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CROSS SECTIONS

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Fighting Cancer with Physics

Chet Ramsey and his team tackle a formidable opponent

ALL YOU HAVE TO DO IS HIT A MOVING TARGET. Without hitting anything else within millimeters of it. All the while knowing that someone's life depends on whether you succeed. And you need to understand anatomy, accelerators, biology, computer science, physiology, and above all, physics, to do that. That's what Chet Ramsey's day is like.

Ramsey is Director of Medical Physics at Thompson Cancer Survival Center, just a few blocks from the Nielsen Physics Building. He is also an adjunct associate professor in the physics department.

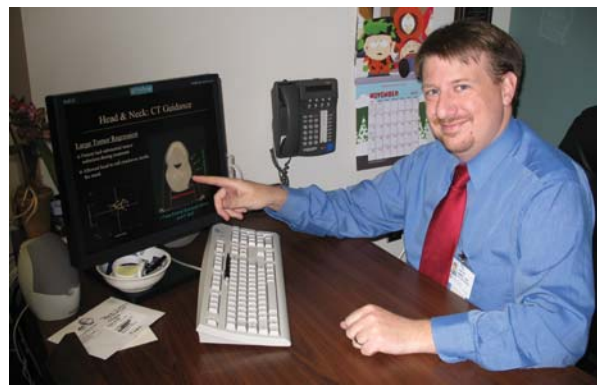
While there are different disciplines within medical physics, Ramsey's role is in radiation therapy. His medical counterparts are the radiation oncologists who see the patients and make the diagnoses. They decide how much radiation to give a particular tumor site, and the medical physicists determine the best way to deliver that prescription.

Ramsey and the team at Thompson have a number of high-tech weapons at their disposal when it comes to fighting cancer. One is positron emission tomography, or PET for short. It involves injecting a patient with a tracer that contains a positron emitter.

"The isotope is tagged onto a molecule that has a particular function," Ramsey explains. "In the case of cancer imaging, the radioisotope in the attached molecule is used by cells that are rapidly dividing. So the radionuclei concentrate in areas of high metabolism, such as tumor."

Then there's magnetic resonance imaging (MRI), which looks at proton density inside the patient, and as such is very good at revealing contrasts in soft tissue, like the brain. But the bread and butter of radiation therapy is computed tomography, or CT imaging.

"In radiation therapy, CT images are sort of the backbone of everything," Ramsey says. "You're shooting x-rays through the patient and measuring how much they've been attenuated on the opposite side; then using that to reconstruct a three-dimensional or four-dimensional model of the patient."



Chet Ramsey uses imaging technology to treat cancer patients

Radiation therapy physicists use CT images to design computational models so they can calculate the radiation dose to the tumor and the surrounding normal tissue. They use MRI and PET images as secondary support to help them define spatially what they're going to target. When designing a treatment plan for a particular patient, they review all the images and map out where the tumor and normal tissues are. Then they run computations to determine the best angles, intensities, and beam energies to achieve the prescription defined by the radiation oncologist.

"Tumors tend to appear close to normal, sensitive structures," Ramsey says. "It's always a trick of determining how can we obliterate all the cancer cells that are sitting immediately adjacent—two, three, four, five millimeters—away from the patient's spinal cord."

Radiation physicists not only have to deliver radiation to the tumor while avoiding healthy tissue, they also have to work around the obstacles presented by normal human physiology.

"Take a tumor in the lung, for example," Ramsey explains. "It's not a simple matter of taking a CT image and saying, 'Here's where the lung tumor is and I'm going to shoot a beam at it.' As you breathe, the tumor

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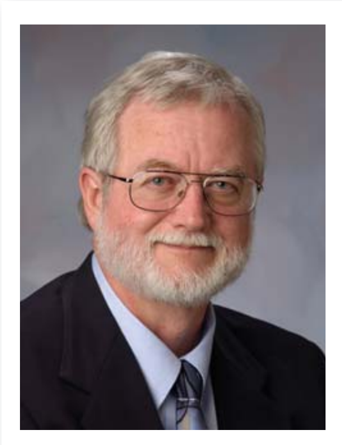


Energy

By Soren Sorensen, Department Head

IT IS NOT DIFFICULT to convince physicists that energy is important, both as a concept in physics and as a resource for our society. But sometimes it is easy to get the impression that few people outside science and engineering departments have a strong appreciation for how important energy is to our society and how important it will be in the future to continue to have cheap energy resources available. So I will use this opportunity to briefly discuss some of the current themes in the energy debate and then address what we as a physics department are doing and can do in the future.

As physicists we have learned ever since our first course that energy is conserved, so technically what we are discussing in connection with energy production in society is really conversion of energy from one less useful form to another more useful form. What these less and more useful energy forms are depends entirely on the problem at hand. Typically we might be interested in converting internal energy to work in machines, but in other cases we want to convert chemical internal energy to kinetic internal energy, like when we are heating a house using natural gas. The first energy conversion ever used by humans was fire. This process is really the earliest example of humans using solar energy, since the chemical energy liberated in burning wood originally comes from solar energy concentrating carbon in plants, so energy can later be generated by oxidizing carbon. The next step forward in humans' use of energy conversions to improve their lives was the domestication of animals and subsequent usage of animals like horses and oxen for work. From a purely physics point of view, this process is conversion of solar energy into chemical energy in plants, which are eaten by animals thereby converting the plant chemical energy into chemical energy in ATP molecules. Finally, the animals convert this chemical energy into mechanical energy by walking in front of a plow, an irrigation system, etc.

