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

CROSS SECTIONS

Spring/Summer 2011

Smart and Adaptable, Soft Materials Find Their Place

ALEXEI SOKOLOV might be the only physicist you ever encounter who explains his work using haircuts, frozen frogs, and plastic planes as examples. Those may seem like unusual illustrations, but in reality they are vivid, approachable images of the deeper science driving his research. Sokolov, a UTK Governor's Chair and a Professor of Chemistry and Physics, focuses his efforts on understanding fundamental physics and going a step beyond, into a future rich with complexity.

At the heart of these studies are soft materials, which are generally examples of matter that don't have a crystalline structure. Liquids, disordered solids (including glasses), and liquid crystals are all examples of soft matter. So too are polymers, which provide an excellent laboratory for experimenting with the structure of materials.

"Polymer means simply a very, very long molecule," Sokolov says, "but it doesn't tell you what the chemistry is. Just by changing the length of the molecule and chemical structure of its building blocks (monomers) we can change properties.

"I can give you a simple example," he continues. "Proteins are built from small building blocks called amino acids. We have only 20 amino acids. But depending on how you combine them you have millions or even billions of proteins, and that's an example of how chemistry actually changes the properties of these polymers."

Understanding polymer dynamics is one avenue that scientists can use in designing materials for specific purposes in areas like energy, or biology and medicine.

"It depends on what you really want to do," Sokolov says. "If you want to design, for example, polymers which will replace metals—so they'll be as tough as metals but they'll be much lighter—we will try to modify polymers in a way that they will have good mechanical properties."

An application for such a material would be replacing metal in airplanes with plastic, which would make for lighter aircraft that would be more fuel-efficient.

Another aspect of Sokolov's studies involves glass transitions, where a liquid is cooled very rapidly to become a glass.

"Glass transition is extremely general," he says. "Even when you talk about your hair, that's a glass transition. You wet your hair before you do any kind of haircut, because when you take any kind of biological system and add water, everything starts to move very fast; everything becomes like a liquid. And in that sense, wet hair has a reduced glass transition temperature, so you can do anything you want with your wet hair. But when you dry (it), (it) becomes glassy again."

Wood frogs, interestingly enough, are another case in point.

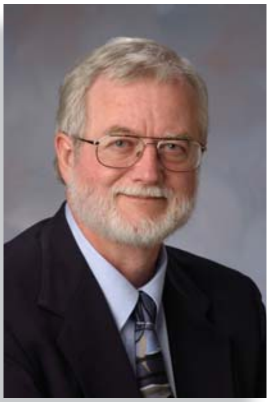
"There are, for example, frogs that can be frozen in ice," Sokolov says. "Dead," he adds, slapping his hand down on his desk to emphasize the point. "No heartbeat. But this frog is alive. When spring comes, the ice melts and it can jump like nothing ever happened. Because this frog, also, undergoes a glass transition.

Professor Alexei Sokolov

"That's why we're studying this phenomenon; glasses and glass transition," he explains. "In general, we start with small, simple molecules to understand the basic physics, then we're trying to apply what we learn to more complex systems, like biological systems."

Some of his students and post-docs are looking at ways to take protein-based drugs or any protein-based products and find a way to keep them for a decade without a freezer or refrigerator. Technologies that would allow for this kind of vaccines preservation would be a tremendous boon in countries where storing them is difficult due to a shortage of proper cooling facilities.

Continued on page 3



The Growing Importance of Development

A Letter from Department Head Soren P. Sorensen

"MONEY MAKES THE WORLD GO AROUND." It is not just Liza Minnelli who has realized that. It also applies all too well to physics departments. It costs a lot of money to run a modern science department. Our classrooms are expensive because we have a lot of demonstration and laboratory equipment, so the students can get hands-on experiences. Our research labs are very, very expensive, in terms of both instrumentation and manpower, since in addition to a professor it usually requires post-docs and students to get the equipment designed, built, commissioned, operated, and maintained as well as to get all the data analyzed and published. We also need a larger staff than most non-science departments to support the teaching and research mission, since we have to have mechanical and electronics workshops. And in physics graduate students are paid as Graduate Teaching or Research Assistants. So there are a lot of expenditures.

How about the revenues? Where do we get our money from? Increasingly the research part of our operation is self-financed through external grants. We have on the order of $9M in research expenditures each year paying for our research. But none of these funds can pay for our operation, our professors, or our staff. Most of the funds for that purpose come directly from the university, who in turn receives them from the state. This is where we have increasingly severe problems. Next fiscal year the University of Tennessee will receive $120M less than we received in 2008. We see this in a loss of positions. Next year we will have 29 faculty members, down from 35 in 2007, and we will have 14 staff members, down from 16. Hopefully this dramatic rate of decrease will soften with an improving state economy. But the trend will continue. Our university and consequently our department will continue to receive a smaller and smaller percentage of our revenues from the Tennessee taxpayers. We are not alone. All public universities all over the USA are seeing a similar trend.

So how do we continue to operate a first-class physics department? We have to a larger and larger extent rely on donations from our alumni and friends. With a strange euphemism this is called "Development," meaning development of funds and endowments from donors and sponsors of the university. Development is increasingly important. When I became department head in 2000 we had annual revenues from our endowment of ~$4,000, whereas we will receive nearly $100,000 this year. We are bringing these funds into good use. The majority of this money is used for scholarships for physics majors. This has over the last 5-10 years allowed us to attract increasingly more and academically better physics majors. This is important not just for our department, but also for our state. There is a huge need for more graduates in the STEM disciplines (Science, Technology, Engineering, and Mathematics), and we are contributing to reducing this need. In particular, we hope to produce more highly qualified high school teachers, since this is an area where the State of Tennessee has a dramatic deficit.

