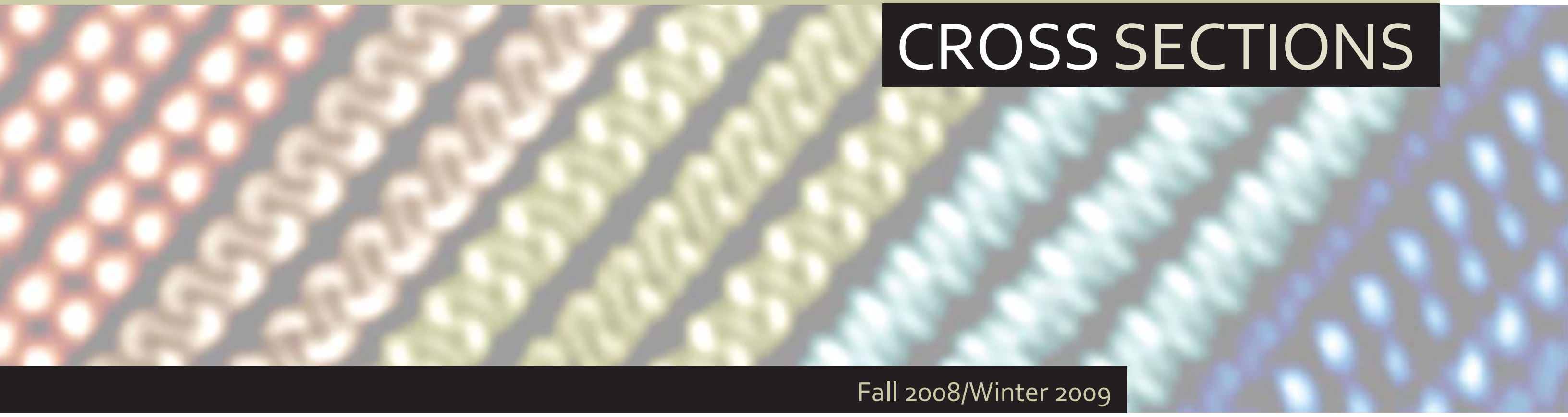
THE NEWSLETTER OF THE UNIVERSITY OF TENNESSEE DEPARTMENT OF PHYSICS AND ASTRONOMY

CROSS SECTIONS



Fall 2008/Winter 2009

Flightpath 13: Home of Frosty Neutrons

Flightpath 13 may not be the most enchanting name, but for scientists like Geoff Greene the beauty is in the science it makes possible. When the shutter opened on this Spallation Neutron Source (SNS) beamline in late September, so too did new prospects for understanding the life, decay, and characteristics of the neutron. In the process, the Fundamental Neutron Physics Beamline (FNPB) can help answer questions about how elementary particles interact, what was going on in the Big Bang, and why the universe is left-handed.

Research Highlight

Greene, a professor of physics with a joint appointment at Oak Ridge National Laboratory (ORNL), leads the effort on the FNPB. The official project began in 2004 and is one of several experiments using beams provided by the SNS. At the SNS a beam of protons hits a mercury target, sending neutrons down a long hall where they are directed off to different beamlines. Researchers will use those neutrons for studies in chemistry, superconductivity, polymer science, and structural biology, among other fields. The FNPB is unique in that the investigations on this line aren't about using the neutron as a tool, but instead understanding it in its own right.

"We are studying the neutron rather than using the neutron to study materials, which is what everybody else at the SNS does," Greene said.

The scientific goals for the FNPB are three-fold: to understand beta decay, study parity violation, and search for the neutron electric dipole moment.

Beta decay, as Greene described it, is "the archetype of all radioactive decays; every beta radioactive decay that one sees is actually the neutron decaying inside that nucleus. Studying it in its pristine form allows one to see nuclear decay without the complexities of nuclear structure."

Researchers like Greene are interested in this process because it's such a fundamental part of why the universe works the way it does.

"For example, the main energy-producing process in the sun, proton-proton fusion, is actually the same mechanism by which a neutron decays," he said. "Studying neutron decay tells us how bright the sun should be; it also ties into how many neutrinos should come out of the sun, which is a hot topic. Similarly, neutron decay was very important during the first few minutes of the Big Bang (when) the essential balance of light elements was established."

Another mystery of the Big Bang—why our universe is left-handed—has to do with parity violation, the second research prong of the FNPB. In physics, parity is all about mirror images. A right-handed system, for example, has a mirror image with identical properties save one exception; the image is left-handed. A particle spinning clockwise would have a mirror image that spins counter-clockwise. Parity conservation says the mirror images obey the same laws of physics as the originals, with no distinction between right and left. This principle holds true in strong or electromagnetic reactions, but for reasons that are not fully clear, parity is violated in weak interactions.

Greene explained that if you could recreate the Big Bang a few dozen times, about half the time you'd expect to get a right-handed universe and half the time you'd get a left-handed universe. The interesting question is whether left and right are equally probable. Of course, such an experiment would be problematic on several levels, he said, "so what we're trying to do is look very, very carefully at the parity violation in beta decay to see if there's a little leftover right-handedness from the time of the Big Bang when there were, presumably, equal amounts of right and left."

He provided an example (originally suggested by Nobel Laureate Abdus Salaam) of dinner guests seated at a round table with a water glass between each place setting. Once the

Continued on page 3

Tough Times

Soren Sorensen, Department Head

These are tough times. The stock market has plummeted, stores and factories are closing, and many people are losing their jobs. Here in Tennessee the tax revenues have been decreasing for the past 12 months and will probably continue to do so for some time to come. As a direct consequence of these decreasing revenues, state funding for the University of Tennessee was cut by 5% for this fiscal year, and during the recent budget hearings in Nashville Governor Bredesen predicted budget cuts for higher education at the 10-15% level for the next fiscal year.

