Fall 2017

PHYSICS & ASTRONOMY

CrossSections

The Newsletter for UT Physics Alumni & Friends

Postdoc Sophia Han:

Studying Neutron Stars and Building Bridges

Working away in labs and cubicles across the department, there's an inconspicuous group of scientists making key contributions to UT Physics research and teaching. Among them are 27 postdoctoral research associates, including Sophia Han, who has won her own funding to study the inner workings of neutron stars.

Han earned a PhD at Washington University in 2015 and joined **Assistant Professor Andrew Steiner's** theoretical nuclear astrophysics group that same year as a postdoc. Earlier this year they published results on studies of what Han called "the normal forms of nuclear matter" inside neutron stars, a project that inspired her to go a step further as an independent researcher.

"After completing this project, I was thinking about extending it to study more exotic phases," Han explained.

She said at that point most nuclear astrophysicists were awaiting news about the launch of NICER (Neutron star Interior Composition Explorer), a NASA mission that will provide neutron star measurements. In the interim, her discussions with Steiner brought them to another observatory: Chandra.

The Chandra X-ray Observatory is the world's most powerful X-ray telescope, designed to detect X-ray emissions in the Universe from exploded stars, galaxy clusters, and matter around black holes. The Smithsonian Astrophysical Observatory hosts the Chandra X-ray Center, which operates the satellite and processes and distributes the data. Steiner himself won a grant from the Chandra Theory program when he was a postdoc.

Sophia Han is one of 27 postdocs in the physics department and recently won funding from the Smithsonian Astrophysical Observatory to study neutron stars. Postdocs (along with adjunct and research faculty and staff) play an important role in the department's mission.

"He had a lot of knowledge about the process and how to connect with co-investigators," Han said. "That was when I actually decided to give it a try."

The Smithsonian Astrophysical Observatory approved nine theory proposals in the latest cycle. Han's was one of them, earning a $70,000 award that begins January 2018 and lasts until the end of July. Steiner, along with Dany Page from the National Autonomous University of Mexico, will serve as a co-investigator. The budget will cover Han's salary and travel expenses for her and Steiner to present their work at conferences.

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What's Inside

Studying Neutron Stars, continued from page 1

"The primary goal is to understand how matter will behave under extreme conditions, as in neutron stars," Han explained.

Neutron stars, which she described as "strange and fascinating" are the remnants of core-collapse supernovae—the explosive death of massive stars where gravity presses the residual electrons and protons at the star's core so that they meld into neutrons.

"This is the only place that astrophysicists can study such extreme condition(s)," Han said.

She is particularly interested in binary systems where neutron stars are in close orbit to other stars, such as the main sequence variety that comprise about 90 percent of the stars in the universe.

"Neutron stars are more compact (and) the gravitational field is much higher," Han said. "Matter can flow from the normal star –it's big but lighter—so the outer part of that star (mainly hydrogen or helium) will be accreted onto the smaller and heavier neutron star. As the particles flow onto neutron stars they are accelerated and we see high energy particles emitting from the surface of the neutron star. And this can tell us what the structure of the neutron star is."

Neutron star studies are certainly timely. In October scientists from LIGO (Laser Interferometer Gravitational-Wave Observatory) and the Virgo Scientific Collaboration in Europe announced they had detected—for the first time—both gravitational waves and light resulting from the collision of neutron stars. Steiner's group had made predictions about the tidal deformability of neutron stars that were cited by a LIGO collaboration paper.

"Now, for neutron star mergers, we can see them *and* hear them," Han said.

This makes the current astrophysics climate ideal for someone beginning a career, and Han's role as a postdoc allows her to pursue her own projects while helping both faculty and graduate students. She said one of the key differences between postdocs and PhD students is that instead of working on assigned projects, as graduate students do, she has the liberty to branch into new research areas independently, as she has with the Chandra grant. Postdocs also play a mentoring role, which Han described as "a bridge between achieving your final goal of working as an advisor and starting as a PhD student."

