The Wisconsin Physicist

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On the Cover

The Astro-H launch on an H-IIA rocket from Tanegashima, Japan (see article page 14)

Inside this Issue

Table of Contents

Vol. 20 | Fall 2015

Greetings from the Chair

Dear Alumni and Friends

Albrech Karle - Department Chair

We are looking back at a great year in 2015. The Department continues to be a vibrant place for Physics in a wide range of areas. This new edition of the Wisconsin Physicist will give you an opportunity to catch up with recent developments in research and education, awards and events in our Department.

In the previous newsletter I mentioned significant challenges in the upcoming years. I am very pleased to report that we had a terrific year of recruiting new faculty. We were successful in hiring 4 new faculty at the Assistant Professor level. Kim Palladino is joining us from SLAC to search for dark matter with the LZ (Liquid Xenon) experiment. Kam Arnold comes from UC San Diego to conduct research on observational cosmology. Alex Levchenko is joining us from Michigan State University. His area of specialization is theoretical condensed matter physics. Our fourth addition to the faculty is Victor Brar, who grew up in Middleton, Wisconsin, and joins us from UC Berkeley. He will perform research in experimental condensed matter physics. You will find profiles on all four of them in this issue of our Newsletter.

Several faculty members, led by Peter Timbie, have started to develop plans for bringing innovative methods to improve the student learning experience in the classroom. An initiative for educational innovation sponsored by the Provost's office will be used to transform the introductory Physics 103/104 course sequence into a more interactive learning experience. Peter Timbie describes the plan in this issue.

In 2015 the American Physical Society dedicated the Tantalus electron storage ring as a Historical Site in Physics. A dedication ceremony was held in the Department where the President of the APS presented a plaque to the Vice Chancellor of Research and Graduate Education. Franz Himpsel looks back at the history of Tantalus.

The 14th Annual Awards Banquet was held in May 2015. The continued generosity of our alumni and friends allows us to present many awards to outstanding students. You can read more about the Awards Banquet on page 15. We are pleased to maintain our tradition of recognizing Distinguished Alumni Awards were given to three alumni:

Prof. Mark Devlin is Professor at Penn State University. Mark studied as an undergrad of Dan McCammon's and graduated in 1988 to go to Berkeley for postgraduate studies. He has been leading several major experiments, amongst them BLAST (Antarctic Balloon telescope for studying the early Universe), MUSTANG (a 100 GHz thermal receiver array at Green Banks Telescope) and ACT (Acatama Cosmology Telescope). Thanks for a great colloquium.

Prof. Mark Pederson completed his PhD with Prof. Chun Lin in 1986. He published numerous papers, one of which has been cited 10,751 times. Today he is at DOE heading the Computational and Theoretical Chemistry Program in the Chemical Sciences and also holds a Research Professorship at Johns Hopkins.

Prof. Tim Stelzer earned his PhD in particle physics with Francis Halzen. Today Tim is performing research in particle physics at the University of Illinois. Tim has also become a leader in Physics Education. He invented the I-clicker that today is widely used in classrooms.

The Physics Department Board of Visitors met twice in 2015. The Board of Visitors continues to help us in a number of ways, by providing feedback to the Department, recruiting of graduate students, and with fundraising.

Whether you are an alum, friend, employee, or student, we appreciate your interest in, and loyalty to, the University of Wisconsin-Madison Physics Department. All of the awards given out are funded with donations. As an example, one substantial donation allowed the creation of a new fund, the Physics Alumni Graduate Support Fund, which allows us to supplement the stipends of incoming graduate students. We had again a matching donor to this fund in 2015. Donations also help in other ways, for example with the Ingersoll Museum for which we are making plans for the 100-year celebration in 2017. You can donate to the Physics Department online by going to http://www.physics.wisc.edu/giving. Please see page 22 for more ways to give.

I sincerely thank our generous alumni and friends who have financially supported the Department. This support truly contributes our margin of excellence.

Stay Connected!

Please continue sending us your professional and personal news!

We will be happy to include updates from alumni and friends in the Wisconsin Physicist.

- **Do you receive email from the department? Sign up to receive our weekly seminar emails: https://www.physics.wisc.edu/twap/ click on " Subscribe to receive email announcements of events "**
- **Send your updates to: info@physics.wisc.edu**

Selected Highlights of 2015

3-D printed trumpet by Garage Physics student Daniel Montez

Friday, February 13, 2015

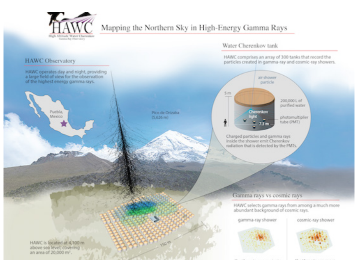
Undergraduate student Daniel Montez uses the 3-D printer in Garage Physics for rapid prototyping of a trumpet. He wanted to see if it was possible to produce a brass instrument with similar sound aspects, while being inexpensive to make and be able to survive being dropped, making it ideal for younger music students first trying out the instrument. Each piece was 3D printed separately using PLA plastic, and they fit together to create the instrument.

New polar neutrino detector on the way

Friday, February 27, 2015

IceCube, the cubic kilometer, sub-polar detector that in 2013 gathered the first-ever evidence of cosmic neutrinos, is the star of particle astrophysics at the South Pole. Soon, however, a complementary detector known as the Askaryan Radio Array or ARA will join the hunt for the highest energy neutrinos.

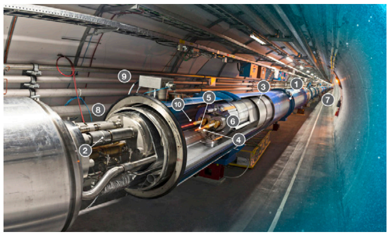
High-Altitude Water Cherenkov Observatory (HAWC)



Friday, March 20, 2015

High on a sleeping Mexican volcano, a new particle astrophysics observatory is about to blink to life, commencing an all-sky search for very high-energy gamma rays — a search that could greatly expand the catalog of known gamma ray sources and chip away at the mystery of the cosmic rays that constantly bombard our planet.

The LHC is back in business, now ready for proton-proton collisions at a record 13 TeV



Sunday, April 5, 2015

After two years of intense maintenance and consolidation, and several months of preparation for restart, the Large Hadron Collider, the most powerful particle accelerator in the world, is back in operation. Today at 10.41am, a proton beam was back in the 27-kilometer ring, followed at 12.27pm by a second beam rotating in the opposite direction. These beams circulated at their injection energy of 450 GeV. Over the coming days, operators will check all systems before increasing energy of the beams.

Garage Physics launches high altitude balloon

Monday, June 1, 2015

Garage Physics launched and recovered a high altitude ballon. Pictured are Brett Unks and undergraduates Bella Nasirudin and Catherine Tuanqui at the launch site, Governor Nelson Park in Middleton. The balloon was recovered in Edgerton after a couple hour flight. The payload featured a digital temperature logger, an Android phone running Justin Vandenbroucke's cosmic ray detector app., an external camera, and a GPS unit. Also participating in the development were Asst. Prof. Justin Vandenbroucke, plant pathology graduate student Alex Biligri, and Physics graduate student Shaun Aslum

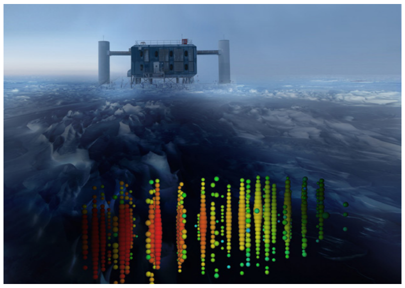
Selected Highlights of 2015

As the giant physics machine restarts, the essential role of UW in the LHC continues

Tuesday, July 14, 2015

UW-Madison has dozens of scientists — including graduate students and postdoctoral fellows — involved in the experiments, analysis, data handling and computation at the Large Hadron Collider. Research has resumed at the 27-mile tunnel on the Swiss-French border after two years spent raising its power.