So how do these budget cuts influence our department? Profoundly! We now have 25.5 FTE (Full Time Equivalent) faculty members in our department. This is two less than just a year ago, since we lost two positions as a result of the budget cuts in June. We have to go all the way back to around 1960 to find fewer faculty members in our department. We have partly compensated for this loss in FTEs by having more Joint Faculty positions with ORNL, so the 25.5 FTE correspond to 33 actual living beings!

Our department used to have a large group of lecturers and adjunct teaching staff, who would be responsible for many of our large service courses and general education courses. Over the past several years we have lost many of them and have not had any funds to replace them, so we are now down to only 3 lecturers. This has placed a strong teaching responsibility on our faculty and they have responded extremely well. Our physics faculty is now teaching more student credit hours than any other department at the university, because our faculty members have been willing and have had the skills to teach general education astronomy and physics for biologists, engineers, and architects. In many other departments the students do not meet a real professor before classes at the 200 or 300 level!

This high efficiency, however, is coming at a cost. There is no more "slack" in the system in the form of professors who can teach more courses. If we have to implement additional budget cuts, we will have to cancel classes. This will result in much higher student dissatisfaction and, more importantly, longer graduation times for our majors, since many students will not be able to schedule 15 credit hours each semester.

We have also had to reduce our staff in the department. We are now operating our Electronics Workshop with only two people instead of three, and our Mechanical Workshop will now be run by only four people after the untimely death of our workshop supervisor, Jodie Millward, since we do not have any funds to replace his position. Our administrative and financial staff now consists of only five people, who manage to run a "business" with approximately 200 employees.

We are not the only department or university facing tough times. The trend all over our nation has been that state universities get less and less support from public funds. At some universities like Washington and Virginia the state support is now less than 10% of the total revenue. I expect that the University of Tennessee will be following the same trend, so even when the financial situation for the state of Tennessee hopefully gets better in a few years, I do not expect we will be able to fully recover what is now being lost.

The problem is being enhanced by the state control of tuition. Private universities have been able to increase tuition to unprecedented levels over the last decade, but UT will not be allowed substantial tuition increases, even if most of our students now are covered by the HOPE scholarship funded by the state lottery.

However, in all this doom and gloom there is one bright spot. Here in the department we have been blessed by wonderful alumni and donors, who over the past 8 years have increased our endowment from $100,000 to nearly $2,000,000. This has enabled us to provide scholarships and support for many of our students at both the undergraduate and graduate level. Increasingly we will have to offset the diminishing state support by relying on the proceeds from our endowment to provide a meaningful educational experience for our students. Many of our donors have graciously made the stipulations of their donations very broad, which has enabled us to use the funds to support a range of activities that used to be state supported: research participation for undergraduate students during the summer semester, support for students on foreign exchange programs, support for equipment used by students in our educational labs, and even in a few cases for research equipment benefitting our graduate students (and their advisors!).

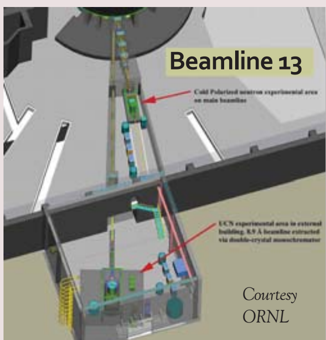
We will also increasingly be using our endowment proceeds as payment/scholarships for our junior and senior physics majors, when they work in our tutoring center. This tutoring center has been a great success and we need to expand that service. Every day many students in the lower-division physics courses come here to get help with homework and help with understanding difficult concepts in physics (like the difference between centripetal and centrifugal acceleration). We would also like to expand this valuable service to cover our astronomy courses.

In the future, it is also my hope that we will be able to cover other activities through our endowment. We have a wonderful astronomy outreach program that we would like to grow by having a planetarium in the high-bay room Nielsen 108. We would also like to grow our physics outreach program, so more of the middle- and high-school children (and their parents) in Tennessee will be excited about physics and might choose a career in our field or at least in science or technology. In the past I had hopes of having a physics outreach coordinator funded by university funds, but as explained above we cannot anymore count on state support for this. So this would be another great donation opportunity.

It is my hope that our alumni and friends will be able to help us to keep this high level of our educational efforts. I will be delighted to speak with you if you wish to obtain more information about the current situation in the department or if you want to explore if there are options for you to support a particular aspect of our efforts that you feel is important. My phone number is (865) 974 7805 and my e-mail address is: sorensen@utk.edu.

Many wonderful people have worked hard in the past to bring our department to its current level. We are determined to avoid being the generation of professors and staff who will let the current financial crisis and the steady erosion of state support result in a weaker department. But we cannot do it alone. We need your help.

Frosty Neutrons, continued from page 1



Courtesy ORNL

first person reaches for a glass (be it on the left or right) all the others will follow suit.

"That's what's known as spontaneous symmetry breaking," he said. "We suspect that's why the universe is left-handed."

The third of the FNPB goals, searching for the neutron electric dipole moment (EDM), also deals with the Big Bang and another symmetry violation.

"As best we can tell, interactions in matter and anti-matter are much the same," Greene explained. "Yet we know that all the stuff in the universe is matter. There's no antimatter, except perhaps what is made at Fermilab, CERN and occasionally in cosmic rays. Most theories of cosmology suggest that at the very beginning, in the earliest moments of the Big Bang, there were equal amounts of matter and anti-matter."

However, as he explained, if the two are present in equal amounts, eventually every piece of matter would find a piece of anti-matter and they would annihilate each other, so we'd end up with a universe that had nothing in it.