She has enjoyed serving as a secondary instructor in Steiner's Astrophysics and Cosmology course, which she audited. She sat in the back of the room, so the students knew her and felt comfortable asking her questions. She also works closely with the graduate students within Steiner's research group.

"I've learned a lot myself by talking to them," she said. "Sometimes they have trouble, for example, reading articles or writing manuscripts. I help them, because (as a student), I was helped."

As a faculty member, Steiner has administrative and teaching obligations, as well as research responsibilities. Han's role as a "bridge" helps out here as well.

"He is willing to help students on scientific ideas—how to forward the project—but for technical issues, I'm happy to help them and ease Andrew's burden a bit," she said.

This kind of experience will be valuable as she works toward her goal of becoming a scientist at a national lab or in academe. She's already seen at Oak Ridge National Laboratory how graduate, undergraduate, and even high school students are involved in research as part of their education. As a postdoc she's also had the opportunity to connect with other fields like high energy physics, and to present her work and ideas both at the university and the national laboratory. Steiner's support has been important in helping her make the most of this postdoctoral appointment.

"Andrew is open to all ideas," she said, "and reminds me of possible opportunities."

Han's role as a postdoc allows her to pursue her own projects while helping both faculty and graduate students. Postdocs also play a mentoring role, which she described as "a bridge between achieving your final goal of working as an advisor and starting as a PhD student."

Hanno Weitering

Breakthrough of the Year

This fall semester seems to have been shorter and busier than ever. Among the highlights of this semester were the announcements of the two DOE SciDAC awards for our nuclear and nuclear astrophysics faculty, as well as the many other research highlights, which you can read about on our website.

Kudos to **Professor Yuri Efremenko**, who led an 80-member research collaboration toward the long-awaited experimental confirmation of coherent elastic neutrino-nucleus scattering, using an inorganic scintillator detector placed near the Spallation Neutron Source at ORNL. Whereas neutrino detectors usually weigh thousands of tons, this one weighs less than 15 kg. For Yuri, this success is the culmination of 15 years of hard work, which included building the science case, assembling the research team, securing the funding, building the experimental setup, taking the data, and finally analyzing and disseminating the results. The final result was published in *Science* magazine in September 2017 and is on the shortlist of the most significant scientific breakthroughs of 2017. The winner will be picked by the *Science* editors and news writers in late December. At the time of this writing, Yuri's "pint-sized" neutrino detector is among the final top four breakthroughs chosen by the people who voted online.

Kudos to **Professor Kate Jones** and **Assistant Professor Haidong Zhou** who received the 2017 Excellence in Research and Creative Achievement awards at the College of Arts and Sciences annual faculty awards dinner. Kate's research is at the intersection of nuclear structure, nuclear reactions, and nuclear astrophysics, and her discoveries have prompted theoreticians to develop more accurate models of exotic, neutron-rich isotopes. Kate is also a member of the Nuclear Science Advisory Committee (NSAC). This committee advises the U.S. Department of Energy and the National Science Foundation on the determination of the scientific priorities within nuclear science. Haidong's accumulated experience and continuous efforts over the past five years allowed him to build a very successful crystal growth program at UTK. He has published close to 200 peer-reviewed articles, many of them appearing in top journals.

Special thanks to **Kranti Gunthoti** and the faculty volunteers who have made the Saturday Morning Physics lectures and "Ask a Physicist" Facebook live chat events a great success. The lectures are well attended, while many others view the presentations online. Find out more about the department's outreach events and other physics news on our Facebook page.

Last but not least, kudos to the office staff. Their workload has increased significantly over time. In particular, with more faculty winning research grants, travel is at an all-time high. Each and every travel request lands on the desk of **Maria Fawver**. She single-handedly processes more travel than anyone else on the UT-Knoxville campus, and she does it with a smile.

This fall, we lost two of our distinguished alumni, **Drs. Rufus Ritchie and Robert Talley**. We are also saddened by the loss of emeritus professors **Horace Crater and Larry Taylor**. You can read about their accomplishments and priceless contributions to the physics department in this newsletter. We will miss them.