Antarctic Neutrino Detector Firms Up Cosmic Neutrino Sighting

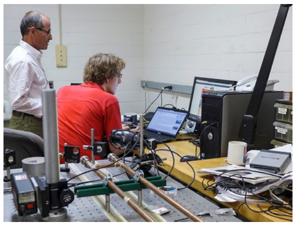


Thursday, August 20, 2015

Sorting through the billions of subatomic particles that zip through its frozen cubic-kilometer-sized detector each year, researchers using the IceCube Neutrino Observatory have gathered powerful new evidence in support of 2013 observations confirming the existence of cosmic neutrinos.

The new observations are important because they herald a new form of astronomy using neutrinos, nearly massless high energy particles generated in nature's accelerators: black holes, massive exploding stars and the energetic cores of galaxies. In the new study, the detection of 21 ultra high-energy muons – secondary particles created on the very rare occasions when neutrinos interact with other particles – from the mass of particles coursing upward through the IceCube detector provides independent confirmation of astrophysical neutrinos from our galaxy as well as cosmic neutrinos from sources outside the Milky Way.

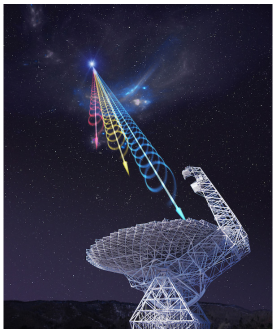
Garage Physics: a makerspace for undergraduate brainstorms



Friday, September 25, 2015

Duncan Carlsmith (left) discusses an advanced search engine with Josh Cherek, the student who developed it, at the Garage Physics makerspace. The twin copper pipes in the foreground replicate an 1851 experiment that Albert Einstein cited as one foundation for his special theory of relativity.

Cosmic Radio Bursts Yield First Clues About Their Origins



Thursday, December 3, 2015

With the help of the world's largest steerable radio telescope, a team of researchers that includes University of Wisconsin-Madison physicists has produced the first detailed portrait of a Fast Radio Burst - a brief but highly energetic pulse of radio waves from unknown sources in the distant universe.

New Faculty Profiles

Kam Arnold joined the faculty in August 2015 as a new Assistant Professor. Arnold is a leader in the field of observational cosmology, particularly measurements of the 2.7 K cosmic microwave background (CMB) radiation. The CMB provides us a nearly perfect view of the cosmos when it was 1000 times smaller than today. Maps of the temperature fluctuations in the CMB have revolutionized the field of cosmology and nailed down cosmological parameters with percent-level precision. From these maps we now know that the Universe is very close to being 'flat' (Euclidean), requiring that the average density of the universe be at the 'critical density.' CMB measurements show that the makeup of this universe is 4% baryons, 27% dark matter, and 69% dark energy or a cosmological constant. Furthermore the fluctuation spectrum is consistent with the inflationary model for the evolution of the Universe and the formation of large-scale structure (LSS). Inflation is believed to have occurred at t ~ 10-36 s and involved energy scales as high as ~ 1015 GeV, eleven orders of magnitude above the LHC.

To take the next steps, Arnold is exploiting the polarization properties of the CMB. Scattering of the CMB in the early Universe imprinted it with faint linear polarization patterns, called 'E-modes'. Gravitational lensing by intervening matter distorts these patterns into 'B-modes.' In particular, the presence of a sea of cosmic neutrinos affects structure formation in a way that he uses to limit the sum of the masses of the three neutrino species. He expects to make a positive detection of this mass in the next 5 years. In addition, gravitational waves from inflation imprint another type of unique pattern onto the polarization, the so-called 'primordial B-modes'; if detected, this signal will be a triumph of the inflation model, determine the energy scale of inflation, and open a new window to early universe physics.

Arnold observes the CMB with the POLARBEAR instrument, which he and collaborators are currently expanding to the Simons Array. These instruments are sensitive polarimeters at an altitude of 5200 m in the Atacama Desert of Chile. As a graduate student at U. C. Berkeley Arnold developed the detectors used in these instruments. He then moved to U. C. San Diego to become the Project Manager of the program. His team used POLARBEAR to make the first measurements of gravitational lensing of the CMB using CMB data alone. He continues to focus on those experiments at Madison and is recruiting postdocs and graduate students to join him in observations, data analysis and detector development.

Arnold is also a key member of the US team proposing to build and fly the LiteBIRD satellite, a joint NASA/JAXA CMB polarization probe. Now in Phase-A study, LiteBIRD will map CMB polarization at large angular scales, which is difficult to do from the ground. The primordial B-mode signal from inflation has unique signatures at large angular scales.

This Fall he co-taught (with Cary Forrest) Physics 247, our introductory course for physics and physics-related majors. Together they provided a treat to our incoming class by supplementing the usual introduction to mechanics with a rapid immersion in special relativity, general relativity, and black hole physics.

Welcome to Madison, Kam!

New Faculty Profiles

Alex Levchenko

I joined the Physics Department at UW-Madison in August of 2015. Prior to this appointment I served four years as an Assistant Professor of Physics at Michigan State University. In addition to that I had two years of experience as the postdoctoral researcher at the Materials Science Division of the Argonne National Laboratory. I got my PhD from the University of Minnesota in 2009 and my final year in the graduate school I spent as the graduate research fellow in the Kavli Institute for Theoretical Physics at the University of California, Santa Barbara.

I broadly specialize in the condensed matter theory, with the particular emphasis on the quantum transport phenomena and nonequilibrium effects. During my PhD work I co-authored with my advisor a review article published in the Advances in Physics on the Keldysh technique for nonequilibrium systems and its applications to various problems. Nowadays this work is widely used in the community as one of the main learning sources for the students and reference point for the experts.

During the postdoctoral work I branched out to study strongly correlated systems with the particular emphasis on the superconductivity in cuprates and iron-pnictides. Perhaps the most significant contributions that emerged from these studies include the papers on the Nernst effect from fluctuating pairs in the pseudogap phase of the cuprates, and theory of magnetic quantum criticality in pnictides as revealed from the London penetration depth measurements beneath the superconducting dome in these materials.

Currently at UW-Madison I am deeply involved in the studies of the quantum anomalous transport effects including anomalous Hall, spin-Hall and Kerr effects in the modern mesoscale materials systems such as topological Kondo insulators and chiral superconductors. In a fruitful collaboration with my colleagues in US and Germany we are excited to uncover the new mechanism of anomalous transport due to diffractive skew scattering. We are exploring emerging consequences of this mechanism in various cases.

In a parallel vein I am intrigued to explore the hydrodynamic regime and nonlocal electron transport as recently realized in the single-layer and bi-layer graphene devices. In a collaboration with the experimental group at Columbia University, and theory colleagues at Rice University and University of Washington we are studying hydrodynamic magneto-transport: magneto-resistance, drag and Hall drag effects. This current research is supported by NSF, BSF and WARF.

In recent years I was privileged to receive international fellowships from the German Academic Research Services (DAAD) and Max Planck Institute (MPIPKS). This gave me an opportunity to collaborate and conduct cutting edge research with colleagues in Germany and specifically in the Karlsruhe Institute of Technology and Max Planck Institute in Dresden. Several important publications appeared as a result of these collaborations and perhaps the most influential one is devoted to the Coulomb drag transport phenomena in the interactively coupled double-layer systems. This particular work was recently accepted for publication by the Reviews of Modern Physics.

During the 2015/2016 school year I am teaching undergraduate classical mechanics and graduate statistical mechanics. I am actively building my group. During the Fall semester I recruited two postdoctoral researchers who will join UW-Madison campus in the August of 2016. I am also looking for a motivated and curious graduate student who is interested to dwell into the exciting and challenging problems of modern condensed matter physics.

Besides science, I love sports, especially ice hockey. I play myself in a local league at Madison Ice Arena and also some pickup games with new friends at the Waunakee Ice Arena. I like the outdoors in general, backpacking in the country and crosscountry skiing. My wife Polina is also at UW-Madison, she is affiliated with the College of Human Ecology, Department of Human Development and Family Studies. We have a 4 year old son Ilya who enjoys the Children's Museum, Vilas Zoo, all the playgrounds and lakes around. We simply love to live in Madison and be a part of the growing wonderful community.