"It appears that what we see is the remnant of a tiny, tiny imbalance between matter and antimatter," Greene said. "That in fact, there were almost equal amounts of matter and anti-matter but something in the first microsecond of the universe led to a little bit of a symmetry-breaking behavior."

Determining what produced the matter/anti-matter imbalance requires a process that mimics the Big Bang. Such a process, Greene said, would also generate a neutron electric dipole moment, which predicts that the positive and negative charges within a neutron are slightly displaced with respect one another.

"If we see a neutron electric dipole moment; that confirms this theory," he said. "If we don't, then we'll just have to look more carefully."

Frosty Bottles of Neutrons

To get to the bottom of these questions requires an awful lot of neutrons. The SNS first began generating neutrons in April 2006. The FNPB team has been working on construction of guides, choppers, and other equipment to safely and efficiently conduct the neutrons down Flightpath 13 to their experimental area. That work came to fruition on September 29 when they opened the shutter and started receiving neutrons.

"We now have a beam of neutrons and we're in a position to install experiments and start doing science," Greene said.

The FNPB has two lines, an "ultra-cold" neutron beam and a cold neutron beam. The first will be allocated to electric dipole moment experiments, with the second reserved for beta decay and parity violation investigations. Having two beams allows researchers to run two sets of experiments simultaneously.

Greene explained that typically a neutron bouncing off a target like that at the SNS would fly through a piece of apparatus in about a millisecond. Cooling neutrons to "ultra-cold status" slows them to a rate of a few meters per second, drastically improving the sensitivity of the experiment. By confining neutrons in bottles filled with super-fluid helium, researchers can actually observe them for a few hundred seconds. With the cold beam, the neutrons will have a much shorter stay in the apparatus, but at any given time there will be thousands neutrons per cubic centimeter available for observation. Two of Greene's current students will do their thesis work on the FNPB.

Greene has been a fixture on the neutron scene, having chased these particles for 25 years at Los Alamos National Laboratory, the National Institute of Standards and Technology, and the Institut Laue Langevin in Grenoble, France.

"I seem to have worked at essentially all the facilities that do this kind of physics with neutrons," he said. "It's a relatively small community and we all know each other. We're friendly competitors. These experiments take years, and everybody has their own particular approach. And we depend upon one another."

Dai Named JIAM Chair of Excellence

Professor Pengcheng Dai's many contributions to superconductivity have earned him a Chair of Excellence. In a special colloquium on September 17, Dai was named a Joint Institute for Advanced Materials (JIAM) Chair of Excellence "for his pioneering work in elucidating the origin of the novel functionality in correlated electron materials using neutron scattering," as the citation read. Distinguished Professor Ward Plummer made the presentation and pointed out that UT Knoxville is not the only place where Dai's work has been appreciated; his most-cited paper has been referenced 243 times and this year alone he has had 15 papers published. Plummer said he was confident of even greater achievements in the future.

"I expect unbelievable success," he said.

Dai's talk, entitled "Strike While the Iron is Hot," explained some of the history behind and latest discoveries in superconductivity, an area where much of his research is focused. Discovered nearly 100 years ago, superconductivity is the phenomenon where electrons form pairs to carry electric current with no resistance. Early superconductors, however, only worked at temperatures far too low to be practical.

By the mid-1980s, scientists had discovered that compounds made of copper and oxygen (termed "cuprates") could become superconductors at much higher transition temperatures (Tc), although they were still far below room temperature. Complicating matters was that no one knows exactly what causes electron pairing in these materials. In conventional superconductors, electrons and phonons interact, causing the electrons to pair up. With the so-called High-Tc superconductors, researchers have differing ideas about the origins of electron pairing. Some accredit it to the presence of copper, while others, like Dai, propose that magnetism is the key factor. A recent development in the superconductivity story might provide some answers.

Pengcheng Dai sees a new class of iron-arsenic superconductors as "a new playground" for condensed matter physicists.

This past spring, scientists in Japan serendipitously put together iron and arsenic and in the process created a new class of superconducting materials. Dai and his research group have been working with the new compounds since May and are encouraged by the results. They published a paper in *Nature* where they showed how doping iron-arsenic compounds can suppress static magnetism and usher in superconductivity—the same approach that works in cuprates, only without the copper. Another paper in the October 26 issue of *Nature Materials* showed remarkable similarities between the electronic phase diagram of an iron-arsenic compound and that of cuprates.

Dai said that for 20 years, scientists have been "beating their heads again the cuprates," as understanding how they work has eluded definitive explanation and getting higher transition temperatures to make them practical has stalled. He said the new class of iron-arsenic superconductors represents "a new playground."

He is optimistic that the more that is understood about superconductivity, the better the chances are that one day scientists can actually design materials for specific purposes—including solving energy problems. Up to now, he said, "most superconductors are discovered by experimentalists doing something else."

While the cuprates have been around for two decades, the new iron-arsenic compounds are only a few months old and consequently require much more study. However, comparing them with their copper-based predecessors will, scientists hope, take some of the mystery out of what makes superconductors work. This is exactly the sort of work championed by the Joint Institute for Advanced Materials, a University of Tennessee-Oak Ridge National Laboratory (ORNL) partnership that capitalizes on the considerable strengths of both institutions in areas like nanophase materials, high-performance computing, and—Dai's expertise—neutron scattering.

Dai earned a bachelor's degree in physics from Zhengzhou University and went on to complete the Ph.D. at the University of Missouri. He was a postdoc and staff member at ORNL before joining the physics faculty in 2001. In 2003 he was recognized as an outstanding young researcher by the Overseas Chinese Physics Association and this past spring he was honored with a Chancellor's Award for Research and Creative Achievement in recognition of his contributions to the understanding of high-temperature superconductors.