The endowment revenues are also used in many other important ways. Over the past five years we have several times been able to offer support to graduate students for maternity leave and to help with child-care costs for some of our students. Using the funds in this manner has really helped us create a better environment for our female graduate students, who in the past would often have had to give up their studies in connection with becoming mothers. It is important to stress that only through having endowments with flexible stipulations on the usage of the proceeds have we been able to support these female students. State funds cannot be used for this purpose.

What are the highest priorities for our usage of the current proceeds and the new funds we hopefully will receive from our many loyal supporters in the near future?

A very immediate need is support for a wonderful workshop one of our post-docs, Christie Nattrass, is organizing in January 2012 here in Knoxville. The name of the workshop is SCUWP (Southeastern Conference for Undergraduate Women in Physics) and the purpose is to invite 50-100 female physics majors to come for a 3-to-4 day workshop where they will learn more physics, see ORNL, and in particular will be encouraged to continue with a graduate and post-graduate career in physics. Too many women are not continuing with graduate studies after their B.S. in physics, and we have to reverse this trend. This is an expensive workshop to organize, since in order to make it possible for as many female physics majors as possible to participate, we will need to provide support for their travel and housing expenditures. Most smaller colleges cannot afford to pay for their students, so we have to find the travel and housing funds. Donations for this particular purpose will be very gratefully received, and we can assure any donor that the money will have a big impact.

Continued on page 5

Soft materials, continued from page 1

Something in the Way They Move

In describing the properties of soft materials, the key, Sokolov says, is molecular motion.

"Soft materials, by definition, can change—that's why we call them soft materials," he explains. "Any change means the molecules move. So molecular motion is a key to many macroscopic properties. If you talk about polymers for batteries, it will be ionic motion. And ionic motion depends of course on the motion of the polymer itself. If you talk about biological systems, then all of life is all about molecular motion. By learning how molecules move, by developing, for example, ways to suppress motion of biological molecules by using different solids, that's how we develop technology."

Motion suppression makes the difference between freezing humans and freezing frogs. As humans, we have too much water to go through the glass transition; if we freeze, the water crystallizes, breaking down tissues and cells. The frog, however, produces glycerol, a kind of natural anti-freeze.

"All metabolic processes inside of this frog will be almost stopped for months. It doesn't eat, it doesn't breathe, it does nothing, and still it's alive. So it's once again about molecular motion," Sokolov says.

He and his group use various experimental techniques to figure out how molecules move. With light scattering, they observe changes in the light's frequency due to molecular motion. With dielectric spectroscopy, they apply oscillating electrical fields and watch as molecules try to orient along the field. But the most advanced tool in their repertoire is neutron scattering, a common technique in condensed matter physics where a neutron bounced off atoms provides critical information about their positions and motion.

"There we can really see the details of molecular motion," Sokolov says.

His group also collaborates with other scientists who run computer simulations, comparing experimental results with digital models to see how well they agree.

Sokolov's work ties in nicely with an emerging idea in modern science, that of complexity. As scientists learn more about basic particles and systems and how they interact, the more obvious the interplay becomes among physics, chemistry, biology, and materials sciences.

"We're conducting fundamental studies," he says. "We don't do batteries. We don't do plastic for airplanes. We're trying to develop basic principles, basic physics, basic understanding of how the nature is, and based on that, give a suggestion how we should design materials with unique properties.

"If you understand small molecules, you can apply it to complex systems," he explains. "So we're stretching all the way from physics to chemistry to biology."

While Sokolov holds both master's and doctoral degrees, as well as a habilitation (doctor of science, or "higher doctorate") in physics, it's this complex relationship between fields that intrigued him to go beyond his traditional education and look for new opportunities in research.

"Of course I started like a regular physicist: solid state physics, photonics," he says. "But then we started to ask more complex questions. We realized that there is great potential in the application of what we know from physics in biomedical research or energy-related fields." This is when he began to study soft materials.

"The advantage of soft materials is that they are self-adapting, self-healing. They are *smart*," he says, with a smile in voice. "You can change them; that's why they're called soft. They respond to any external force or field or even a change in pH . . . that's what we like about soft materials."

His expertise in soft matter physics and polymer science is what brought Sokolov to UTK as a Governor's Chair in 2009. He currently leads soft matter research efforts at both at the university and Oak Ridge National Laboratory. Prior to his UTK appointment he was the Thomas A. Knowles Professor of Polymer Science at the University of Akron.

As a Governor's Chair, Sokolov's time is split evenly between the university and ORNL. Technically he is a professor of both physics and chemistry, although chemistry is his home department.

"My chemistry background stopped in high school, and I'm a chemistry professor," he jokes.

"A new world awaits our exploration. Things act differently in this world, but that is its attraction. It is a world of small things and of complex things. When we understand them and can control them, they will have an enormous impact in our lives."

From *Complex Systems: Science for the 21st Century*, published by the U.S. DOE

Still, most of the students in his research group are from the physics department.

"For chemistry students, we are doing very weird stuff," he says, "because what we are doing is mostly physics. It's not yet considered to be classical physics because the complexity is so high, but it's still physics."

Soft matter physics and biophysics are becoming more and more prevalent in universities throughout the world, Sokolov says, and he predicts they will become increasingly important in attracting strong graduate students. In the past few years, UTK has begun building a biophysics program on campus, with the addition of Jaewook Joo in theory and a new hire in experimental biophysics, Jaan Mannik, who will join the physics faculty in the fall. (Sokolov has already had discussions with him to determine areas of mutual interest.)

