Fall 2018

PHYSICS & ASTRONOMY

CrossSections

The Newsletter for UT Physics Alumni & Friends

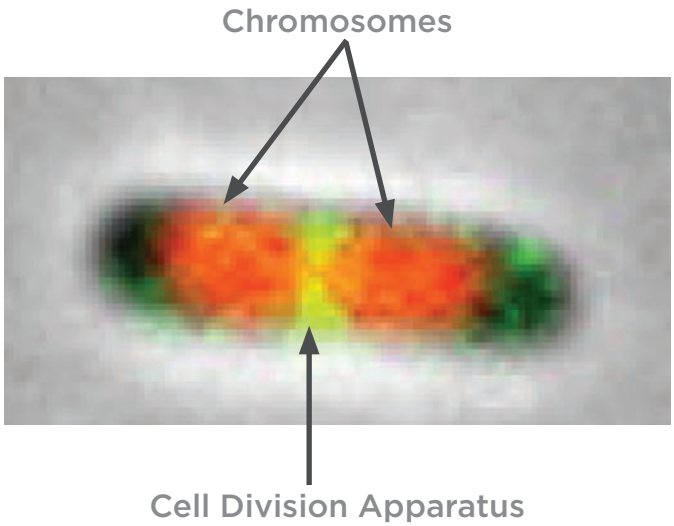
Looking at biological systems through a physics lens

Männik group wins NIH grant to study self-organizing processes in E. coli

When *E. coli* appears in the news the stories often focus on an outbreak of food-borne illness that makes for wary supermarket shoppers. Yet not all *E. coli* are the same, and the most common strains can actually be helpful. These are the subject of **Associate Professor Jaan Männik's research, which has won the physics department's first direct grant from the National Institutes of Health (NIH).** With $1.1 million in funding over four years, Männik is working to understand the cellular processes in *E. coli* from a physics perspective. Studies like these can help build a framework for designing antibacterial therapies.

The Hydrogen Atom of Biology

Jaan Männik, a biophysicist, cites bacteria as the simplest of living organisms and sees them as the perfect system to understand basic processes in the life of a cell. *Escherichia coli* (*E. coli*) is a good candidate for a number of reasons: it was the first genome to be sequenced and about one-half of its proteins (the molecular machinery of cells) are known. Männik describes *E. coli* in biological research as akin to the hydrogen atom in atomic physics. While some strains are pathogens, those that commonly live in (and aid) our digestive systems are safe, and these are the specimens he studies.



Microscope image of *Escherichia coli* cell showing its chromosomes (red) and cell division apparatus (green). Scale bar 1 μm.

"Our research is very fundamental," Männik said. "We're looking at how, at the molecular level, the mechanism starts that gives rise to cellular-level structures and behaviors. Our particular focus is to understand how cell division and chromosome replication are coordinated. What triggers the cell division process? That's not known for bacteria, and that's a really big question."

Männik explained that knowing what triggers this process gives researchers a way of inhibiting bacterial growth. Antibiotics inhibit cell division, "so if cells can't divide, then they don't die necessarily, but they don't propagate," he said. "If we know what gives

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the signal to say 'okay, go and divide now' then we can stop this process."

From Milliseconds to Days

Männik looks at describing these biological processes through the lens of physics principles, stemming from statistical mechanics. His group hopes in particular to see how cell division and chromosome replication are coordinated over both time and space.

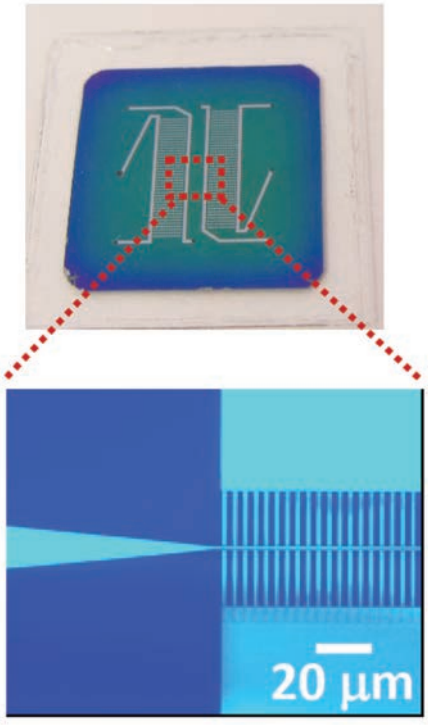
"We have the capacity to look at orders of magnitude over different time scales as processes happen from milliseconds to days," he said.

They will use high and super-resolution microscopy and image analysis, trying to push the resolution limit to get ever-greater detail of cell structure and function. They also plan to use computer modeling to develop a framework for fundamental and vital cell processes—data which could be helpful in finding solutions for stemming growth of bacteria that have proven resistant to multiple drugs.

