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Takeshi Egami

Heavenly Disorder

For Distinguished Scientist Takeshi Egami, Real Beauty Lies in Imperfection

TAKESHI EGAMI IS NOT CONCERNED WITH PERFECTION. It's the quirks, the misfits, the oddities and the rebels that intrigue him; because in the new world of materials, that's where things are going to get interesting.

Egami is a Distinguished Scientist and Professor

with Oak Ridge National Laboratory and UTK, holding university appointments in both materials science & engineering and physics. He is the epitome of a gentleman but also quick to laugh, with a gracious smile that hints at just a touch a mischief. The heart of his successful research program is figuring out materials and their properties—whether they'll hold up under stress, flow like liquid, become superconductors or ferroelectrics, etc.—in terms of behavior of atoms making up the material. And most of that detective work begins with a material's structure.

As early as the 1600s scientists recognized reappearing patterns in the composition of quartz crystals. Over time, a predictable repetition of atoms, ions, or molecules within a structure came to be known as the crystal lattice. Even when these systems aren't flawless, their defects are isolated and easy to find. With the evolution of scientific tools and knowledge, this framework became a benchmark for defining the properties of materials.

"We understand crystals. You have a unit cell and this repeats many, many times—infinite times," Egami said. "And I always say that nothing is more boring. There is no freedom; there is no choice. It's too perfect. And when it's perfect it's not interesting. I

always tell my students, 'Don't go to heaven. Up there everything is perfect. You are physicists, and if you go to heaven, it will be fun for three days, and then it will become totally boring,'" he said, laughing.

For Egami there is much greater inspiration in figuring out disordered systems; materials that don't have a neat, reliable structure but instead are marked by random arrangements of atoms and plenty of imperfections. Among these are liquids and glasses. In materials science, glasses are a much broader category than window panes or tumblers for drinks. They might be made of metals, molecular liquids, or aqueous solutions, but they possess a common trait: they're all cooled quickly enough to prevent crystallization so that they retain their random structure.

Atomic Democracy

In the middle of the last century, Egami explained, researchers started to rapidly cool metal, producing metallic glasses. The problem was that they were unstable. In the past 20 years, however, scientists have found ways to stabilize these materials so they can be fabricated in bulk and used in common items like golf clubs or cell phone cases; even computer chips. He sees these flawed but fascinating materials as inherently more democratic than their crystalline cousins.

"In a pure element, if you have one atom in the unit cell, everybody (every atom) is equal—then by definition, you have to be happy," he continued. "This is sort of the compulsory state. I always say that crystals are like a dictatorship. There's no individuality. A liquid and a glass are much more humane. Everybody's environment is different. Everybody is different. So some are happy and some are not."

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The Yin and Yang of Headship

A Letter from Department Head Soren P. Sorensen

AS I PREPARE TO STEP DOWN AS HEAD OF OUR DEPARTMENT by the end of July 2012, it is natural to reflect over what I might have learned about the character of the job as head. If nothing else it might give the next head a better understanding of the job than I had when I started more than 11 years ago.

Contrary to what many of my colleagues seem to imagine, being the head of an academic department is not the same as being the Big Boss, who can unilaterally decide everything within the department. On the contrary, being a good department head requires balancing many diverse issues and principles in a harmonious manner. That is why I chose the title of “the yin and yang of headship.” If the head has the right balance of yin and yang in her priorities the departmental administration will be successful and the department will prosper. Let us look at some examples.

THE BIG PICTURE VS. MAKING THE WHEELS TURN. Being able to “see the big picture” and direct the department in the best possible strategic directions is of course very important; maybe even the most important task of a head. Often the faculty believes that this is all the head should really do. However, I have learned that it is just as important to be able to make the wheels of the departmental machinery turn with ease. The head should not be involved in all the many daily operational details, but she should be closely aware of what is going on in the department and be able to improve procedures, create and appoint the best committees, make the optimal assignments for staff and service jobs for faculty, be available to quickly resolve all issues that are “falling between the cracks,” help students, staff and faculty asking for advice on how to handle concrete problems, etc., etc. There is actually so much work that can be done in just operating the department that a serious danger for most heads is to eventually place too much emphasis on this yin, forgetting the yang of strategic leadership. On the other hand, it is also dangerous for the head to avoid being involved in the day-to-day operation of the department and then lose touch. For example, one of our sister departments recently advocated for getting a top staff position as essentially a Chief Operating Officer to would take care of most of the operation of the department and leave the head to only look at the big strategic decisions and to represent the department externally. It will never work, in my opinion: too much yang of strategy and not enough yin of operation.

FOLLOWING RULES VS. PUSHING BOUNDARIES. There is an absolutely enormous amount of rules and regulations that determine all aspects of life in an academic department. We have our own bylaws, college rules, and university rules. We have a large and complicated faculty handbook and manuals for how to search, evaluate, promote, etc. We have 9 Board of Trustees policies, 55 fiscal policies, 64 human resources policies, 4 information technology policies, and 10 safety policies! We have rules from the Office of Research and the 130 page OMB A-21 memo governing all federal research contracts. We have federal rules for employing foreigners and how to obtain visas for them. Etc., etc, ... but don't despair. The head does not need to know all these rules. However, she needs to know the main content and spirit of them and she needs to have staff within the department who know them all and can guide the decision process. But all these rules can stifle creativity, so a good head will also know how to “go close to the lines” or how to overwrite the rules when it is in the best interest of all parties. In some cases inflexible rules should motivate a good head to try to change and improve the rules. A wonderful example of this was the creation many years ago of a new employment category at UTK: Distinguished Scientists. Instead of just following the rules, Lee Riedinger et al. went outside the box and created new types of positions for top-notch researchers, who were paid both from UTK and ORNL. So pushing the boundaries is good as long as we stay inside them most of the time.

DEPARTMENT VS. UNIVERSITY. A head represents two constituencies: the department and all the people in the department on one hand and the university administration on the other hand. Typically a new head, who has spent most of her academic career absorbed in her research and her teaching, will place all the emphasis on fighting hard on behalf of the department and will feel that her department is by far the best department in the whole university and the only one that really deserves to be allocated resources. Being a strong advocate for the department is indeed important, but it can also be overdone. (Trust me, I know!) The college and university administration have a legitimate need for having a responsible head who can carry out needed, but sometimes unpopular, policies within the department. A good head will also learn to limit the requests from the department to a reasonable level (+25%), because if the university administration finds the level of requests unreasonable it will backfire. In other words, a good head will be able to understand

the bigger picture within the university instead of just knowing her own department, and will therefore be able to balance the advocacy of the department externally with the need to represent the administration internally in the department. If the yin-yang balance on this issue is not good, the head will either be very popular within her department but ineffectual with the dean and provost; or will lose respect within her department if she is only seen as somebody carrying water for the administration.