All fields of physics are important, Sokolov says, but "the future of physics is in these complex systems. It's much more complicated—that's the beauty of physics.

"I really have this feeling that we're doing exciting and important stuff," he continues. "It's far from applications; even if we design the basic understanding of how to create these polymers, it doesn't mean that the next day you'll have a battery. It still will take time. But that's what we like in all the work that we do, that we do something that nobody knows how to do. And that's what makes it exciting."

More Information

Professor Sokolov's Research Group
http://www.chem.utk.edu/sokolov/index.html

UTK Governor's Chair Program
http://www.utk.edu/govchairs/

Complex Systems: Science for the 21st Century (DOE)
http://science.energy.gov/bes/news-and-resources/reports/abstracts/#CS

Alumnus Profile

The Love of a Life's Work

IF YOU WANT TO KNOW about Richard Martin's many accomplishments and scientific honors, you might have to prod him a little, or better yet, look him up on the Internet. But if you want to know about his love of physics or his ideas on how science can open doors to other work that improves people's lives, all you need to do is ask.

Participants in the 2010 ASESMA Summer School in Africa. Dr. Richard Martin is on the right.

Martin is a bachelor's graduate in engineering physics and has also volunteered his time and expertise as a member of the physics department's Board of Visitors. He has worked both in industry and academe, specializing in understanding the electronic structure of materials—an area for which he is renowned. He is now a professor emeritus with the University of Illinois at Urbana-Champaign. On Honors Day (*see page 8*) the department was pleased to recognize him with the Distinguished Alumni Award "for his outstanding career in theoretical condensed matter physics and his seminal contributions to the theory of the electronic structure of solid materials." And while his research has helped define bedrock ideas about condensed matter physics, what is equally intriguing about his career is how he has tied physics to a broader humanitarian aspect that goes well beyond the labs and universities where he has hung his hat.

Martin's journey in physics began in his hometown of Somerville, in West Tennessee. In high school he had the only physics class, where what his teacher may have lacked in formal physics training he made up for with enthusiasm. (Martin also argued over math problems with a girl named Beverly, who would become his wife in September 1964. She was also a guest of honor at the Honors Day ceremony.)

Martin began his college studies at Georgia Tech, but transferred to UTK to major in engineering physics and take advantage of the co-op program. He worked year-round at Union Carbide (now Oak Ridge National Laboratory), picking up extra classes as needed, and managed to finish a five-year program in four. As a co-op student he worked primarily in radiation chemistry.

"I learned one really important thing at that time," he said, "and it was that I was not cut out to be an experimentalist."

After finishing his bachelor's degree in 1964, he began applying to graduate schools.

"I wanted to study things like quantum mechanics," Martin explained. "And one of the places to go was Yale. Yale turned me down. I had a full National Science Foundation Fellowship, and they turned me down."

Not one to be deterred by a setback, he put in a late application to the University of Chicago, where, he said, "they were happy to take me." That's also where his interest gravitated toward condensed matter, with his doctoral dissertation focusing on a model for lattice vibrations in diamond-structure crystals. An exciting new direction for his work and an excellent graduate program made Chicago a great fit for him.

That's a lesson that can easily be passed on to younger physicists, Martin said: "Don't be too fixed on what you want to do; look for what's interesting."

After finishing the Ph.D. in 1969, he accepted a two-year post-doctoral position with Bell Labs. When that assignment came to a close, opportunities that had once been plentiful were suddenly scarce.

"When I finished in 1969, there were lots of jobs," he said. "That was still the time when physics and all sciences were highly supported. And then in 1971, when I finished the post-doc, there were no jobs. Labs were closing. Universities weren't hiring."

Martin sent out lots of applications, hoping to join a faculty at a small college or a university.

"One place that did not give me a job was the University of Illinois," he said, laughing.

The Xerox Palo Alto Research Center, however, had a place for him, and so he and Beverly and their young children, Michael and Barbara, moved to California.

"I was quite fortunate with Xerox," he said. "I'd done some work that was interesting to them, so it worked out. It was a wonderful environment. When I first went, there were 30 employees in the entire lab. It was a small, very good group."

Martin was a principal scientist working on theoretical calculations, mainly on semiconductors. He stayed with the company for 16 years, and was also a consulting professor in the Stanford University Department of Applied Physics.

"I was interested in things that would put me closer to what you're doing at a university," Martin explained. "We had post-docs at Xerox so we had the possibility of doing work that was really very much university-type work."

In 1987, it turned out that the University of Illinois had a job for him after all, and he accepted a professorship there. He arrived the same year as his colleague David Ceperley, and together they have performed significant work, such as Monte Carlo calculations on the metallization of hydrogen at high pressure: the most accurate simulations ever done for this system. Martin also founded the Materials Computation Center at Illinois, which he said drew on the university's strength in computation to develop programs and codes that would work well and be useful to a lot of people. And somewhere he found the time to write the textbook *Electronic Structure: Basic Theory and Practical Methods*, which has an accompanying Web site he updates when time allows.

"I worked on that for 10 years," he said of the book. "It was clear that something like this was needed."

He was willing to cover a broad set of areas so that it would work as a general text, and those efforts have been appreciated, as the book has since been translated into Japanese and published in China. That suits Martin just fine, as he is a big believer in sharing physics on an international level.