This fall Dai was also named a Fellow of the American Physical Society "for his contribution to understand fundamental properties of magnetic excitations in high-transition temperature superconductors, f-electron heavy Fermions, and colossal magneto-resistance manganites."

As a new JIAM Chair of Excellence, he joins fellow Physics Professor Hanno Weitering and Civil and Environmental Engineering Professor Dayakar Penumadu, both of whom were named JIAM Chairs in 2006.

For more information on the Joint Institute for Advanced Materials, visit www.phys.utk.edu/taml/jiam/.

An Award-Winning Collaboration Works across the Nuclear Landscape

If no one had ever been curious about what makes a nucleus work, there would be no MRIs, no nuclear energy programs, and no detailed understanding of how stars are born and die. Fortunately, the engine of matter has both charmed and challenged scientists for decades, and recent work involving UT Knoxville physicists can help make the properties of the nucleus—its size, its shape, the energy that holds its together—a bit more easy to predict.

The collaborative team of Gaute Hagen, Thomas Papenbrock, David Dean, and Morten Hjorth-Jensen has moved a little farther across the chart of the nuclides, the map that arranges nuclei from light to heavy. Over the past decade, scientists have been able to compute the properties of the lighter nuclei, up to the carbon isotope 12C or so, starting from first principles—the established laws of physics.

But beyond nuclei with relatively few protons and neutrons, it has been frustrating to make calculations across the chart because the systems become much heavier. Added nucleons mean more and more interactions and configurations, and make nuclei increasingly difficult to compute—an obstacle scientists call the many-body problem. It's the equivalent of taking every high school soccer team in Tennessee and putting together as many player combinations as possible with a complete dossier on each combination's strengths, bonds, temperaments, and probabilities. Expanding that data set to include every team in the Southeast, then the United States, and so on, is much like the increasing number of protons and neutrons across the nuclear chart. It takes a massive amount of computer power and time to sort out all the possibilities.

There are promising techniques to describe nuclei from first principles that consider the forces between their protons and neutrons. Effective field theory (EFT), for example, provides a framework for understanding nuclei in terms of quantum chromodynamics, the theory of strong interactions. Unfortunately, the dominant methods employed in first-principle calculations have not scaled favorably with increasing mass numbers and cannot easily reach beyond the region of light nuclei.

To move into the territory of medium-mass nuclei, researchers from UT Knoxville, Oak Ridge National Laboratory, and the University of Oslo decided to use coupled-cluster theory. First developed in the 1950s, coupled-cluster theory is a numerical technique that solves many-body problems. Among its advantages is that it has a low computational cost and that it is size extensive, meaning it's scalable across the chart of nuclides. The theory is also microscopic, taking into account individual nucleons rather than simply the nucleus as a whole. And it is a method well-suited for working with doubly-magic nuclei, those having both protons and neutrons in so-called "magic numbers" (2, 8, 20, 28, 50, 82, 126), which are particularly stable.

Using this approach, the team computed the binding energies, radii, and density for doubly-magic isotopes of helium, oxygen, calcium, and nickel. They reported their findings in "Medium-Mass Nuclei from Chiral Nucleon-Nucleon Interactions," published in *Physical Review Letters* in late August. The group's most recent computations show that inter-nucleon forces can account for up to 90 percent of the binding energy in nuclei, a first look at what role EFT-based forces play in holding a nucleus together.

David Dean (top photo) and Thomas Papenbrock were part of the research group honored by Oak Ridge National Laboratory for their work using coupled-cluster theory to describe medium-mass nuclei.

For their efforts, Oak Ridge National Laboratory honored the group at its annual Awards Night on November 14. They were recognized in the Scientific Research category "for their development and implementation of coupled-cluster theory for medium mass and neutron-rich nuclei." Papenbrock is an assistant professor of physics at UT Knoxville who holds a joint appointment with the ORNL Physics Division. Dean and Haute are both with the ORNL Physics Division, and Dean is an adjunct associate professor with the physics department. Hjorth-Jensen is with the University of Oslo Department of Physics and Center of Mathematics for Applications. Further recognition of this work came when Papenbrock was named the university's Scholar of the Week for December 1-6.

Also honored at the ORNL Awards Night ceremony was David J. Singh, who was recognized as a Distinguished Scientist "for outstanding scientific impact on condensed matter physics through development of effective theoretical approaches and the application to key problems associated with novel and complex materials for basic science as well as technical advances." Singh is with the ORNL Materials Science and Technology Division and is an adjunct professor of physics at UT Knoxville.

Going *Ultrasonic*

John Cantrell's scientific journey began in the seventh grade with a famous equation and a profound curiosity. In the years since, what started with a kid's wonder at $E=mc^2$ has taken him down a road where his ideas and ingenuity have helped make aircraft safer and medical testing less invasive. It's a pilgrimage where both the storied halls of Cambridge and—oddly enough—chicken legs from a Knoxville grocery store had roles to play, and one he cheerfully recounted on a late October afternoon.

Cantrell came to the UT physics department after graduating from high school in Memphis. Although he had been recruited by Columbia University to study physics there, he chose Tennessee because of its proximity to both Oak Ridge National Laboratory and the Great Smoky Mountains National Park.

"I racked up a lot of miles in the Smokies while I was at UT," he said.

After finishing a bachelor's degree in physics in 1965 he decided to pursue graduate work, but deliberated awhile on what path to take for his dissertation research. He was interested in both biomedical science and condensed matter physics, and after looking around, settled on an area that gave him opportunities in both.

"Ultrasonics caught my fancy," he said.