RESEARCH VS. TEACHING. There should not be any tensions or issues in priority between the emphasis we place on our research mission versus our teaching mission. But in the real world the head will have to balance these missions in many interactions with the faculty and with the college. Most faculty members in physics are very focused on their research and that is wonderful, since creating new knowledge is an important part of our mission and getting research grants helps both research and graduate education. But it is also important to disseminate knowledge by teaching our students or the public, and often the professors are less than enthusiastic if they are requested to teach large service or general education classes. These classes are the “bread and butter” of nearly all physics departments and without them our department would be much smaller. On the other hand, most of our interactions with the college involve issues related to undergraduate education and often the argumentation in budget requests has to be based on how much good a particular proposal does for undergraduate education, whereas a proposal that will only benefit the research mission is a hard sell. Once more, a good head will balance the yang of research with the yin of teaching and by reaching harmony will get better results for both.

SUPERVISOR VS. ASSISTANT. As mentioned in the beginning, most faculty members view the head as the Big Boss who evaluates them and can determine raises, promotions, teaching assignments and hiring priorities. And yes, this is part of the job (but far from the most enjoyable part!). But it is just as important to assist and help the faculty in obtaining their objectives. A good head spends a lot of time promoting her faculty members for awards or for being successful in obtaining grants. The faculty and students rightfully expect the head to write recommendations and to use whatever “oomph” she has to help them in being successful in their requests. If a head can balance the yang of supervision with the yin of assistance, the faculty is usually happy.

SERVICE DEDICATION VS. PERSONAL INTEREST. Maybe the most important yin-yang complementary relationship is how the head balances her own perception of the task as head. The head should work hard, with dedication, for her two constituents—department and university administration—without thinking about what is in it for her personally. This is a tall order, but a good head is dedicated to the common good and should not view the position as a way to promote herself. This is fundamentally the reason it is often so difficult to find good candidates for headships. It requires a lot of work and many faculty members do not want to commit the majority of their professional time for 5 or 10 years

to what is essentially a service task. Maybe they want power, but if that is their main motivation, they will not be good heads. (Too much supervisor yang!) On the other hand, the head should not dedicate all her time to the headship. It is very important that she retains whatever activities made her professionally successful prior to the headship. In physics, this is usually research. To keep the balance between work as a head (yang) and work as a researcher (yin) is important for a lot of reasons, but let me mention two. First of all, there will come a time after the headship, and if she has lost touch with research during her headship, it is very, very difficult to “get back in the game.” Secondly, and probably most importantly, a large part of the influence a head has is not derived from the factual power allocated to her as part of the university rules, but instead from the respect her faculty peers have for her. And most of that respect derives from her research reputation. The faculty is willing to follow a leader who they consider their peer with an active research program. So a good head will balance the yin of research and academic pursuits with the yang of dedicated service as a head.

There is, however, one aspect of the job as a head where it is reasonable to have too much yin and very little yang. Being a head is a people job. The head spends most of her time meeting, discussing, arguing, listening, instructing, consulting, and chatting with people. Working with people and having decent people skills is so important. A head should enjoy interacting with people, whether it is the chancellor or a high school student visiting with her parents in order to find out if our department is the right one for her. Many professors love to hide in their office, the library or their laboratory. Sometimes this is out of dedication to their scholarly or research pursuits, but sometimes it is also because they are not “people persons”. There is absolutely nothing wrong in not being a people person, except if you wish to be a good head. It should be the enjoyment of meeting many different people from all walks of life and interacting and learning from them that should be one of the strongest motivations for anybody to seek a headship. So a good head has a lot of people yin.

Finally, a personal note of caution: just because I have described above some of the important aspects of a headship, it does not imply that I have also been able to live up to all of it. It is very difficult to balance all these requirements and I know a lot of situations where I have not been successful, but I will keep them to myself. The key is not to do everything perfectly well, because that is impossible, but to have good moral, strategic, and tactical principles and then try to do your best to live up to them. Balancing yin and yang of headship is just one such principle.



This more egalitarian paradigm opens up largely unexplored territory for materials research. Egami said that while 20th century physics worked out the periodic systems (those with a lattice structure), the physics of non-periodic systems is far behind. He is a pioneer in this new terrain, and one approach he uses to map out the physics is to look at a material from the atom's point of view. That includes paying attention to its stress level, which is not wholly unlike that of humans.

"We are stressed out or unhappy when what we want to do doesn't match the expectations of the environment," Egami said. "The environment doesn't allow you to be yourself. It's exactly the same (with an atom). Just like us, each atom wants to be in a certain environment, but it's put in an environment that it doesn't necessarily want. That's the origin of the stress."

A stressed atom offers clues about its parent material and its properties. In liquids, for example, the structure is dependent on temperature.

"Just like us, each atom wants to be in a certain environment, but it's put in an environment that it doesn't necessarily want. That's the origin of the stress."

"At high temperatures you have a more disordered topology. Stress describes this degree of disorder," Egami said. "That decreases as you go down in temperature, and becomes frozen in the glass.

"We know how to describe order: by symmetry, etc.," he continued. "But we don't know how to describe disorder. Every disorder is different, just as every storm that comes from the Gulf is different. And we don't have language to describe (it). So I'm trying to produce, with scale and language, the degree of disorder."

One of Egami's colleagues in this quest is Simon Billinge of Brookhaven National Laboratory and Columbia University. The two wrote "Underneath the Bragg Peaks," a book that introduced the concept of using pair distribution function (PDF) to understand the properties of materials that are crystalline but strongly disordered. The PDF approach involves subjecting the material to x-rays or neutrons and calculating the probability of two atoms in a material being separated by a given distance from the scattering intensity. This method was used for a long time to describe liquids and glasses. Egami and Billinge applied it to the description of disordered crystals.

"We used PDF to find where (the atoms) are and found a lot of things people didn't know," Egami said. "So we breached this disordered world.

"In crystallography, you look from the outside or from the top, like a god looking at the world," he said. "But we don't do that. We put ourselves inside, on the level of the atom. To describe a war, you can take national statistics, but you don't really understand what it is like until you take a personal viewpoint,

like in 'War and Peace.' We want to take this people's point of view; a more democratic approach. PDF is the way to look at local disorder from an atomic point of view."

That foray into disordered territory will become increasingly important as industry makes greater demands of materials.

"In the past we were using rather simple materials. But more advanced materials are much more complex," Egami said, adding that how a material functions is often tied to its disorder or imperfections. In silicon, for example, a little impurity is required to make it a conductor.

"In the same way, materials are largely controlled by these imperfections, and in the case of modern materials by a lot of them," he said.

Punks, Rebels, and Explorers

In 2010 their work on PDF won Egami and Billinge the J.D. Hanawalt Award. Every three years, the International Union of Crystallography bestows the honor on scientists making an important contribution to the field of x-ray power diffraction. It was a fitting recognition of a successful partnership going back to the 1980s, when Billinge first arrived as a graduate student at the University of Pennsylvania, where Egami was a faculty member. He made a lasting first impression, as much for his persona as for his intellect.

"He was a punk," Egami said, smiling. "Big earrings, wild hair, riding a motorcycle."

He also had a keen mind for materials.