All in all, this has been a very good year for the physics department. As always, we love to hear from our alumni. Please share your stories and stay in touch.

I wish you a healthy and productive 2018.

The Physics of In-Between, Everyday Stuff

Not every scientist sees the physics at work in a pollen grain, but that's what sets **Max Lavrentovich** apart. He creates models to study the intricacies of biological systems, looking at how patterns develop and populations evolve.

Lavrentovich first developed an interest in physics when he took calculus in high school.

"I really liked that kind of math," he said. "I came to the realization that it was invented for physics, so that got me into theoretical physics, in particular."

He went on to earn a bachelor's degree in physics and math at Kenyon College, followed by a PhD in physics at Harvard University in 2014. He first became interested in mathematical models of biological systems at Kenyon, while studying the way calcium concentrations change in brain cells called astrocytes. He was then drawn to how statistical mechanics describes the way matter moves from one state to another and how similar transitions occur in biological systems.

Lavrentovich's next stop was at the University of Pennsylvania, where he was postdoctoral scholar in the soft condensed matter theory group. He joined UT's physics faculty this fall as a biophysics theorist.

Biophysics and soft condensed matter studies, he explained, are "the physics of stuff we're familiar with. It's not too cold and not too hot. It's not too dense. It's right in the middle where things are soft and roughly at room temperature.

"You see examples of these everyday materials everywhere," he continued. "Sometimes they have properties that are in between phases. You learn about solids, liquids, and gases. But if you think about something like toothpaste or a microbial colony, that's somewhere in between. It may flow like a liquid if you wait long enough, but it can also hold its shape like a solid. A lot of soft matter physics deals with these mesophases."

Lavrentovich studies how these everyday materials evolve in time, including how they develop patterns. Even something as common as pollen has a story to tell. Pollen strains that are closely related may have coatings with drastically different patterns. A population of tumor cells may invade or spread in otherwise healthy tissue. Physics and math actually have a great deal to offer in understanding how these things happen.

Lavrentovich said there are two major themes guiding his work. The first is phase transitions.

"You can have many constituent pieces like cells or all the microscopic details," he explained, "but if you zoom out a little bit and view things on a coarse-grained level, you can interpret a lot of biological processes as transitions between macroscopic states—either pattern or no pattern; or in the case of evolution, extinction or no extinction. And then you can try to understand the universal features of such transitions."

The second idea Lavrentovich considers is that the *shape* of things in biological systems is crucial to understanding them.

"Geometry matters," he said. "The fact that pollen, for instance, develops this pattern on a sphere, or that populations can grow in many different shapes. It's the coupling between either pattern development and geometry, or evolution and geometry. Spatial dimension and

Max Lavrentovich's research focuses on biophysics and soft condensed matter studies. He joined the faculty this fall as an assistant professor.

geometry can have a profound influence on what you observe in these systems."

Lavrentovich has different tools to understand those influences. For example, to see how populations evolve, he treats the process like a chemical reaction, using a statistical field theory formalism to understand how it works in a particular space or specific geometry. Understanding the behavior of complicated, synthesized soft matter materials requires close interaction with the experimentalists who make them, and he'll have the chance to work with Associate Professor Jaan Mannik, an experimental biophysicist.

Lavrentovich will provide theory support by developing phenomenological models to scientists at Oak Ridge National Laboratory, where he holds a 25 percent appointment. He pointed out that he doesn't do heavy-duty modeling—he is more apt to throw out extraneous details and look at foundational pieces. This offers great opportunities for students, especially undergraduates. (Freshman Mary Kemp, a Robert Talley Scholarship recipient, is currently working with him.)

"Since I do a bare-bones kind of modeling, that means when I write a computer program it's foundational programming. The priority is to write fast code, which is necessary for simulating large cell populations, for example. It's very close to the hardware, in some sense," he said laughing. "You develop everything from scratch. My group has excellent opportunities for those interested in learning how to code."

