

Quantum Leap for Appalachia

UT's physicists aren't afraid of a little disruption. On the contrary, they're joining scientists and engineers from across the university—and the region—to welcome it. With support from a National Science Foundation (NSF) grant they're building on collective strengths to tackle the still-new and formidable field of quantum information sciences and make Appalachia a leader not only in research, but also education and training for the future workforce.

The grant is part of an NSF program to set up Quantum Leap Challenge Institutes. These will be large research projects that draw expertise across disciplines in the sciences and engineering to advance the frontiers of quantum science. The expectation is that they will focus on quantum computation, quantum communication, quantum simulation, and/or quantum sensing. The institutes will also develop workforce goals in these areas.

UT was among 18 lead universities awarded a one-year "conceptualization grant," beginning January 1, 2020, to lay out a strategy for building a challenge institute. The next round of awards will fund the institutes themselves, which will each have five years of support at a level of up to \$5 million per year.

The principal investigator for UT's conceptualization grant is **Physics Professor George Siopsis**, who is no stranger to the quantum realm.

"Throughout my career as a theoretical physicist, I have been trying to understand how nature works at the most elementary level," he said.

His research evolved to black holes and Hawking's information loss paradox that exposed the incompatibility of Einstein's theory of relativity and quantum mechanics.

"Jumping into the quantum information realm was natural," he said. "But what I found most attractive was that this field had the potential to lead to practical applications that will benefit people in the very near future. I was fortunate to be in close proximity to colleagues who were knowledgeable (at Oak Ridge National Laboratory). The first project we did together was in quantum cryptography and was funded by the Navy."

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George Siopsis is principal investigator on a NSF conceptualization grant for a Quantum Leap Challenge Institute.

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Siopsis has since expanded his collaborations to include colleagues at other institutions and government labs, including the Department of Defense and Homeland Security. Now he helps lead a team of 37 (and growing) scientists and engineers from UT and ORNL, including nine physics faculty members, three joint faculty members, and one physics alumna. **Associate Professor Steve Johnston** is also part of the grant leadership, as are faculty members from chemistry, electrical engineering, and industrial systems and engineering.

They've set three goals for themselves over the next year for the project (called the Appalachian Quantum Initiative): coordinating research, coordinating community engagement, and developing an educational curriculum in quantum information science. They'll build on the existing infrastructure (e.g., supercomputing technology at ORNL, UT-ORNL joint institutes) to extend partnerships to regional universities and industry. Microsoft, Tennessee Tech, and Volkswagen have already signed on.

A key factor will be developing a curriculum for students—regardless of background—to equip them with the knowledge and skills to work in the quantum information world. The plan is for internships and career opportunities to help raise the economic fortunes of Appalachia. According to the Appalachian Regional Commission, the area is one of economic contrasts. Some communities have successfully diversified their economies and others are in need of basic infrastructure. A goal of this challenge institute would be to level out the opportunities across the region while at the same time taking the lead in a critical research area.

"This is a unique opportunity for UT to assume a leadership role in quantum information," Siopsis said.

"We have experts in the area at UT and ORNL, great educators, and a large number of students who are eager to acquire skills in the field. We are already talking to other universities in the Southeast, national labs, and industry. We will be bringing experts in the field to work with scientists and engineers who are not familiar with quantum information, but whose research stands to benefit from the development of quantum software. Moreover, we will be developing a curriculum to train the future workforce that will be able to take advantage of the emerging technologies."

Over the next 12 months the team will work to flesh out ideas for how a possible challenge institute will work. With workshops, seminars, and curriculum development, they hope to build a "regional ecosystem" for quantum information sciences. The area is among the 10 "Big Ideas" the NSF unveiled in 2016 as key to national competitiveness in science and engineering. While technical revolutions can sometimes be daunting, Siopsis and his colleagues see these advances as opportunities.

"The new technologies taking advantage of the quantum realm will be truly disruptive," he said. "It is important to develop quantum software for scientists and engineers who are not quantumly trained, as well as do workforce development in close consultation with industry and national labs. Both are challenging, because currently only a fraction of physicists (and) physical chemists and a smaller fraction of computer scientists have the required knowledge. I welcome the challenge and hope to make UT a center of these promising future technologies."

