific use can be calculated. This new system takes effect on May 20, 2019. The new definitions of these constants are given in the table.

Physical Constant	value	units
hyperfine transition frequency of cesium 133 atom, $\Delta\nu_{Cs}$	9 192 631 770	Hz
speed of light in vacuum, **c**	299 792 458	m/s
Planck constant, **h**	$6.62\ 607\ 015 \times 10^{-34}$	J second
charge on the electron, **e**	$1.602\ 176\ 634 \times 10^{-19}$	Coulomb
Boltzmann constant, **k**	$1.380\ 649 \times 10^{-23}$	J/K
Avogadro constant, N_A	$6.02\ 214\ 076 \times 10^{23}$	moles^{-1}
luminous efficacy of monochromatic radiation frequency of 540×10^{12} Hertz, K_{cd}	683	lumen/Watt

Then, for example, we define the following "usual" physical units:

- Time: the **second** (**s**) is defined from $\Delta\nu_{Cs}$, where 1 Hz = 1 second^{-1}
- Length: the **meter** (**m**) is defined from **c**, in units of m/s where, **s** is from $\Delta\nu_{Cs}$
- Mass: the **kilogram** (**kg**) is defined from **h** in units of J s = kg m^2 s^{-1}
- Electric current: the **ampere** (**A**) or Coulombs/second is defined from **e** in units of Coulombs and seconds defined by $\Delta\nu_{Cs}$
- Temperature: the **kelvin** (**K**) is defined from **k** which is in units of J/K = kg m^2 s^{-2}/K
- Number: the mole (**mol**) is defined from N_A, where 1 mole contains N_A entities
- Luminosity: the candela (**cd**) is defined from K_{cd} in units of lumen (lm) per Watt = cd sr W^{-1} = cd sr kg^{-1} m^{-2} s^3

graduate students

GRADUATED IN 1998

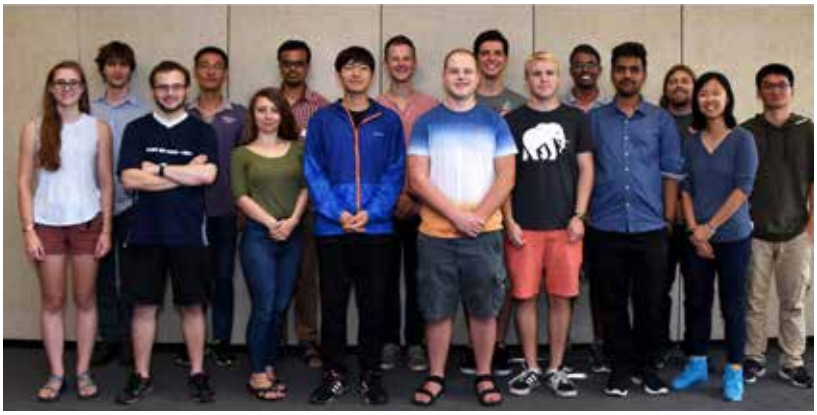
Steve Churchwell, Paul Eugenio, Xiaodong Jiang

Kyriacos Markianos, Kenneth Moriarty,

Thomas Schicker, Winfried Teizer

1998 MS and PhD graduates not pictured: Bruna Grimberg, Stefan Klein , Patricia Sappenfield, Tibor Torma, Piotr Zygmanski

ENTERED IN 2018



Back from the left: Muldrow Etheredge, Chenan Wei, Pratyush Patel, Harold (Doug) Pickney, Matthew Downing, Miryala Karthik, Seth Tibado, Guanchu Chen

Front: Mary Elizabeth Lee, Cooper Wagner, Makayla Vessella, Haote Lee, Justin Jozokos, Nicholas Hackney, Jay Sandesara, Winnie Wang

Not pictured: Ajit Kumar, Javier Lopez Piqueres, Jonah Chaban, Freeman Song Dong, Yue Yu

outreach

UMASS SCIENCE OUTREACH AT THE BIG BANG SCIENCE FAIR

Description at waterfire.org

This past year, Professor Stéphane Willocq was invited by a colleague at Brown University to participate in the Big Bang Science Fair at Waterfire, a festival held in the city of Providence, RI. He approached Guy Blaylock and Shubha Tewari, faculty advisors to the UMass Science Outreach Club, as a result of which, roughly 16 members of the UMass Science Outreach Club accompanied Stéphane, Guy and Shubha to Providence on September 22nd, 2018. The group set up their demonstrations on 3 tables behind the auditorium of the Rhode Island School of Design along the banks of the Providence River. Table 1, on Optics, featured demonstrations familiar to many instructors of introductory physics and gen-eds: the double concave mirror mirage, index-matching, thin-film interference and a refraction tank. Table 2 showcased non-newtonian fluids such as oobleck and foam, and Table 3 had experiments and games on the physics of granular materials. Taking over from Brown University, the team had barely unpacked when interested onlookers started to arrive, and the outreach club students, including freshmen for whom this was their first public event, kept spectators of all ages rapt for the next three hours.

Editor's Note: oobleck, named after a sticky greenish substance in a book of the same name by Dr. Seuss, is a non-newtonian fluid that has properties of both solids and liquids. https://www.instructables.com/id/Oobleck/

Tent Marie Curie: Amazing Science!
Hosted by : The Science Outreach Team (University of Massachusetts, Amherst)

Hands-on experiments for everyone. Witness strange and amazing phenomena with light, heat, pressure, and some extraordinary materials. Come explore optical illusions, disappearing beakers, dancing oobleck, monster marshmallows, cola volcanoes, spontaneously combusting cotton balls, assorted explosions and much more. Try your hand at the Brazil nut game, exercise your artistic talent at the surface tension paintbox, and test your strength with the Magdeburg hemispheres.

NEW LIFE TO THE PHYSICS COMMUNITY ORGANIZATION

The Physics Community Organization (PCO) aims to foster community within the physics department. PCO is run by graduate students, for graduate students, and encourages connections among students from different entrance years, research areas, and cultures. We aspire to make the UMass Amherst Physics Department a welcoming and collaborative environment for all graduate students.

During the year, PCO hosts events to build community amongst ourselves and offers opportunities to develop professional skills. We host free coffee/tea once a week in the new WES kitchenette. At the end of each month we host a board game night with pizza, soda, and a plethora of game choices. Each year we spend an evening practicing giving presentations. The opportunity is open to all graduate students, but we time the event to be a week before APS March Meeting so the department's representation there is strong.

We are involved in the welcoming of prospective students, and connect with them to share personal experiences of life as a graduate student at UMass Amherst, even before they arrive. In the fall, we assist with the new student orientation and welcome our new colleagues on day 1. By pairing the incoming students with a mentor, we assure a smooth and helpful transition into the department.

faculty awards

KAWALL PROMOTED TO FULL PROFESSOR

Associate Professor David Kawall has been promoted to the rank of Full Professor. Dave is a member of the nuclear experimental group and has been at UMass since 2005. During his first years here, he was a member of the RHIC Spin collaboration, which studied the detailed spin structure of the proton via high energy scattering experiments at Brookhaven National Laboratory (BNL). Currently, his research centers on high precision studies of the magnetic moment of the muon and a search for fundamental electric dipole moments.

The interest in the muon magnetic moment (the muon g-2 experiment) arises from earlier experiments at BNL which indicated possible deviations from the very precise prediction of the Standard Model of particle physics. The muon in many ways resembles a heavy electron and has a magnetic moment which would, in the absence of electromagnetic effects, have a value given by ''g'' Bohr magnetons, with g being equal to 2. However, due to the presence of electromagnetic corrections, there exists a small modification of this value (called therefore g-2) which has been measured in the BNL experiment, to ten significant figures, to be 0.0011659209. However, the standard model prediction is 0.0011659180, which is close but not equal to the experimental value by a little more than three standard deviations.