A Self-Sustaining Scientific Community

In July 2010, Martin helped organize the African School on Electronic Structure Methods and Applications (ASESMA) held in Cape Town, South Africa. On the heels of an earlier school in 2008, this initiative was the launch of a 10-year program designed to build a self-sustaining scientific community on the continent. Martin became involved through the interest of a former student from South Africa, and he now chairs the international advisory panel for ASESMA. The idea is that in countries that lack sophisticated laboratory facilities, materials research can be a conduit to build a strong scientific infrastructure because it involves a great deal of computation, which requires less expensive capital outlay but has wide-ranging relevance for materials in areas like solar energy, and especially minerals, which are prevalent in Africa. Over a two-week period, the 39 participants (chosen from more than 150 applicants) worked with mentors, attended lectures given by experts hailing from all over the globe, and did hands-on work exploring scientific codes. Martin was an organizer and lecturer, and also helped recruit mentors. He plans to do the same for the next school in Kenya, scheduled for 2012.

His attitude toward service reflects why, in addition to his many scientific honors—including General Councilor of the APS, fellowships in APS and AAAS, and a Senior Research Fellow Prize from the Humboldt Foundation—Martin was a member of a group honored with the Champaign-Urbana International Humanitarian Award in 2005. That was primarily for his work with a Shallow Well Project to provide clean drinking water for people in Malawi, Africa, where polluted water causes a multitude of health problems. The villagers dig the wells by hand and a team of Malawians install and maintain the wells. Martin has made three trips there.

"I believe that physicists can do a lot," he said of his commitment. "The travel a person can do in science can be instrumental in doing other things. The first time I went to Malawi is when I was invited to a physics conference in South Africa."

Travelling is part of his retirement, as is more time for his humanitarian efforts, gardening, reading, and especially his family that now includes two granddaughters. While he no longer has to write proposals or monitor graduate students (his last two graduated in May), his interest in physics is unflagging, and now, back in California, he is working on his next book and rides his bike to his office at Stanford to stay abreast of what's going on in physics. In many ways, Richard Martin's career has very much followed the advice he gave UTK's physics students at Honors Day: "Find something you love doing; something you can realistically envision loving as your life's work."

From the Head, continued from page 2

Another important need is increased funding for undergraduate research participation. We used to have funds from the Science Alliance to pay for our summer research program, where our physics majors can participate in research during the summer semester. However, over the years the Science Alliance funds have been reduced and most of the remaining funds have been earmarked for GTA salaries. So in order to continue the summer research program, we have to increasingly rely on endowment proceeds. We are placing very high emphasis on this program, since we know from the students that their research participation consistently is mentioned as the most exciting and rewarding experience they had in their undergraduate education.

Endowment proceeds have also been crucial in realizing a long term dream we have had: a planetarium. This year we have been able to purchase most of the equipment for a planetarium (projector, dome, and chairs) through a wonderful collaboration with the UTK Department of Earth and Planetary Sciences (who donated the projector) and our College (who supported the purchase of the dome and the chairs). But we still have a long way to go in getting 108 Nielsen ready (the high-bay room on the first floor formerly housing Alvin Nielsen's infrared spectrometers) to receive visitors, school children, and all the UTK students taking astronomy courses. We hope to finish this project with endowment proceeds and future donations, so this planetarium can be a real showpiece and a cornerstone in our outreach efforts to the surrounding community.

I hope this small article has been able to convey to all the friends of our department how important endowments and donations have become for us. It is not anymore just a little bit of "spice," but an integral part of the "meal." Without that revenue we will not any longer be able to operate at the level we have and wish to attain in the future.

Physics Behind the Scenes

It's Never the Same Thing Twice

WHEN KENNETH HERTEL WAS HEAD OF THE PHYSICS DEPARTMENT back in the 1930s, he foresaw that if the department were going to thrive, it would need a research program, and for that program to succeed, it would need the support of an instrument shop. Ray Mink was the first machinist on the job, back in the early days when the department's research was dedicated primarily to measuring the properties of cotton fibers. Now, some eight decades later, the physics instrument shop has machined and built components for research collaborations around the world.

At present, there are four machinists who shape stainless steel and aluminum into the apparatus used in detectors and ultra-high vacuums, among other things. Rick Huffstetler, Randy McMillan, Alvin Peak, and Frank Spencer have, collectively, more than 100 years of experience in the cavernous shop in the Nielsen Physics Building. Huffstetler has been the shop supervisor since 2008. He came to UTK in 1981, and was hired by then-supervisor Clyde Cupp.

"I liked Clyde. He was an ex-military man, so you know how he was," he said laughing.

Although he can't say for certain, Huffstetler thinks the first projects he worked on were probably gamma ray detectors for Dr. Bill Bugg's high energy physics program. Things are much different now.

"The technology has changed a lot," he said. "We used to make our own tools."

There was a time when a machinist would need to tool, saw, and grind one piece just to work on a larger project. The advent of CNC (computer numerical control) equipment changed all that.

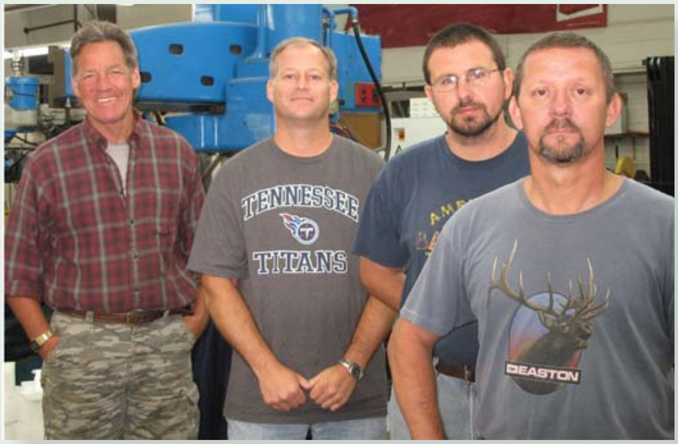
"We have a software. It's called Mastercam," Huffstetler explained. He can now take a drawing and upload it to the software, which makes a toolpath. That's saved to a disk and then loaded on the appropriate machine, which will cut exactly what's on the drawing.