In more recent history, the Industrial Revolution that started approximately 200 hundred years ago was caused by our capability to effectively convert the oxidation energy of carbon (=coal) into mechanical energy through the steam engine. It is hard to underestimate the importance of this invention in improving the materialistic aspects of our lives. I recently read an estimate in the *New York Review of Books* of how over the course of a century the Industrial Revolution improved the effective standard of living of people in England by a factor of 6 after a period of nearly 1,000 years with no substantial change. However, this dramatic improvement, which is still taking place in many developing countries, has come at a high price. The energy conversion source we are using is carbon that has been concentrated in the upper crust of the Earth over hundreds of millions of years in the form of hydrocarbons. Based on (too) simplistic extrapolations, it looks like we might be able to convert all these hydrocarbons to CO2 in the atmosphere or seawater over a period of only 500 years. The situation is even worse for the particularly useful liquid and gaseous form of hydrocarbons: oil and natural gas. We started using these forms approximately 100 years ago, and unless we substantially change our usage patterns, oil and natural gas will be very scarce resources within the next 40-60 years.

However, the problems related to our rapid depletion of oil and gas will not wait 40-60 years, when there might be no resources left. Already now it is becoming increasingly difficult to find and pump new oil and gas fields, and as the demand continues to rise, the price of oil will increase dramatically. We have already witnessed the tripling of the crude oil price (averaged over seasonal oscillations) over the past 8 years. I might be too pessimistic, but personally I am convinced that over the next decades we will witness a doubling of the oil price every 5-7 years. Under these conditions oil and gas will be very expensive, especially for the developing countries, and these conditions can easily lead to severe political instabilities both within countries and between countries.

This all sounds very pessimistic, and if nothing substantial is done over the next decades to develop new cheap energy sources, these pessimistic scenarios have a high likelihood of being reality. However, there are many, many possibilities for new and better energy sources, so the issue is not lack of scientific and engineering opportunities, but more willingness among the general population and our politicians to make the high investments in research, development, and implementation that are needed.

A Historic Crossroad

Humankind is therefore at a historic crossroad, where we have to make a turn away from generating the majority of our useful energy from hydrocarbons stored over geological time spans in the crust of the earth. And as physicists and educators we have a particularly important role in getting this turn to happen as soon as possible and with as few side effects as possible.

So what are we doing about this issue within our department and at UTK, in general? First of all we are increasingly focusing part of our departmental research toward issues related to advanced materials that might be important for new energy forms in the future. A great example of that is the experimental and theoretical research of Ward Plummer, Jim Thompson, Hanno Weitering and Zhenyu Zhang on ultrathin metal alloys that might have controllable capabilities for absorbing and releasing hydrogen. Such materials would be very important in developing the potential to transport and store hydrogen in a safe and controllable way, especially in future cars.

Hydrogen is not in itself an energy source, since we will initially have to use energy to generate free hydrogen from water. But if we can then find simple ways to transport and store hydrogen, it can be used in simple fuel cells to generate energy, when it recombines with oxygen to water. Conventional technology will require us to transport hydrogen under high pressure (an inherently very dangerous process). The high diffusivity of hydrogen might also lead to large losses. But if the UTK/ORNL researchers are successful, we might be able to store large amounts of hydrogen absorbed in relatively small devices with large internal surfaces. Storage devices like that could potentially replace gas tanks in cars. In other words, the research of UTK/ORNL scientists might one day be an important step toward all of us keeping our personal transportation vehicle, the car. And a hydrogen-driven car will be able to operate without any CO2 emissions!

Zhenyu Zhang is going a step further. In his theoretical investigations he is looking for other materials that can store even larger amounts of hydrogen. In their latest work he and his collaborators are finding great possibilities in the carbon networks like fullerenes or nanotubes. Unfortunately these materials also seem to pose larger problems with controllability, but the research is of course still in its early stages.

Physics is of course not the only department at UTK working on issues related to energy. In chemistry, Professor Jimmy Mays is working on improving the crucial membranes in fuel cells, and in biology and agriculture a large effort is underway together with ORNL on carbon-neutral biofuels. In addition, a lot of the research in the new buildings on the Cherokee Campus will focus on energy related issues: The Joint Institute for Advanced Materials will, in addition to Weitering and Zhang, also include many other researchers studying new materials and their usage in novel energy solutions, and a new center for sustainable energy research (SEERC) has also been proposed, originally spearheaded by our own Lee Riedinger.

Our department is also active in new initiatives for educating the next generation of people working on all aspects of energy issues through the creation of a new Interdisciplinary Program on Energy. The idea for this IDP comes from the fertile mind of Lee Riedinger, who at the moment is trying to put the program together. Lee plans to teach a new honors course on energy, primarily from a physics perspective, while other people from UTK will teach a wide range of other courses within the program on the political aspects of energy, the engineering aspects of energy productions and transformation, the geographical resource issues, the historical issues of energy, etc. I am sure you will hear more about this exciting educational initiative in this newsletter in the future.