Despite a flurry of activity checking the theoretical prediction, no significant corrections have been identified. The new experiment, at Fermi National Laboratory (Fermilab) near Chicago, will attempt to substantially improve on the BNL measurement in order to see if the existing discrepancy is real, indicating some sort of new physics.

Interest in the possible existence of an electric dipole moment (EDM) is due to the fact that time reversal and parity symmetries forbid it. An electric dipole moment signifies an asymmetry in the distribution of charge in a system and present limits for subatomic particles are already quite precise: If we imagine an apple expanded to the size of the Earth, then the current limit corresponds to a small charge asymmetry about the size of the original apple! Major efforts are underway around the world to detect a possible EDM of the neutron. However, Kawall's effort, based at UMass and at Yale, involves looking for a possible EDM of the electron, by exploiting the property that the interior of molecules can support an electric field far greater than can be generated in the laboratory.

ROSS – APS FELLOWSHIP AND PROMOTION TO FULL PROFESSOR

Professor Jenny Ross was recognized this year as a Fellow of the American Physical Society for her important contributions over the course of her career. Her citation reads: "For significantly advancing understanding of the self-organizational principles of the microtubule cytoskeleton via motor proteins and severing enzymes and how that organization affects intracellular transport. Also, for outstanding service to DBIO and the biophysics community." She was nominated by the Division of Biological Physics (DBIO).

Professor Ross was also promoted to Full Professor of Physics, effective Sept 1, 2018. Her research includes the experimental studies of cellular cytoskeleton components and motor proteins described in the APS Fellowship citation, as well as studies of biologically-inspired self-driven systems, known as active matter.

SANTANGELO's PROMOTION TO FULL PROFESSOR

The Department is pleased to report that Chris Santangelo has been promoted to the rank of Full Professor, effective September 1, 2018. Chris's research uses geometry to understand the behavior of soft materials. In his recent work, Chris has been developing methods to design thin structures that can be patterned to fold themselves into complex structures, similar to the way that origami can be used to fold a piece of paper into a variety of shapes. The ability to create self-folding structures, often dubbed "4D printing," stands to revolutionize the manufacture of micro-machines and other devices. In addition to self-folding structures, he is studying materials that can assemble themselves from their individual constituents rather than relying on a top-down assembly process.

KASTOR – PROMOTION TO SENIOR LECTURER II

Effective September 1, 2018, David Kastor was promoted to the position of Senior Lecturer II. David joined the department in 1992 and is currently the Associate Head of the Department, and in all respects is included in departmental affairs as a Full Professor. As reported in our

Newsletter from 2014, David Kastor is also a Fellow of the American Physical Society, cited for "his influential work on a broad span of topics in gravitational physics, ranging from the formal definition of conserved quantities in General Relativity through new exact black hole solutions all the way to brane architectures relevant for string theory."

HATCH PROMOTED TO SENIOR LECTURER II

We are pleased to report that Heath Hatch has been promoted to the rank of Senior Lecturer II. Heath joined our department in 2001. Since then, he has mostly taught the courses of introductory physics for life science majors, PHY131 and PHY132, but also PHY125 ("Seeing the light") and PHY105 ("Weather and our atmosphere"). Each of these courses typically has several hundred students per semester. During these years, Heath has evolved into one of our most effective and appreciated instructors: among other recognitions, he won the CNS Outstanding Teacher Award in 2010 and was one of the two faculty members who received the UMass Distinguished Teaching Award in 2014. Heath has constantly pushed for innovation in our classrooms, introducing the "blended" format for the PHY131 class and eventually being a major actor in the conversion of PHY131 to a Team-Based Learning format. In addition, since 2015, Heath has been Director of Program Development for the College of Natural Sciences.

TEWARI PROMOTED TO SENIOR LECTURER

It is pleasure to announce that Shubha Tewari has been promoted to the rank of Senior Lecturer, effective September 2017. Shubha joined our department in January 2015 and has taught courses in electromagnetism (Physics II) for physics and for life science majors, a course on the "Physics of Music" and an iCons (Integrated Concentration in Science) class on "Global challenges, scientific solutions." Besides being a very respected instructor, Shubha has been conducting a successful research program on the behavior of granular materials and foams, and has also put significant work into outreach. For the last three years, she co-organized a one-day field trip to UMass for the entire eight grade class (more than 200 students) from the Amherst Regional Middle School, during which the students attend several presentations delivered by UMass instructors on various aspects of science. She has also co-organized the Biological and Soft Matter Research Traineeships (B-SMaRT) Research Experience for Undergraduates (REU).

HOLSTEIN WINS APS FESHBACH PRIZE

The American Physical Society has awarded its 2019 Herman Feshbach Prize in Theoretical Nuclear Physics to Professor Emeritus Barry Holstein. He is cited "for seminal theoretical studies of fundamental symmetries in nuclei, including radioactive nuclear decays, parity-violating nucleon-nucleon interactions, and chiral dynamics of mesons and baryons." Holstein has been at UMass since 1971, with the exception of two years spent as program officer for theoretical physics at the National Science Foundation and a year spent at Forschungszentrum Jülich as a Senior Humboldt Fellow. Although he retired in 2008, Holstein maintains an active research program in particle/nuclear physics and is editor of the Annual Review of Nuclear and Particle Science, consulting editor of the American Journal of Physics, and associate editor of the Journal of Physics G. He is a longtime member of the American Association of Physics Teachers and a fellow of the American Physical Society.

BABAEV - APS FELLOWSHIP

Egor Babaev was for several years earlier in his career associated with the Physics department as an Assistant Professor. He is currently Professor in the Department of Theoretical Physics at the Kungliga Tekniska Högskolan (KTH Stockholm) of the Royal Institute of Technology in Sweden. Nominated by our department, he has been named a Fellow of the APS. His citation reads: "For pioneering contributions to the theory of multicomponent superconductors and superfluids." His previous awards include the 2010 Tage Erlander prize and the 2015 Göran Gustafsson Prize, both from the Royal Swedish Academy of Sciences.

VASSEUR - EARLY CAREER AWARD

Romain Vasseur has received an Early Career Award from the Department of Energy. The $750,000 award spans the period 9/2018 through 8/2023 and will be used to study quantum criticality and topology in non-equilibrium systems. Traditional condensed matter systems are usually in a thermal equilibrium state and typically are at very low temperatures. Very recently, however, experimental advances have sparked interest in non-equilibrium settings. Non-equilibrium systems can host new phases and phenomena with no equilibrium counterpart and could also enable robust ways to build quantum memory devices to store and manipulate

quantum information in a coherent manner. These phases and phenomena are inherently "dynamical" because they are described not by changes in the arrangement or structure of the constituent particles but instead are marked by sharp distinctions in how the particles move and exchange energy or quantum information. The discovery of robust non-equilibrium phases raises many fundamental questions: can we develop a systematic theory of non-equilibrium states of matter and of dynamical transitions between such states? How can such states be realized and probed experimentally? This research will explore the emergence of topological phases and quantum criticality — two cornerstones of modern condensed matter physics in equilibrium—in quantum systems far from thermal equilibrium.

GOLDNER NAMED CHANCELLOR'S LEADERSHIP FELLOW

The Chancellor's Leadership Fellow program seeks "to cultivate future campus leaders by offering a half-time, one-year, temporary appointment to an administrative area on campus and by providing shadowing and mentoring from the leaders of the host units. In addition, fellows are expected to launch a significant program during the fellowship year."

Prof. Lori Goldner has been named a fellow for 2019. Lori is director of the UMass Center for Biological Physics, having moved to UMass in 2008 after a 17-year career at the National Institute of Standards and Technology. Her background in experimental physics and measurement science is broad, with work in low temperature physics, nonlinear dynamics, atomic physics, optical physics, and biophysics. She is best known for her work in near-field and single-molecule-sensitive microscopies. In 2006, she was a founding co-chair of the first "Single Molecule Approaches to Biology" Gordon Research Conference. She is active in faculty governance through her work on the Research Council of the Faculty Senate.