Although they still do some manual machining, the CNC equipment is clearly the future. "Before CNC, we were kind of limited on what we could do," Huffstetler said.

Their inventory includes mills, lathes, drill presses, and grinders; they got their first CNC machine around 2003. And every craftsman in the shop knows how to use them all.

As supervisor, Huffstetler reviews drawings that come in from the department's research groups, calculates and orders the needed materials, and then assigns the project to one of the machinists.

"They do the whole drawing, no matter what machine it takes," he said. "They do the whole job: milling, lathing, welding," or whatever is needed. Learning the necessary skills takes time,



The physics machine shop staff (from left): Frank Spencer, Randy McMillan, Alvin Peak, and Rick Huffstetler.

however. "If you took someone off the street, it would take two or three years to make them a machinist," he explained.

Beyond knowing how to use the proper tools, a machinist in the physics department needs the ability to adapt to a constantly-changing environment. As Huffstetler said, the only predictable tasks in the shop are sweeping the floor or performing routine maintenance on the machines.

"It's not like production, where you're cranking out the same parts day after day, month after month, year after year," he said. "Most of the time, you'll get a drawing of something you've never seen before. Every day is a learning day."

Every job requires a different set-up, different materials, different RPMs and different feed rates, but, he added, "You learn a lot more that way."

A seasoned machinist can draw on that experience when a job comes in that might seem impossible at first. Huffstetler recounted an instance several years ago when Dr. Tom Callcott brought in some stainless steel bellows (at .020 thick) he wanted welded to a flange for an ultra-high vacuum.

"I always say you've got to try something before you say you can't do it," Huffstetler said. "So I just made up some jigs, clamped it, and welded it." Dr. Callcott was duly impressed.

Then there was the time the shop made a stainless steel table for the condensed matter group.

"We had to fabricate it all. It probably weighed over 1,000 pounds," Huffstetler said. "A lot of people don't realize what can be done in this shop."

They typically have three or four jobs going at one time, and much of their work ends up far away from Knoxville. They've machined pieces for the Spallation Neutron Source at Oak Ridge National Laboratory, Fermilab in Chicago, and the SLAC National Accelerator Laboratory in California. They machined the structure securing a huge crystal deep in a diamond mine in Japan. Anywhere a UTK physicist might go, the machine shop's work can follow.

"If somebody's tied in with research there, we've got stuff there," Huffstetler said. "We've got work all over the world."

On occasion they've worked for other units like mechanical engineering or even the university's agriculture institute, and they do quite a bit of work for the chemistry department as well.

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.

#9

Title:	Above- surface neutralization of highly charged ions: the classical over-the barrier model
Authors:	J. Burgdörfer P. Lerner F.W. Meyer
Journal:	Phys. Rev. A 44, 5674-5685 (1991)
Times Cited:	362 (as of 6/2/2011)

Summary

Courtesy of Dr. Joachim Burgdörfer
Institute for Theoretical Physics
Vienna University of Technology

In the eighties of the last century novel ion sources producing intense slow and highly charges ions became available, most notably electron cyclotron resonance (ECR) and electron beam ion trap (EBIT) sources. Intense electron beams strip atoms of all or most of their electrons leaving behind a highly charged ion (HCI) storing a large amont of potential energy (up to hundreds of keV). Studying the subsequent interaction of such HCI's with atoms, molecules, and solid surfaces and the pathways of dissipation of this energy developed into an active field of research that has continued up this date. One of the more spectacular discoveries at the time was the formation of "hollow atoms" by Briand *et al* in 1990. When a HCI interacts with a metallic surface, an exotic transient state of a multiply excited atom with many electrons in outer shells but an empty or sparsely populated core is formed.

Our classical over the barrier (COB) model, combining simple analytic estimates with numerical simulation, provided the first consistent description of the formation and decay of hollow atoms which could account for key features of many experimental observations of this exceedingly complex problem. Because of its simplicity and versatility, the COB model has remained the cornerstone of most descriptions and interpretations of HCI surface interaction to date. The focus of current investigations has shifted primarily to material science applications, in particular to nanoscale surface modifications of insulator surfaces by HCIs for which extensions and refinements of our original model are still being developed and used.

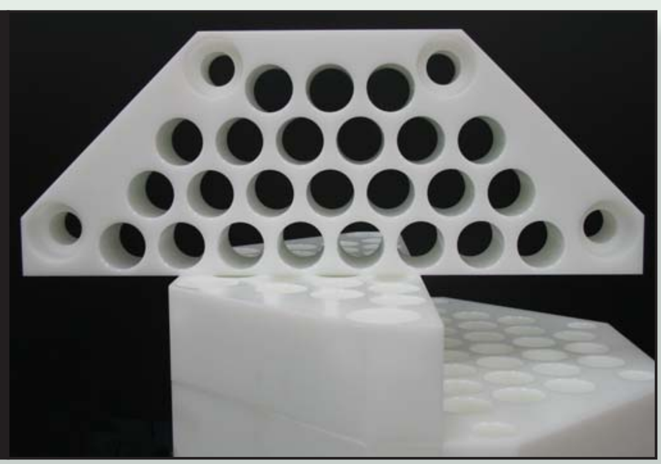
The research reported in this paper was an outgrowth of a successful collaboration between the UTK theory group and the ORNL experimental atomic physics group led by Fred Meyer.