As you can see, our department is centrally involved in the increasingly important energy issues from both a research and an educational point of view. But we also realize that these issues are so large that only by working together with a large cross section of researchers and educators from all of UTK and ORNL will we have a chance of making an impact.

There are many, many possibilities for new and better energy sources, so the issue is not lack of scientific and engineering opportunities, but more willingness among the general population and our politicians to make the high investments in research, development, and implementation that are needed.

moves in a complicated pattern that changes depending upon how deep you inhale or exhale. For tumors that are close to the heart, as the heart beats, you now have an interaction of both the heart as it beats, pushing the tumor side-to-side, and the tumor moving during respiration."

Understanding the physics of the human body helps medical physicists model and predict respiration and cardiac motion. But success at hitting the moving tumor actually makes things more difficult.

Ramsey turns to his computer and pulls up several different frames, each showing how a patient's condition has changed after a single day's treatment. Because radiation therapy is typically given daily over a course of one to eight weeks, Ramsey has an electronic journal documenting where the patient started and how the cancer has responded to radiation. As he clicks chronologically through the images, the tumor—which started as a large mass—begins to shrink. From the beginning of treatment to the end, Ramsey says, there are changes in the size, shape, and density of the tumor itself.

"The anatomy's actually changing," he says. "We compensate for this each day prior to treatment. We're looking at hitting things with the accuracy of a millimeter."

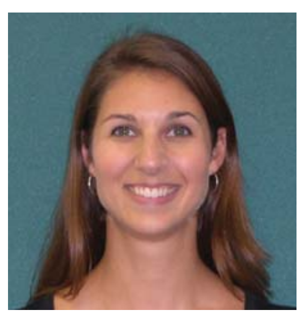
Paging Doctor Howser

Ramsey was born right across the street from Thompson Cancer Survival Center, but his route to medical physics wasn't quite a straight line. His original interest was fusion applications. But then a family illness changed everything.

"When I had just started in graduate school, my grandfather had been diagnosed with lung cancer," he says. "Nine months after being diagnosed, he had died. That opened my eyes to the world of cancer. I decided that that's what I wanted to dedicate my life to, helping the fight against cancer."

So in January of 1997 he started at Thompson as a medical physics resident.

"I was very Doogie Howser-ish," he jokes, making reference to the TV teenage doctor. "I started working here as a resident while I was still working on my master's degree."



Michelle Neeley

Ramsey went on to earn a Ph.D. in nuclear engineering and became Director of Medical Physics at Thompson in 2001. Among his chief responsibilities is directing the research program. His group has undertaken several investigations, including how to measure the radiation doses delivered to the first half millimeter of a patient's skin as a way to minimize skin reactions. They're also working on a long-term project that can help predict how successful a treatment plan will be.

"We've created a database of patients that have previously been treated, and we've created memory vectors in the computer that contain how each of these tumors responded to a treatment," he explains.

When new patients come in, physicists can measure how their tumors change during the early stages of treatment and compare them against those in the database. It's sort of the way a coach might look at game film to see what's worked before in taking on a particular opponent.

"It interpolates and finds similar patterns in the database and predicts what the tumor is going to do," Ramsey says. If the prediction indicates the treatment is not going to be as effective as they want it to be, they can change it. They can customize treatment for each patient to get the best predicted outcome.

Ramsey says that imaging has brought about the biggest changes in radiation therapy over the past three years. Before, patients were imaged once, maybe twice, during their entire course of treatment.

"Now, patients are CT imaged every day before treatment," he says. "And there's an enormous amount of anatomical and physiological information that's in those serial CT images that (we've) never seen before. There are innumerable projects that can be done to use these images and extract information to help us deliver better treatments to the patients. In radiation therapy that's where a lot of research focus is going today."

Students are an important part of the center's research program, and Ramsey currently works with three Ph.D. students and two master's students, including Michelle Neeley of the physics department. She has volunteered at Thompson two days a week this fall and in the process has learned some of the most important steps in making sure a patient's therapy is delivered properly.

"In layman's terms, we test to make sure the linear accelerator is actually delivering the prescribed amount of radiation during a patient's treatment," she says. "We have a series of mechanical, energy, and output tests that we perform to check that the accelerator is functioning properly. I have learned how to calculate the dose that the accelerator delivers by hand to double-check that our planning system is calculating dose properly during the planning phase of the radiation therapy treatment process."

She explains that some of the testing requires x-ray film to "see" the field of radiation being delivered and to test mechanical aspects of the accelerator. Once the films have been irradiated, they have to be analyzed and registered, meaning the physicist tells a computer where to look to find radiation on the film. Processed film is then compared to a computer plan to see how accurately a dose is being delivered to the patient.

"If you tell the computer to look in the wrong place on the film," she says, "it is like comparing apples to oranges."

As with all learning environments, there are occasionally long hours, but Neeley insists that gaining the experience in medical physics is certainly worth the time invested.

"I love what I am learning," she says.