Lori's Leadership Fellow work will focus on data and data analytics for a more robust and responsive research effort. She will begin her fellowship in the spring and looks forward to working under Provost John McCarthy.

Lori notes: "At UMass, increases in research expenditures, investment in new core facilities and research centers, and the vision of becoming a Top-20 Research University are crashing up against the reality of a dropping number of doctoral applicants, fewer research associateships, and the rising cost of research. At the same time, the nature of the research endeavor is changing. As the University responds to societal and technological needs in an ever-tighter funding climate, accurate and up-to-date data on research strengths and synergies, and a holistic understanding of that data, will be increasingly important to the success of the University."

ROSS CHANCELLOR'S LEADERSHIP FELLOW

When you think of UMass Physics, what do you think of? Your friends from classes? Struggling with Quantum Mechanics? Sitting in Hasbrouck? For many students, they remember their instructors. Indeed, faculty members are most often the face of the university for students. Faculty members are vital to UMass' missions of research excellence, being a destination of choice for students, and commitment to inclusive excellence. Faculty members are an essential resource of the university; the job we are tasked with is multi-faceted. Faculty members were trained in the skills of research scholarship and may have taken some workshops on teaching before arriving here, but are not trained for many aspects of the job. Some of the additional skills they need include managing personnel, collaborations, resources and funding, health and safety… the list goes on and on.

Jennifer Ross, professor of physics, is hoping to help faculty to attain these skills here at UMass. Ross was awarded a Chancellor's Leadership Fellowship to work with the new Vice Provost for Faculty Development, Michelle Budig, to develop new programming on management and leadership for faculty. The first set of workshops will focus on new principal Investigators (PIs), entitled, "I'm a new PI, now what?" Further, Ross will work on creating management and leadership workshops for mid-career faculty who will take on new leadership roles as they continue their careers. Ross has been interested in faculty development and mentoring for a long time. Previously, she helped develop an Academic Leadership Training workshop with Research Corporation and the American Chemical Society, and authored a blog, Woman of Science, to help women in academic science. http://womanofscience.com

student awards

ROSIN RECEIVES DOE RESEARCH AWARD

Physics PhD candidate Guy Rosin was recently named one of 47 young scientists in the nation to receive the Department of Energy's (DOE) Science Graduate Student Research Program award. The award prepares graduate students for STEM careers that are critically important to the DOE Office of Science's mission by providing graduate thesis research opportunities at DOE laboratories.

Rosin, of Watertown, Mass., is working on his doctorate in high-energy physics in Carlo Dallapiccola's lab and will be studying at Brookhaven National Laboratory on Long Island from October 2018 this year until Sept. 1, 2019. The DOE award provides support for travel to and from the laboratory and a monthly stipend of up to $3,000 for general living expenses while at the host DOE laboratory.

During his year at Brookhaven, Guy will work on upgrades to the ATLAS program, one of seven particle detector experiments at the Large Hadron Collider, a particle accelerator at CERN in Switzerland. As he explains, "ATLAS detects all kinds of particles and interesting physics, and lets us look at collisions. It's elementary physics, looking at the nature of what the universe is made of."

"It's very exciting," he adds. "I'll be working with some of the best scientists in the world in this field. It's a big honor." Guy's advisor, Professor Dallapiccola, says, "I'm very excited that Guy will have this opportunity to work on cutting-edge techniques while working on hardware components of one of the world's foremost particle detectors. His having received this prestigious national award is a testament to his tremendous hard work and promise as a rising scientist in the field."

At Brookhaven, Guy will collaborate with DOE scientists Stefania Stucci, Dave Lynn and Alessandro Tricoli as part of a team that over the next 10 years will increase the number of collisions taking place at the collider to increase its total luminosity 10-fold.

CHANG RESEARCH AWARD

Professor Edward Shih-Tou Chang had an enduring special interest in undergraduate teaching and advising. He was the Physics Department Chief Advisor and Undergraduate Program Director before becoming the Associate Dean for Advising. After his retirement in 2008, Professor Chang established a generous endowment – the Edward S. Chang Fund for Undergraduate Research – to provide funds in perpetuity for small grants to undergraduate physics majors pursuing research projects. The Physics Department is very grateful for the generosity of Professor Chang and his family. These awards will provide valuable enriching opportunities for students for many years to come.

In spring of 2018, four Chang awards were given to physics majors. Yihan Gao worked with Professor Verena Martinez Outschoorn on a muon detector; Anthony Raykh, with Professor Scott Hertel on the LZ (LUX/Zeplin) dark-matter experiment; Anwesha Saha, with Professor Andrea Pocar on cryo-coolers for the Darkside and nEXO projects; and Justin Roberts with Professor Shubha Tewari on simulations of granular flows. Congratulations to all four awardees!

Justin Roberts wrote to tell us more about his project. His title was "Analyzing the flow of a system of spheres using shape-anisotropic particles" to find new science insights into the very common (and industrially costly) problems with flowing and jamming granular materials. He wrote, "if we are able to accurately measure the velocity profiles of a system of flowing spheres using a dilute number of dimers (i.e., two spheres attached to each other), we could potentially reduce the cost required to conduct experiments involving granular flow. This past summer we were able to use data gathered in our simulations to measure autocorrelations of dimers' orientation vectors. We found that, while there is very little reorientation in the bulk far from the opening, we do see a bit more on the edges and near the opening. We are now considering treating reorientation as a random event by looking at possible regions of vorticity, fluctuations sphere velocity, and fluctuations in the amount of reorientation in discrete regions." After graduation, Justin hopes to continue improving the programming skills developed here to eventually begin a software-related career.

Anthony Raykh wrote: "I worked on the development of calibration hardware for the Lux-Zeplin (LZ) dark matter experiment. LZ will be the most sensitive WIMP detector of its kind, and a comprehensive calibrations program will be critical to the success of the experiment. At UMass I worked on building and developing the electronics for the Liquid Xenon detector at UMass, which is designed to test a prototype of one of the calibration systems that will be a part of LZ. I also developed a user interface for monitoring data from all of the system's sensors. Moving forward, I'll be working on data analysis and helping to operate the UMass detector while we develop the calibration procedures that will be ported to LZ. I hope to go on to graduate school and continue to work for LZ."

There will be another round of scholarships for the summer of 2019 and every year thereafter. Each year, the application deadline is the last Monday in February. For details, please email upd@physics.umass.edu.

HASBROUCK SCHOLARSHIP FUND

The Physics Department bestows several awards annually on worthy students. These awards are supported by generous friends and graduates of the department, and many of them are named in honor of department faculty. The earliest such current award is the Hasbrouck Award, which was created with the establishment of the Hasbrouck Scholarship Fund, in memory of Philip B. Hasbrouck. Hasbrouck was the first Chair of the Department of Physics when the department was created in 1911. He also served as Registrar. He passed away

from heart failure in 1924 at the age of 54. Hasbrouck Hall was named for him when it was constructed in 1950. The creation of the fund that established the Hasbrouck Award was suggested by the Treasurer of the class of 1910 in a letter sent to the Trustees in January 1960. The Fund was formally created by Trustee action in April of 1960. The initial principal of the fund was $1,360.

Philip B. Hasbrouck

The purpose of the fund as stated in the endowment documents was to encourage and assist students in a science essential to the national welfare, particularly Physics. The Hasbrouck Award was explicitly created to reward "Juniors and Seniors who have qualified as major students in Physics, and are eligible for Departmental Honors; and who are United States citizens, regardless of legal residence or domicile, sex, race, and religion."