Dr. Jim Parks, associate head of the physics department, explained that "the reason we really need a machine shop is because they respond quickly, which is important when you're doing research. You have somebody dedicated to doing your work." Further, he said, "We have talented machinists. And they use modern tooling, whereas a lot of the old machine shops still use old tooling."

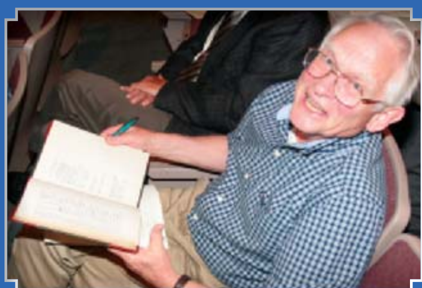
Their expertise keeps these machinists busy. Huffstetler said that whenever it looks like things are beginning to slow down, three or four new drawings will come in on one day. That's fine with him, though, because he said what he likes best about the work is that there's always something new.

"You'll never make the same thing twice," he said.

The instrument shop machined these polyethylene pieces as part of the neutron detector Dr. Robert Grzywacz's research group is constructing in collaboration with ORNL. The detector is based on ^{3}He tubes, provided by ORNL, filled with 10-atm pressure gas. These tubes will be inserted in the high-density polyethylene, which serves as a neutron moderator. The neutrons will thermalize (slow down in collisions with hydrogen atoms) to very low energy. This way they can be captured on ^{3}He in the nuclear reaction, releasing some ~800 keV of energy, which can be measured, allowing neutrons to be counted. ^{3}He-filled detectors are commonly used in the oil industry, homeland security, and space research because they are simple and rugged. The Grzywacz group will use this detector to measure nuclei very far from stability, which decay in a process involving neutron emission.



Honors Day 2011



Just 42 years after his induction, Dr. Tom Callcott signs the Sigma Pi Sigma membership book.

Dr. Richard Martin (left) accepts the department's Distinguished Alumni Award for 2011 from Professor Soren Sorensen.

Dr. Jim Parks (left) presents Noah Birge with a Robert W. Lide Citation.

MONDAY, APRIL 25, marked the physics department's annual Honors Day celebration, when alumni, students, and faculty all were recognized for their respective achievements.

Dr. Richard Martin (*see the alumnus profile on page 4*) and his wife Beverly were the guests of honor, with Dr. Martin accepting the UTK Department of Physics and Astronomy Distinguished Alumni Award for "his outstanding career in theoretical condensed matter physics and his seminal contributions to the theory of the electronic structure of solid materials."

Dr. Martin earned a B.S. in engineering physics at UTK in 1964 and went on to finish master's and Ph.D. degrees at the University of Chicago. His career as a condensed matter theorist includes work at the Xerox Palo Alto Research Center and a professorship in the Department of Physics at the University of Illinois at Urbana-Champaign, where he is now a Professor Emeritus. In his Honors Day address, he encouraged physics majors to find something they love doing; something they can realistically envision loving as their life's work.

Students should also be aware that there is no avoiding Professor Jon Levin if you are inducted into Sigma Pi Sigma, the national physics honor society. He tracked down Professor Emeritus Tom Callcott during the festivities, having Dr. Callcott sign the membership book, 42 years after his induction. Fortunately this year's inductees were on hand to add their signatures next to their names.

The Society of Physics Students also presented their annual SPS Teacher of the Year Award, which went to Professor Geoff Greene.

Several special guests were present for the awards, including Kay Roseberry McCarron and Steven Roseberry; and representatives from the College of Arts and Sciences including Dr. Christine Boake (Associate Dean for Research, Graduate Studies, & Facilities), Dr. Lynn Champion (Director of Academic Outreach and Communications), and Ms. Cathy Dodge (Senior Director of Development). Below is a list of the honorees.

STUDENT HONORS

Outstanding First Year Student: Jacob Clark
Robert Talley Award for Outstanding Undergraduate Research: Eric Martin
Robert Talley Award for Outstanding Undergraduate Leadership: George Duffy
Douglas V. Roseberry Award: Cole Lillard
Robert W. Lide Citation: Noah Birge
Outstanding Graduate Teaching Assistant Award: Robert Potts
Outstanding Tutor Award: Caleb Redding
Colloquium Award: Matthew Bailey
Stelson Fellowship for Professional Promise: Roy Dar
Stelson Fellowship for Professional Promise: George Papadimitriou
Fowler-Marion Award: Olga Ovchinnikova

FACULTY HONORS

Society of Physics Students Teacher of the Year Award: Geoff Greene

SIGMA PI SIGMA INDUCTEES

Undergraduate Students: Steven Crawford, Adam Feldbruegge, Rob Goodman, James Hitchcock, Geoffrey Laughon, Cole Lillard, Eric Martin, Alex Perhac, and Bart Weitering. **Graduate Students**: Dirk Bartkoski, Marek Chertkow, Irakli Martashvili, Rachel Miller, Philip Mason, Kyle Preece, Byron Smith, and Nick Vence.