New Faculty Profiles

Dr. Palladino inspects the inner teflon surface of the LZ system test prototype detector.

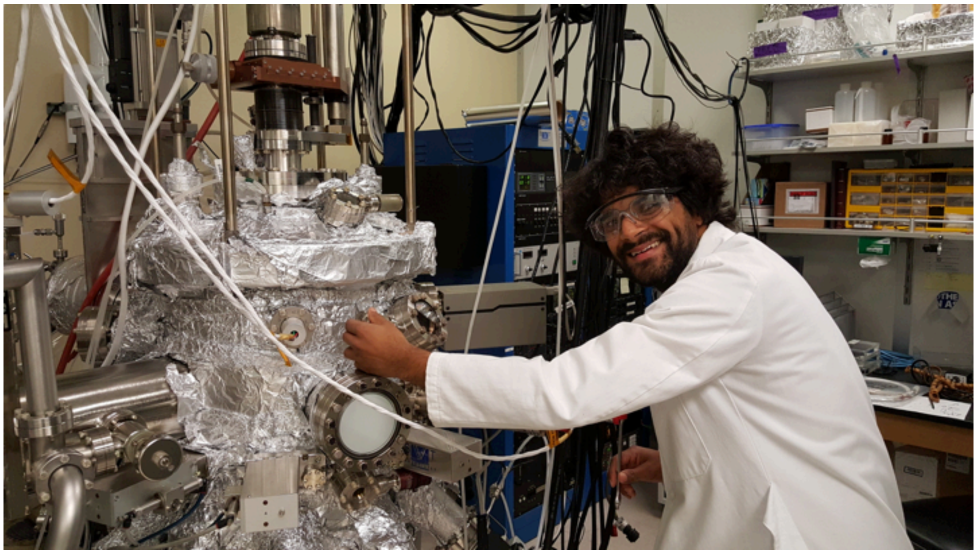
Scientists from the LZ collaboration install the system test prototype detector for its first run at the SLAC National Accelerator Laboratory.

Dr. Kimberly Palladino joined the faculty this fall in the high energy physics group, working in the field of direct dark matter detection. Understanding the particle nature of dark matter is one of the biggest questions in particle physics and cosmology, as it is approximately five time more abundant than the regular matter in our universe. Dr. Palladino's work focuses on large liquid xenon detectors, which are capable of clearly identifying the nuclear recoil signal of candidate dark matter interaction from the electronic recoil caused by background radiation. She joins Profs. Carlsmith and Dasu on the future LZ experiment, and continues to work on the currently running LUX experiment.

Dr. Palladino, in collaboration with faculty at the SLAC National Accelerator Laboratory, has been leading an 18-scientist group of LZ experimenters, including UW graduate student Shaun Alsum, in constructing and operating a system-test prototype for LZ. The goal of the tests is to ensure control over the high voltage operation, which is an important aspect to demonstrate as LZ has a goal of operating at voltages over ten times higher than have been achieved in large scale predecessor experiments. Two commissioning runs for the liquid Xenon handling and high voltage operation occurred in the Fall of 2015, while a full test of a prototype detector, with 120 kg of Liquid Xenon, will begin in March 2016.

The full LZ detector, with approximately 10 tons of liquid xenon, will begin fabrication in 2017 and begin taking data in 2019. It will operate at the Sanford Underground Research Facility in Lead, SD, where the LUX detector is running through the summer of 2016. Both Dr. Palladino and Mr. Alsum are also engaged in collecting data with the LUX experiment. The LUX collaboration has had a number of publications on its calibrations and searches for dark matter from its initial 85 day run from 2013, and looks forward to updating that with 300 days of new data in 2016.

New Faculty Profiles



Victor Brar will be joining the Physics department in June 2016 as a new assistant professor focused in the area of condensed matter physics. Brar is a Wisconsin native, who grew up in Middleton and worked on the Madison Symmetric Torus while in high school. He obtained his Ph.D. from UC Berkeley where his research focused on nanomagnetism and impurities on graphene, and then moved to Caltech, where he was a Kavli Nanoscience Fellow and performed experiments on tunable metamaterials. Brar's work is centered on exploring and creating new phenomena in low dimensional systems, such as < 5nm diameter nanowires, or atomically thin crystals, including graphene, black phosphorus, or hexagonal boron nitride. Many of these materials exist in bulk, 3D forms, but as their dimensions are reduced their optical and electronic properties begin to deviate, and they can be tuned by controlling the local environment. This has allowed for the creation of materials that host quasi-particles with novel properties such as fractional charge, zero mass, and spin-momentum locking. Additionally, by patterning and layering these materials in atomically precise ways, new useful properties can arise that have dramatic effects the macro-scale.

In order to search for new phenomena that can exist in these materials, Brar uses low temperature scanning tunneling microscopy (STM), which allows for sub-Angstrom imaging of the topographic and electronic properties of conductive surfaces. When imaging a surface with this technique, the quasiparticles (electrons or holes) appear as waves that scatter off impurities, and interfere with one another. By mapping this interference pattern at different energies, the quasiparticle dispersion relation of the material can be determined, and the role of local environmental variables can be directly measured. Brar will seek to stack 2D crystals on top of each other and on top of various substrates in order to tune the electronic properties, and create new electronic phases made possible through substrate-surface interactions. Furthermore, in an STM experiment the material can also be modified in situ by evaporating charged or magnetic atoms onto the surface. These impurities locally modify the electronic structure of the surface in ways that can be directly probed using the STM, and the STM tip can also be used to move the atoms around on the surface to control their interactions. By using these methods, Brar hopes to find and/or create new novel impurity states that are predicted to exist in 2D systems, but are yet to be observed.

Brar also seeks to employ 2D materials in the field of metamaterials, where electron beam lithography is used to pattern structures (aka 'meta-atoms') at length scales much smaller than optical wavelengths, such that a new effective medium is created with an anomalous index of refraction. Metamaterials constructed from conventional metals or dielectrics have displayed a wide range of properties, including refractive indices that are zero or negative, however, thus far most metamaterials are static, with properties that cannot be varied. By incorporating electrostatically tunable 2D materials into meta-lattices, Brar will seek to make materials that have optical properties that can be dynamically changed. This will allow for the creation of structures that have unusual behavior, such as non-reciprocal optical transmission or thermal emission that is pulsed, and highly directional.

Tantalus

Tantalus becomes historic site of the American Physical Society

by Franz Himpsel

Tantalus is the nickname of a small storage ring for electrons, a miniature version of the big storage rings for protons which have pushed the frontier of particle physics to ever higher energies. In fact, it was conceived as testbed for the proton storage ring at Fermilab, which held the energy record for many years. Its location in the middle of the corn fields between Madison and Stoughton provided natural bedrock as solid base for a machine that requires excellent stability. During a typical storage time the electrons travel at nearly the speed of light for a distance that would get them to the outer planets and back while remaining on their track within a fraction of a millimeter.

After completing the original mission in the late Sixties, a group of people from the Physics Department thought of a new purpose for Tantalus. The idea of using it as source of UV-light and soft X-rays was pursued in particular by **Ed Rowe** (*pictured*). This so-called synchrotron radiation is generated when electrons are forced into a circular orbit by strong magnets. It is a great nuisance to high energy physics, because is drains energy from the electrons and requires building larger and larger storage rings to reach higher energies. But it presents a boon to atomic and condensed matter physics, since it is very difficult to produce a continuous spectrum of electromagnetic radiation in this energy range. Under the guidance of Ed Rowe and with the help of energetic early users from all over the world Tantalus became famous for its ground-breaking research exploring the behavior of electrons in atoms and solids with new techniques that were enabled by synchrotron radiation. About a dozen of the postdocs who started their research career at Tantalus became directors and scientific directors of newer synchrotron light sources that started popping up worldwide after it was recognized how useful synchrotron radiation could be. Four of them were honored for their work at Tantalus with the Davisson-Germer Prize of the American Physical Society (APS), its most prestigious prize in atomic physics and surface science. Work at Tantalus and its successor Aladdin also produced two winners of the Buckley Prize, the top APS prize in condensed matter physics.