There were a few stipulations with regard to the award. The documents make clear that the award was originally intended to be "restricted to students who do not use alcoholic beverages." Another directive is that "in the case of a tie, or close to tie, in scholastic records, the award should be to the more needy student." And, finally, the documents from 1960 state that "If after the year 2000 the Scholarship Committee deems it advisable in the national interest in advancement of study in science, the name and word 'Physics' may be changed to that of another science. In 1971 the then Secretary/Treasurer of the class of 1910 eliminated the restriction on the consumption of alcoholic beverages. There is no intention to change "Physics" to some other science.

The Hasbrouck Scholarship Fund has a current balance of approximately $33,000, which results in approximately $1,650 available annually (up to 5% of the fund balance) to be awarded. The Department may elect not to award the full amount available and, in that case, the fund principal will be enhanced. Although it is not stipulated in the award documentation, at times when there is a very near tie in academic records, the award has been shared by more than one student.

Anyone is welcome to make a contribution to the fund at any time to help recognize and support our talented undergraduate students.

UNDERGRADUATE AWARDS MAY 2018

Hasbrouck Scholarship Award
(junior, academic excellence)
Thomas Connolly, Amy Ralston

LeRoy F. Cook Jr. Memorial Scholarship
(academic excellence and activity in outreach or teaching)
Olivia Comeau, Anthony Englert

Morton & Helen Sternheim Award
(educational outreach and/or teacher preparation)
Jack Jenkins, Aidan Philbin

Ida and Joseph Simenas Award
(academic excellence)
Michael Buckely

Kandula Sastry Book Award
(academic excellence and versatility)
Nathan Rose

Richard Kofler's Class of '76-'77 Scholarship
(strong intention of career in Physics)
Bridget Mack

Edward S. Chang Fund
(supporting outstanding reasearch)
Yihan Gao, Anthony Raykh, Anwesha Saha, Justin Roberts

GRADUATE AWARDS MAY 2018

Quinton Teaching Assistant Award
(outstanding teaching assistant)
Alissa Monte, Yuan Tang Chou

Dandamudi Rao Scholarship
(research in biological physics or closely related area, in memory of Kandula Sastry)
Leila Farhadi

Kandula Sastry Thesis Award
(presentation of outstanding thesis)
Nathan Bernard

Physics Award Recipients, May 2018

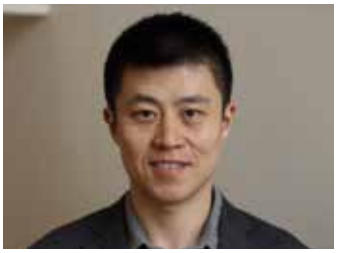
Back from left: Anthony Englert, Jack Jenkins, Justin Roberts, Michael Buckley, Thomas Connolly
Middle: Yihan Gao, Aidan Philbin, Bridget Mack, Anwesha Saha, Amy Ralston, Olivia Comeau, Nathan Bernard
Front: Yuan Tang, Leila Farhadi, Alissa Monte, Nathan Rose

people

NEW FACES

Shuang Zhou

Dr. Shuang Zhou joined the physics department in the fall of 2019. He received his bachelor's degree in Applied Physics from Xi'an Jiaotong University in China. Then he worked as a research and development engineer in the LCD industry for a few years. Fascinated by liquid crystals, he decided to continue his education in soft condensed matter physics. In 2016 he received his PhD in Chemical Physics from the Liquid Crystal Institute at Kent State University. Before joining UMass, Shuang was a postdoc with Professor Zhigang Suo at Harvard University in the School of Engineering and Applied Sciences, working on soft elastomeric materials such as hydrogels and elastomers.



Shuang's research mainly focuses on the physics of liquid crystalline materials and active matter. His group conducts experimental studies of a family of novel water-based liquid crystals, examples of which include drugs, food dyes and short DNA oligomers. The formation of liquid crystalline phases in these materials involves several steps of self-assembly and condensation, making the system very sensitive to externally tunable factors, such as temperature, concentration, ionic additives, pH and so on. The physical properties of these systems are remarkable: for example, the anisotropic viscosities can be 10,000 times different between two perpendicular directions. Unlike most liquid crystals, which are known to be bio-toxic, these materials are biocompatible, which allows them to interface with living organisms such as bacteria. The combination of swimming bacteria and biocompatible liquid crystals (known as "living liquid crystals") gives rise to many fascinating out-of-equilibrium phenomena, which Shuang developed and became widely known for a few years ago. Here at UMass, Shuang is building a platform to explore the living liquid crystal system by means of collaboration with microbiologists, chemists, engineers, and fellow physicists.

Shuang is also interested in soft solids, such as hydrogels and elastomers. These are materials capable of giant deformations —a rubber band can easily be stretched to 10 times of its free length. Introduction of liquid crystalline order at the molecular level gives the materials new abilities, such as light or thermally driven actuation, and indication of tiny deformation by optical birefringence. Shuang is currently interested in creating and characterizing new liquid crystalline hydrogels and hydrogel-elastomer hybrid systems for biological and mechanical applications.

In the fall of 2018, Shuang taught the discussion sessions of two classes, Mechanics-I and Waves & Thermodynamics. He enjoyed interacting with students and helping them with various physics questions. He is looking forward to teaching Mechanics and Optics in the coming years. He found teaching not only fun, but also beneficial in strengthening his own knowledge of physics.

Kumar Named Gluckstern Professor

Last year's newsletter included a summary of early departmental history written by the late former department head, Bob Gluckstern, who later became Chancellor of the University of Maryland. A decade ago, Gluckstern's son, Stephen, a successful entrepreneur, endowed a chair in honor of his father: to be granted to an "individual with a high-quality scientific program who has played, or will play, a key role in providing leadership of the physics department at UMass Amherst. Appointment to the Gluckstern Professorship lasts for seven years and is non-renewable."

The first Gluckstern Professor was Adrian Parsegian, a biophysicist formerly at NIH, who came to UMass in 2009 and retired in 2016. A nationwide search then led to the appointment of Krishna Kumar, who began his term as Gluckstern Professor in January 2019. Kumar is a prominent nuclear experimental physicist, who began his career at Princeton before coming to UMass in 1999, where he remained for fifteen years before moving to a position at SUNY-Stony Brook. His early research involved challenging precision experiments involving polarized electron scattering, including leadership of SLAC E158, which used electron-electron scattering to measure the weak mixing angle, and HAPPEX at Jefferson Laboratory, which looked for the presence of strange quarks in the proton. In recent years, his efforts have been focused on EXO, involving the use of ^{136}Xe to measure the lifetime for two-neutrino double beta decay and to look for neutrinoless double beta decay. His efforts as Gluckstern Professor will include higher precision versions of E158, to be performed at Jefferson Laboratory, as well as NEXO, a significantly upgraded version of the neutrinoless double beta decay search. His office and laboratory are in the new Physical Sciences building. Welcome back Krishna!

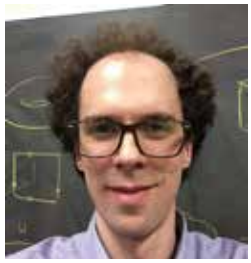
Jordy de Vries Joins ACFI

Jordy de Vries, a nuclear/particle physics theorist, was born in the Netherlands and obtained his BS, MS, and PhD from the University of Groningen. His PhD thesis was on an effective field theory approach to the problem of time reversal symmetry in hadronic interactions and won high honors from the University. He then proceeded to postdoctoral positions in Germany (Juelich/Munich) and North Holland at Nikhef (Dutch National Institute for Subatomic Physics) before arriving in Amherst in Fall, 2018. During his time as a postdoc, Jordy continued his study of time reversal symmetry by looking at the possibility of measuring electric dipole moments of light systems. The existence of such an EDM, which could be detected by measurement of a tiny energy shift in the presence of an external electric field, would signal the breakdown of both time reversal invariance as well as parity, which represents symmetry under reflection in a mirror. With this in mind, Jordy proceeded to study the tiny violation of parity in the nucleon-nucleon interaction, due to the existence of weak interactions. Despite being studied for over six decades, the structure of the parity-violating NN interaction is still not settled. (Indeed, this was the subject of Professor John Donoghue's UMass PhD thesis some fifty years ago!)