See the Honors Day slideshow at
http://www.phys.utk.edu/events/HonorsDay2011/index.html

See the stories behind our awards at
http://www.phys.utk.edu/honors.html

Paying it *Forward*

Pattersons Establish New Scholarships

Joan and David Patterson

PHYSICS ALUMNUS DAVID O. PATTERSON AND HIS WIFE JOAN have established two scholarships for students in the sciences and engineering, including one in the UTK Department of Physics and Astronomy.

The Dr. David O. Patterson Endowed Scholarship will recognize students pursuing a major in the UT Martin College of Engineering. The Joan Greene Patterson Endowed Scholarship is reserved for students pursuing study in physics or engineering physics at UTK. Both awards will reward successful academic performance.

Dr. Patterson holds a B.S. in engineering physics (1962) and a Ph.D (1966) from our physics department and is retired from the Defense Advanced Research Projects Agency (DARPA). Technologies developed in his Advanced Lithography Program are now being used to produce leading edge computer chips. Upon its 50th anniversary, DARPA ranked its top developments; Advanced Lithography ranked favorably with others, including GPS, the Internet, stealth bomber, cruise missile, and unmanned air vehicles.

Dr. and Mrs. Patterson live in Virginia Beach, Virginia.

Keeping the Lecture Slides, Just in Case

PROFESSOR JIM THOMPSON will be a bit delocalized in the future, but that's actually by design. After four decades with UTK, he is retiring on July 31 to begin a new chapter of adventures involving travel, family, and maybe getting just a little more mileage out of his lecture slides for pre-meds.

Thompson joined the physics faculty in 1971 and has had an adjunct scientist appointment at Oak Ridge National Laboratory since 1978. His roots, back to graduate school, are in low-temperature physics, an area he said has always fascinated him. That interest lead to research in superconductivity, where he has made significant contributions. In 2009 he and his colleagues fabricated and tested a new kind of superconducting wire that avoids the "frictional" losses plaguing earlier versions. Their efforts culminated in an R&D 100 Award, one of Thompson's many honors. He is a recipient of a UTK Chancellor's Research Award for Research and Creative Activity, an ORNL Significant Event Award, a "Nano-50 Award," and is a Fellow of the APS.

Dr. Jim Thompson (left) accepts a retirement gift from the department, presented by Department Head Soren Sorensen.

A native of Charlotte, North Carolina, Thompson attended Davidson College, graduating in 1964 with a bachelor's degree in physics. During this time he met his wife, Dawn, who was enrolled in Queen's College (now University) in Charlotte. At the time, Davidson was an all-men's institution, whereas Queen's, about 20 miles away, was an all-female school. There was, understandably, a lot of traffic on the road between.

After finishing at Davidson, Thompson went to Duke University, where he studied condensed matter at low temperatures and completed a Ph.D. in physics in 1969. As an undergraduate he had been a member of the Reserve Officers' Training Corps, so after completing his doctorate he was sent to Redstone Arsenal in Huntsville, Alabama. Then, as he said, he was given "an opportunity to travel," which meant an assignment in Vietnam. At the same time, he was also thinking about his career.

Thompson explained that the job market at the time was bleak. He sent out lots of inquiries, saying he would like a job in one-and-a-half years when his "travel" assignment was over. His thesis advisor, Dr. Horst Meyer, began looking around on his behalf. Thompson came home for four days in January 1971, and Meyer had arranged an interview trip to Rensselaer Polytechnic Institute in Troy, New York. It was minus 29 degrees, and the job seeker hadn't seen temperatures below about 70 degrees Fahrenheit in a year or so.

"I like low temperatures to play with," Thompson said, "but not to experience."

Two months later, he talked to Dr. Bill Bugg (then physics department head) via telephone, a conversation that eventually lead to Thompson's hiring at Tennessee, which worked out splendidly for the department. He is well-known for his kind demeanor, top-rate research, and excellent teaching. He was the first professor to win the Society of Physics Students' Teacher of the Year Award, an honor he has claimed more than once.

In retirement he plans some physics activity, but also more time for reading, travelling, and family. He and Dawn have two grown children (Jennifer and Michael) and they plan to divide their time between San Diego, Tennessee, "the road," and "delocalization." He joked that his granddaughter also has plans for him to teach 3rd grade science, and he's thinking, he said jokingly, of using the PowerPoint slides from his pre-med course.

Physics Family News

Alumni

Stephen Wilson (B.S., 2002; Ph.D., 2007—Dai Group) is an assistant professor of physics at Boston College and has won a National Science Foundation Career Award. He will receive $600,000 over a five-year period to support his research on three new classes of materials: spin-orbit coupled materials, including strange iridium oxide-based metals and a new class of "topological" insulators. He will also study iron-based high temperature superconductors where spin-orbit effects may play an important role.

Rachel White (B.S., 2006) is teaching physics at Clinton High School in Anderson County, and her CHS Tesla Club finished third in the nation for the MythBusters' Bust-a-Myth competition. They were charged with creating a video entry to bust a myth the television show had already attempted. They experimented to see if, in fact, it's possible to fold a piece of paper more than seven times. See their results video at: http://blog.discoveryeducation.com/blog/2011/06/03/and-the-winner-of-the-bust-a-myth-video-challenge-is/.

Students

Undergraduate Physics Major **Eric Martin** took first place in the Student Poster Presentations at the 2011 Annual Meeting of the Tennessee Section of the American Association of Physics Teachers (TAAPT), held at The University of the South in March. Just one week later, Eric presented this work on "Electronic Structure Determination of the Thermoelectric $CuRh_{1-x}Mg_xO_2$ using Soft X-Ray Spectroscopies," at EUReCA, the university's Exhibition of Undergraduate Research and Creative Achievement, where he was named a winner in the College of Arts and Sciences Physical Sciences Division.