Cantrell began working with Dr. Mack Breazeale and finished the Ph.D. in 1976, completing his dissertation on the ultrasonic investigation of hydroxyl ions. But he also kept tabs on Dr. Loucas Christophorou's group, where fellow student Ron Goans (B.S., '68; M.S., '69; Ph.D., '74) did his doctoral work. Goans was involved with a project at the ORNL Health Physics Division to study the depth and severity of burns, particularly those caused by electrical or chemical injuries. He was looking for a non-invasive measurement tool and knew Cantrell worked in ultrasonics.

"As well as a personal friend, he has always been a terrific resource to me in the use of ultrasound in material science," Goans said.

Cantrell joined the division as a consultant in 1975, after a little preliminary research.

For physics alumnus John Cantrell, the greatest satisfaction of his work has been "discovering something that no one else knew, and having it accepted and appreciated."

"I went to the grocery store and bought chicken legs," he said.

He burned them on a hot plate and brought them into the ultrasonics lab at UT to see if he could discern any tissue damage. He saw something he could measure, and thought the idea would work with human tissue as well. He and Goans went on to develop an ultrasonic technique to characterize skin necrosis that earned them both a patent and an R&D 100 Award.

The Rocket Man

After finishing his work at the university and ORNL, Cantrell accepted an appointment as a research associate at NASA Langley Research Center in Hampton, Virginia. Now a senior materials physicist there, his primary responsibilities lie in the development of new materials for aerospace purposes.

"We're supposed to keep airplanes flying (and) keep rockets up there," he said. "We're always looking for stronger, better materials."

A crucial element of this work is developing materials that can withstand harsh environments. Ultrasonics allows scientists to study samples without destroying them by instead observing waveforms, amplitude distortion, and radiation pressure. An additional benefit is that these investigations have inspired spin-off projects in medicine.

"You can use those techniques and apply them to the biomedical field," Cantrell said.

He explained that the microstructure of a material will change as a function of its environment, and this change results in an ultrasonic signature that provides information about the material's physical properties.

"The same thing is true of human tissue," he said.

Cantrell and his colleagues used ultrasonic diagnostic tools, for example, to address the problem of space sickness that befalls roughly half of all astronauts as their bodies adapt to changes in gravity during space flights. To get to the heart the problem, they took a look at intra-cranial pressure.

"In 1998, that was the number one project in our division," he said.

The traditional approach involved drilling a hole in the skull and using a transducer to take measurements, which, as Cantrell joked, didn't sound too appealing to astronauts. Instead, his team developed an acoustic measuring system that also produced a method for non-invasive assessments of pressure within the human skull. The project resulted in two patents, which is not unusual for Cantrell's efforts. He currently holds 26 patents with three more pending, and in 1994 was presented with a commendation from the Virginia General Assembly for his contributions to the development of technology benefiting the state's citizens. Technology transfer is important to Cantrell, who said NASA encourages cross-disciplinary research and real-world applications. That bent toward problem-solving and cooperation has served him well at Langley and at Cambridge, where he first visited 20 years ago.

Across the Pond

In 1985 Cantrell gave a physics colloquium at UT Knoxville where he struck up a conversation with Rufus Ritchie (Ph.D., '59), who had been his professor for a modern physics course. Ritchie had just returned from a sabbatical at the University of Cambridge in England, where Cantrell was hoping to pursue research in electron microscopy as a visiting scientist. Ritchie volunteered to write a letter of recommendation, and Cantrell ended up with a Winston Churchill Foundation Overseas Fellowship.

"He wrote, apparently, a very nice letter," Cantrell said.

Ritchie likens Cantrell to the multi-talented Enrico Fermi in terms of "his remarkable ability as an experimental physicist, (who) seems equally at home in abstract theory. John's exceptional ability and creativity in research led to his being accepted as a visiting scholar at the world-famous Cavendish Laboratory, where he carried out truly pioneering work."

Cantrell's efforts at Cambridge resulted in a record number of publications for a visiting scientist and an award from the Chinese Academy of Sciences for "exceptional contributions to scanning electron acoustic microscopy and image analysis of advanced inorganic materials." He also earned an M.A. in microstructural/materials physics. Cantrell had three subsequent appointments at the Cavendish and it was there he met L.M. Brown, an authority on the physics of metal fatigue, a serious problem in the aerospace industry and consequently one of great importance to NASA. The collaboration resulted in a number of papers, including one in the *Proceedings of the Royal Society of London* outlining a model to predict fatigue in metals based on their microstructure.

"That was a breakthrough paper," Cantrell said. "That set the stage for the work that's followed."

He currently studies materials at the nano- and micro-scale to assess issues like damage accumulation. He also develops novel methods and tools to make those characterizations more precise, including the resonant difference-frequency atomic force ultrasonic microscope, or RDF-AFUM. This instrument provides images of materials at the nanoscale by combining ultrasonic measurement methods with the atomic force microscope. An interesting point about the invention is that Cantrell developed and patented it with his son, Sean, a senior at the University of Virginia. The younger Cantrell has worked at NASA Langley in the Advanced Materials branch both as a high school and college student, and already has a few published papers under his belt.

"He's definitely going to eclipse me," Cantrell said of his son, whose interests lie in physics beyond The Standard Model.

No Stopping Him Now

As Sean is starting out on his career, his father is considering the next phase of his own. The greatest satisfaction of his work, Cantrell said, has been "discovering something that no one else knew, and having it accepted and appreciated."

While he has enjoyed, as Goans aptly described it, "a long and distinguished career at NASA," he wants to stay on that path of discovery when he steps down sometime in the future.

"The question is, 'Where do I want to go?'" Cantrell said. "There's ultrasonics. There's Sean's quantum mechanics. Whatever catches my fancy."

As is typical of physicists, Cantrell believes there's always something new to learn, and for his part, he said, "I'm never going to stop."