Learn more about UT's Appalachian Quantum Initiative
www.phys.utk.edu/quantum/

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Laser Focus



Message from Department Head Hanno Weitering

The end of the Fall 2019 semester is already behind us although for many faculty and staff, things remain quite hectic as we close out 2019 and prepare for 2020. On December 20 we said farewell to **Maria Fawver**, who has been with us for many years. Maria handled all travel requests and travel reimbursements in the department. This is a formidable task since physicists travel more than anyone else on campus. She truly became the campus' "travel expert" and trained others how to navigate the complexity of UT's travel policies and approval processes. Maria has always been laser focused on the task at hand and always remained friendly to everyone needing her help, including the impatient types among us, and even under the most stressful conditions. We are sad to see her go, but wish her a joyful and happy retirement. Thank you Maria!!

Professor Lloyd Davis also announced his retirement after having served for almost 35 years on the physics faculty at UT's Space Institute in Tullahoma. Lloyd is an expert in laser physics and primarily worked in molecular, bio- and optical physics. He made a name for himself in the important field of single-molecule detection and trapping. Recently, he ventured into femtosecond laser machining for a variety of materials applications. Lloyd and his wife plan to spend part of the year in his home country of New Zealand and part in Tullahoma, making sure the weather is nice most of the year. We wish them both good health and the very best.

Many of us can look back at a great semester. Our faculty have once again been very successful with grants and contracts, and published exciting research results. This year we expect to graduate one of the largest cohorts of physics students ever. We are offering more courses and sections than ever before as many classes are currently oversubscribed. This will require additional faculty and two searches are currently underway. Next semester promises to be busy again, as the department needs to lay out its strategic plan for the next five years, a process that requires many discussions and tough choices. A most exciting and novel research direction is in artificial intelligence (AI) and quantum information (QI). There are now several efforts underway to establish AI and QI centers at UT, led by **Associate Professor Steven Johnston and Professor George Siopsis**, respectively. These efforts also tie in with the ongoing cluster hires in "quantum materials for future technologies," led by **Professor Cristian Batista**. Many students are interested in taking courses in these fields, not only because they are intellectually challenging but also because it will boost their competitiveness on the job market. I anticipate that there will be additional faculty hires in these areas.

You can keep up with the exciting highlights on the physics department website. Meanwhile, I always love to hear from our alumni and learn about their careers. I wish you a joyous holiday season and please keep in touch!

Introducing Nau Raj Pokhrel



Nau Raj Pokhrel

Some things are familiar—hills and mountains, for instance. Others, like snowfall and fall colors—not so much. Yet **Nau Raj Pokhrel** has found himself at home in Tennessee, and he brings nearly two decades' worth of teaching experience to the undergraduate students enrolled in UT's physics courses.

Pokhrel joined the department as an instructor on August 1. Originally from Nepal, his journey has included not only a great deal of the globe but also a remarkable tour of technology.

"I'm from a very small town in the hilly region," he explained. "I grew up in an area where there were no roads, no electricity, nothing—until high school I hadn't seen electricity. No mosquitos, also!" he added, laughing.

Yet with an obvious sense of optimism, he was quick to describe how the remoteness of his childhood home gave him a tremendous gift in terms of his future.

"The sky was very clear," he said. "Without the light pollution, I was fascinated by the night sky. I enjoyed much more time watching the night sky to recognize the planets, constellations and zodiac signs. The curiosity of 'why the things the way they are' inclined me towards astronomy and physics."

While many of his undergraduate classmates were interested in medicine, Pokhrel never chose that route. He decided on physics as a major and astronomy as a specialization during his master's degree studies at Tribhuvan University. Along with astronomy, he also discovered another keen interest.

"In the meantime, I started teaching also, and liked teaching as well as doing research," he said. "I started teaching after my undergrad. I have taught all grade levels from elementary to undergraduate level."

When he decided to pursue a doctoral degree, he left Nepal and chose Florida International University in Miami, in part because he had friends already enrolled in the program, and in part because he didn't want a too-dramatic shift in climate. While there, he dedicated himself to research specializing in Radio Astronomy and taught several traditional and reformed physics and astronomy labs. When he graduated in 2016, he taught physics and astronomy courses for two semesters at FIU before making another move—this time to Texas.

"I was *all* the way South—just half a mile from the border," Pokhrel said. He added that going from a huge metropolitan area to South Texas College in McAllen, Texas, brought with it some interesting perspectives. While Miami blends many cultures and nationalities, his time in Texas gave him smaller classes with one-on-one interaction and a majority of Hispanic students.

"I spent two years there, teaching physics, physical sciences, and astronomy," he said.

Pokhrel enjoys meeting new people and exploring new places (travel is among his hobbies). He has taught large classes and small ones; lived in remote rural areas and large multi-cultural cities. Snow, however, was something he had never experienced before coming to Tennessee when a winter weather system came through in early November.