"(Simon) was asking the most stupid questions in the world," Egami said. "But the most fundamental. And I saw right way, 'This guy has something.' He was not afraid of asking stupid questions because he wanted to know."

For Egami, that kind of fearlessness has always been a major point in his evaluation of students.

"The ones who aren't afraid to ask stupid questions are the ones who grow fastest," he said.

He may also have seen a bit of himself in the young scientist. When Egami started college in his native Japan in the 1960s, he said, "I was also a rebel. And young and ambitious."

He earned a bachelor's degree in applied physics at the University of Tokyo in 1968, but an important part of his education came from a trip he took abroad following his sophomore year. His grandfather was a successful industrialist who was more interested in philanthropy than personal wealth, so he provided his grandson with a fellowship to pay for college. With the money left over, Egami struck out with a friend to see the world. They started in Russia and made their way to Western Europe, travelling by train and plane (once with fellow passengers carrying chickens). They stayed in youth hostels, where many of their fellow travelers were young guys from America.

"I found them refreshing and intelligent," Egami said. "It changed my view about the U.S. completely."

It was also the era before Sony and Toyota were household names, and Egami quickly learned that even though he knew the European culture and history well, few people outside of his native country knew much about Japan. While that was not surprising, he was surprised they were not at all interested either.

“This was a huge shock. It was like falling in love with somebody and she doesn’t care,” he said. “I found that I was living in a small country in the corner of the world. So I had to move to the center.”

At the same time, Japanese industry was preoccupied with semiconductors and Japanese physicists were devoting their studies to elementary particles. Neither field held any attraction for him.

“Already I wanted to study something much more disordered,” he said. “My advisor also saw that I wouldn’t fit in the Japanese system. He said, ‘Maybe you’ll be better off in the States.’ And I wanted to go.”

So Egami headed to the University of Pennsylvania, where he earned a Ph.D. in materials science in 1971. He then spent half a year at the University of Sussex and a year and a half at the Max Planck Institute before returning to Penn as an assistant professor in materials science, becoming department chair in 1997. He was also heavily involved in neutron research, using the High Flux Beam Reactor at Brookhaven National Laboratory before it was decommissioned. He then shifted his base to Oak Ridge.

“I had been using the High Flux Isotope Reactor and was heavily involved in Spallation Neutron Source planning, and then Ward Plummer (formerly of UTK and ORNL) came to my office one day and pulled me out,” he said.

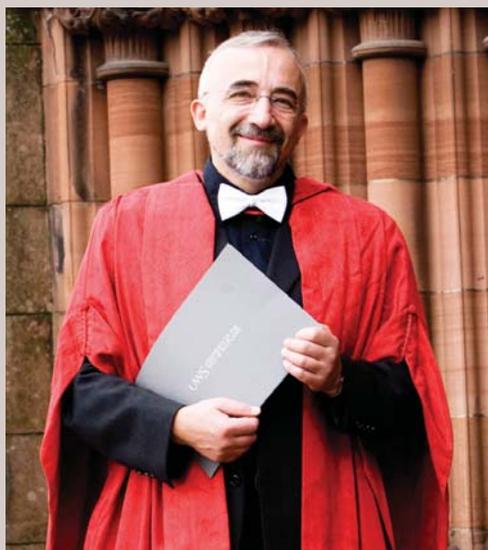
As Egami was completing his chairmanship at Penn, he wanted to focus more on research in metallic glasses, preferably within a larger collaboration. A joint appointment with UTK and ORNL provided that opportunity, so he made the move to Knoxville in 2003. He works with colleagues from both the national laboratory and the university, including physicists Pengcheng Dai and Norman Mannella.

“Now I have a really big group,” Egami said. “I’m quite happy I made the transition South.”

He is also the director of the Joint Institute for Neutron Sciences (JINS), located at the Spallation Neutron Source. JINS works to attract the best neutron scientists from all over the world with workshops, fellowships, and sabbatical programs. At present the institute is focusing on soft matter physics, including metallic glasses. Egami said eventually he would like to extend the seed in liquid and glass physics into a wider field of soft matter—macromolecules or even proteins. As he and his fellow scientists delve deeper into a world of more complex materials, they’ll be writing the guidebook as they go.

“We start with a simple thing: to understand simple metallic glasses,” he said. “That is the purpose; creating language. We are sort of explorers.”

Professor Witek Nazarewicz Honored with 2012 Bonner Prize



Dr. Witek Nazarewicz

GIVE HIM HALF AN HOUR, and Witek Nazarewicz can rivet your attention with a description of nuclear physics that includes 17th Century French theater, *The Wizard of Oz*, and the stewardship of nuclear weapons. His enchantment with nuclei is palpable, and he weaves that enthusiasm into a rich tapestry of research, teaching, and service that has garnered several honors over his career, the latest being the Tom W. Bonner Prize in Nuclear Physics.

Bestowed by the American Physical Society, the Bonner Prize recognizes and encourages outstanding experimental research in nuclear physics, including the development of a method, technique, or device that significantly contributes in a general way to nuclear physics research. Nazarewicz was recognized “for his foundational work in developing and applying nuclear Density Functional Theory, motivating experiments and interpreting their results, and implementing a comprehensive theoretical framework for the physics of exotic nuclei.”

Nazarewicz’s expertise sweeps across a wide swath of territory, including nuclear physics, interdisciplinary many-body science, and computational physics. To successfully navigate this much terrain requires the right tools, including Density Functional Theory, or DFT.

“There are various approaches to describing nuclei theoretically,” Nazarewicz said. Some are very precise, such as ab-initio methods, and some are more limited.

This is because of the many-body problem—the tricky issue of trying to simulate a system that has more than two bodies. The heavier a nucleus becomes with the addition of protons or neutrons, the more difficult it is to accurately describe it. DFT works around this problem using different degrees of freedom and describing a system in terms of proton and neutron densities and currents rather than its individual constituents.

“This can work throughout the nuclear landscape,” Nazarewicz said. “It’s been used for a very long time in various flavors.”

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When I started working in nuclear physics in the 1970s, we called this framework “self-consistent mean-field theory and its extensions. It wasn’t called DFT because the explicit connection with the electronic DFT—in the mid-1960s—had not been made at that point.”

Here he draws the comparison between what he was doing and the French play *The Bourgeois Gentleman*, where a man lacking noble birth aspires to pass as a member of the elite by acquiring their manners. In one scene with his philosophy instructor, Monsieur Jourdain proclaims that he has been speaking in prose all of his life without knowing it.

“This is like with DFT,” Nazarewicz said, smiling. “We were using DFT, we were speaking DFT, but we didn’t call it DFT. But,” he added, laughing, “We never pretended to be who we weren’t.”

The Exotic Explains the Ordinary

All through his career, regardless of the language he used, Nazarewicz has been interested in nuclei far from stability—the more exotic sort. These rare isotopes with extreme numbers of protons and neutrons have complicated internal structures and live short and precarious lives, making them difficult to study. With the growing sophistication of experiments over the years, Nazarewicz said that nuclei considered quite exotic in the 1980s are seemingly closer to stability today. In the 1990s, new physics came along as scientists developed new paradigms and tools, particularly in computing.