Jordy's current research focuses on the study of various symmetries. Among other things, it involves an attempt to understand, via effective field theory, the physics of neutrinoless double beta decay. If it exists, this is a very rare process, occurring (with a lifetime greater than ~10^{25} years or so) in so called "even-even" nuclei, having an even number of both protons and neutrons, which are kinematically forbidden from decaying via ordinary beta decay to an electron/neutrino and instead decay to two electrons but no neutrinos. This is the only practical way to determine if the neutrino is its own antiparticle (has "Majorana" character) and is the focus of large experimental efforts around the world, including the ^{136}Xe measurement being pursued by Professors Andrea Pocar and Krishna Kumar in and the NEXO collaboration.

Jordy's teaching assignment this fall was the combined undergraduate nuclear/particle physics course 556/714, offering him a chance to introduce students to his research specialties.

Ben Heidenreich Joins ACFI



Ben Heidenreich is a string/particle theorist, whose work is somewhat more formal than that of de Vries. Ben obtained his BS in Physics and Music from Amherst College, where he worked for a number of summers in Professor Larry Hunter's laboratory. He then proceeded to Cornell University where he earned his MS and PhD in Physics.

After postdoctoral positions at Harvard and at the Perimeter Institute in Waterloo, Ontario, he joined the UMass faculty this fall. During his years as a postdoc, he worked on a number of string-related topics, including aspects of supersymmetry and of various dualities. The focus of much of Ben's present work is in the area of quantum gravity. The "weak gravity conjecture" is a proposition concerning the strength of the gravitational interaction in any consistent theory of quantum gravity relative to the strength of the gauge forces in the same theory. Roughly, it asserts that gravity should always be the weakest force in any consistent theory of quantum gravity. While this is still a conjecture at this point, it has a number of potential important implications, such as the (im)possibility for certain fundamental quantities to take arbitrarily large values, and there is ample room for additional theoretical study and for future breakthroughs in this field.

After teaching the mathematical physics course during the fall 2018 semester, Ben is teaching a graduate course on string theory in spring.

INTERSECTIONALITY OF PHYSICS AND DIVERSITY: SHATTERING THE LAVENDER CEILING

In the summer and fall of 2018, Michael Ramsey-Musolf delivered multiple presentations highlighting physics and intersectionality -- the interconnections between various identities and the associated experiences of discrimination. As an invited speaker at the National Nuclear Physics Summer School held in June at Yale University, Ramsey-Musolf, Professor of Physics and Director of the Amherst Center for Fundamental Interactions, lectured on the theoretical physics of neutrinos and then co-lead a roundtable discussion on diversity and inclusion. This roundtable was co-facilitated with Prof. Agnes Moczy of the Pratt Institute. Later that week, Brookhaven National Laboratory invited Ramsey-Musolf to give a laboratory-wide presentation on LGBTQ inclusivity. His presentation, "Shattering the Lavender Ceiling: A Gay Theoretical Physicist's Perspective," offered insights from his own

30 plus year career, shared experiences of explicit and implicit bias, and highlighted best practices that members of the Brookhaven Lab community can adopt to engender a more inclusive climate for sexual and gender minorities at the Lab. These best practices had been developed during Ramsey-Musolf's participation in lgbt+physicists, a grassroots organization advocating for sexual and gender minorities in physics. This presentation was sponsored by Brookhaven's GLOBE (Gay, Lesbian, Or Bisexual Employees resource group), Physics Department, and Inclusion & Diversity Office (https://lgbtphysicists.org). It was the first such lab-wide talk on LGBTQ inclusivity given at any US national laboratory.

Later that summer, Ramsey-Musolf co-organized a three-week school on Fundamental Symmetries and Neutrinos at the Institute for Nuclear Theory, as part of the Training in Advanced Low Energy Nuclear Theory (TALENT) series. Together with Dr. Vincenzo Cirigliano, who carried out a portion of his PhD research at UMass under the direction of Prof. John Donoghue, Ramsey-Musolf lectured on neutrino theory, CP-violation and electric dipole moments, and precision tests of the Standard Model. He also led a round table discussion of diversity and inclusion in physics involving the TALENT participants – PhD students and post-docs from both the U.S. and abroad. Participants shared their experiences of bias as related to identity; discussed the challenges faced by physicists of non-majority identities; and reflected ways each person might help address those challenges.

As a sequel to the Brookhaven Laboratory presentation, Ramsey-Musolf presented a colloquium on "Shattering the Lavender Ceiling" in November at the Helsinki University Physics Department where he was also invited to speak on tests of lepton number conservation and to collaborate on theoretical analyses of the electroweak phase transition in the early universe. To our knowledge, this was the first time a physics department in Europe has hosted a colloquium on LGBTQ inclusivity. Audience members expressed appreciation for the common challenges faced by LGBTQ physicists and those from other non-majority identities, as well as recognition of the unique hurdles encountered by sexual and gender minority physicists.

Video recordings of the Brookhaven and Helsinki University presentations are available at

https://www.bnl.gov/video/index.php?v=581 and https://www.helsinki.fi/en/unitube/video/6140c814-2aa2-4110-b60f-69ff0fb1aaf8

IN MEMORIAM

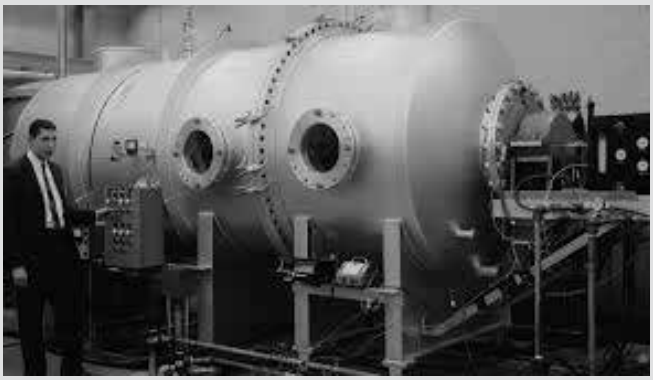
Philip Brockman (1938 – 2017)

Philip Brockman was a native of the Boston area. He earned a BS in 1959 from UMass/Amherst and joined the National Advisory Committee for Aeronautics at the NASA Langley Research Center, later earning a MS in physics from the College of William and Mary in 1963.

His early career dealt with supporting Project Mercury astronauts. He was one of the "Mad Scientists of MPD" (magnetoplasmadynamics), a form of propulsion. Among his research areas were reentry studies using a shock tube and current plasma propulsion of Hall thrusters on spacecraft. Phil liked to remember his time working with the gigantic wind tunnel. In 1963 he re-invented himself at Langley by turning to studies in remote sensing and the use of radar as well as technologies to detect turbulence, wind shears and other dangers in the practical arena of commercial flight.

In 1997, he was awarded the NASA Exceptional Service Medal (ESM) "for outstanding contributions and exceptional service in the development of NASA's laser remote sensing technology and capability".

In 2000, he received a commendation from NASA in recognition of his 40 years of outstanding service to NASA and the public. As the NASA Windshear Radar Principle Investigator, he "helped establish the engineering fundamentals of airborne and space-based LIDAR that has led to numerous aviation safety enhancements and a greater understanding of our atmosphere and its complex processes." Philip retired in 2003 as Distinguished Research Associate and died in Raleigh NC.



NASA Langley Research Center research physicist Philip Brockman started an MPD-arc plasma generator. 1964.