"I'm really liking the landscape," he said of East Tennessee, especially the hills and mountains. His family (he and his wife have a two-year-old son) have settled into life in Knoxville, and while some things are of course different from their previous stops, some things are the same. For Pokhrel, from a primary school in Nepal to pre-meds enrolled in Physics 221, the constant has always been his love of teaching.

"Every year we are interacting with another new generation with a new idea, different perspectives and different aims of life—this fresh knowledge—and that's an amazing opportunity for us to interact and share knowledge," he said. "It's my pleasure to be in the class, to be actively involved in teaching-learning activities."

He also likes seeing students and their promise through the lens of UT's history. He learned at employee orientation that UT is celebrating its 225th anniversary this year.

"I was surprised at how old this institution is, and I counted back and saw how many generations passed in this building," he said. "I am proud to be a member of this university."

Physics and Architecture:

Finding the Balance

Alumnus Jeff Badger has a sincere appreciation for the role of synthesis and balance when it comes to creativity—how to start with well-understood concepts and draw on inspiration to design something functional.

He spent some time from his lunch break to explain how his career has evolved along those lines and took him to Santa Monica, California, where he works as a designer for Moore Ruble Yudell Architects & Planners.

Originally from Franklin, Tennessee, Badger came to UT as a physics major and graduated with a bachelor's degree in 2008. He was drawn to the Knoxville campus for multiple reasons: he was a Tennessee football fan growing up, UT was close to home, and he knew the physics department was a strong one. That last bit was especially important to someone who, like many science students, has always been intrigued by getting to the bottom of things.

“As a kid I always liked how you could explain how the world works with physics,” he said. “Kind of the idea that if you drill down far enough into the experiments and the math you could figure out how and why anything works the way it does.”

For Badger, the more tangible aspects of physics were the most interesting: particularly the lasers, mirrors and fiber optics in **Professor Marianne Breinig's** optics course, which he cites as his favorite class. Yet he was also someone who enjoyed drawing floor plans as a kid, so he found a way to bring those areas together when he decided to pursue architecture after finishing a degree in physics.

“It was a mid-stream decision,” he said. “I think as I got further and further into physics and math courses I realized that I enjoyed the real-world aspect of it a little bit more, and I missed some of the drawing and the design that I used to enjoy, so architecture seemed like a good synthesis of those things.”

Badger went on to the University of Cincinnati and completed a master's in architecture in 2012. His physics degree proved helpful in gaining admission to the program.

“It gave me a unique background compared to a lot of other people going into architecture,” he said.

An Unexpected Positive

Badger interned with Moore Ruble Yudell and ultimately went to work with the firm, where his physics education is still paying dividends.

“An important part of architecture is that synthesis of design and engineering,” he explained. “I'm not a



Jeff Badger, Class of 2008

structural or electrical engineer but my physics background helps me understand the underlying concepts better; it makes it easier to integrate all these different building systems together. I can inform my designs from the very beginning with an understanding of those concepts before the engineer is even involved. And the more we can integrate those things like lighting, acoustics, and building systems early on, the more successful the design is going to be.”

His firm has a myriad of clients with work ranging from single family residential projects to academic lab buildings, courthouses, embassies, etc. As a designer, his responsibilities may start with researching local building codes and investigating the building site and carry through to inspecting the actual construction as a building goes up.

Badger's enthusiasm for building extends to his free time, where his hobbies include landscape and architectural photography, as well as woodworking. While he logged plenty of hours in the Nielsen Physics Building as an undergraduate, he also spent a great deal of time in the Art and Architecture Building, where he learned or enhanced his skills in drawing, woodworking, and metal fabrication. He emphasized that courses like these were a good idea for any physics major and it was never too soon to start.

“I would recommend art classes to any of the current physics students as a good balance to their math and physics coursework,” he said.

He also had some advice for students who may be on the fence about majoring in physics out of concern that it might limit their options later on.

“A physics education is a great foundation for a lot of different careers,” he said. “Personally, looking for jobs in architecture, I've never had anybody look at my resume and say a physics degree was a negative. It's almost always an unexpected positive.”

News from **the Physics Family**

Alumni

Congratulations to **UT Physics Alumna Saskia Mioduszewski** (PhD, 1999) on her election as a Fellow of the American Physical Society! Mioduszewski is a professor of physics at Texas A&M University and an expert in experimental nuclear physics with an emphasis on relativistic heavy ion collisions (RHIC). She is also a member of the Texas A&M Cyclotron Institute. She was cited “for sustained leadership of high-precision measurement of the quark-gluon plasma using direct photons and their correlations with hadrons and jets at the PHENIX and STAR experiments at the Relativistic Heavy Ion Collider.” This is the latest in her long list of accolades, including a U.S. Department of Energy Presidential Early Career Award for Scientists and Engineers, Brookhaven National Laboratory’s Sambamurti Award, an Alfred P. Sloan Foundation Fellowship, and the Maria Goeppert Mayer Award from the American Physical Society. (Photo courtesy of Texas A&M.)