A Long and Winding Road

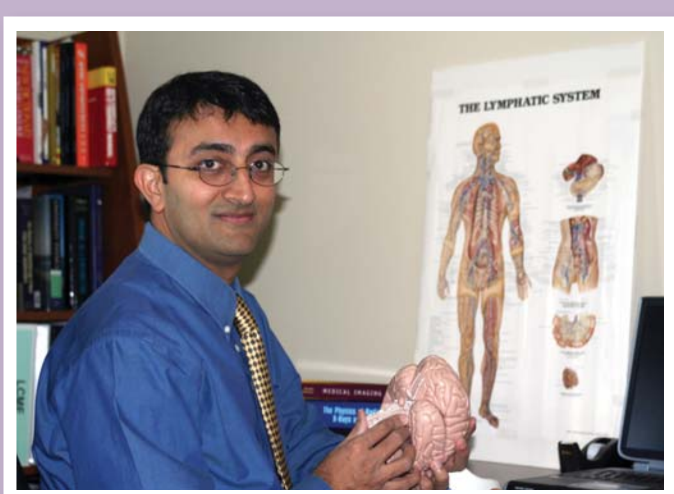
Medical Physicist Dharmin Desai

NOWHERE IS "FEARLESSNESS" listed among the physics courses and seminars outlined in the university's graduate catalog. But it was an attribute Dharmin Desai developed during his time in the department, and ultimately the skill that led him to a career in medical physics and a faculty position with the University of Kentucky College of Medicine.

An assistant professor in radiation medicine, it can be difficult to pin down Dharmin for a chat. He describes his job as "80 percent patient care," and for him that means a lot of time on the road. Like UTK, UK is a land-grant institution and as such counts outreach as a vital component of the university's work. Dharmin explains that UK has clinics in rural areas to provide health care to people in territory where other providers don't traditionally go.

"Everyone has the opportunity to get good care," he says. "I go 70 miles east of Lexington two days a week to provide that service."

Dharmin explains that an M.D. determines what type of cancer a patient has and prescribes radiation to a specific organ. It's his job as a medical physicist to determine how best to deliver that radiation without negatively impacting the surrounding sites. He says the work is challenging, but not as challenging as setting up atomic physics experiments for Professor Marianne Breinig, his former graduate advisor.



Dharmin Desai

While dedicated to his patient responsibilities, Dharmin is still interested in research, particularly building models of charged particle propagation through matter. But because field work often takes up the better part of his schedule, he says, "Research is something you do on the side. At night."

He also teaches medical residents in radiation oncology and next year will start teaching master's students in UK's two-year medical physics professional program.

Dharmin says he's seen student interest in medical physics rise in recent years, and he can understand the appeal.

"You get to see the fruits of your research instantly," he says. He explains that the industry is quick to implement developments (such as new image processing algorithms), which means you're helping people faster.

Dharmin's own journey into the field, however, included a few detours.

"I took a long, winding road to medical physics," he says.

Originally from Bulsar, India, Dharmin earned a bachelor's degree in physics at UT-Chattanooga in 1989 before joining the graduate program in physics at UTK.

"I was always interested in physics," he says, and it was during his doctoral work that he began to think about medical physics as a specialty. "I figured I could use my knowledge in physics and do medicine. Medical physics was the perfect avenue to do that."

Although at one point he considered moving to a different school to earn a master's degree in the field, it was Breinig who convinced him that a doctoral degree in physics from UTK would open more doors for him.

He decided to stay in Knoxville, and finished the Ph.D. in 1997.

He next began working as a post-doc with Dr. Thomas Thundat at Oak Ridge National Laboratory. Then another employment opportunity presented itself—writing software for an atomic force microscope. Although he'd never done that sort of work before, encouragement from Breinig convinced him that he shouldn't be afraid to try something different.

"Marianne had told me never to be afraid of new things," he says. "That's always in the back of my mind."

So he took the job and became a software engineer, moving to different parts of the country before landing a position at Ortek in Oak Ridge. He says at first working in software development was interesting because he enjoyed mastering something new. But after awhile, the scientist in him needed a different challenge, so once again he sought advice from Breinig.

"She said, 'There's a guy from Los Alamos who came here and gave a talk. His name is Geoff Greene,'" Dharmin says. So he and (now UTK Physics Professor) Greene agreed to meet, and Greene offered him a post-doc position.

"That was my way back into physics," he says.

Dharmin also went through a trainee program with Chet Ramsey at Thompson Cancer Survival Center. And when the faculty job at UK came open, he fearlessly put in his application. He got the position, moving to Lexington in 2005. He and his family (wife Debbie and children Sarah, Adam, and Isaac) have settled into this stop on the road, and he gives a great deal of credit to Breinig for guiding him along.

"She has been instrumental in my career," Dharmin says, instilling in him the mantra "no fear of new stuff." She taught him that his physics background would always ease the transition into the areas that pique his interest and challenge his abilities.

And as he says, "It surely has."