In addition to welcoming students to his research program, Lavrentovich is looking forward to teaching Physics 321 (Thermal Physics) in the spring. Though teaching and research take up most of his professional hours, he does have time for a few outside interests. His family moved from Ukraine to Kent, Ohio, when he was a kid and consequently he became a fan of buckeye athletics in the broadest sense, including Ohio State sports and the Cleveland Cavaliers. (He actually grew up about 15 minutes from basketball superstar LeBron James.) As a downtown Knoxville resident he's close to the Riviera Theater, which works out well for the self-described movie buff.

Lavrentovich has come a long way from the high school calculus class that first encouraged him to use math and physics to figure out the properties of the world. Now he's bringing that expertise to UT as one of the newest members of the physics faculty.

Miguel Madurga, a former postdoc, returns to UT Physics as a member of the faculty, joining the nuclear physics group where he studies the structure of exotic nuclei using beta decay.

The Detectorist

Miguel Madurga likes to tinker, especially when it comes to detectors that help reveal the properties of atomic nuclei. And though he's always been interested in a hands-on approach to research, he actually began his studies with an undergraduate degree in theoretical physics.

A native of Spain, Madurga attended the Universidad Autónoma de Madrid, where he earned his bachelor's, master's, and doctoral degrees.

"They have a very strong theoretical physics background," Madurga said of his alma mater. "Almost all the professors are theoretical physicists. From the very beginning (I was) interested in experimental physics—I did much better in the practical courses than the theoretical ones. But the way my physics supervisor put it was that it's good to have a theoretical background when you're an experimentalist so you know what you're talking about."

Continued on page 6

The Detectorist, continued from page 5

As a graduate student Madurga got to put his theory background into practice, writing code and putting together the experiments supporting his thesis.

"Some of us physicists, we like to tinker, and I'm very much a tinkerer," he said.

After finishing his PhD in 2009, Madurga came to UT Physics as a postdoctoral research assistant, where among his chief responsibilities was the development of the neutron time-of-flight detector VANDLE (Versatile Array of Neutron Detectors at Low Energy). With the ever-improving capabilities of scientific facilities like FRIB (Facility for Rare Isotope Beams) to create isotopes previously only produced in the cosmos, detectors like VANDLE play an important role in making measurements that help describe the physics of neutron-rich environments. The more scientists learn about the atomic nucleus and how it's structured—especially via precision measurements—the more practical and scientific opportunities present themselves.

"If we decide as a society that we want nuclear power, we want to do it reliably and safely," Madurga said. "We need more precise, better data sets that will allow for designing new power plants. This is a problem that has been identified for the past 10-to-15 years and the International Atomic Energy Agency is working with us to get better data sets."

On a more general level, he explained that understanding the nucleus is important in answering deeper scientific questions, such as how elements are formed.

"Nuclear structure plays a fundamental role in astrophysical processes," he said. "It's not only what powers the stars, but now we know thanks to LIGO (the Laser Interferometer Gravitational-Wave Observatory) that when neutron stars collide there is a lot of nucleosynthesis in this process. The nuclei that are involved in these collisions are not something you have on earth. They have to be produced in facilities, and these are the types of things that we measure."

With the closing of VANDLE's original home, Oak Ridge National Laboratory's Holifield Radioactive Ion Beam Facility, the detector has found new incarnations for experiments at Argonne National Laboratory, Michigan State University, and ISOLDE (Isotope Separator On Line Device at CERN). Madurga used the VANDLE model to build a complimentary detector at ISOLDE when he was stationed there from 2014 until joining the UT faculty this August.

Madurga, who has been working on silicon detector arrays since graduate school, said building a good detector is a mix of knowing what you want to find and knowing what goes into a sound design, making allowances for improvements along the way.

"You think about incremental improvements each time to approach the performance that you need," he said. "You always have to start with something you think you can achieve before you can go to the next step."