On November 13, 2015 a special colloquium took place where Sam Aronson (president of the APS and a former faculty member in our Department until 1978) presented a plaque to the Vice Chancellor of Research, Marsha Mailick. Katharine Gebbie spoke about the historic sites initiative of the APS. She was the longtime director of the Physics Division of the National Institute of Standards and Technology, leading it to several Nobel Prizes. The plaque emphasizes the pioneering role played by Tantalus and the Synchrotron Radiation Center (SRC) in Madison: Located at the Synchrotron Radiation Center, near Stoughton, WI, Tantalus was the first dedicated synchrotron light source. Operating for nearly 50 years, the SRC was a birthplace of synchrotron radiation science, hosting thousands of researchers from all over the world and leading to fundamental scientific discoveries.

Tantalus

Today the Tantalus storage ring is long gone - half of it is in the collection of the Smithsonian Museum. But the vault under the lonely hill (pictured) continues to serve the physics community. Prof. Cary Forest from the Physics Department operated a simulation of the molten inner core of the Earth, using liquid sodium to understand how the Earth's magnetic field is generated. Currently Prof. Mark Anderson from Engineering Physics is testing molten salts at high pressure and temperature for heat exchange in nuclear reactors and storage of solar energy.

Teaching Innovations

Teaching Innovations

by Peter Timbie

If you walk around the main floor of Chamberlin Hall on a typical weekday you are likely to hear discussion sections abuzz with students solving problems in small groups under the expert guidance of a graduate teaching assistant. Nowadays almost all our TA's use 'active learning' techniques like these to engage students and help them learn the problem solving techniques that we expect them to take with them as life skills when they graduate. Our instructional labs have also worked this way for years.

And, increasingly, if you step into one of our lecture halls, you'll find a similar transformation is starting to occur. In some courses the 'sage on the stage' is being replaced by the 'guide on the side'. Rather than passively gazing at Powerpoint slides, in these classes students respond to an instructor's multiple choice questions with a 'clicker' (personal response system). If they don't 'get it' the instructor usually has them talk with peers and then repeats the question or has volunteers explain their thinking to the class. These 'flipped' or 'blended' classrooms were pioneered twenty years ago by Harvard's Eric Mazur and have been shown to be effective for improving learning outcomes.

This year we are beginning to introduce active learning in a systematic way to some of our largest introductory courses. If we do this right the impact will be enormous. Across campus, more than 40 departments require introductory physics for their majors. Each semester we enroll more 3000 of these undergraduates; by the time they graduate, 40% of UW students will have taken at least a year of physics.

Teaching Innovations

The challenges are formidable. Most of our students are majoring in one of the life sciences and don't see the value of physics for their careers. They enroll only because they are required to. And although enrollments have increase by over 15% in the last decade, our faculty numbers have decreased.

Nevertheless, we have plenty of encouragement and advice and every reason to expect success. In particular, Steve Cramer, the Vice Provost for Teaching and Learning, has asked us to join his new REACH initiative to transform large, introductory, lecture-based courses into sustainable, active learning environments that increase students' engagement in their own learning. We are working closely with Sarah Miller, from DoIT Academic Technology, and Greg Moses, Professor of Engineering Physics, who has modified his own courses in this way, to transform our two largest courses, the algebra-based Physics 103 and 104.

We are fortunate to have been allowed to hire Dan Thurs as the Physics 103/104 Course Coordinator, a brand new position for us. Thurs lectures in the off-semester sequence and has already introduced numerous innovations to the classroom. He joins Jim Reardon, who leads the training of our TAs and oversees the assessment of our introductory courses.

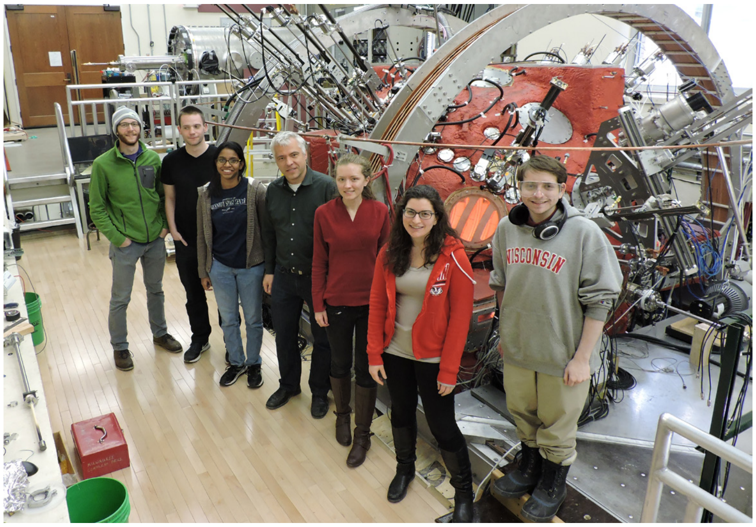
We also receive advice from our own highly-successful Physics Learning Center (PLC), led by Susan Nossal and her team, including Eric Hooper, Amihan Huesmann, Chris Moore, and Larry Watson. The PLC works with students potentially at risk for having academic difficulty and has used active learning techniques for years to provide academic support and small group supplemental instruction to students studying introductory physics.

And we have had tremendous support from our alumni. In Fall 2015, Tim Stelzer, a Professor of Physics at UIUC, came to advise us. Stelzer earned his PhD here with Francis Halzen in 1993. He is a national authority on physics education research and spoke about his development of online materials ('prelectures') that students watch and interact with before coming to class. This approach frees up valuable lecture time for instructors to focus on particularly challenging topics (aided by feedback from online prelecture questions) and problem-solving. In 2013 he and collaborators were awarded the APS Excellence in Education award for the development of these materials (called 'SmartPhysics'). He received our Distinguished Alumni award in May. He reports that Illinois students responded enthusiastically to these modifications and had dramatically improved attitudes toward physics. We hope to create a similar transformation at UW.

A Learning Team facilitated by an undergraduate Peer Mentor Tutor in the Physics Learning Center

Magnetic Reconnection, a Celestial Phenomenon in the Laboratory

By Jan Egedal



Magnetic reconnection is a mysterious phenomenon ubiquitous to all space plasmas. Evidence from solar probes has indicated that it is the catalyst of the most powerful explosions in our solar system, coronal mass ejections. Associate professor Jan Egedal joined the faculty at UW-Madison in the summer of 2013 and, with a team of six PhD students, is gaining new insight into this process through theory, numerical simulations and experiments.

Magnetic reconnection directly impacts the Earth and its environment. As is well known, the Earth is embedded in the Sun's extended atmosphere, and its magnetic field, for the most part, shields us from the direct effects of the incoming solar wind plasma. Most of the solar particles are deflected around a three-dimensional boundary called the magnetopause, much like water is forced to flow around a submarine. However, this shielding is not perfect, and, through a process known as magnetic reconnection, solar particles can penetrate the magnetosphere. Figure 1 shows the primary reconnection sites in the magnetosphere. The magnetosphere provides adequate protection except during severe solar storms when the Sun releases massive amounts (over 1025 J) of energetic particles and radiation (a process also driven by magnetic reconnection). These particles are ejected into space and, upon reaching the Earth, wreak havoc on technological systems. Over $4 billion in satellite losses have been traced to space weather damage. It is estimated that a solar storm of the magnitude of the 1859 Solar Superstorm (the Carrington Event) would cause over $2 trillion in damage today.