Physics Alum Wins Maria Goeppert Mayer Award

Saskia Mioduszewski (Ph.D., 1999) is the 2009 recipient of the Maria Goeppert Mayer Award from the American Physical Society. Named for the 1963 Nobel Laureate, this award recognizes outstanding achievement by a female physicist in the early years of her career. It also provides opportunities for her to present these achievements to others through public lectures in the spirit of Maria Goeppert Mayer. The award consists of $2,500 plus a $4,000 travel allowance.

Mioduszewski is an experimental nuclear physicist and was cited "for her pioneering contributions to the observation of jet quenching and her continuing efforts to understand high- p_T phenomena in relativistic heavy- ion collisions." She received a B.S. in physics and mathematics in 1994 from North Carolina State University. Following completion of the doctoral degree at UT Knoxville, she worked at Brookhaven National Laboratory on the PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC). In 2005, she moved to Texas A&M University as an assistant professor and became a member of the STAR Collaboration at RHIC, where she continues to pursue her interest in high-energy heavy-ion collisions. She received the Department of Energy Presidential Early Career Award in 2004 and was awarded an Alfred P. Sloan Fellowship in 2006.

Ph.D. graduate Saskia Mioduszewski was recognized for her pioneering contributions in relativistic heavy-ion collisions.

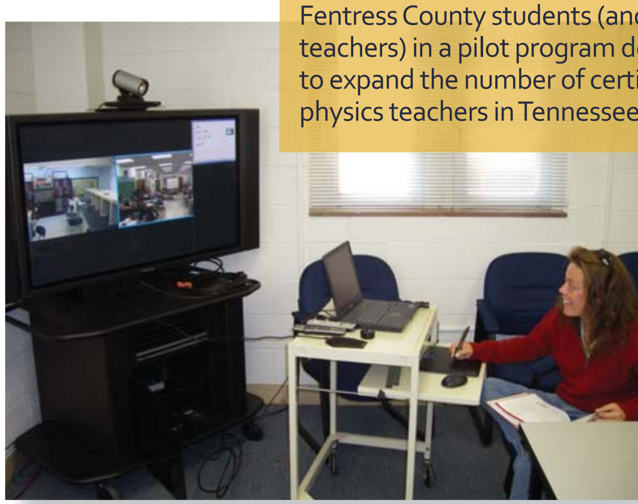
It's a Wednesday morning in Room 307 of the Nielsen Physics Building and Erica Johnson is keeping a watchful eye on her students, despite the fact that they're literally 100 miles away.

Johnson is a teaching assistant (TA) in the physics department and an experienced high school science teacher. She is also part of an innovative outreach effort to expand the number of certified physics teachers in Tennessee. This pilot project uses videoconferencing and other state-of-the-art equipment to teach students at Clarkrange High School and the Alvin C. York Institute. While Johnson and Physics Professor Jon Levin are in a conference room on UT's Knoxville campus, their students are in their respective classrooms in Fentress County. Learning along with them are their teachers, who are working toward physics certification through this initiative.

Dr. Lynn Champion is the Director of Academic Outreach and Communications for the College of Arts and Sciences and explained that the program addresses a national and state priority to increase the number of graduates in science, technology, engineering and mathematics, known as the STEM disciplines. Physics graduates in

Physics from a Distance

particular are in short supply, with enrollment in college-level physics unlikely to grow in an environment lacking sufficient numbers of teachers qualified to teach physics in the state's high schools. So she began thinking about ways the college and the physics department could collaborate with the community to address this need.



TA Erica Johnson interacts with Fentress County students (and teachers) in a pilot program designed to expand the number of certified physics teachers in Tennessee.

"We had very capable and knowledgeable physics teachers here at UT Knoxville and students interested in physics in our Tennessee high schools without a high school physics teacher available," she said. "As we considered possible solutions for addressing the shortage of qualified physics teachers in the state, one option that came to mind was distance education."

Champion worked with Physics Department Head Soren Sorensen and Professor Levin to develop the project, bringing on board the Office of Information Technology (OIT) as another university partner. Linda Jordan, a science consultant for the Tennessee State Department of Education, recommended Fentress County Schools for a pilot program because of the need for physics teachers there and the schools' enthusiasm for the project. The college provided significant funding by committing endowment earnings from private gifts to support K-12 outreach activities.

The program proposal outlines Tennessee's deficit in physics education. While the state has more than 310 public high schools, fewer than 200 offered physics instruction in the 2007-2008 academic year, and many of these courses were taught by teachers not accredited in physics. Neither Clarkrange nor the York Institute, for example, had offered physics courses before.

Levin is the professor in charge of what's become known in the department as "The Fentress County Project" and explained what it hopes to accomplish.

"The big reason we're doing this is to get the teachers certified," he said.

Levin said this approach offers the most leverage because one certified teacher could teach physics to thousands of students over the course of his or her career. While typically teachers work toward certification by taking a two-week class in the summer, this way they have the benefit of learning physics over the course of an entire semester.

Kelly Ramey is the classroom teacher at the York Institute. She is certified to teach chemistry and is also committed to earning her physics certification.

"I think the project is an excellent solution for the short-term and long-term when it comes to the lack of physics accessibility in the high school classroom," Ramey said. "My students are able to take physics *now*, and I am able to work on certification so we can ensure the sustainability of the physics program here at (York). With the increasing emphasis the state of Tennessee is placing on physics in the curriculum, more programs like this will need to be implemented across the state to help meet demand."

In all there are 30 students enrolled in the class; 24 at York and six at Clarkrange. Levin said that York had about 50 students interested in the program, but logistics limited participation to 24 seniors.