Now an assistant professor in the nuclear physics group, he's studying the structure of exotic nuclei using beta decay. Among his colleagues are **Professors Kate Jones and Robert Grzywacz**, with whom he originally worked as a postdoc. He also has a strong collaborative relationship with ISOLDE, further developing a technique to measure the magnetic properties of nuclei using lasers.

With facilities and collaborations all over the map, Madurga travels frequently. On this particular morning—the Wednesday before Thanksgiving—he was actually in between trips.

"I just came from Japan and I'm going to Chicago next week," he said.

He's also balancing those travels with departmental responsibilities, such as overseeing the nuclear seminar schedule for this fall and preparing to teach the Modern Physics course in the spring.

"I'm busy these days," he said laughing.

When he does have some time away from physics, he and his wife Callie like to avail themselves of the nearby mountains as a retreat.

"At least once a semester we try to take a weekend in a cabin and disappear," he said.

They also just bought a house, which typically brings projects and begs the question: does he tinker at home?

"She does more than I do," Madurga said of his wife, with a smile in his voice. "I used to be a tinkerer before I was an experimental physicist, and the experimental physicist in me kind of satiated the tinkerer at home."

Yet the experimentalist who's always looking for ways to improve a system cannot be suppressed for very long.

"We just installed a new smart thermostat," he said. " It was fun to rewire a 15-year-old HVAC control to make it compatible with modern standards!"

DOE, SESAPS Honors for Physics Students

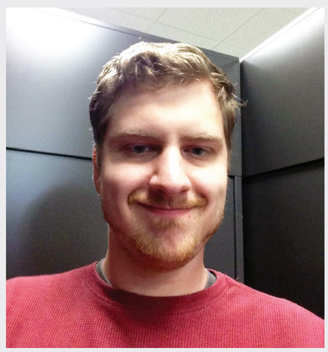
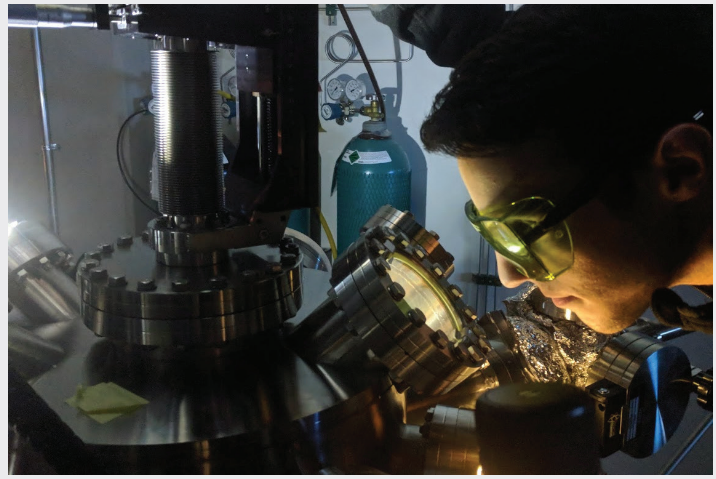
They study the trails neutrinos leave behind, and the intricacies of ultra-thin materials, and they have been duly rewarded for their efforts.

Graduate Students **Andrew Mogan** and **Gray Yarbrough** have won awards from the Department of Energy Office of Science Graduate Student Research (SCGSR) program, while Undergraduate Physics Major **Peyton Nanney** was recognized for the best undergraduate oral presentation at the Southeastern Section of the American Physical Society Meeting (SESAPS).

Both Yarbrough and Mogan work with **Assistant Professor Sowjanya Gollapinni** at MicroBooNE, a neutrino experiment at Fermilab,where the interaction of neutrinos with liquid argon produces various charged particles that strip off electrons from the argon atoms, leaving a trail as they pass through a detector. Scientists study these trails left by particles to learn more about the neutrinos themselves, which ultimately leads to a better understanding of the Universe we live in.