“I think we made a lot of progress,” Nazarewicz said. “Suddenly we find ourselves in the process of rewriting textbooks.”

Exotic nuclei enjoy a wide following because they’re useful in a number of different areas. For example, Nazarewicz explained, because they have such a dramatic difference in the number of neutrons over protons (or protons over neutrons) than their more work-a-day relatives, they can actually reveal a deeper understanding of their stable cousins.

“It’s like using a magnifying glass over small bits and pieces that play a major role in understanding stable nuclei,” Nazarewicz said. “You go far away from stability to better understand stability,” much like how Dorothy travelled all the way to Oz so that she could recognize happiness in her own backyard.

Exotic nuclei are also important for astrophysics, which can answer questions about the origins of matter we take for granted.

“How was uranium born? How were the rare earth elements born? They (exotic nuclei) are very short lived, but important,” in providing the answers, Nazarewicz explained.

The nuclear reactions in supernova go through the neutron-rich territory of the nuclear chart, and this is also true for processes taking place in modern fission reactors, yet another area where exotic nuclei have a critical role.

Nzarewicz’s interest in these rare isotopes played a leading role in bringing him to East Tennessee. He first visited in the mid-1980s, working both at the university and Oak Ridge National Laboratory with fellow nuclear physicists like Lee Riedinger and Carrol Bingham. In 1990, he was finishing a term

as an associate dean at his home institution, Warsaw University of Technology, just moved to the University of Warsaw, and was ready for a sabbatical. So he came to the UT-ORNL Joint Institute for Heavy Ion Research in 1991. His original plan had been to come for one year, which was then extended to two. Then came an opportunity that has kept him here ever since.

“The RIA (Rare Isotope Accelerator) project was launched, and I was immediately involved in making the physics case for RIA,” he said. “So I stayed here.”

Because the physics around rare isotopes addresses basics in nuclear structure, astrophysics, and fundamental interactions, nuclear physicists like Nazarewicz have lobbied for a next-generation exotic beam facility—the Rare Isotope Accelerator. This would give scientists the equipment and space to address increasingly important and exciting avenues in nuclear physics research. That goal has come to fruition with the Facility for Rare Isotope Beams (FRIB) now under construction at Michigan State University.

Already, supercomputers like Jaguar and Kraken at ORNL have upped the ante on scientific calculations. These supercomputers can take scientists to a new dimension, Nazarewicz said. By calculating predictions and determining uncertainties, nuclear theorists design new models to coax nuclei into giving up their secrets.

“We are working more and more to use the nuclear structure tools that we’ve developed” to study areas and applications useful to society, he continued, including data on fission for stewardship applications.

“The need for nuclear theory in this area will only grow,” he said.

Taking Matters to Heart

Nzarewicz helps lead many of the expeditions as scientists explore new areas in nuclear physics. He is a co-director of the U.S. Department of Energy’s UNEDF (the Universal Nuclear Energy Density Functional) collaboration program and has served on three committees of the National Research Council of the National Academies of Science. He was a driving force in founding two international institutes devoted to theory studies of exotic nuclei—one in Japan and one France. To expand opportunities for young scientists interested in the field, he has been involved in a number of summer schools, the most recent being a 2011 program in South Africa. It is little wonder he has been drafted to serve on numerous committees for DOE, the National Science Foundation, and the APS. His work has been cited more than 14,000 times and he’s listed by ISI among the most highly cited in physics.

Nzarewicz has a gift for building teams and pooling talent, something he attributes to his early days in Warsaw, when he was an up-and-coming physicist.

“I think that I was very lucky in my career,” he said. “I was raised, scientifically, in Warsaw.”

He described working with a friendly and enthusiastic group of talented scientists and paid particular homage to his mentor, the late Prof. Zdzisław Szymański, who became a role model for collegial behavior.

“He was a wonderful person and a great mentor,” Nazarewicz said. “He taught me that scientific research can be fun. It doesn’t have to be a rat race. I took it deeply to my heart. You

can be friends with your collaborators and students.”

Many of UTK’s physics students have benefited from that approach. Nazarewicz teaches courses for both graduate and undergraduate students, which can be a conduit for building new research relationships.

Perhaps one of Nazarewicz’s greatest strengths is the attitude he adopted coming through the ranks: he makes friends and keeps them for a very long time. He has never broken his connection with the University of Warsaw, where he remains a professor, and over the past three decades has continued to expand his network of colleagues. He is a professor of physics at UTK, where he has served as chair of the department’s planning committee for many years. He is

also distinguished research and development staff at ORNL, a faculty member with CIRE (the Center for Interdisciplinary Research and Graduate Education at UTK, recently renamed for Former Governor Phil Bredesen), and keeps ties with the University of the West of Scotland, where he was named a 2008 Carnegie Centenary Professor.

When the APS holds its March 2012 meeting in Atlanta, a special session will be dedicated to the Bonner Prize, and Nazarewicz is slated to give a talk. With a world of good friends and an impressive list of accomplishments, assembling his remarks probably won’t be that difficult.

“I’ve been working on this topic for the last 35 years or so,” he said, laughing. “I will be well prepared.”

Getting Ready for the Next Round

IT MIGHT BE VIRUS PREVENTION. Or overcoming the dreaded Blue Screen of Death. Or tracking down a replacement part for equipment in the teaching labs. Whatever the electronic or computing predicament, Gene McGuire and Brad Gardner keep the physics department humming along in roles that are often equal parts detective work and technical know-how.

The department’s electronics shop can trace its roots to the late Dr. Alvin Nielsen (former professor, department head, and dean) and one Glenn Cunningham. As McGuire explains, Cunningham “was the person that Nielsen brought from Tullahoma to do the electronics repair.”

In May of 1969, Cunningham hired McGuire on a part-time basis.

“I started with little projects; building simple things for the labs,” McGuire said. “(Professor) Linda Painter had a spark gap and a bunch of other things. I was building a digital readout stepping system for that.”

By September he was offered a full-time position, but only at his part-time salary, so instead he accepted a position at Oak Ridge Technical Enterprises Corporation (ORTEC).

When his ORTEC supervisor learned he knew how to get information into teletypes, McGuire said, “I had to teach a whole class of engineers for about two hours just to show them.”

This was the era of schematic sheets, and to demonstrate Gardner disappeared into a back room and returned with a

drawing the size of a beach towel.

“This is what we used to have to look at,” Gardner said. “It was all done on a drafting table. This was a schematic for one piece of equipment.”

Before long, Cunningham was looking for someone who could work with digital equipment, a skill McGuire had picked up during his years of military service. Cunningham rehired him at UTK in October 1970.

After Cunningham’s retirement, McGuire took over as supervisor in 1988. At the time, the staff included McGuire and two other technicians (Tom Caylor and Paul Cummins), as well as a part-time student helper.

In February 1990, McGuire hired Gardner, who had an interesting path to university employment. He was dating a young lady named Tracy and had told her they would get married as soon as he found a permanent position with employment benefits.