David Vernon Webb (1941 – 2018)

Dave was born on 21st November, 1941 in Melbourne, Australia and attended the University of Melbourne, earning a BSc and PhD in nuclear physics. Dave, his wife Liz and son Chris then moved to Saskatoon, Saskatchewan, where he was a post-doc at the University of Saskatchewan's linear accelerator facility. Three years later the family moved to UMass Amherst where, after first working as a post-doc, Dave was promoted to Assistant Professor.

After five years, with their US visas expiring, the family moved back to Melbourne in 1977. Dave worked at the Melbourne University Physics department for two years and then joined the staff at the Australian Radiation Laboratory (later the Australian Radiation and Nuclear Protection Agency, now ARPANSA).

He was one of the first four PhDs recruited to join the Laboratory by Director, Dr. Keith Lokan, with a mandate to move the laboratory into radiation protection. Dave will be remembered for the research LINAC he set up with David Jenkinson, a second-hand LINAC originating from the National Research Council in Canada. The LINAC came in two parts or stages, only one of which was ever made operational. At full power, this one stage could deliver an electron beam of 22 MeV.

Dave also secured the funding for the first medical LINAC in 2009, which paved the way for the ACDS (Australian Council of Deans of Science), a network of research organizational leaders in Australia's science faculties and schools established at ARPANSA, in effect setting the Medical Radiation Branch on its current path.

Dave represented Australia at the CCRI (Committee for Radiation Measurement Standards, established under the Treaty of the Metre) meeting in Paris every two years and at the local branch of this committee in the Asia Pacific region. He made significant contributions to both, including chairing the latter for three years. But perhaps his biggest contribution was to overcome the significant language barriers that existed amongst the members. Armed with only his enthusiastic personality, interest in people, and whatever local alcoholic drink could be found, Dave made friends with absolutely everyone, whether they could speak English or not. In effect, he broke down the barriers of culture and language so that the committee was able to communicate, and he made lifelong friends along the way. To this day, his colleagues are still asked by attendees of these meetings about Dave.

Artist Chris Henschke's latest piece inspired by particle physics mixes constancy with unpredictability, the natural with the synthetic.

A testament to the practical physicist that Dave was is the outcome of his far-sighted vision for his LINAC, once its working life at ARPANSA was over. Various parts, impossible now to source anywhere else, including critical vacuum tubes, were sent back to the National Research Council in Canada, as spare parts for an equivalent working LINAC from that era.

Other parts of this magnificent machine were obtained by an artist-in-residence at the Australian Synchrotron, where it hums away, a reminder to those who knew Dave of the scientific beauty and amazement of a piece of equipment far more wondrous than its modern, 'off-the-shelf,' sterile white machine successors. See image and story at: https://www.symmetrymagazine.org/article/art-intimates-physics

Dave's long years of work with the Australian Radiation Labs were mainly devoted to radiation standards and radiation protection, both on a national and international level, for over 35 years until his retirement. His connections with UMass/Amherst remained active from the day he and Liz departed. They stopped by every year or so, whether on a ski trip or professional mission, and were greeted with enthusiasm by his colleagues here.

Ken langley (1935 – 2019)

Emeritus Professor Kenneth Langley passed away peacefully on Thursday, March 14, 2019, after a period of declining health. He was 83. Ken began his undergraduate education at Washington State University in Mechanical Engineering and completed it with a BS degree in Physics from MIT in 1958. He and his wife Joan were married in 1959. He earned a PhD in Physics from UC Berkeley which was conferred in February 1966. He continued at Berkeley as a Research Associate and Acting Assistant Professor and then joined our Department as an Assistant Professor in September, 1966. He rose through the ranks and became a full Professor in September, 1981. He retired in May, 2002. Ken was a talented experimentalist with expertise in light scattering and for many years he carried forward externally funded research with an emphasis on critical point phenomena and macromolecular diffusion. This work included collaborations with faculty colleagues in the department as well as in the departments of Polymer Science and Biochemistry on campus. He and his Physics department colleague Norman Ford were instrumental in the development of the technique of photon correlation spectroscopy and used it to study conformational changes in macromolecules in solution as well as particle streaming in living cells. Norm and Ken's advances in correlation techniques led to their creation in 1977 of Langley Ford Instruments, an early local high-tech company that developed, manufactured and sold some of the first digital correlators. Ken was Vice President and Treasurer of LFI until it was absorbed into a large instrumentation company in 1983. In retirement, Ken was an active member of the UMass Outing Club, the Appalachian Mountain Club, was an avid kayaker and canoeist, loved music and enjoyed playing piano and recorder with musical groups. Ken and Joan were active members and regular volunteers at their church. In addition to Joan, Ken leaves a daughter Christine, a son Mark and two grandchildren, Sebastian and Josephine. A memorial service was held on April 6, 2019, at the First Congregational Church in Amherst.

Tara Baron (psych '19), Menon, Jared Howenstein '06

Jennie Traschen - gave a talk about Stephen Hawking and his influence on her career.

Rory Miskimen and Jose Marrero (PhD '85 - visiting from Spain for the year)

2018 PHYSICS ALUMNI REUNION

The UMass Physics Department hosted its Alumni Reunion on April 21, 2018, as part of the annual University Alumni Weekend festivities. The event was well attended by alumni, faculty and current Physics undergraduates. There were brief remarks by Department Head Narayan Menon and lots of interactions among those present. Unfortunately, the University has cancelled the Alumni Weekend for the spring of 2019.

alumni news

Jessica Cook (PhD '13) writes: I started as a PhD student at UMass in August of 2008. Early on I had a wonderful experience working with Andrea Pocar's group on the EXO (Enriched Xenon Observatory) experiment which aims at detecting neutrinoless double beta decay. I became much better at programming by running and editing the simulation code for the experiment.

I've always wanted to work on cosmology, so I later transitioned to working with Lorenzo Sorbo. We looked for new observable signals from inflation that could emerge from the decay of the inflaton into quanta of other fields. In fact, after the end of inflation (which is supposed to have occurred during a fraction of the first second of the life of the Universe), the inflaton has to decay into the matter which currently fills the universe. Some quanta of these other particles should be produced *during* inflation as well. One would not expect to see these particles directly since their number densities will be diluted away by the enormous expansion of the Universe that occurred during inflation. However, by decaying into these other particles the inflaton will leave a signature on its own - inhomogeneities, which are measured today with great precision in the Cosmic Microwave Background radiation. The constraints emerging from such measurements mean that observation of such features in the scalar spectrum is unlikely. However, we found that it *is* possible that such features could be discovered in the yet unobserved gravitational waves that were produced during inflation.

I obtained my PhD in August of 2013 and then started a three year postdoc at Arizona State University working with Lawrence Krauss. I collaborated with a variety of colleagues in Arizona while continuing to work on inflation.

In August of 2016 I started as a one year visiting professor in upstate New York at SUNY Oswego. The next year, in the fall of 2017, I began a tenure track position at Eastern Connecticut State University. I'm having fun teaching introductory physics to students from a variety of different majors. One of the wonderful things about my current position is that, as the main physics professor at Eastern, I have total freedom to design the lectures and labs as I wish. In particular, last year I had a lot of fun designing laboratories. I turned the E&M inductance lab into a "build a playable radio" exercise. In place of the traditional lenses and mirrors ray-tracing optics lab, I built photoelectric effect devices. Although not part of a standard introductory E&M course, I wanted to make the photoelectric effect one of our optics labs, because I think it is one of the most important and fundamental (and hopefully memorable) optics concepts that I can teach.