From Knoxville, Johnson and Levin watch both classrooms via a split screen on a four-foot-wide monitor. In the upper right hand corner they can see whatever is displayed on their laptop; be it a PowerPoint file, a physics worksheet, or hand-written notes and graphs sketched out on a drawing tablet connected to the computer. The students in Fentress County see the same thing and can also watch the Knoxville team through two-way videoconferencing as they work through the day's topic (e.g., gravitational potential energies). Both schools have state-of-the-art equipment and OIT provided the interfacing at each to assure adequate Internet connectivity.

The setup allows students, in a broadcast sense, to meet with their professor and TA each day for their 90-minute physics block. Levin is a veteran of teaching undergraduate physics courses with high marks from students for his effectiveness. Johnson is a certified high school physics teacher with a master's degree in education from UT Knoxville and draws on her experience to help Levin develop the curriculum, prepare course materials, and assist with both online and on-site teacher support. She is completing her master's degree in physics through the department's project option, and has chosen Fentress County as her assignment.

"This is my project," Johnson said, "and I've landed in a nice one."

While she acknowledges that, as with any classroom, there are some glitches (making eye contact is difficult, for example), she said she certainly thinks the program is effective. And the students have found a way to good-naturedly rib their TA even when she's two counties away.

"They'll rub the microphone just to annoy me," Johnson said, laughing. "It's like fingernails on a chalkboard."

She and Levin travel often to Fentress County to give lecture demonstrations or provide university equipment for the students to perform labs. They added this dimension to the program to get classroom time with the students and their teachers and to offer hands-on instruction.

"The students always look forward to the days they come visit," Ramey said, "because they know they will bring something exciting."

The visits, demonstrations, peer-tutoring, and Web activities the university team uses are put together based on their effectiveness at making physics engaging and understandable.

"We're not following any model," Levin said. "We're blazing new ground. And we're using technology to facilitate these collaborative conversations."

While the distance education course will not be offered in the spring of 2009, Levin said he hopes they will be able to offer it again next fall. He has requested funding for a second phase of the program—a two-week workshop for 15-to-20 teachers to be offered in the summer of 2009. He has also submitted a proposal to the Tennessee Higher Education Commission to expand the program, allowing teachers to earn six hours of graduate credit for one year of teleconferenced physics classes and two one-week workshops. By 2010, as many as 40 teachers could earn their physics certification, translating into thousands of Tennessee high school students getting solid physics instruction. They aren't the only beneficiaries of the program, however.

As Champion said, "This pilot project with Fentress County Schools is an excellent example of outreach scholarship and engagement with the community and has reciprocal benefits. Certainly the students in Fentress County will learn physics, but the department will also learn a great deal about teaching students of this age group and the pilot project will, no doubt, inform their teaching of introductory physics classes at UT Knoxville."

Physics Receives $1 Million Endowment

A generous gift from the late James W. McConnell will reward outstanding physics students and faculty and help the department enhance its overall academic mission.

McConnell established the James W. McConnell Physics Excellence Endowment with a $25,000 donation. He chose to supplement this contribution with an extremely generous bequest in his estate, which has resulted in $1 million in gifts to the physics department. He established an identical fund in the Department of Electrical and Computer Engineering department.

The physics endowment is set up to allow for tremendous flexibility. It may be used for scholarships and fellowships for students, faculty awards to acknowledge outstanding teaching and/or research, technology purchases, and any other uses that support or enhance the department's academic mission as determined by the department head and the dean of the college.

McConnell earned a bachelor's degree in electrical engineering in 1961 and a master's in 1962. He passed away on March 25, 2008, at the age of 68. He was by all accounts a quiet, humble man who sought no recognition for his generosity during his lifetime, but his kindness to the physics department will certainly be a lasting legacy.

Physics Family

Students

The physics department welcomed 12 new undergraduate scholarship students this fall: **David Anderson**, **Erin Caracappa**, **Clay Cobb**, **William Finney**, **Taylor Fullerton**, **Matthew Gabriel**, **Geoffrey Laughon**, **Thomas Liddell**, **Eric Martin**, **Alex McNeilage**, **Thomas Robacker**, and **Sarah Wood**.

Congratulations to graduate students **Amal Al-Wahish** and **Usama Al-Binni** on the birth of their daughter, Leena, who arrived August 8.

Faculty Honors

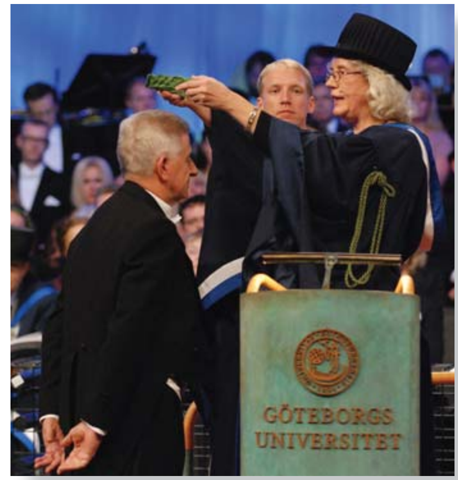
Professors Pengcheng Dai and Soren Sorensen have been elected Fellows of the American Physical Society. Dai was chosen "for his contribution to understand fundamental properties of magnetic excitations in high-transition temperature superconductors, f-electron heavy Fermions, and colossal magneto-resistance manganites." He was nominated by the Topical Group on Magnetism and its Applications. Sorensen was cited "for his important contributions to the field of relativistic heavy ion collisions, in particular for systematic studies of stopping and transverse energy production, and for his early leadership in the PHENIX offline computing framework and in establishing the program of J/psi measurements at RHIC." He was nominated by the Division of Nuclear Physics.