The SCGSR program provides supplemental awards to outstanding U.S. graduate students to pursue part of their graduate thesis research at a DOE laboratory in areas that address scientific challenges central to the Office of Science mission. Multiple fields are represented, including physics, chemistry, engineering, math, and computational sciences. This funding cycle awarded 52 students from 37 U.S. universities. Five of those students were from the University of Tennessee. With Mogan and Yarbrough's awards, Gollapinni is the advisor to both UT Physics recipients, and they're the first students to win SCGSR support to work on MicroBooNE at Fermilab. Each will spend a year there, beginning in January 2018.

It's not only the graduate students making contributions to the department's research. Senior **Peyton Nanney** was recognized for his outstanding presentation on the "Synthesis of Ruddlesden-Popper Strontium Iridate Epitaxial Thin Films" at the SESAPS meeting in mid-November.

Andrew Mogan (top left) and Gray Yarbrough (left) have won awards from the DOE Office of Science Graduate Student Research program, while Peyton Nanney (above) was recognized at this fall's SESAPS meeting for the best undergraduate oral research presentation.

Nanney, who as a freshman won a Dorothy and Rufus Ritchie Scholarship, first began working with **Assistant Professor Jian Liu's** group in 2016 through the department's Summer Research Fellowship program. His project focuses on optimizing conditions to synthesize thin films made from strontium and iridium within the Ruddlesden-Popper family.

Thin films range in thickness from a single layer of atoms to just a few micrometers. The Ruddlesden-Popper structures have interesting properties such as superconductivity and ferroelectricity. Nanney's work involves how best to grow these films via pulsed laser deposition. The group investigated the factors influencing the thermodynamic interactions of this process and the resulting material phases—culminating in a map that allows for the most stable phases in these materials, and consequently for the best analysis of their magnetic properties.

Fitzsimmons Elected 2019 President of Materials Research Society

Professor Michael Fitzsimmons will begin 2018 as vice president of the Materials Research Society, taking over as president in 2019 and past president in 2020. With a worldwide membership of more than 14,000, the MRS promotes communication and collaboration among researchers to advance interdisciplinary materials research and technology. Fitzsimmons, who joined the faculty in 2016 and holds a joint appointment with Oak Ridge National Laboratory, previously served as MRS treasurer. His research specialty is in thin films and nanostructures. Earlier in 2017 he and his colleagues published findings in the journal Advanced Materials reporting they had engineered an ultra-thin material that shows enhanced magnetization that persists to a record temperature of 200 Kelvin. The work is a step forward in the quest to find new materials that can provide the vehicle for controlling magnetism in nanomaterials, especially at higher temperatures.

Tennessee Fellows

Four physics graduate students were among those selected for the first class of Tennessee Fellows for Graduate Excellence. They are:

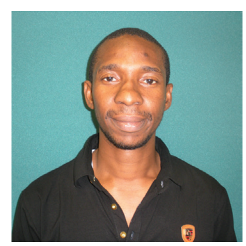
- **Zack Elledge**, PhD student, Wayne State University (Detroit, Michigan)
- **Chinmay Mishra**, PhD student, Stony Brook University (New York)
- **Shree Neupane**, PhD student, Central Michigan University
- **Olugbenga Olunloyo**, PhD student, Obafemi Awolowo University (Nigeria)

The new $4 million fellowship program, administered by the Graduate School, was designed to help UT recruit top graduate students from around the world. The first class comprises representatives from 31 states and nine countries.