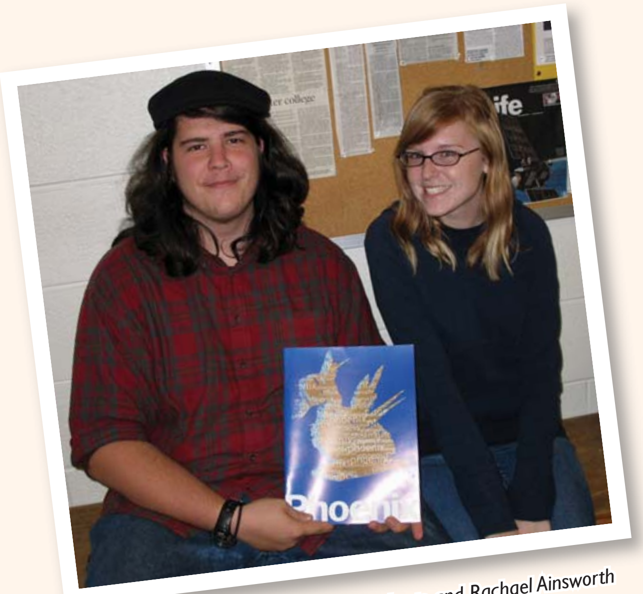
Physics & the Phoenix

Physics majors Rachael Ainsworth and Nick Roberts bring their creative talents to UTK's literary arts magazine

RACHAEL AINSWORTH AND NICK ROBERTS are still a year and half away from finishing their bachelor's degrees, but they're already seasoned veterans of *Phoenix*, the university's literary arts magazine.

Now juniors, both physics majors started working on the publication during their freshman year.

Roberts says he saw an ad in *The Daily Beacon* for editors and support staff and thought, "I like art. I like literature. Why not?"



Nick Roberts and Rachael Ainsworth

The editorial positions were full, so he signed on as support staff and worked his way up through the chain of command.

"I went from support staff to managing editor to editor-in-chief in the space of one year, so I must have done something right," he says.

Ainsworth has also taken on a number of editorial responsibilities for the magazine.

"I was fiction editor freshman year, managing editor last year, and then art editor this year," she says.

Phoenix comprises poetry, fiction, photography and art. The staff has already reviewed submissions and made selections for the next issue, scheduled for release in early 2008.

"We go through everything," Roberts says of the selection process. With poetry and fiction entries, "usually it's fairly quick. Either everyone loves it (or) everyone hates it. That takes about half of them out. The other half we debate."

When it comes to art submissions, Roberts says the staff gauges instant reaction to see which pieces get the most positive response. Once they've gone through everything, they look at the big picture and make final decisions to see how all the elements fit together in one publication. Artists' names are withheld during the review phase.

"All of it's blind," he says. "It's a good process. It just takes time."

As editor-in-chief, he says his role is mostly administrative, making sure everything is running smoothly. He schedules meetings, sets deadlines, works with sponsors and advertising, and even helps with Web site design.

"As a physics major, grammar is not my strong suit," he jokes. "So when I got involved in this I made sure I stayed away from positions that required me to know anything about grammar. I can do it, but I have to have the *Harbrace Handbook*."

He also hired the staff, including Ainsworth.

"It's really nice having her in classes, because she can't hide from me," he says.

Both students have creative interests that made working for the magazine a natural fit.

In high school Roberts excelled at creative writing and was also involved in theater, although, he says, "I never could get the hang of art. But I appreciate it. I know there are people who are really great and want to devote their lives to this, and I think *Phoenix* is a great way to get them recognized."

Ainsworth has a minor in studio art and an interest in photography. One of her photographs was chosen for the Spring 2007 *Phoenix*, and she also penned an article on FILM@UTK, a student organization devoted to photography and filmmaking.

"I took a lot of photography in high school and I did an independent study," she says. "I really like it."

Photography also piqued her interest in physics because of the optics involved.

"I wanted to design cameras and lenses and go into camera production," she explains. "I don't consider myself a phenomenal artist. So instead of trying to make a living through art, I would be able to make a career out of the physics aspect of it."

Now, however, her aspirations have changed somewhat.

"I really kind of want to go into cosmology," Ainsworth says. "I love it. But I could still take pictures of the stars, via Hubble." She's currently enrolled in the Physics 599 Seminar on Particle Physics, Astrophysics, and Cosmology.

"That's a lot of fun when they talk about cosmology," she says. "The first lecture they had was big bang nucleosynthesis and I just thought that was so cool."

Profile: Professor Emeritus Ed Hart

PHYSICISTS, ED HART SAYS, DON'T REALLY RETIRE. There's always something more to investigate, or discover, or hear about. And that's what's kept him coming back to the department whenever he can, nearly 10 years after his official retirement from full-time faculty responsibilities.

Ed Hart

Hart grew up on Flatbush Avenue in Brooklyn, just eight blocks from the storied Ebbets Field. As is often the case with physicists, his childhood was influenced by a natural curiosity about how things worked.

"I played with electric trains," he says. "I made little bombs. I had a chemistry set. I made little radios."

Hart earned a bachelor's degree in physics at the College of the City of New York in 1952, and from there went to Cornell University for doctoral work. Among his Cornell professors was Hans Bethe, who worked on the Manhattan Project and won a Nobel Prize for his contributions to the theory of nuclear reactions.