Chris Davis (BS '85) writes: The path from the Worcester Dining Hall to the Sylvan residence halls was surprisingly familiar. It had been 34 years since I walked on this path. Yet it seemed so much like I remembered, walking back on a crisp October evening. But so much had changed for me, and for UMass, since I graduated in 1985. This past October, I had the opportunity to visit the campus for the first time since I left. I had kept up with the changes over the years: The Commonwealth Honors College, the Library, the Life Sciences Building, and I had recently heard about the new Physical Science building. Yet, seeing them first hand was a treat. Of course, I also walked through Hasbrouck Hall, where I spent a lot of time in the early 80's as a Physics major.

UMass Physics was vital in the initiation of my career, despite my change in direction to study the atmosphere. Physics provided the quantitative analysis skills necessary to pursue my field. I still remember taking Physics 354, Meteorology, taught by Bob Hallock during my Junior year. That class provided further motivation for my career trajectory. After graduating from UMass, I went to graduate school at MIT where I received a PhD in 1990 in Meteorology. My work developed quantitative analysis tools to understand and predict large-scale weather systems. From there it was off to Boulder, Colorado, and the National Center for Atmospheric Research (NCAR), where I started a postdoc in the fall of that year.

Twenty-eight years later, I am still at NCAR. I have had the good fortune to be able to work on a wide variety of research problems in that time. These topics have ranged from studying field observations and numerical simulations of how thunderstorm complexes organize, how hurricanes form, and how mountains distort the flow and create effects far downstream. Studying the fluid in which we live, and where phase changes are the essence of most of what we call weather, is endlessly

fascinating. However, I especially enjoy working with and mentoring early-career scientists, many of whom enter my field as I did, from another discipline such as physics, math, chemistry or another branch of geosciences. In the past eight years, I have moved into more management positions, now directing a lab of more than 50 scientists and 70 total staff since 2015. Yet, every day in my work, I am still brought back to my "physics roots" in thinking about the fundamental behavior of the fluid in which we live and breathe.

The editors add: In recognition of Chris's long experience and success in a non-academic setting, he was invited back to campus in October 2018 to speak with students in Physics and Geosciences about careers in a non-academic setting.

Sebastian Fischetti (BS '10) writes: After a wonderful four years at UMass, I headed to UCSB for grad school (despite my reservations regarding the perpetual sunshine – I love snow and winter!). UMass gave me an excellent foundation in physics: GR with Jennie Traschen, QFT with John Donoghue, quantum mechanics with Nikolai Prokof'ev, math methods with Boris Svistunov, and all my other courses (not to mention my experience working on LIGO with Laura Cadonati) made the transition to grad school almost effortless. While at UCSB I worked with Don Marolf on string theory, specifically a form of gravitational holography called AdS/CFT. I also made the most of my new home and became an avid backpacker, visiting the Sierra Nevada mountains plenty of times and celebrating my PhD in 2015 with a through-hike of the John Muir Trail. I then hopped across the pond to Imperial College London for a three-year postdoc in the Theoretical Physics Group. As exciting as London was, I realized even their weather wasn't enough to make up for five years of sunshine and drought (London really isn't as rainy as its reputation would have you believe!), so for my second postdoc I headed back to the northeast; I'm now at McGill University in Montreal.

Despite having a brief existential crisis about leaving the LIGO collaboration when the first direct detection was announced, I'm very happy with my decision to pursue quantum gravity – I still get to think about black holes! AdS/CFT basically makes quantum gravity tractable by giving an indirect non-perturbative definition of such a theory: it says that quantum gravity (in string theory) is the same as a special kind of non-gravitational quantum field theory, just expressed in a very different language. The hard part is translating the familiar QFT lingo into gravitational terms to understand what's going on in the gravitational picture. This translation, technically termed bulk reconstruction, is the focus of my current research. We now have ample evidence that this translation must be intimately tied to ideas in quantum entanglement and information theory. The "It from Qubit" collaboration, of which I became a member when I started at McGill, seeks to understand the details of this connection.

In addition to my research, now that I'm at McGill I'm also looking forward to participating in diversity initiatives in physics in the US and Canada. In Europe I attended a couple of Workshops on Gender and String Theory, and I think the North American string theory community, in which minorities are particularly underrepresented even compared to other subfields of physics, would be well-served by following that example. And of course, I'm excited about experiencing my first proper winter in eight years, skiing every weekend, and visiting UMass now that I'm only a half-day's drive away!

Jose Mestre (BS '74, PhD '79) received bachelor and PhD degrees in physics from the University of Massachusetts, and spent his career until 2005, at the University of Massachusetts, rising through the ranks to full professor.

He left for the University of Illinois at Urbana-Champaign in the fall of 2005, as a full professor of physics and of educational psychology. Although trained as a nuclear physicist, his academic interests evolved more than 30 years ago to the questions of how students learn physics. He is a distinguished scholar of physics learning and arguably among the most highly regarded researchers in the field of physics education in the United States. He has adapted tools from cognitive and educational psychology to investigate forefront issues in problem solving and the development of scientific knowledge, and how those are conveyed in instruction.

His research focuses on the organization and deployment of physics knowledge by experts and novices, and addresses questions such as: What is the mechanism by which a beginner develops expertise in a complex domain such as physics? Why is it that the problem-solving skills for traditional textbook

physics problems often develop faster than conceptual understanding? Why is appropriate transfer of knowledge, even across the same domain and across remarkably similar contexts, so difficult to achieve?

Jose has taken up golf in the last 5 years, and, as researcher of expert-novice behavior, has found it interesting to observe his own progression from total novice to "respectable journeyman." For physicists thinking of taking up the sport, he can attest that knowing the kinematics of golf ball trajectories in great detail does nothing in terms of hitting the ball straight and near the hole, although the sport can become addictive. His major accomplishments in this new endeavor is shooting in the mid-80s and scoring two eagles from a distance of 125 yards.

Jose plans to retire at the end of the 2019 academic year and move to Florida with his wife Lori, a retired librarian from UMass. Honors and awards--Selected Fellow of the American Physical Society, 2010; National Academies Education Mentor in the Life Sciences, National Academy of Sciences, 2008-2013; Chancellor's Medal recipient, for exemplary & extraordinary service to the Univ. of Massachusetts, 2001. Selected publications can be found at the University of Illinois web site.

Doug Smith (PhD '88) completed his PhD work in Bob Hallock's Low Temperature Physics group, using third sound in thin helium films to study Anderson localization. He then accepted a postdoctoral position as a physicist at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD (then still the National Bureau of Standards). A few years later he accepted an offer of a permanent staff position there, and has been with NIST ever since. Aside from a brief stint in management and a few detail assignments along the way, he has stayed primarily hands-on in the lab, designing, building and using a variety of precision instruments for the measurement of forces, displacements and electronic properties at the nanometer scale and smaller. As part of a long-term NIST program to develop intrinsic force standards at the nanonewton level, he helped to develop and use an experimental platform to make direct measurements of the force required to break a gold-gold atomic bond in a single-atom Au chain, while also studying in detail the quantized electronic conductance in those 1-D systems.

Doug has lived in Frederick, MD, since 1994. He has two sons, both of whom received undergraduate degrees from the University of Maryland Baltimore County (in physics and computer engineering), and the older son just received his PhD in Materials Science from Penn State. Ever since high school, one of Doug's big (part-time) passions has been recording music and, since 2010, he has been slowly establishing a recording studio, *Shab Row Recording*, in Frederick as he charts a course from his NIST retirement to a new career as a full-time audio engineer.

Richard Poeton (BS '71) writes: A counterpoint to Prof. Gluckstern's comprehensive perspective on the history of the UMass physics department, I would like to offer the following slice of personal experience.