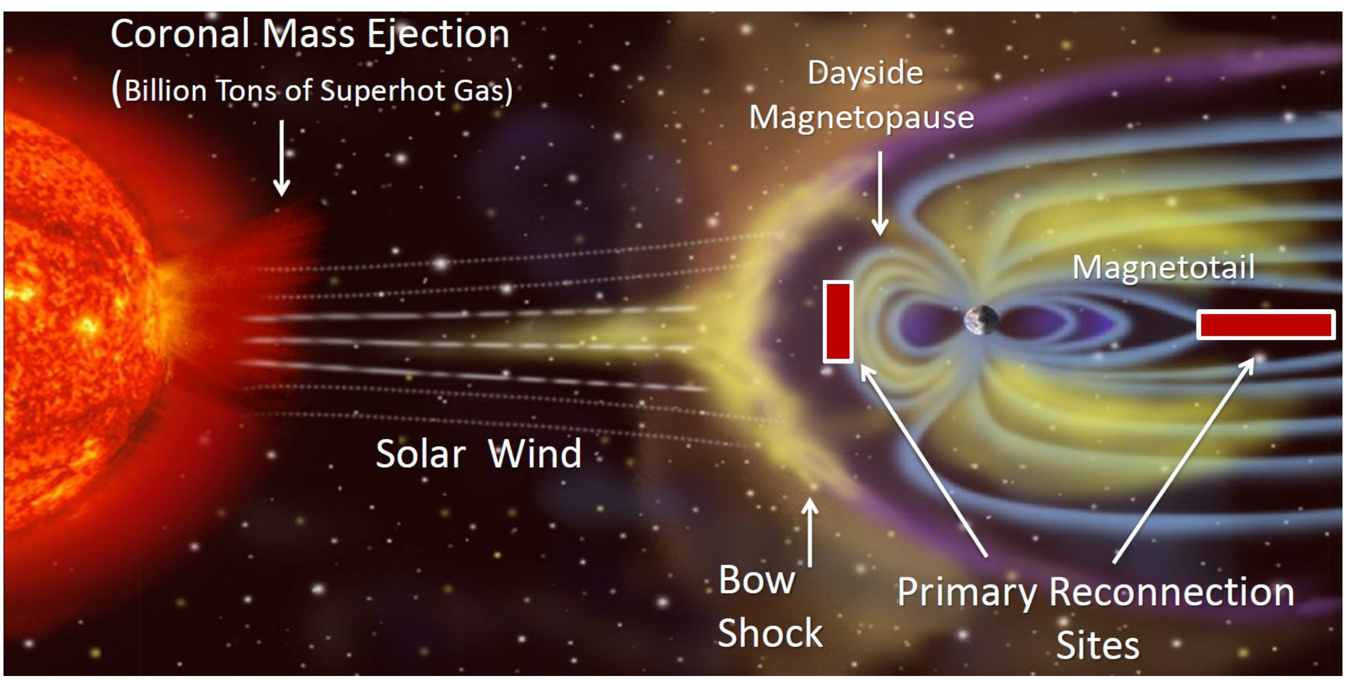


Figure 1: Interaction of the solar wind with the Earth's magnetosphere. Powerful storms on the Sun can release billions of tons of superhot gas containing charged particles that impinge on the magnetosphere. Magnetic reconnection breaks the Earth's protective magnetic shield, enabling some of these particles to penetrate and damage satellites, power grids, and radio communication. This process also gives rise to the familiar Aurora Borealis.

Magnetic Reconnection

In the face of this continual threat, there is an urgent need to develop accurate space weather forecasting capabilities. It takes 1 - 5 days for the energetic particles released during a solar storm to reach the Earth. This provides sufficient time to take preemptive measures (e.g., shutting down the power grid). However, there are currently no reliable forecasting models that can predict the severity of the effects and/or the location of the impact on Earth for a given solar storm. One key factor contributing to this poor performance is the lack of accurate descriptions of reconnection in the global magnetospheric models. The computational challenge is due to the extreme multi-scale nature of the reconnection process, spanning from the smallest electron scale dynamics to the size of the Earth's magnetosphere.

To improve our understanding of magnetic reconnection, the new Terrestrial Reconnection Experiment (TREX) is now implemented in the Wisconsin Plasmas Astrophysics Laboratory (WiPAL). In TREX reconnection is driven in a hot target plasma under controllable and reproducible conditions. The experimental setup is shown on the left of Figure 2, including the 3m diameter vacuum vessel, external Helmholtz coil and fast internal reconnection drive coils. When the internal drive is applied, a magnetic bubble expands rapidly away from the coils. On the inside of the coil the magnetic field of the bubble is oppositely directed compared to the externally imposed Helmholtz field, and at this interface a layer of intense electrical current develops. It is inside this current layer that the reconnection process occurs.

The measurements in Figure 2 right were obtained during the Fall 2015 term, and documents the evolution of the reconnection process as recorded over at 12 μs time interval. The colormap represents the magnitude of the electrical current density, whereas the overlaid contours are the measured lines of the magnetic force. In two of the panels the magnetic field lines inside the current layer form closed loops known as magnetic islands. These islands strongly modulate the rate of the reconnection process, and it is believed from theory that magnetic islands are fundamental for energization of electrons during reconnection events on the sun. Similar magnetic islands have been observed before in the laboratory, by spacecraft and in simulations. However, unique to the TREX measurements is a revelation that these islands are initiated at the smallest length scales characterizing the electron dynamics.

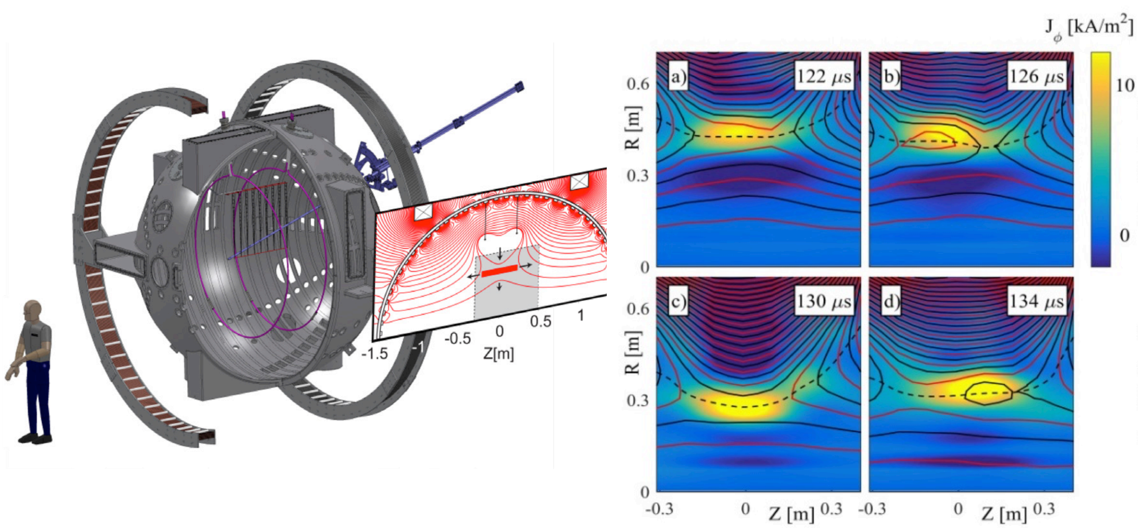
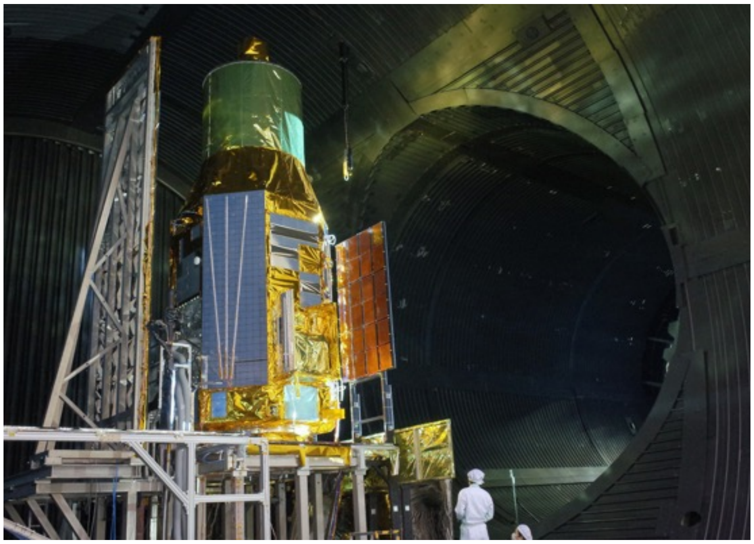


Figure 2 Left: Schematic of the Wisconsin Plasma Astrophysics Laboratory (WiPAL) experimental facility, where the TREX configuration is implemented by application of internal coils.
Figure 2 Right: Measured profiles of the out-of-plane electrical current. The black and red contours represent the magnetic lines of force, with closed loops documenting the formation of magnetic islands, strongly perturbing the reconnection process.