"Hans Bethe was a great teacher," Hart says. "He could teach you anything. The only problem was, once you walked out of the classroom, you didn't understand it anymore."

After completing a Ph.D. in physics in 1959, Hart joined Brookhaven National Laboratory as an assistant physicist. He also spent a year at the University of Pisa as a research fellow before moving to the University of California at Riverside in 1966. Three years later he came to Knoxville to join UTK as an associate professor of physics.

"The faculty had grown quite a lot," he says, and included Bill Bugg, George Condo, Ed Deeds, Ed Harris, David King and Alvin Nielsen.

Hart's research area was elementary particle physics. An experimentalist, he was a bubble chamber physicist, which entailed, as he describes it, "being on the floor at ungodly hours, and sitting on top of the chamber, watching the beam go by. That was fun. It was spitting particles at me. Fortunately, I don't think many hit me. I enjoyed running the chamber."

Hart's work took him to France, Switzerland, Italy and Russia, and he says he always enjoyed how science served as a link between people from different cultures and countries.

"I never met a physicist I couldn't talk to," he says.

During his tenure at UTK he also served on the faculty senate, advised graduate students, and did some consulting work at Oak Ridge National Laboratory. But teaching was one of the responsibilities he enjoyed most.

"I really do love to teach," Hart says. His father taught math at the prestigious Stuyvesant High School in Manhattan and Hart taught engineers, physics majors, and pre-med students while he was on the physics faculty.

Physics Family

"I liked teaching the engineers; they were responsive," he says. "I liked teaching the physics majors; they were responsive too. And these days, when I get tangled up with doctors, I tell them, 'I used to teach you guys.'"

Hart and his wife Barbara still reside in Knoxville. His oldest son, Philip, is a high-energy physicist like his father and now works for NASA. His younger son, Jason, is a musician living in New York.

"There's a close connection (between physics and music), but there's no way you could get Jason to do physics," he says.

Although he officially retired in 1998, Hart has been a frequent visitor to campus to keep an ear to the ground where science is concerned.

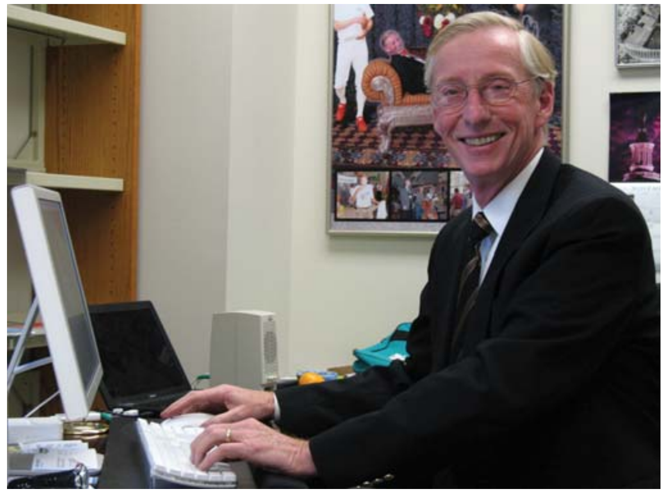
"I'm still around, but I don't get paid," he says. "Physicists don't really retire, because we always want to contribute."

Ainsworth plans to apply for a NASA research internship within the next year, and Roberts says he hopes to pursue physics more in-depth and get involved in departmental research. A double major in physics and math, he's already working four days a week in the physics tutorial center and helping teach the Physics 135 lab. Both students say they'll keep working with *Phoenix*, although Roberts says he'll be stepping back to support staff at the end of next year to give someone else an opportunity to be editor-in-chief. And it's not a stretch to think another science major would be a good fit.

"I've had a number of professors talk about the beauty of an equation, or looking at something in real life and then seeing an equation that describes that almost perfectly and how wonderful that is," Roberts says. "And I think that kind of ties in to an appreciation for art. You start looking at things in a new light."

There's No Place Like Home

After more than two decades of administrative service, Lee Riedinger is once again a full-time professor of physics



IT ALL STARTED WHEN BILL BUGG WENT TO SWITZERLAND IN 1982. A 30-something physics professor named Lee Riedinger agreed to take over as interim department head for eight months while Bugg was on sabbatical leave in Europe.

And since then, "it's been one thing after another for about 20 years," Riedinger says.

Among those "things" would be posts as science advisor to Senator Howard Baker (1983 to 1984), acting director of the Science Alliance (1985 to 1987), director of both the Science Alliance and the Joint Institute for Heavy Ion Research (1988 to 1991), and acting associate vice chancellor of research (1991 to 1995).

"And then," he says, "I had a year of peace."

But it was not to last. In 1996 Riedinger took over as head of the physics department, a position he held until 2000, when Oak Ridge National Laboratory came calling. He spent the next six years serving ORNL, first as deputy director for science and technology and then as associate director for laboratory partnerships.

Given all the meetings, the travel, the responsibilities, and the time away from the laboratory, why would this nuclear physicist—a fellow of the American Physical Society and a recipient of a Chancellor's Research Scholar Award—agree to take on these administrative duties?

"It's the people," is Riedinger's immediate response. "I got to meet and work with a lot of sensational people."