"I was a zoology/chemistry undergrad at UMass in the late 1960s when I answered a classified ad in the Collegian for part time work in High Energy Physics in Hasbrouck Labratory. The '60s were an interesting time, and I looked the part of a '60s student. But the professors and grad students who interviewed me did not seem to care. It was my first real job. I think the pay was $1.25 an hour. Before long I was 'scanning' triplet rolls of bubble chamber film from BNL to identify stopped particle tracks and characteristic 'NV' signatures. I learned that I was looking not just for particles but for 'events' (i.e., 'events in time'). Then I ran the same film through a viewer and digitized the tracks onto punch cards for computer analysis. Later, I would wade through reams of oversize printouts to identify likely candidate events for the grad students to include in their studies. These were the days of Kofler and Yamamoto: bubble chambers, film, and punch cards. When we needed to do calculations, we used slide rules.

"It was a great experience, very different from the lecture hall and classroom work that was most of my experience at UMass. The grad students treated the techs like part of the team and let us in on what we could understand of what they were trying to do. I am still in touch with Tony Mann, one of the then grad students, who is now teaching at Tufts. A BNL bubble chamber photo keeps pride of place in my study.

"The process of chasing, finding and measuring ephemeral things in order to understand the workings of the universe was thrilling and life-changing. So, a few years later when I decided I needed to go back to grad school in some kind of engineering and was asked to select which kind, I did not have to think long before selecting 'nuclear.' I am now retired after a career with EPA as a Health Physicist, and I trace it back directly to that day when I scanned the want ads over coffee at the Hatchet and Pipe.

"While at UMass, I shared an overcrowded dorm room with two other guys and, what with 50th high school reunions this past year, we met for the first time in years and traded stories about UMass. To my surprise, I had forgotten that both of my roommates had also worked at the HEP lab at various times. Each had unique but similar recollections of the spirit and feel of the place at the time. Both testified to the important influence it had on their lives. One was a theater major who worked at the lab until he found his way into graduate work and an eventual position as Dean of Anthropology at DePaul. The other was a mechanical savant who learned how to troubleshoot and problem-solve in a research environment and is now running his own business supplying the oil and gas industry in Texas. It was a happy surprise to hear how they had been influenced by the laboratory experience, just as I had.

"Recently I made a small donation to UMass. When I was asked where to direct the money, I once again did not have to think long before answering 'Physics'."

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Alumnus or alumna, please officially update addresses via http://www.umass.edu/umassmag/contact/address.html, and also inform the department by using the newsletter address

Future PhD alumni (current P181 TA's) Elisabeth Kiff, Emily Hansen, Anthony Englert, Doug Pinckney, Brian Nguyen, and Jackson Harmon, with Scott Hertel, Jenny Ross, and Chancellor Subbaswamy.

PHYSICISTS IN INDUSTRY

We have continued to invite alumnae/i and other physics-degree holders to campus to talk about their work in fields outside academia, both in industry and national labs. Our visitors present seminars and join small-group meetings with students and faculty. They are a great resource for our students to learn about career options. Many of these visits are hosted as part of our "Physicists in Industry" series under the sponsorship of the Massachusetts Center for Autonomous Materials.

Since the Spring 2018 newsletter, we have had the pleasure of hosting these physicists:

Jared Howenstine (UMass BS in Physics and Astronomy, 2006) is a patent attorney working with Cantor Colburn LLC in Hartford, CT. We learned who makes patents work, what patent law is like, and how physics graduates can get involved.

Justin Brown of Physical Sciences, Inc., (www.psicorp.com) spent a day with us and talked with faculty and students about his work on atom-based sensors for precision measurements.

Margaux Burnham (UMass BS Math, 2017) and Matt Leary of Newgrange Design (www.newgrangedesign.com) spent an evening with us to talk about printed-circuit board design and to recruit students to work with them.

Chris Davis (UMass BS, 1985) is Associate Director at the National Center for Atmospheric Research. Chris was hosted jointly by the Physics and Geosciences Departments, rather than by MassCAM. He talked with us about atmospheric dynamics and about opportunities for young scientists at NCAR (https://ncar.ucar.edu/opportunities).

We are very grateful indeed to these folks for taking the time to visit and talk to students and faculty. If you are interested in participating in this program, please do contact Irene Dujovne at dujovne@physics.umass.edu.

Degrees awarded since the Spring 2018 Newsletter

BS and BA Degrees

Mufid Alfaris
Justin Alfonse
Bren Backhaus
Allyson Bergeron
Matthew Bissaillon
Thomas Bogue
Michael Buckley
Matthew Burke
Alexandra Burkott
Ian Carrick
Joshua Carey
Jonah Chaban*
Ziyang Chen
Ryan Clark
Olivia Comeau
Danielle Conceison
Drew Curto
Freeman Dong
Tara Dowd
Matthew Downing*
Sylvia Fournier
Noah Gioiosa
Emma Hibbard
Ryan Hong
Camden Iwanicki
Martyna Laszcz
Cameron Lane*
Sonya Leaf
Haote Li
Michael Maxwell
George Meltzer*
Alexander Moschella
Bela Nelson
Liam O'Brien*
Kyle O'Connell
Priyank Patel
Jonathan Pham
Jonathan Powers
Nathan Rose*
Nicholas Russo
Susmitha Saripalli
Neil Shah
Rex Tufts
Makayla Vessella
Jonah Weigand-Whittier
Darrell Workman
Guangfeng Yu*

* honors capstone listed below

BS Degrees	Thesis Title	Advisor
Jonah Chaban	Dynamical Black Holes and Klein-Gordon Fields in Inflation	Traschen
Matthew Downing	Studying the Presence of Krypton-85 in the DarkSide-50 Detector	Pocar
Cameron Lane (iCons)	Improving the Performance of Photovoltaic Cells on the UMass Amherst Campus Using Rainwater	Tuominen
George Meltzer	Kinesin-1 Motility is Unaffected by Crowding Agents	Ross
Liam O'Brien	Production of Particles and Struts in 3-d Euclidean Space	Sorbo
Nathan Rose	Microcanonical Annealing for First-Order Phase Transitions	Machta
Guangfeng Yu	Stick-slip Friction at a Soft-Rigid Interface	Menon

"iCons" means that the student is part of the Integrated Concentration in Science program here at UMass Amherst.

MS Degrees

Suman Bharti
Christopher Nedlik
Sarah Zuraw
Zachary Meadows

PhD Degrees

Qingyou Meng, "Complex Ground States of Vortex and Filament"

Jiayue Tong, "Antenna Enhanced Graphene Terahertz Emitter and Detector and Graphene Microwave Detector"

Alissa Monte, "Alpha Radiation Studies and Related Backgrounds in the DarkSide-50 Detector"

Alphan Aksoyoglu, "Equilibrium Partitioning of Binary Polymer Mixtures into Biological Nanopores"

Hamid Reza Shojaei Mahib, "Dynamic and Structure of Polyelectrolyte Complexes"

Greg Farrell, "Preparation, Mechanics and Structure of Sphere Packings near the Random Loose Packing Limit"

Kun Chen, "Emergent Phenomena in Quantum Critical Systems"

Yuan Huang, "First Principle Approaches to Strongly Correlated Quantum Spin Systems"

Peijan Wang, "Combined Spectroscopic and Scanning Probe Studies of Electronic Interactions in nanostructured 1D and 2D Semiconductors"

Salem Al Mosleh, "Geometry, Growth and Pattern Formation in Thin Elastic Structures"

Wei He, "Measured Capillary Forces on Spheres at Liquid Interfaces and the Mechanics of Interfacial Particulate Assemblies"

Zhiyuan Yao, "Quantum Phase Transitions in Disordered Boson Systems"

Shao-Yu Chen, "Probing Quantized Exitations and Many-body Correlations in Transition Metal Dichalcogenides with Optical Spectroscopy"

Wenming Ju, "Characterization and Manipulation of the Magnetization of Nano-Scale Magnetic Structures"

Haolin Li, "Collider Tests of Fundamental Symmetries and Neutrino Properties"

Nina Zehfroosh, "Characterization of the Motion of Cellulose Synthase Protein Complexes (CESA) in the Cell Membrane of Flowering Plants"

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