Based on the experimental results, students in Egedal's group are now conducting new kinetic simulations on the world's most powerful supercomputers. These simulations will help establish possible links between the experimental observations and spacecraft observations primarily from the Earth's magnetosphere.

Hitomi

By Dan McCammon



Completed spacecraft in the thermal-vacuum test chamber

The Japanese X-Ray observatory Astro-H (now christened *Hitomi*) was launched on February 17th, carrying a spectroscopic instrument with novel detectors developed in a long-standing collaboration between Wisconsin's X-ray group and the X-ray Astrophysics Laboratory at NASA's Goddard Space Flight Center. In contrast to conventional radiation detectors that measure the charge created by the absorption of a photon and use this to estimate the photon energy, the new microcalorimeter detectors measure the temperature rise of a detector element produced by a single photon. This sidesteps the statistical fluctuations inherent in the charge production process that limit the energy resolution of a theoretically perfect silicon solid state detector to about 120 eV FWHM (full-width at half-maximum) for 6 keV X-rays, and the 6x6 pixel imaging array on Hitomi achieves about 4.3 eV FWHM. The microcalorimeters are cooled to 1/20th of a degree above absolute zero by a combination of mechanical and magnetic refrigeration to achieve this sensitivity.

Since most information about astronomical sources is obtained by spectroscopy, this factor of 30 improvement in resolution promises real breakthroughs in understanding the growth of supermassive black holes, the way they form high-energy jets, and the kinematics of large clusters of galaxies. More than 80% of the normal matter in the Universe is so hot it can only be observed in X-rays, so there is a real possibility of many new discoveries. "First light" for the new instrument was a two-day observation of the Perseus cluster of galaxies. Like all such large clusters, Perseus is centered on a ball of 50-100 million degree gas with a mass many times larger than that of all the galaxies in the cluster put together. Studying the mass distribution of clusters would allow us to determine the evolution of Dark Energy over cosmic time scales, but first we must know if there is significant turbulence in the hot gas. This observation of Perseus is the first with sufficient spectral resolution to measure the velocity distribution of the hot gas through Doppler broadening of the emission lines from hydrogen-like iron ions.

Although microcalorimeter development has been going on for a long time, this is the first observation they have made from orbit. Up to now, the only astronomical X-ray data obtained with these detectors has been on a series of 5-minute sounding rocket flights by the Wisconsin group using a 50 mK refrigerator built in the department. These relatively inexpensive suborbital missions provide the opportunity to test new designs for the detectors, just enough time above the atmosphere to get some interesting and useful new data on hot interstellar gas in our galaxy, and lots of valuable hands-on experience with flight hardware for our graduate and undergraduate students. But long exposures with a large imaging telescope are needed to observe the most exciting targets, and astronomers around the world will soon be using our instrument Hitomi to do just that.

Meanwhile back in the department, we are working on detectors employing second-generation thermometers that use a sharp superconducting transition to make an exquisitely sensitive thermistor that can achieve 1 eV FWHM energy resolution. Then we'll build a new sounding rocket payload to try them out.

2015 Physics Awards Banquet

The 2015 Physics Physics Banquet & Awards Ceremony to honor the Department Award Recipients and Alumni Fellows was held on Friday, May 8, 2015 at the Fluno Center. We honored our award winners with a reception, dinner, and awards ceremony for the family and friends.

Undergraduate Awards

Fay Ajzenberg-Selove Award

Jennifer Witt

This award is presented to undergraduate women majoring in Physics, Astronomy, or Physics/Astronomy to encourage them to continue their careers in science. Dr. Ajzenberg-Selove, who received her Ph.D. in Physics in 1952, is currently a Professor Emerita the University of Pennsylvania.

Dr. Maritza Irene Stapanian Crabtree Award

Mackenzie Meyer

This fund was established by William Crabtree to honor his wife, Dr. Maritza Crabtree, who graduated with a Physics degree in 1971. This annual award benefits undergraduate students in physics based equally on merit and need.

Bernice Durand Undergraduate Research Scholarship

Mackenzie Meyer

This award was established by Emerita Physics Professor Bernice Durand to promote meaningful undergraduate research and to support and encourage women and ethnic minorities as undergraduate majors in Physics and Astronomy.

Hagengruber Undergraduate Support Fund

Joshua Cherek

The Fund was established by Roger Hagengruber (BS Physics 66; PhD Physics 72) in gratitude to the Department of Physics for providing opportunities to fund his education while in school and imparting the skills that led to a long; successful career in the field of physics.

L. R. Ingersoll Prize

Spring 2013–2014: Meichen Pan (103) | Alex Rokni (104) | Thejas Wesley (201) | Jonathon Gulliver (202) | William Maes (208) | Noah Johnson (248)

Fall 2014–2015: Vik Patel (103) | Eric Peloza (104)| Daniel Vigil (201) | Nicolaas Angenent-Mari (202) | Kari Fossum (207) | Victoria Cooley (208) | Tom Stone (247) | Idris Boukahil (249)

This prize is given for distinguished achievement in introductory physics. It is underwritten by a fund established by the family and friends of the late Professor Ingersoll, a distinguished physicist and teacher at the University who served as Department Chair for many years.


Thejas Wesley

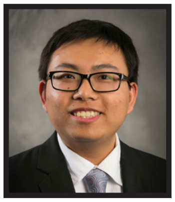

Eric Peloza


Kari Fossum


Victoria Cooley


Idris Boukahil

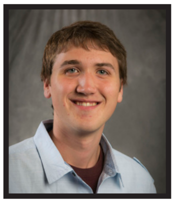
Liebenberg Family Research Scholarship



Ruifeng Xie

This scholarship is awarded is for Physics, AMEP, or Astronomy/ Physics majors. This scholarship opportunity was initiated by the Liebenberg family for the purpose of promoting undergraduate summer research opportunities.

Albert Augustus Radtke Scholarship Award



Luke Hartman

This scholarship is is given to outstanding junior or senior students majoring in Physics or Applied Mathematics Engineering and Physics. This award was made possible by a bequest of the late Mrs. Elizabeth S. Radtke in honor of her husband, a 1900 degree recipient from UW-Madison.

2015 Physics Awards Banquet

Graduate Awards

Carl and Brynn Anderson Graduate Physics Fund

Nick Brewer

This fund provides support for graduate student recruitment and retention, travel for study and research, materials for study or research; recognizing achievement in scholarship.

Joseph R. Dillinger Award for Teaching Excellence

Danny Crow

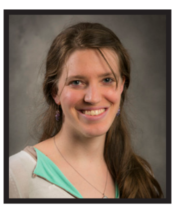
This Award for Teaching Excellence was made possible by the family of Joseph Dillinger in honor of their father. The award provides recognition to an outstanding teaching assistant in undergraduate-level Physics. Prof. Dillinger was a faculty member of the department with a special interest in improving undergraduate education.

Phyllis Jane Fleming Graduate Student Support Award

Stephanie Kubala

This Award is made possible through the generosity of Linda B. Miller and Dr. Phyllis Fleming. Dr. Fleming received her Ph.D. in 1955 under Professor Dillinger. This fund provides support for a female doctoral candidate in physics.

Elizabeth Hirschfelder Scholarship



Anna Korver

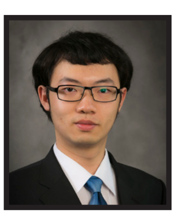
The Elizabeth Hirschfelder Fund for Graduate Women in Math, Chemistry and Physics was established 2001. Dr. Betty Hirschfelder received a Ph.D. in Chemistry in 1930 from the University of Wisconsin-Madison.

Allan M. and Arline B. Paul Physics Award

Todd Garon

The late Mrs. Arline Borer Paul (1914-2012) created this endowment fund, for graduate scholarships in memory of Walter Max Borer. Walter was Arline's brother and received an MS degree in 1937

Emanuel R. Piore Award



Ruiyang Feng (Fall 2014)

Adrian Fraser (Spring 2015)

The award is made possible through the generosity of the Piore family. It is awarded to the graduate student with the highest score on the qualifier examination.