The opportunity to help shape the course of both the university and the national laboratory appealed to him as well.

"The chance to work in a leadership role at both institutions really was pretty neat," he says. "A national lab tends to be a top-down organization. A university tends to be a bottom-up organization. They're very different, but they're tied at the hip in many ways. That's what's made my life so fun for the last 20 years; the chance to work in both environments.

"And, of course, the people," he repeats. "I know so many people at the two institutions that it's like old home week every time I go to the Andy Holt Tower or out to the Lab. That's what it's all about. People come first, at any institution."

On the first of September, 2006, Riedinger agreed to one more administrative post, this time as interim vice chancellor of research. But he did so with the understanding that this would be the last stop before he returned to his first love, physics research and teaching.

"I've said for a long time that before I retired I wanted to get back to the physics department," Riedinger says. "When I left in 2000 my tenure remained intact, but the salary for my position disappeared. So I went to see the Chancellor a couple of years ago and said, 'I want to go back home, but I need your help.' He said, 'Sure, I'll help you, but you've got to do something for me first.'"

Riedinger oversaw research operations on the Knoxville campus for a year, until Bradley Fenwick took over as the new vice chancellor for research. And on September 1, his sole title once again became professor of physics. He is still getting settled into his office on the sixth floor of the Science and Education Research Facility, but the family photos are already displayed. In fact, the four children in those pictures—Madeleine, Nicholas, Lily, and Clare—are part of what nudged him to give up administrative work.

"Through your career you're often thinking about the next step," he says. "It's always in the back of your mind. But for me, and for many people, I think, when you turn 60 you take stock about what you want to do professionally for the last step of your career, and then personally. Those pictures were one strong reason. I'm very close to those four grandkids. Having more time for them got to be very important to me."

Another group of people who are high on Riedinger's priority list are his fellow nuclear physicists.

"That's my second family for the last 40 years. Getting re-established with them fully is very important to me," he says. "I've stayed in touch with nuclear physics. I've had two students get their Ph.D.s in the last five years, so I was engaged, but I didn't have enough time to go to meetings and work on experiments. I don't care so much anymore about the competitive things—how many papers I publish, or getting invited talks. What I care about is working with my colleagues."

Riedinger will also be reconnecting with undergraduate students. He is scheduled to teach astronomy in the spring and is putting together a course called "Energy in the Modern World" for students in the university's Haslam Scholars program. It will be part of a suite of courses in a new interdisciplinary program on energy he is developing.

"Getting back to the classroom and teaching is something I really want to do, because I like students. I like talking to them," Riedinger says.

Now that he has shed his administrative roles, many may wonder if the always impeccably-dressed professor will give up wearing a tie. He laughs before responding to that question, but is quick to answer.

"I don't think so. Because I've got these great ties," he says, showing off his latest neckwear, a birthday gift from his wife (and former astronomy instructor), Tina.

"In spite of my glib assessment that it's time to change, it wasn't easy to go through that thought process and say, 'Am I ready to step out of the fast lane? Am I ready to be done with those high-level jobs? Am I ready to stop wearing a tie?,'" he says. "I can give up two of them, but I'm not going to give up wearing a tie. That's me. Why change?"

New Faculty

Assistant Professor Norman Mannella

THE PHYSICS DEPARTMENT'S EXPERTISE in advanced materials continues to grow, most recently with the addition of Norman Mannella, who joined the faculty August 1 as an assistant professor.

Mannella most recently held a joint appointment with Stanford University and Lawrence Berkeley National Laboratory. He worked at Stanford's Geballe Laboratory for Advanced Materials as a research associate and was also a beamline scientist at the Advanced Light Source at LBNL.

At Tennessee he has joined the condensed matter group, working alongside Professors Ward Plummer and Hanno Weitering. Like his colleagues, he is interested in the physics of novel materials and is intrigued by the properties, growth, and characterization of nanostructures and materials surfaces. Mannella says he has an advantage in that many of the resources he needs to dig into these studies are already here.

"Typically when you start as a professor you have to build everything from scratch," he says. "In my case, we're just more in a phase of tweaking things."

Mannella explains that the condensed matter lab comprises equipment to both make and study materials. The apparatus includes a chamber where scientists can grow their own materials using molecular beam epitaxy, or MBE. (MBE produces high-quality films used in semiconductors and other sophisticated electronic devices.) It also has the tools they need to analyze the structure of materials; to find out how they're built, so to speak. They can use photoemission, for example, to liberate electrons from a solid, studying their momentum to find clues about a material's basic structure. A scanning tunneling microscope provides them with a detailed profile of a material's surface.

The ability to grow materials locally is valuable, Mannella says, because "whenever you use photoemission or a scanning tunneling microscope, these techniques are very sensitive to what's on the surface. And so if you make the materials somewhere and then you transport them here, they get contaminated. Here (we) have the capabilities to make the materials without contamination and to directly study them."

Another benefit is having a famous neighbor in Anderson County.