“She’s the one who told me about the job,” Gardner said, smiling. “I was hired in February 1990. We were married in September of 1990. Needless to say, she didn’t forget.”

Gardner’s first project was working on Professor Bill Bugg’s drift chambers for experiments at Fermilab.

“The first thing; I mean the first *day*, I was drilling and tapping aluminum posts. I was cutting and drilling standoffs. Drill and tap. That’s what I did for the first two

Physics Behind the Scenes



Gene McGuire and Brad Gardner keep the department’s computers and other electronic equipment up and running.

weeks I was here.”

Over the years, however, his duties have changed quite a bit, primarily with managing the growing demand for computing power in the physics department. This was actually sort of a return to his first professional position. After graduating from the Tennessee Institute of Electronics in 1989, Gardner worked for a year at MCS Services, Inc., a company specializing in Apple computers. He and Cummins drew on their collective experience to master new software and keep up with the department’s evolving needs in terms of computer equipment.

“Over time, it got to where instead of

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Biophysicist Brings Lab-on-a-Chip Work to UTK

OVER THE COURSE OF THE DEPARTMENT'S HISTORY, many young scientists have moved to Knoxville to join the physics faculty. Jaan Männik, however, is the first to bring an interest in the workings of bacteria with him.

Männik is the newest assistant professor to join the department's ranks, arriving in August 2011. He is an experimental biophysicist, but took a slight detour to arrive in that particular field. His Ph.D. work at the Stony Brook University (SUNY Stony Brook) was actually devoted to superconducting single electron transistors. After finishing his doctorate in 2003, he stayed on as a postdoc, where he helped develop charge and flux qubits for quantum computing. His move toward the merger of biology and physics began during his two subsequent appointments: first at the University of California, Irvine; then at the Kavli Institute of Nanoscience at the Delft University of Technology in the Netherlands. At Irvine he studied the detection of charged biomolecules using carbon nanotube transistors. At Delft he added to biosensing a new line of research: bacterial biophysics using nanofabricated silicon chips.

Männik said the "lab-on-a-chip" work dovetails nicely with his interests in miniaturizing systems and building circuits. Adding *E. coli* bacteria to the equation was not that difficult a step.

"*E. coli* are easy to handle," he said. "It does not require much know-how to grow these bacteria."

The choice of *E. coli* was also straightforward for other reasons. As Männik explained, these particular bacteria are to biophysics now what the hydrogen atom was to physics a century ago; they are one of the simplest life forms and very well characterized.

"Biophysicists are eager to explain their behavior quantitatively now," Männik adds.

While we hear scary news about these organisms from time to time there's no need for concern about their safety in a research setting like his.

"Some forms of *E. coli* are of course pathogenic, but the strains I use are not," he said. "In fact, every one of us carries huge numbers of non-pathogenic *E. coli* in our guts."

To study these bacteria, he builds what might be called nanoscale laboratories.

"There are different ways to make them, and I use different technologies and processes," he said.

He showed one example made of silicon, the material of computer chips.

"Basically you have a silicon wafer and you cover it with a polymer layer, which is sensitive to light or electron beams," he explained. "And then you can define various patterns on the surface."

He uses what he calls "micromachining" to etch the silicon, using designs he creates in his computer. He typically uses a four-inch silicon wafer with 20 or so designs to make individual chips.



Dr. Jaan Männik's research is at the intersection of physics and biology. He joined the physics faculty in August 2011.

Each chip is about the size of one U.S. cent.

The etching creates a labyrinth of chambers and channels that trap bacteria in a certain pattern. To demonstrate, he placed a small, silver square of silicon under a microscope to reveal a snapshot of its architecture: a square chamber connected to a long and narrow channel where bacteria can squeeze through, flanked by several additional and much narrower pathways that hold nutrients to sustain them.

In earlier work published in the *Proceedings of the National Academies of Science*, he looked at how bacteria propagate and move in these channels.

"Besides finding that common bacteria are very well adapted to move through narrow passages, we also found that some bacteria take very different shapes when squeezed into these channels. Surprisingly, they're still able to divide and grow despite their irregular shapes," he said. "It's quite remarkable how the protein machinery in these bacteria can adapt and still work in these shapes. In processes such as cell division, where a mother splits into two daughter cells, chromosomes need to be accurately positioned so that each daughter cell inherits a full genetic code. How cells achieve this positioning is a fundamental question in biology. Furthermore, it is very little understood what role shape plays in this but also in a variety of other molecular processes in bacteria."

This is the work he's transferring to UTK.

"I will be mostly working with bacteria and trying to develop microfluidic chips to better study them," he explained. "I'm interested in self-organizing processes in bacteria; how do the molecular systems work and give rise to behaviors and structures in these cells. In experiments, I want to see these self-organizing processes happening in real time down to details at single-molecule level."

Studying bacteria on chips might seem a long way from the single electron transistors Männik previously worked with, but in fact the transition was not all that difficult.

“I have carried [an] interest in biology for a long time and gradually moved from one field towards another,” he said, with his current research taking place at the intersection of physics and biology. Among his interests are modeling biochemical processes in bacteria based on statistical mechanics and polymer physics, as well as developing micro-fluidic structures for high resolution microscopy of bacteria in their physiological conditions. As an experimentalist, he’ll be developing instrumentation to non-invasively probe single molecules in a cellular milieu.

Physics graduate student Matthew Bailey is starting to work with him, and he hopes to recruit additional students, including some from outside the department to build a true multi-disciplinary group.

“Since I’m working at the intersection of different fields then it would be very nice to have people who have backgrounds from

these different fields,” he said. “I’m also looking at students from biology. I’m holding an adjunct position with the genome science and technology program, so I hope to attract students from that program as well.”

At present he is setting up his lab and preparing to teach Physics 222 in the Spring 2012 semester. His wife, Jaana, is also settling in to her new responsibilities as a research scientist in the UTK Department of Biochemistry and Cellular and Molecular Biology.

When he’s not working on physics, Männik enjoys the outdoors and reading. At least one interest, however, has been sidelined as he tackles his new faculty responsibilities.

“I used to like travelling,” he said, laughing. “But I don’t expect much time to do it now taking on the whole set of new responsibilities. On the other hand, the Smokies are conveniently close and it is a really great place for an outdoors enthusiast like me.”

Pageantry and Physics

Dr. Carrol Bingham Retires After 45 Years of Service to Physics

CARROL BINGHAM’S STELLAR CAREER IN NUCLEAR PHYSICS IS NO SECRET. The fact that he was part of a Miss USA telecast, however, might come as a surprise.

After 45 years of teaching, research, and a little bit of broadcast fame, Bingham retired on June 30, although he’s not quite done with physics just yet.

Bingham grew up on a farm outside of Shelby, North Carolina, and attended North Carolina State University, where he earned a bachelor’s degree in nuclear engineering in 1960.