Van Vleck Award

Tyler Ruggles

This Award is used to support graduate students in physics.

Department TA Awards

Best Teaching Assistant


Richard Sayanagi


Cameron King


Joe Olson

Richard Sayanagi (Spring 2014)

Cameron King (Fall 2014)

Joe Olson (Spring 2013)

Rookie of the Year

No photo available

Andrew Hard

Alumni Awards

Distinguished Alumni, Distinguished Scientist, & Distinguished Service Awards


Mark Devlin


Mark Pederson


Tim Stelzer

Mark Devlin

Mark Pederson

Tim Stelzer

UW Physics Degrees Awarded

Undergraduate Degrees

Fall 2014
Bollom,Patrick
Challe,Christopher
Hansen,Maxwell
Siewert,Jordan
Snell,Joseph

Spring 2015
Aiello, Maxwell
Almousa, Ayah
Bennett, Clayton
Binti Mohsin, Saniah
Birenbaum, Adam
Blonsky, Adam
Clinton, Madeline
Cyr, Patrick
Duban, Steven
Favill, Evan
Giesenschlag, Kyle
Haugstad, Alexander
Hoppe, Kelly
Horvat, William
Joers, Amanda M
Lu, Xinyang
Melcher, Brandon
Reierson, Kellan
Rosseter, Cailean
Schlenker, Francisco
Simanjuntak, Paul
Stemo, Aaron
Sturdevant, Stephen
Swinkels, Brian
Taylor, Stephen
Vanasse, Thomas
Wahl, Carl
Yan, Chunling
Ziesemer, Mitch

Summer 2015
Lu, Wing

Fall 2015
Bohling, Brandon
Christenson, Anna
Frickelton, Michael
Wu, Tianyao
You, Tae Yang

Doctoral Degrees

Fall 2014

Carmody, Daniel | Advisor: Terry | Thesis: Microinstabilities and turbulent transport in the reversed field pinch | Employment: Science Instructor at Astrocamp

Dally, Adam | Advisor: Karle | Thesis: Towards a precise energy calibration of the CUORE double beta decay experiment | Employment: Honeywell

Fei, Jianjia | Advisor: Joynt | Thesis: Theoretical issues in quantum computation : spin bus, exchange only qubit and separability probability | Employment: Research Scientist at Goral Trading Company, LLC

Feintzeig, Jacob | Advisor: Karle | Thesis: Searches for point-like sources of astrophysical neutrinos with the IceCube Neutrino Observatory | Employment: Post-Doc at Berkeley Lab

Gladstone, Laura | Advisor: Karle | Thesis: A study of atmospheric neutrino oscillation using the IceCube DeepCore detector | Employment: Post-doc MIT

Mohr, Robert | Advisor: Eriksson | Thesis: Fabrication and measurement of devices in Si/SiGe nanomembranes | Employment: Engineer Western Digital

Parke,Eli | Advisor: DenHartog | Thesis: Diagnosis of equilibrium magnetic profiles, current transport, and internal structures in a reversed-field pinch using electron temperature fluctuations | Employment: Post-doc UCLA

Parker, William | Advisor: Herndon | Thesis: Search for the Higgs boson decaying to W+W- with associated jets and measurement of the W+W- production cross section and differential cross sections with jets in ppbar collisions at square root s = 1.96 TeV | Employment: Post-doc Maryland

Riedel, Benedikt | Advisor: Halzen | Thesis: Modeling and understanding supernova signals in the IceCube Neutrino Observatory | Employment: Post-doc University of Alberta

Van Santen,Jakob | Advisor: Karle | Thesis: Neutrino interactions in IceCube above 1 TeV : constraints on atmospheric charmed-meson production and investigation of the astrophysical neutrino flux with 2 years of IceCube data taken 2010--2012 | Employment: Post-doc DESY

UW Physics Degrees Awarded

Doctoral Degrees

Spring 2015

Choi, Eunsong | Advisor: Perkins | Thesis: Computer simulations and theoretical studies of complex systems : from complex fluids to frustrated magnets | Employment: Financial Software Developer at Bloomberg LP

Cosgriff, Margaret | Advisor: Evans | Thesis: Electric field response of strained BiFeO3 and BaTiO3/CaTiO3 superlattices | Employment: Higher Education Professional

Fiorino, Daniel | Advisor: Westerhoff | Thesis: Observation of TeV-energy cosmic-ray anisotropy with the HAWC observatory | Employment: Post-doc UW Madison

Maller, Kara | Advisor: Saffman | Thesis: Single- and two-qubit operations on an atomic qubit array | Employment: Post-doc Georgia Institute of Technology

Morgan, Kelsey | Advisor: McCammon | Thesis: Transition-edge sensor microcalorimeters for a diffuse soft X-ray sounding rocket mission | Employment: Post-doc NIST

Schroeder, Daniel | Advisor: Eriksson | Thesis: Thermal resistance of interfaces created by mechanical transfer of silicon nanomembranes | Employment: Intel

Weaver, Christopher | Advisor: Karle | Thesis: Evidence for astrophysical muon neutrinos from the northern sky | Employment: Post-doc University of Alberta

Wu, Xian | Advisor: Eriksson | Thesis: Singlet-triplet electron spin qubit in Si/SiGe double quantum dot | Employment: Post-doc NIST

Summer 2015

Brookhart, Matthew | Advisor: Forest | Thesis: Subcritical onset of plasma fluctuations and magnetic self-organization in a line-tied screw pinch | Employment: Intel

Cook, Carson | Advisor: Hegna | Thesis: Shear Alfvén continua and discrete modes in the presence of a magnetic island | Employment: Associate at McKinsey & Company

Hubbard,Antonia | Advisor: Karle | Thesis: Muon-induced backgrounds in the DM-Ice17 NaI(TI) dark matter detector | Employment: Post-doc Northwestern University

Lichtman, Martin | Advisor: Saffman | Thesis: Coherent operations, entanglement, and progress toward quantum search in a large 2D array of neutral atom qubits | Employment: Post-doc University of Maryland

Miles, Jared | Advisor: Yavuz | Thesis: Localization of atomic excitation beyond the diffraction limit using electromagnetically induced transparency | Employment: Wright Patterson Air Force Base

Pettus,Walter | Advisor: Halzen | Thesis: Cosmogenic activation in NaI detectors for dark matter searches | Employment: Post-doc Yale University

Simmons,Zachary | Advisor: Yavuz | Thesis: Progress toward a negative refractive index in an atomic system : spectroscopy and simulations of a rare-earth doped crystal | Employment: Post-doc UW-Madison

Wang, Yuxuan | Advisor: Chubukov | Thesis: Charge-density-wave and pair-density-wave orders in underdoped cuprates | Employment: Post-doc University of Illinois

Xu, Canran | Advisor: Vavilov | Thesis: Topcs in quantum dynamics of solid state qubits | Employment: Post-doc University of Hong Kong

Ye,Fang | Advisor: Shiu | Thesis: A study of beyond standard model scenarios from string compactifications| Employment: Post-doc North Central University Taiwan

Yoast-Hull, Tova | Advisor: Zweibel | Thesis: Cosmic ray interactions in starbursting galaxies | Employment: Post-doc UW-Madison

Zhdankin,Vladimir | Advisor: Boldyrev | Thesis: Intermittency of energy dissipation in magnetohydrodynamic turbulence | Employment: Post-doc University of Colorado Boulder

2015 Fall Admissions

Aman Abhishek
Indian Institute of Technology Roorkee
Bai - Phenomenology Dylan

Dylan Adams
Colorado State University
Smith - High Energy Experiment

Phan Ahn
Knox College
Shiu - String Theory

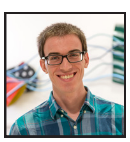
Kevin Baker
University of Chicago
Saffman - Quantum Computing

Edward Basso
Rice University
Everett - High Energy Theory

Weng-Him Cheung
Williams College
Chung - String Theory

Alexander Cole
Pomona College
Shiu - String Theory

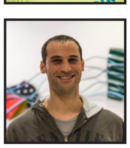
John Dodson
University of California Santa Barbara
Eriksson - Condensed Matter Experiment