"Some materials are easier to grow than others," Mannella says, "so to grow some of the fancy advanced materials that we like to study, you need lots of expertise and sometimes techniques other than MBE. But the wonderful thing is that because of the close proximity to Oak Ridge (National Laboratory), you can envision a situation where the material can be grown in Oak Ridge and transported here in vacuum. We will have a unique and very competitive experimental capability here on campus, but also the close vicinity to one of the best groups in the world for growing materials."

Mannella is opening these research possibilities to motivated graduate students who have an interest in novel materials and complex electron systems. His group offers students a great deal of experience working with state-of-the-art facilities, both on campus and within a wider collaborative environment.

"Some of my activities will take place at synchrotron radiation facilities where there is a tremendous affluence of users from all over the world, (which) provides a good opportunity to meet people, to talk to them, to establish links and collaborations," he says.

Mannella completed the Laurea in Fisica in his native Milano, Italy, in 1996. In 2003 he earned a Ph.D. in physics from the

(continued on page 10)

New Faculty (from page 9)

University of California, Davis, before moving to Berkeley. That particular location proved attractive not only because of the physics, but also because the San Francisco Bay area meant lots of good jazz for Mannella, who once played guitar professionally. He even played with a band that experimented mixing jazz and rap.

"We had a producer and everything," he says. "We were playing in the main clubs in the city."

Mannella says his musical pursuits slowed down a bit after he and his wife, Joelle, welcomed their son Aidan, four years ago. The logistics of life in the Bay Area also complicated things.

"To rehearse, I had to drive 70 miles," he says.

But he's hoping to get back into playing now that his family has settled in East Tennessee.

"Knoxville has a very vibrant music scene," he says. "I hope that I settle in where I can continue to do something like that."

He says the transition from west to east has gone well, both personally and professionally. The city is welcoming to young families, and the research at UTK promises to produce very good science.

"I'm happy about Knoxville," he says.

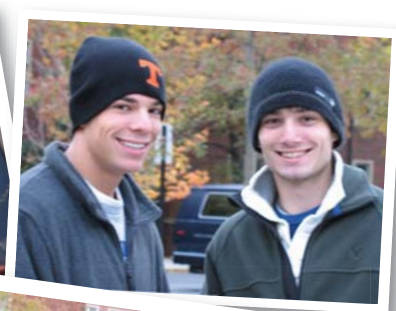
News from the Physics Family

Faculty

Adjunct Associate Professor **David Dean** became Director of the Office of Institutional Planning at Oak Ridge National Laboratory on October 1. He will hold the post for two years and will provide leadership for institutional planning related to science and technology issues.

Congratulations to Lecturer **Margie Abdelrazek** and her family on the September 13 arrival of son Adam. Associate Professor **Robert Grzywacz** and Assistant Professor **Kate Jones** also have a new addition; they welcomed daughter Natalia on November 29.

Distinguished Professor **Ward Plummer** was honored in October with the Distinguished Alumnus Award from Lewis & Clark College. The award recognizes alumni for rendering superior performance in their chosen fields and superior service in their chosen communities. Plummer has also been instrumental in the UT Pre-Collegiate Research Scholars Program (PRSP), which pairs faculty mentors with exceptional high school students in the STEM (science, technology, engineering, and mathematics) disciplines.



Students brave the chilly weather to enjoy the Society of Physics Students fall cookout on November 11.

Students

The department welcomed nine freshman scholarship students this fall, all from Tennessee:

- **Steven Crawford** of Cedar Hill
- **George Duffy** of Brentwood
- **Robert Goodman** of Collierville
- **Drew Gorman** of Knoxville
- **Matt Hicks** of Shelbyville
- **Oleg Ovchinnikov** of Knoxville
- **Jill Pierce** of Knoxville
- **Zach Ridder** of Hixson
- **Sam Smith** of Carthage

Alumni

Luis E. Cuéller (Ph.D., 1993) is a software developer with the Texas Department of Housing and Community Affairs and an adjunct professor at Austin Community College.

John Stewart Hager (Ph.D., 2001) is a senior research associate with Atmospheric and Environmental Research, Inc. (AER) in Lexington, Massachusetts.

Paul G. Huray (B.S., Engineering Physics, 1964; Ph.D., 1968) is a professor of electrical engineering at the University of South Carolina.

Stacey (Thomas) Kaufman (B.S., Physics, 2005) teaches AP and honors physics at The Franklin Academy in Wake Forest, North Carolina.

Erin McMahon (B.S., Physics, 2002) is a research scientist with Johns Hopkins Applied Physics Laboratory in Laurel, Maryland.

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The UTK Department of Physics and Astronomy has several award and scholarship funds to support our vision of excellence in science education at both the undergraduate and graduate levels:

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- The William Bugg General Scholarship Fund
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- The Dorothy and Rufus Ritchie Scholarship Fund
- The Robert and Sue Talley Scholarship Fund

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- The Douglas V. Roseberry Memorial Fund
- The Robert Talley Undergraduate Awards

GRADUATE AWARDS & FELLOWSHIPS

- Paul Stelson Fellowship Fund
- Fowler-Marion Physics Fund

OTHER DEPARTMENTAL FUNDS

- Physics General Scholarship Fund
- Physics Equipment Fund
- Physics Enrichment Fund
- Robert W. Lide Citations
- Wayne Kincaid Award

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