Congratulations are in order for our students recognized at the 2011 Chancellor's Honors ceremony:

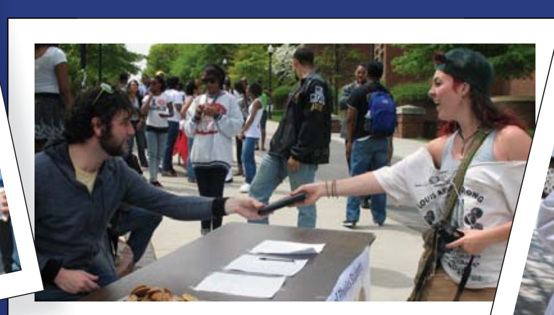
- Extraordinary Academic Achievement: **Cole Lillard**
- Extraordinary Professional Promise: **Andrew Gorman**
- Extraordinary Professional Promise: **Matthew Hollingsworth**
- Extraordinary Professional Promise: **Oleg Ovchinnikov**

Congratulations also to our Spring 2011 graduates, as confirmed by the Office of the University Registrar: **Roy Dar**, Ph.D.; **Ronald Goans**, M.S.; **Lauren Ballard**, B.S.; **Jackson Enix**, B.S.; **Andrew Gorman**, B.S.; **Daniel Joe Snider,** B.S.; **Meagan White**, B.S.; and **Cole Lillard**, B.S., Engineering Physics.

In Memoriam

The department is saddened by the loss of **Virginia Duckett**, who passed away at the age of 75 on May 11, 2011. She was the wife of Professor Emeritus Kermit Duckett. Originally from Canton, North Carolina, Mrs. Duckett was a graduate of Watts Hospital of Nursing in Durham, and worked in the newborn nursery at UT Medical Center. The physics family will greatly miss her kind and gracious manner.

Dr. Ted Welton, whose distinguished career in physics included three decades at Oak Ridge National Laboratory, passed away November 14, 2010, at the age of 92. Dr. Welton was instrumental in involving the physics department with the ORNL Physics Division, and he made significant contributions to the development of nuclear reactors, particle physics, lasers, and atomic scale electron microscopy. His outstanding work in theoretical physics garnered a prestigious Humboldt Prize.



With free cookies and liquid nitrogen ice cream, the **Society of Physics Students** helped raise awareness across campus for the Calculators for Classrooms campaign. They explained to their fellow UTK students that many kids in underprivileged high schools lack access to calculators and consequently struggle in math and science courses. SPS racked up 100 commitments to donate calculators to students who need them.

Thanks to our Donors

The department is pleased to acknowledge the generosity of our donors for their support:

Chang-Hyuk An
Kim An
Patricia Black
Margaret M. Compton
Robert N. Compton
Dean A. Deeds
Dennis John Erickson
Edward R. Fleming
John Ronald Frazier
Michael W. Guidry
Leigh Hunt Harwood
Sandra J. Hinsdale
James S. Jarratt
Larry D. Johnson
Albert C. Kahler, III
Sarah H. Kahler
Joseph Thomas Lewis
Beverly C. Martin
Richard M. Martin
Kay R. McCarron
Raymond L. Murray
Witold Nazarewicz
Sally A. Nichols
Trent L. Nichols
Barbara C. Parks
James Edgar Parks
David O. Patterson
Joan Greene Patterson
Leo L. Riedinger
Margaret S. Riedinger
Helen K. Roseberry
George Siopsis
Maria Siopsis
Soren P. Sorensen
Robert M. Talley
Sue Williams Talley
Dawn Thompson
James R. Thompson, Jr.
Elise Irene Young
Glenn R. Young

Gifts forwarded to the department from the Office of Development (Gifts dated November 28, 2010, through May 30, 2011)

Giving Opportunities

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

Undergraduate Scholarships

The William Bugg General Scholarship Fund
The G. Samuel and Betty P. Hurst Scholarship Fund
The Dorothy and Rufus Ritchie Scholarship Fund
The Robert and Sue Talley Scholarship Fund

Undergraduate Awards

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

If you would like more information on how to make a donation or a pledge to any of these funds, please contact either the physics department, or the College of Arts and Sciences Office of Development at (865) 974-2365.

You can donate online at:
http://www.artsci.utk.edu/development/index.asp

Address Changes

☐ Please remove my name from the *Cross Sections* mailing list.

☐ Please update my information as marked below:

Name: ____

Address: ____

City: ________________________________ State: _______

Zip or Postal Code: ____________________________________

E-mail Address: _______________________________________

Return by mail to:
401 Nielsen Physics Building
The University of Tennessee
Knoxville, TN 37996-1200
USA

or

Send an e-mail message to cal@utk.edu

CROSS SECTIONS
is published twice each year by the UTK Department of Physics & Astronomy.

Department Head: Dr. Soren Sorensen

Associate Department Heads: Dr. Marianne Breinig and Dr. James E. Parks

Publications Coordinator: Catherine Longmire

(865) 974-3342 phone (865) 974-7843 fax

physics@utk.edu

www.phys.utk.edu

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

DEPARTMENT OF PHYSICS AND ASTRONOMY
CROSS SECTIONS

401 Nielsen Physics Building

The University of Tennessee

Knoxville, TN 37996-1200

PA#E01-1060-001-11

A project of the UTK Department of Physics & Astronomy, (865) 974-3342, with assistance from the UT Creative Services Division. 6872