He went on to earn a master’s degree in applied physics at NCSU in 1962. As an alumnus of both N.C. State and Tennessee, he has been an avid fan of football and basketball at both institutions, but he has spent five and a half years at State and 50 years at UTK, and thus, like most Knoxvilleans, he pulls for the Vols. However, if the Wolfpack came to Neyland Stadium for a contest, he says “I probably would be more neutral than normal, and would applaud the winner.”

His favorite professor at NCSU was his thesis advisor, Dr. Raymond Murray, who was UTK’s first Ph.D. graduate in physics and a recipient of our Distinguished Alumni Award in 2004. (Dr. Murray, sadly, passed away this past June.) Murray’s history at UTK, along with the opportunity to work in nuclear physics at Oak Ridge National Laboratory and the fact that it was close to home, all influenced Bingham’s decision to come to UTK for doctoral work. His, in fact, was the first thesis finished at the Oak Ridge Isochronous Cyclotron, in December 1965.

The following spring he interviewed with Dr. Alvin Nielsen, head of the UTK Physics Department and was offered a position as an assistant professor.

Although he was supposed to start teaching in the Fall of 1966, Nielsen asked if he might like to go ahead and get started by taking on a 300-level course in modern physics for the summer. That fall he taught two courses, teaching six days a week.



Dr. Carrol Bingham (left) and Department Head Soren Sorensen at the August reception honoring Dr. Bingham’s 45 years of service to the university.

Continued on page 11

The Physics Top 10 List

In the fall of 2010, Cross Sections began highlighting the Top 10 Most-Cited Papers from our department, with insight from the authors, beginning with Number 10. These papers show the breadth and influence of the physics department's research program.

#8

Title: The Monte-Carlo Program KoralZ Version 4.0 for Lepton or Quark Pair Production at LEP/SLC Energies

Authors: S. Jadach, BFL Ward, and Z. Was

Journal: *Computer Physics Communications* 79, 503 (1994)

Times Cited: 394 (as of 12/1/2011)

Summary

Courtesy of B.F.L. Ward, Distinguished Professor of Physics Department of Physics Baylor University, Waco, Texas

During the period 1989-2000, the cutting edge in high energy e^+e^- collisions was the experimental program of the Large Electron-Positron (LEP) collider at CERN operating first on the Z^0 resonance at 91.19 GeV and, after 1996, above the W^+W^- pair production threshold at 161 GeV. Its highest energy was 209 GeV when it stopped in 2000.

There were four multi-purpose detectors at LEP, ALEPH, DELPHI, L3 and OPAL, all designed to make the most precise measurements ever of the properties of the Z^0 and W^\pm electroweak gauge bosons and to discover new degrees of freedom such as the Brout-Englert-Higgs particle or its supersymmetric cousins or other types of cousins, should any of the latter exist[†]. In order for all of these experimental programs to be successful, precision theory predictions for the known Standard Model processes on the Z^0 resonance and above the W -pair production threshold were needed. What was novel is that these had to be provided in the form of a Monte Carlo (MC) event generator in which multiple photon higher order radiative effects were treated on an event-by-event basis with the large infrared (IR) effects treated to all orders in perturbation theory

so that no arbitrary IR cut-offs remained in the predictions.

At the time of our research, all competing MC's had such arbitrary IR cut-offs because they were based on finite order perturbative results. In the event-by-event all-orders resummation MC form, arbitrary detector cuts could be implemented with rigorous predictions. This had to be done then for all relevant 2-fermion ($2f$) processes and 4-fermion processes.

The research we did in the paper provided the world standard realization of these theoretical predictions for the $2f$ processes (e^+e^- annihilation to quark and lepton pairs with multiple photon radiation) by the first ever MC realization, in the MC KoralZ, of the all orders exact amplitude-based Yennie-Frautschi-Suura resummation theory (Ann. Phys. **13** (1961) 379) with the respective residuals treated to the second order leading-log pragmatic accuracy of 0.1% when one is near the Z^0 resonance for observables such as the Z^0 line shape in muon-pair production. These processes are needed to such accuracy both in measuring the precise properties of the Z^0 and as a precise determination of possible backgrounds to searches for new degrees of freedom such as supersymmetric particles. The signals which were determined using efficiencies calculated with KoralZ for Z^0 production were instrumental in establishing the correctness of the one-loop corrections to the $2f$ processes as predicted by the non-Abelian gauge theory renormalization methods of G. 't Hooft and M. Veltman, a prediction for which 't Hooft and Veltman were awarded the Nobel Prize in Physics in 1999.

The methods we introduced in this paper have now been adopted by two of the three leading energy frontier MC's for the treatment of higher order EW resummation, the now standard codes Herwig++ and Sherpa in wide use at the new Large Hadron Collider in CERN.

[†]A somewhat more specialized version of the CERN program at the Z^0 resonance also existed at SLAC in the SLC single-pass e^+e^- collider, where the primary focus was the measurement of the lepton left-right polarization asymmetry by the SLD Collaboration. UTK was a participant in SLD via Bill Bugg's experimental group.



Electronics Shop, continued from page 7

having a rack full of equipment running the experiment, they've got one box and a computer, and that does everything that those five or six pieces did," he explained. "It's just an interface box and a computer and the computer controls everything. There's still a lot of analog equipment and other equipment to be worked on, but nothing like what was. Everything now has gotten pretty much digital, which is all chip-controlled. Where it used to be all resistors, capacitors, and transistors, and you had a giant board that did a job, now it's all done on one little chip."

When Cummins went to work across campus at Hodges Library, Gardner took over computer operations, with McGuire overseeing administrative aspects of the shop—making sure they have needed supplies and parts—and continuing his work with electronics.

"Brad takes care of the computers and I take care of the lab equipment and some of the experiments that professors are doing," McGuire said.

Gardner also works to keep up with his technical certifications as well as the latest gadgets.

"Every day it changes," he said. "What's top of the line now won't be tomorrow. It's a full-time job just trying to keep track of what's new."

Keeping everything from instrument amplifiers to office desktops running can require as much research as it does hands-on work. If a professor needs a new computer setup for a research lab, for example, the shop needs to figure out how to build that system on the professor's budget while honoring university contracts with specific vendors and state purchasing policies. If a piece of equipment burns out in one of the introductory physics labs, they have to "measure and match" to determine what replacement part to order.

"You have to measure the dimensions of it and go look at dimensions of individual parts to find one that will fit," Gardner said. "We've done that I don't know how many times. It takes a lot more time than you realize."

The shop also has to tackle some mystifying problems that come through the door from time to time.

"We had a circuit board that was generating voltage. It had nothing on it—it was just a circuit board, yet we could read

voltage on it," Gardner said. "We haven't figured that one out yet."

Then there was the case of a really sick laptop, brought in by a physics postdoc.

"He had two anti-virus programs running on it, and over 2,000 infections," Gardner said. "The anti-virus itself was infected. When it went to run the scan it re-infected everything else."

Much like the schedule in the department's instrument shop, both McGuire and Gardner said there's no such thing as a "typical" day on their calendars. With budget cuts and the like, the staff is now just the two of them, so they work together to troubleshoot whatever comes their way.