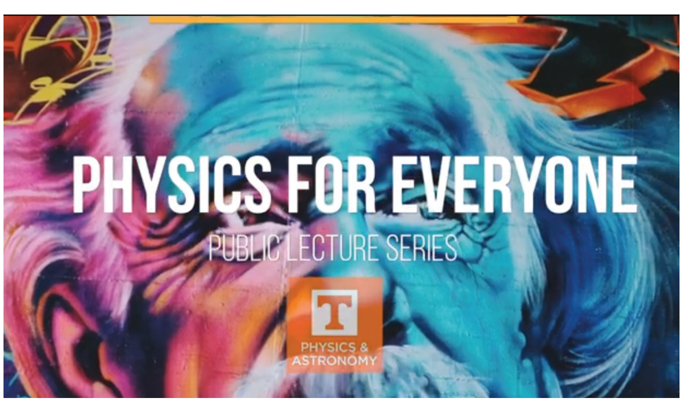
Zack Elledge

Chinmay Mishra

Shree Neupane

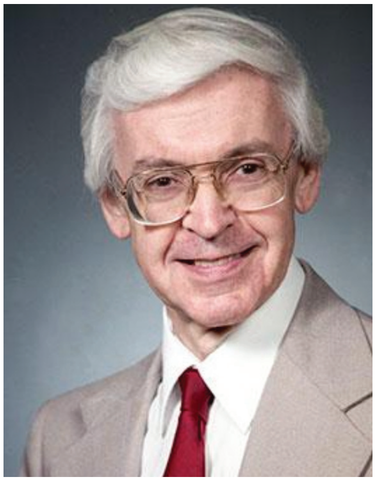


Olugbenga Olunloyo



Physics for Everyone

Building on the success of the spring's Saturday Morning Physics program, **Outreach Coordinator Kranti Gunthoti** organized a general-audience lecture series called Physics for Everyone. Held on five Saturday mornings throughout the fall, the talks featured physics faculty presenting topics like "Don't Stand Too Close to Me: Short-Range Nucleon-Nucleon Repulsion." All talks were streamed live on the physics Facebook page and the videos are posted there. Saturday Morning Physics will return in the spring, including speakers from other UT departments as well as Oak Ridge National Laboratory. More information is always available at physics.utk.edu.



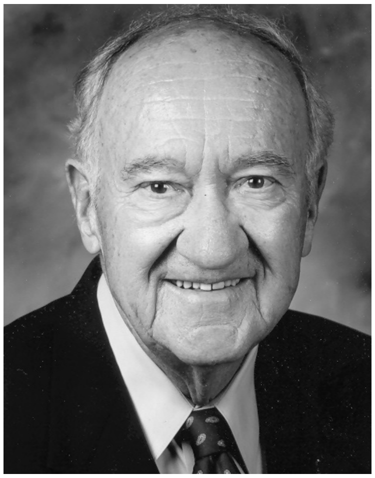
Rufus Haynes Ritchie, Distinguished UT Physics Alumnus and Ford Foundation Professor, passed away July 29, 2017 at the age of 92. He was best known for his discovery and later work on the surface plasmon, although his groundbreaking discovery almost didn't get published. In the 1950's he was working with Dr. Bob Birkhoff at Oak Ridge National Laboratory, helping Birkhoff analyze experimental data and investigate energy losses—plasmon losses—in metals and, as he once explained, "developing that sort of thing about surfaces." Ritchie was interested in the way energy losses were distributed when a fast electron passes through a thin metal foil. He worked out the theoretical spectrum to describe how the metal should respond. Birkhoff presented the work on Ritchie's behalf at a conference, but was met with fierce resistance from those who doubted the surface plasmon existed.

Initially Ritchie hesitated to move forward with the work, but with encouragement from others, including David Pines, he did so. In 1957 *Physical Review* published "Plasma Losses by Fast Electrons in Thin Films" by R.H. Ritchie. Three years later, a series of experiments at NIST confirmed surface plasmon losses by electrons in reflection geometry. The full impact of Ritchie's discovery only became clear decades later with the advent of nanotechnology in the late 1990's. Specifically, the surface plasmon polariton can now be exploited to confine and manipulate light at the nanoscale, i.e., far below the diffraction limit of light. To date, Ritchie's 1957 paper has been cited more than 1800 times. In recognition of his pioneering work on the surface plasmon, Ritchie was later nominated for the Nobel Prize in Physics.

Ritchie was born in the coal mining camp of Blue Diamond, Kentucky, and originally studied electrical engineering, earning a bachelor's degree from the University of Kentucky in 1947. During the Second World War he served in the Army Air Corps as a 2nd Lieutenant and attended Kenyon College, Yale Communications Cadet School, Harvard University, and MIT. He joined the ORNL Health Physics Division in 1949, spending his entire scientific career there with the exception of a few sabbaticals. In 1959, he finished a PhD in physics under the supervision of Dr. Richard Present at UT. Ritchie went on to become a Ford Foundation Professor at UT and a Senior Corporate Fellow at ORNL.