Professor Witold Nazarewicz will be recognized in July 2009 with the honorary degree of Doctor of the University of the West of Scotland. The University Court awards the DUniv to persons who have made outstanding contributions to the university and to those who have earned recognition for their academic work. They chose Nazarewicz for the honor as a fitting way to mark his very distinguished career. He was a 2008 Carnegie Centenary Professor, giving lectures and invited talks at Scottish universities from March through May. He is the first person representing nuclear physics to hold this prestigious honor.

Distinguished Professor Joseph Macek has been elected a member of the Scientific Council of the Ioffe-Physical-Technical Institute in St. Petersburg, Russia. The Ioffe Institute is one of Russia's largest institutions for research in physics and technology and is affiliated with the Russian Academy of Sciences. It was founded in 1918 and run for several decades by the Russian scholar Abram F. Ioffe. Macek's research specialty is theoretical atomic physics and he has worked with Research Professor Sergei Ovchinnikov (also of the Ioffe Institute) on analytical and numerical techniques to describe proton-hydrogen and electron-hydrogen collisions. The formal presentation of the honor was October 31 in tandem with a celebration of the institute's 90th anniversary.

The silver medal awarded to Joseph Macek to honor his election as a member of the Scientific Council of the Ioffe-Physical-Technical Institute in St. Petersburg.

The Faculty of Science at the University of Gothenburg (Sweden) honored **Professor Emeritus David Pegg** with the degree of *Doctor Honoris Causa* at a promotion ceremony on October 24. The award was presented in recognition of his work as a world-leading atomic physicist for almost four decades and for his contributions to the University of Gothenburg through his research collaborations with both faculty and students there. David Turner, Dean of the Faculty of Science, wrote in his invitation letter to Pegg: "You have contributed to successful research and research training, thereby inspiring our students both during their academic studies and for their future careers."



David Pegg receives the degree of *Doctor Honoris Causa* from the University of Gothenburg.

Staff

Jodie Millward

The physics family is saddened by the loss of our instrument shop supervisor, **Jodie Millward**, who passed away on November 30 at the age of 61. He came to the physics department from the Ag Campus in August 1969 at age 22, beginning his work as a machinist under supervisor Ray Mink. Millward would later replace Clyde Cupp as head of the instrument shop and continued what former department head Bill Bugg called "a long tradition of outstanding leadership. The excellence of his work was responsible for much of the research success of the department."

As Professor Emeritus Tom Callcott wrote, "one of Jodie's outstanding characteristics as shop foreman was his imagination and willingness to master new techniques and technologies. There were very few materials that he could not find a way to machine, and to join together . . . he devised ways to construct stainless steel ultrahigh vacuum chambers for our surface physicists. For the high energy physicists, he built spark chambers of fiberglass and mylar, and cradles for vacuum tube radiation detectors. In recent months, his shop has been producing massive steel shielding for neutron science experiments at the Advanced Neutron Source at ORNL."

For his many contributions to physics, Jodie will be greatly missed.

Alumni

Scott D. Berry (Ph.D., 1985) is a Professor of Physics and Director of Network Services at Limestone College in Gaffney, South Carolina.

Zhiyu (Jerry) Hu (Ph.D., 2000) is Director and Chief Scientist at the Institute of NanoMicroEnergy at Shanghai University.

Jerry L. Pate (B.S., 1965) is a teacher at the Chattanooga School for the Arts and Sciences.

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Giving Opportunities

The physics department has several award and scholarship funds to support our vision of excellence in science education at both the undergraduate and graduate levels:

Undergraduate Scholarships

The William Bugg General Scholarship Fund
The G. Samuel and Betty P. Hurst Scholarship Fund
The Dorothy and Rufus Ritchie Scholarship Fund
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Other Departmental Funds

Physics General Scholarship Fund
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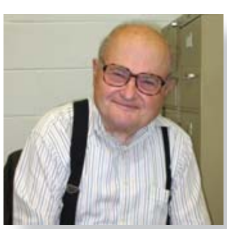
If you would like more information on how to make a donation or a pledge to any of these funds, please contact either the physics department or the College of Arts and Sciences Office of Development at (865) 974-2365 (phone) or on the Web at www.artsci.utk.edu/development/index.asp

In Memoriam

Marian Bugg, wife of Professor Emeritus Bill Bugg, passed away September 28. She was 77 years old. Born in East St. Louis, Illinois, she earned a degree in dietetics from Webster College in 1952. A tireless volunteer, she was a charter member of Sacred Heart Parish, served as Girl Scout Leader, and shared her time with the League of Women Voters, the American Cancer Society, the Ladies of Charity, and Mobile Meals. She and Dr. Bugg established the Bill and Marian Bugg Physics Endowment in 2008 to support the department's education and research goals.


Ed Hart

Ed Hart, Professor Emeritus of Physics, passed away November 14 at the age of 78. A Brooklyn native, he earned a bachelor's degree in physics at the College of the City of New York in 1952 and a Ph.D. in physics at Cornell University in 1959. In the late 1960s he came to UT Knoxville, where he pursued both his research in elementary particle physics and his great love of teaching. He also served on the faculty senate, advised graduate students, and did consulting work at ORNL. He retired in 1998 after 30 years with the department, but visited often to maintain contact with his colleagues and keep up with the field of physics. A more in-depth profile on Dr. Hart and his many contributions appeared in the Fall 2007 issue of *Cross Sections* and is available on the physics Web site at www.phys.utk.edu/news.html.

John P. Judish (Ph.D., 1974) passed away June 23 at age 82. Born to immigrants of East Prussia (now Poland), he was brought up in Canonsburg, Pennsylvania, and earned a degree in electrical engineering at the University of Pittsburgh on the GI Bill. After master's level work at Vanderbilt University, he joined ORNL. While working there full-time and attending night classes, he completed his doctoral degree in 1974. Judish retired from ORNL in 1989.

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