"It all depends on what time of year it is," Gardner said. "Our workload changes with the classes. When school's in session we're more equipment intensive—fixing equipment, printers—keeping things going so they can finish."

With classes over for the fall term, they'll have some time to overhaul equipment, make sure the labs are ready for the spring semester, and catch up on any backlogged requests. Or, as Gardner said, laughing, "Get ready for the next round."

Carrol Bingham, continued from page 9

"Nielsen was baptizing me by fire," Bingham said, smiling. With the exception of summers and a short sabbatical in 1975, he taught every term from Summer 1966 through Fall 2010.

Bingham's research is devoted to experimental nuclear physics and has been, as he describes it, "multi-faceted."

He started out using nuclear reactions to study properties of nuclei and over the years his program evolved to encompass the study of nuclei far from stability via radioactivity studies, as well as the measurement of nuclear spins and moments of rare isotopes by means of laser spectroscopy. Working with colleagues from the U.S. and abroad, he became a co-discoverer of 20 or so new exotic isotopes decaying by proton emission.

In 1968 he won his first research grant. He had planned to submit his proposal to the National Science Foundation, but Nielsen said it wouldn't hurt to send it to the Army Research Office as well. He took the advice, which paid off: NSF turned him down, but the Army funded him for the next three years. In 1975, he and Dr. Lee Riedinger won a Department of Energy grant for \$15,000, and DOE has funded their research ever since. In the early 1980s, he and colleagues set up and operated a laser spectroscopy lab at UNISOR, the University Isotope Separator at Oak Ridge, to measure the radii of nuclei and determine the nuclear spins of rare isotopes.

In his reflections of his career at UTK, he recounted that, "At one point in that era, I had the pleasure to provide an interview with the reigning Miss USA, 1982, Miss Terri Utley, in which I was supposed to give a sampling of research being conducted

at ORNL. A mini-documentary was presented on national TV during the 1983 Miss USA pageant in Knoxville including part of the interview."

For the past 20 years, Bingham has also managed the Joint Institute for Heavy Ion Research (JHIR), an intellectual center offering workshops, support for meetings and conferences, and physical accommodations to visiting scientists conducting research related to the Holifield Radioactive Ion Beam Facility. He described this post "one of the highlights" of his work at UTK and ORNL.

"This has become an excellent place for me to work in nuclear physics," he said. "I couldn't have picked a better one."

Bingham said what he counts as his greatest success is that he may have helped influence the attraction of terrific nuclear physicists to UTK. Over the years the group has added Mike Guidry, Soren Sorensen, Witek Nazarewicz, Robert Gryzwacz, and Kate Jones.

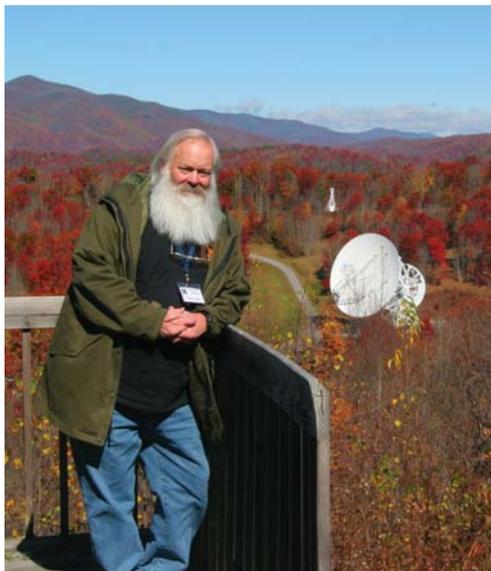
"Nuclear physics is well-heeled for the future," he said.

As for *his* future, Bingham will now have more time for his family (his wife Sandy and his three children and five grandchildren) and a little more travelling that involves purely recreation. But he's not finished with physics. He plans to keep managing the JHIR for another year or two and will still keep working some with the nuclear physics group, although now as a Professor Emeritus.

"So it's not a complete retirement," he said. "I got retired, and then sort of rehired."

Physics Family News

Staff



Paul Lewis was invited to speak at the 2011 PARI Fall Star Party. This picture was taken on the optical ridge overlooking the 26 meter in the valley.

You can head back down to the kitchen and fix yourself a sandwich and then head on over to the main building for a session of talks or maybe some time on "Smiley," the 4.6 meter radio telescope. It's just a great all around experience.

By Paul Lewis
Director of Astronomy Outreach and
the Teachers' Resource Distribution Center

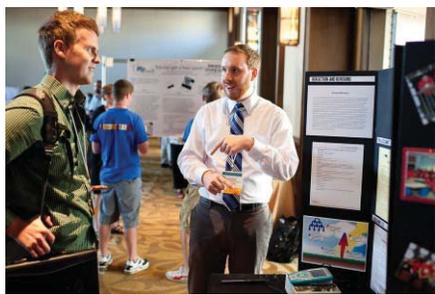
The Pisgah Astronomical Research Institute (PARI) is located just outside of Rosman, North Carolina. The site has a rather interesting history. Built by NASA in 1962 as the nation's East coast satellite-tracking facility, the then-Rosman Research Station was transferred to the Department of Defense in 1981, where it served the National Security Association until 1995. Of the 23 antennas on-site, four were abandoned and left to the elements. The government considered dismantling the facility in 1995 and returning the site to nature.

Enter private investors and a not-for-profit foundation and what you have today is a radio telescope facility: its largest telescopes are two 26-meter instruments that can be outfitted for various tasks. About \$10 million in private investments, countless volunteers, and a now full-time paid staff make PARI an exciting Astronomy research and teaching facility. For the past several years, PARI has hosted the PARI Fall Star Party. It is an opportunity for a small number of dedicated amateur and professional astronomers to gather for a weekend of talks, training and sharing knowledge with each other and the public. I was invited to give a talk in 2010 on the "History of the Space Shuttle Program." I was invited back to continue that talk in 2011: "The Legacy of the Space Shuttle and the Future of the U.S. Manned Space Flight Program."

PARI is an absolutely serene and beautiful facility. You can take a walk across campus or make the steep climb to the optical ridge and just enjoy the surroundings.

Students

Joel Smith, a senior physics major enrolled in the university's VolsTeach program, was one of two UTK students invited to the 5th Annual UTeach Institute-NMSI Conference in May 2011, where he walked away with a student poster prize. Smith was one of 26 students, faculty, and staff who presented posters in a competitive session. His poster, entitled "Technology Based Lesson on Weather Predictions and Data" won the Open Topic category, one of two categories for students. He presented an analysis of a technology-based lesson he developed to teach weather and atmosphere from the perspective of a scientist. To learn more about VolsTeach, visit the Web site at: <http://volsteach.utk.edu/>.



Senior Physics Major Joel Smith won a student poster prize at the 5th Annual UTeach Conference in May.

(Photo courtesy of the UTeach Institute.)

George Duffy, a senior in physics, started Calculators to Classrooms as an awareness campaign. He got word in early December that the project is now a state-recognized Non-Profit Organization.