Benjamin Fasig
Purdue University
Dasu - High Energy Experiment

Jiarui "Jerry" Gong
Peking University
Rzchowski - Condensed Matter Experiment

Nathan Holman
Creighton University
Eriksson/McDermott - Condensed Matter Experiment



Shay Inbar
Ben Gurion University of the Negev
Bai - Phenomenology

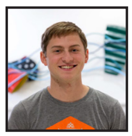
no photo available

Gabriel Jaffe
University of Texas at Austin
Eriksson - Condensed Matter Experiment

Alex Loving
James Madison University
Carlsmith - High Energy Experiment

Deepak Mallubhotla
Illinois Wesleyan University
Friesen - Condensed Matter Theory

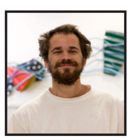
Sarah Mancina
University of Chicago
Karle - Astroparticle



Thomas McJunkin
Ohio State University
Eriksson - Condensed Matter Experiment

Mitch McNanna
Univesrity of Notre Dame
Hashimoto - String Theory

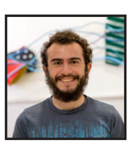
Rachel Myers
Princeton Univeristy
Egedal - Plasma Experiment



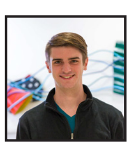
Alexander Opremcak
University of Hawaii
McDermott - Condensed Matter Experiment

Baris Ozguler
Koc University
Shiu - String Theory

Will Ruchotzke
Ohio State University
Eriksson - Condensed Matter Experiment



Alexander Scherer
Illinois Wesleyan Univ.
McCammon - Astrophysics



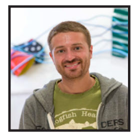
Austin Schneider
Texas A&M University
Smith - High Energy Experiment

Susan Sorensen
Brigham Young University
Eom - Condensed Matter Experiment

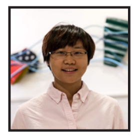
no photo available

Blake Wetherton
Purdue University
Egedal - Plasma Experiment

Colin Whisler
Texas A&M University
Chung - High Energy Theory



Miles Winter
Illinois Institute of Technology
Terry - Plasma Theory



Zhaoning Yu
Univ. of Science & Technology of China
Eriksson - Condensed Matter Experiment

Support Physics via the UW Foundation

Undergraduate

132691618. Fay Ajzenberg-Selove Undergraduate Scholarship provides encouragement for undergraduate women majoring in Physics, Astronomy or Physics-Astronomy to continue their careers in science.

132693412. Dr. Maritza Irene Stapanian Crabtree Undergraduate Scholarship provides assistance to undergraduate students based on merit and need.

132693561. Bernice Durand Research Scholarship promotes meaningful undergraduate research opportunities, plus supports and encourages women and ethnic minorities as undergraduate majors in the Departments of Physics and Astronomy.

132693645. Henry & Eleanor Firminhac Scholarship provides assistance to students in Physics with financial need. (Undergraduate or Graduate)

132692683. Liebenberg Family Research Scholarship supports Physics, AMEP or Astronomy-Physics majors in summer research experiences.

132697989. Hagengruber Fund provides assistance to undergraduate physics students who are Wisconsin residents with financial need; and who show exceptional promise for a future in physics or a related field.

112697824. Physics Board of Visitors Undergraduate Research Fund provides funding for awards that will assist directed study projects in pure and applied physics; multidisciplinary projects linking physics to such fields as biology; engineering; business; and creative expression; and participation in related conferences.

Graduate

132697960. Allan M. and Arline B. Paul Physics Fund provides support to graduate students in memory of Walter Max Borer (MS 1937).

132697988. Carl and Brynn Anderson Graduate Physics Fund provides support for graduate student recruitment and retention, travel for study and research, materials for study or research; recognizing achievement in scholarship.

132697201. Casey M. Durandet Graduate Fund provides support, in memory of Albert R. Erwin, Jr., to graduate students working in experimental high energy physics.

132692082. Cornelius P. & Cynthia C. Browne Endowed Fellowship Fund provides support to graduate students pursuing doctoral studies in the Physics Department.

132693190. Elizabeth S. Hirschfelder Endowment supports women graduate students in Physics research.

132691960. Jeff & Lily Chen Wisconsin Distinguished Graduate Fellowship provides a full year fellowship to an outstanding graduate student in the department.

132691359. Joseph R. Dillinger Teaching Award Fund provides recognition to an outstanding teaching assistant in the Department of Physics.

132693916. Karl & Alice Knapp Jansky Fellowship Fund provides alternate year funding to an outstanding graduate student in Physics and Astronomy.

132696175. Phyllis Jane Fleming Graduate Student Support Fund provides support for a female doctoral candidate in any year of training in physics.

112698294. Physics Alumni Graduate Award Fund provides support to incoming graduate students who hold Teaching Assistant appointments in the department.

132695150. E. R. Piore Award provides support to the recipients of the highest qualifying exam scores each semester.

132692106. Graduate Student Recruiting provides assistance in recruitment expenses of Physics graduate students.

132691808 and 132692368. Ray & Anne Herb Wisconsin Distinguished Graduate Fellowships provides a full year fellowship to one or two outstanding graduate students engaged in materials research in the department.

132697430. Robertson Leach Graduate Student Fund provides support for incoming, first year graduate students in the department.

112696443. L. Wilmer Anderson & Dave Huber Graduate Support Fund provides a number of awards to new graduate students entering the department. This award is in honor of Profs. L. Wilmer Anderson and David Huber.

132695370. Van Vleck Fellowship Fund in Physics provides support to graduate students in the department.

Research

132694421. Barschall Enterprise Fund was established in 2005 in honor of former Professor Heinz Barschall. Provides unrestricted-use fund for Chair in recruiting senior researchers to faculty.

132906418. David Grainger Physics Library Fund provides funding for the acquisition of books and other materials related to physics.

132694069. Friends of the Physics L. R. Ingersoll Museum provides funding for museum display upgrades and student docents.

112694622. Physics Community-Building Fund provides funding for Chair in establishing and reaffirming a sense of community among the faculty, staff, students, and alumni of the Department.

112698078. Wonders of Physics Outreach Fund provides support for the continuation of the Wonders of Physics annual shows as well as the grade school show program.

132692106. Atomic Collision Research Fund encourages and supports research on atomic collision processes and their application to studies of weakly ionized gases in perpetuity.

112691418. Elementary Particle Physics Institute provides funding for activities of the institute.

132690387. L. R. Ingersoll Fund provides support for colloquia and seminars in the department.

132691720. Physics Newton Fund is a general, unrestricted fund administered by the Department Chair. The purpose of this fund is to aid the Department of Physics in its research, teaching and public service roles.

132697999. Quantum Computing Research Center Fund provides support for research in quantum computing in the physics department.

112696250. Thomas G. Rosenmeyer Cosmology Fund provides support for the Prof. Peter Timbie research group in its teaching, research, and public service roles.

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For a description of all UW Foundation Physics Funds, go to:http://www.physics.wisc.edu/donate/funds

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☐ Physics Newton Fund (#1269172)—An unrestricted general fund—greatest need.

☐ Undergraduate Support—General (#1269172)
To provide for undergraduate student special needs.

☐ Undergraduate Support—Specific
Indicate fund name and number below.
Select from list of "undergraduate" funds on previous page.

Fund Name: _____________________________________ Fund Number: ____________

☐ Graduate Support—General (#1269172)
To provide for graduate student special needs.

☐ Graduate Support—Specific
Indicate fund name and number below.
Select from list of "graduate" funds on previous page.

Fund Name: _____________________________________ Fund Number: ____________

☐ Research
Indicate fund name and number below. Select from list of "Research" funds on previous page.

Fund Name: _____________________________________ Fund Number: ____________

Should you prefer to make your donation electronically by credit card on a secure server, please go to: http://www.physics.wisc.edu/donate/funds. Click on the fund in which you are interested for information and then complete the UW Foundation secure site form.

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University of Wisconsin Department of Physics