Ritchie worked closely with friend and colleague Sam Hurst for several years and in 2005 the department honored them both with the Distinguished Alumni Award. Ritchie was recognized "for his discovery of the concept and theory of surface plasmons and his pioneering contributions to the theory of energy losses by particles to matter." It was one of many honors he earned over the course of his career, including the Jesse W. Beams Award and an honorary PhD from the University of the Basque Country.

Ritchie was known as a great friend and colleague with a welcoming and generous nature. In recognition of those attributes, Hurst established the Dorothy and Rufus Ritchie Scholarship Fund at UT to honor his longtime friend and fellow scientist.



Distinguished Physics Alumnus Robert Talley, who earned a master's in 1948 and a PhD in 1950, passed away on September 11. He was born in Erwin, Tennessee, in 1924 and served as a skipper of a mine sweeper in the Pacific Theater during World War II. After completing his studies at UT, his career took him to Maryland to work for the U.S. Naval Ordnance Laboratories, specializing in infrared detectors. In 1958 he and his family moved to California, where he became the Director of Research and Development for the Santa Barbara Research Center. He would later become president of the company, which grew to become the largest private employer in Santa Barbara county. Talley was also heavily involved in community service and in 1998 he and his wife, Sue Williams Talley, established a scholarship fund in the physics department. In 2004 the department honored him with the Distinguished Alumni Award "for his outstanding contributions to the infrared technology industry and his extraordinary dedication to the students of our department."

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In Memoriam, continued from page 9

Professor Emeritus Horace Crater passed away October 25 at the age of 75. A native of Falls Church, Virginia, he graduated from the College of William and Mary with a bachelor's degree in physics and earned a PhD at Yale University. After a postdoctoral appointment at Princeton University, he served five years on the faculty at Vanderbilt University. He joined the University of Tennessee Space Institute in Tullahoma in 1975 and served as Physics Program Chair from 1995 to 2012. Crater's research field was theoretical particle physics, particularly studies of fundamental problems in relativistic quantum mechanics and quantum field theory. He was also a dedicated instructor, having taught several graduate-level classes and in total teaching 200 semester hours of physics and math courses. He was the faculty advisor for several master's and doctoral students at UTSI before his retirement in 2015.

Professor Larry Taylor of the Earth and Planetary Sciences Department passed away September 18 at the age of 79. Though on faculty with EPS, he was also involved with the physics department through his love for space science outreach. He worked closely with Paul Lewis, who directs the physics department's astronomy outreach program, and was instrumental in securing funding for our planetarium. Taylor was also part of research grants involving physics faculty and students. He served on the UT faculty for 46 years, was named a University Distinguished Professor in 2004, and was honored with the prestigious College Marshal Award from Arts and Sciences last fall.

Giving Opportunities

Thank you for your interest in supporting the Department of Physics and Astronomy. You can "help where it's needed most" by giving to the Physics Enrichment Fund, which funds a range of priorities. You can also contribute to a specific scholarship, fellowship, or other support fund. See our website for opportunities at physics.utk.edu/alumni-friends/giving.html.

If you'd like to explore more options for supporting students, faculty, equipment or other priorities in physics, **Don Eisenberg** would welcome your call at 865-770-1913 or your email at don@utfi.org. You can also donate online by going to visiting our website at physics.utk.edu.

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(Gift records forwarded to the department dated July 1 through October 31, 2017)

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This fall UT launched a bold capital campaign to raise $1.1 billion for scholarships, faculty support, fellowships, programs, and facilities. By early December more than $800 million had already been raised. Visit journey.utk.edu to see the campaign video (including **Professor Kate Jones**, below) and learn more about this ambitious university goal.

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Members of UT's Society of Physics Students pose for a group photo during the annual pumpkin drop.