Duffy founded the Calculators to Classrooms project to make science and math education more equitable at the high school level. In April 2011 he led the Society of Physics Students effort encouraging the university community to donate used calculators to students in underprivileged schools. These students often have little if any access to calculators and consequently struggle in math and science courses. At campus stations offering free cookies and liquid nitrogen ice cream, the SPS garnered 100 commitments to donate calculators to students who need them.

On November 16 Duffy gave a TED talk (via TedxKnoxville) about the program and on November 30 local NBC affiliate WBIR-Channel 10 ran a story on the group's donation of 30 graphing calculators to Dr. Paul L. Kelley Volunteer Academy, a non-traditional Knox County high school.

For more information on this new organization, visit the Calculators to Classrooms Web site at: <http://calculatorstoclassrooms.org/>

Faculty

In recognition of his outstanding service as head of the physics department, as well as many other contributions to the university, the College of Arts and Sciences has bestowed its highest honor—that of College Marshal—on **Dr. Soren Sorensen**. He will represent the college and carry its banner at the spring and fall commencement ceremonies in 2012.

In October 2011 the university renamed the Center for Interdisciplinary Research and Graduate Education (CIRE) in honor of former Tennessee Governor Phil Bredesen. Our own **Professor Lee Riedinger** is director of the newly-christened Bredesen Center for Interdisciplinary Research and Graduate Education, which is a joint program between the university and Oak Ridge National Laboratory offering interdisciplinary doctoral programs designed to attract top-tier graduate students to UTK.

In early December, the department got word that **Riedinger** has been elected a Fellow of the American Association for the Advancement of Science.

Professor Emeritus Jim Thompson and his colleagues have won yet another R&D 100 Award. Following awards in 2009 and 2010 for research in superconductivity, this third honor in three years recognizes their research in nanomagnetism. Thompson and co-developers Amit Goyal, Claudia Cantoni, and Junsoo Shin of Oak Ridge National Laboratory were honored for their invention of Ultra-high Storage Density, Self-assembled, Magnetic Media, which for the first time, allows data storage densities approaching and exceeding 1 terabyte per square inch. Sponsored by *R&D Magazine* since 1963, The R&D 100 Awards identify and celebrate the top high-technology products of the year and are known as the “Oscars of Innovation.”



The Graduate Physics Society hosted a fall picnic in October, where faculty and students had the opportunity to show off their athleticism (and knowledge of moving objects) with a softball game.



Dr. Lee Riedinger (back row, far left) is the director of the newly re-named Bredesen Center for Interdisciplinary Research and Graduate Education. Next to him are Dr. Jim Roberto of ORNL, Former Governor Phil Bredesen, UTK Chancellor Jimmy Cheek, and Jim Murphy, Vice Chair of the UT Board of Trustees. In the front row (L to R) are students Stephen Wood, Kemper Talley, Callie Goetz, and Kyle Sander.



Dr. Soren Sorensen was named College Marshal at the College of Arts and Sciences annual celebration of faculty in November.

In Memoriam

The department is sad to announce the passing of four members of our physics family.

Dr. Bruce Blackburn earned a Ph.D. in physics from UTK in 1981, working with Dr. M.A. Breazeale and specializing in ultrasonics. Following a career in engineering that took him to Maryland and California, he returned to East Tennessee and taught for several years at Pellissippi State Community College. He was an avid fan of UTK sports, particularly the Lady Vols Basketball program. He passed away on November 1, 2011, at the age of 61.

Dr. Don Forester passed away on August 29, 2011, at the age of 74. He was a native of Knoxville and graduated from Rule High School before going on to earn a bachelor's degree in physics at Berea College in Kentucky. He then came to the UTK Physics Department, where he received both master's and doctoral degrees, in 1961 and 1964, respectively. He worked for Oak Ridge National Laboratory and was also a member of the physics faculties at both the University of Nebraska and the Georgia Institute of Technology. He worked for the Naval Research Laboratory (NRL) in Washington, D.C., for 35 years before his retirement. A highly acclaimed scientist, inventor, and writer, his accomplishments included five patents and more than 150 papers. He was one of only 75 recipients to be honored with the NRL's 75th Year Recognition for Innovation, and in 1999 he was honored with the Navy's prestigious Meritorious Civilian Service Award. He was a member of several professional organizations, including Sigma Pi Sigma and Phi Kappa Phi honorary societies, Sigma Xi, the American Physics Society, and the Berea College Alumni Association.

Dr. Raymond L. Murray, the first Ph.D. graduate the physics department, died Wednesday, June 22, 2011, at the age of 91. He was born in Lincoln, Nebraska, and enrolled in the Teachers College of the University of Nebraska in 1936 with plans to become a high school teacher. He quickly developed an interest in physics and earned a bachelor's degree in science education in 1940. He finished a master's degree in physics at Nebraska in 1941, and from there headed to the University of California at Berkeley to continue his studies. With the onset of the Second World War, he joined the research effort on the electromagnetic method of uranium isotope separation at the UC-Berkeley Radiation Laboratory. In 1943 he was transferred to Oak Ridge to the Refining Division of the Tennessee Eastman Corporation, and chose to finish his graduate work at UTK. In 1950, his became the first doctoral degree granted by the physics department. He then accepted a faculty position at North Carolina State University, rising to become head of the physics department in 1960. In 1963, Murray became head of the nuclear engineering department at N.C. State, continuing to teach courses in reactor analysis and directing graduate research for two generations of students. He was the author of more than 75 technical papers and several books. Among his many honors were the O. Max Gardner Award of the University of North Carolina, the Arthur Holly Compton Award, and the Eugene Wigner Reactor Physicist Award of the American Nuclear Society. In 2004, the UTK Physics Department honored him, along with Dr. Robert Talley, with our inaugural Distinguished Alumni Award, "for his exceptional accomplishments in cross-disciplinary physics and his significant contributions to nuclear engineering." Murray was a featured alumnus in *Cross Sections* in the Fall 1999 issue. The article is online at: <http://www.phys.utk.edu/xsections/cross4c.htm>.

Dr. Mario Stoitsov, a Research Professor in the UTK Nuclear Physics Group, passed away August 4, 2011. Born in Bulgaria in 1953, he studied at the Faculty of Physics of the "St. Kliment Ohridsky" University of Sofia, earning a master's degree in atomic and nuclear physics in 1978. He earned the Ph.D. in 1983 under the supervision of Professor Ivan Zh. Petkov, and his D.Sc. degree in 1993. He worked at the Laboratory of Theoretical Nuclear Physics of the Institute of Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences, beginning in 1978 as a research scientist and attaining the rank of full professor in 1997. Stoitsov's work with Petkov on the development of nuclear density functional theory produced pioneering results, and they were co-authors of the book *Nuclear Density Functional Theory*. Stoitsov began collaborating with UTK and ORNL nuclear theory group members at the end of the 1990s, where the area of his main scientific activity was the nuclear density functional theory, with a strong focus on advanced numerical simulations. His is remembered among faculty, students, and staff for his encouraging demeanor and optimism, and he will be greatly missed.

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Original photograph by Chad Middleton (Ph.D., 2005)



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