Students



The Society of Physics Students and the Graduate Physics Society were busy fall semester, with SPS hosting a booth at Engineer’s Day, sharing physics and chemistry knowledge on Halloween, and attending PhysCon—the 2019 Physics Congress. The GPS hosts social get-togethers, helps new students get acclimated to the department, and offers resources on helping members succeed in their academic, research, and teaching assistant responsibilities. Check out all our student groups and their busy schedules by following them online—their web and social links are listed on the physics website at phys.utk.edu.

Left: SPS members spent Halloween at Hodges Library explaining the physics and chemistry of glowing drinks and glow sticks—but also managed to find time to study.

Staff

After 25 years with the university, **Administrative Specialist Maria Fawver** is retiring as we wrap up the Fall 2019 semester. She has shepherded many students, visitors, and faculty through the finer points of UT travel policies, and pitched in wherever needed to help keep the front office running smoothly. On December 4 the department gathered to thank her for years of service. We wish Maria all the best in retirement.

Right: Maria Fawver with department heads (current and former) Hanno Weitering, Soren Sorensen, Lee Riedinger, and Bill Bugg.



Faculty

Assistant Professor Jian Liu and Associate Professor Haidong Zhou have won a \$400,000 Department of Energy grant to look for new possibilities in response to the need for electronics that can function in ever-smaller and more complex systems. They are creating quantum-scale materials and taking advantage of their inherent physical properties to influence how electrons behave.

Biological membranes are something like sentries, deciding what can enter and leave a cell; how it can send and receive signals; and how it responds to different stimuli. In the spirit of building collaborations and encouraging crossover between scientific disciplines, **Assistant Professor Maxim Lavrentovich** helped organize a workshop at ORNL to bring together scientists who study these membranes and their properties. Titled “Workshop on Lateral Membrane Heterogeneity,” the program was held in October.

Nadia Fomin (Associate Professor) and Sarah Cousineau (Joint Faculty) joined a panel discussion on the intersection of technology, art, and physics as part of the *Science in Motion* Exhibition hosted by the Frank H. McClung Museum of Natural History and Culture. The exhibition began in September and runs through January 5, 2020.



A screenshot of the Department of Physics & Astronomy website. The header includes the University of Tennessee Knoxville logo and the department name. A navigation menu on the left lists: Search This Site, Home, Prospective Students, Current Students, Research, Teaching Labs, Tutoring, & Demos, People, Outreach, Alumni & Friends, About, and Give to UT Physics. The main content area features a molecular structure diagram, a heading 'Turning Frustration into Next-Generation Devices', a 'Welcome to UT Physics!' section with a paragraph about the department, and a blue box with logos for AAAS and APS physics and text about faculty fellowships.

You can always learn more about happenings in the department and read in-depth highlights about our faculty’s research at our website: phys.utk.edu.

Professor Robert Grzywacz presented a talk on “Tennessee and the Road to the Island of Stable Superheavies” for the November gathering of Mic/Nite, a “Pecha-Kucha Powered” social gathering sponsored twice each year by the Office of the Provost. Mic/Nite gives faculty from across university disciplines the chance to share their research with a large and varied audience in a social setting as a means to promote interaction across fields. You can see Grzywacz’ presentation online at: micnite.utk.edu.


Outreach (and Inreach)

About 1,000 students, faculty, staff, and members of the public hit the roof of the Nielsen Physics Building for the November 11 Mercury Transit (left). Don’t forget to check the astronomy viewing schedule, including public viewings on the roof on the first and third Fridays of the month—those events will resume in February.

Spacebar!

Christened this fall, the department has opened what is formally known as the Physics Collaborative Space but has quickly become Spacebar (thanks to the undergraduates). This renovated area (Room 201 in Nielsen) is now a popular spot for all members of the department—students, faculty, and staff—to spend time together studying, working on homework, taking a lunch break, or just relaxing.

 facebook.com/UTKPhysicsAndAstronomy

 Want to support the department?
physics.utk.edu/alumni-friends/giving.html

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Everywhere You Look, UT International Edition

Here's **Physics Professor Yuri Efremenko** representing the university atop Mount Kilimanjaro. Efremenko's research speciality is experimental elementary particle physics; he's also a joint faculty member with Oak Ridge National Laboratory.

CrossSections