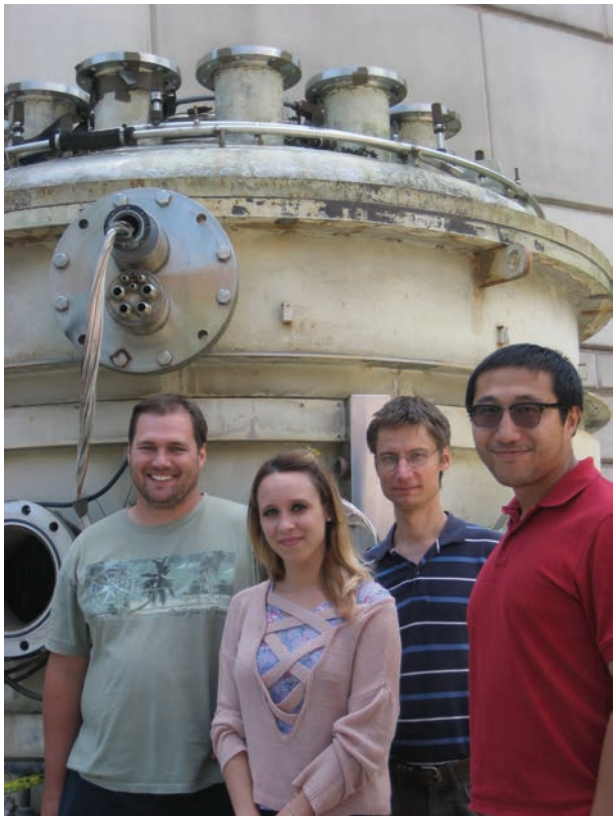
The four-year award began in September 2018 and includes Jaan Männik as principal investigator as well as **Jaana Männik**, a research assistant professor in UT's Biochemistry & Cellular and Molecular Biology Department, as co-principal investigator. Physics graduate students **Da Yang and Bryant Walker** are also part of the project, and Männik said he's looking for new people to join the group, which also includes work on other, concurrent grants.

The NIH award came through the National Institute of General Medical Sciences, which supports basic research that increases understanding of biological processes and lays the foundation for advances in disease diagnosis, treatment, and prevention.

"Our particular focus is to understand how cell division and chromosome replication are coordinated. What triggers the cell division process? That's not known for bacteria, and that's a really big question."



Top right: photo of a nickel-size microfluidic chip for bacterial studies. Bottom right: zoom-out region from the microfluidic chip.



The Männik Group (L-R): Bryant Walker, Alexa Cusick (undergraduate), Jaan Männik, and Da Yang.

Hanno Weitering

Gentleman Scholar

In October we received the sad news about the passing of **Physics Professor and Chancellor Emeritus John Quinn.** You can read about John's lifetime achievements in this newsletter. He was a renowned scholar and a true gentleman. At a personal level, I am greatly indebted for his mentorship during my tenure track career some 20-25 years ago. After John retired in 2015, he quite often stopped by my office to announce his latest progress in writing down a trial wavefunction for the Laughlin states of a fractional quantum Hall system, and he would do so with the enthusiasm of a beginning graduate student making his or her first major discovery. John's love and passion for physics were contagious, inspiring, and dazzling at times. I must admit that his theory was usually way over my head, but the conversations were always fun. With his passing, we have lost a wonderful colleague and a dear friend. John was 85 years old.

Several faculty members received special recognition this fall for their extraordinary achievements in research. **Professor Kate Jones** was named Fellow of the American Physical Society (APS). The APS Fellowship is a distinct honor signifying recognition by one's professional peers. Each year, no more than one-half of one percent of the society's membership (excluding student members) is recognized by their peers for election to the status of Fellow of the APS. **Professor Adriana Moreo** was elected Fellow of the American Association for the Advancement of Science (AAAS). The AAAS Fellowship is awarded in recognition of one's extraordinary achievements in advancing science. This year, there were only 19 new Fellows in physics, meaning that the election is very competitive. Congratulations to both of you.

Kudos to **Professor Yuri Efremenko** who received the 2018 Distinguished Senior Research Award at the College of Arts and Sciences annual faculty awards dinner. This award is the College's highest honor in the research category and is given in recognition of one's entire 20+ research career at UT. Yuri's accomplishments over the past decade have placed him as a worldwide leader in the important field of neutrino research. Neutrinos, elementary subatomic particles with infinitesimal mass and no electric charge, are extremely challenging to detect. Yuri was on the team proving that neutrinos have in fact a tiny mass and change "flavor" as they travel through space. He recently led a team of 80 researchers that spotted these elusive particles when bouncing off atomic nuclei in a coherent fashion. This achievement fulfilled a four-decade long search, using a small portable detector. This work was featured on the cover of *Science Magazine* (and in our Fall 2017 newsletter) and was selected by the public as the second most important Breakthrough of 2017.

Also recognized at the faculty awards night was **Dr. Sean Lindsay**. He received the College Excellence in Teaching award for lecturers. Sean joined the department in 2015 and almost single-handedly revived our then struggling gen ed astronomy program. His reputation as an exciting and knowledgeable teacher has gone all over campus and students suddenly again have found it worthwhile to select astronomy as their general education science topic. The enrollment in our 100-level astronomy courses has doubled since Sean took over. This comment from a student says it all: "*Best instructor I've had at UTK. His passion for astronomy lights up the room. You can't help but be excited with him.*"

Congratulations to **Associate Professor Jaan Männik** for winning the department's first-ever direct award from the National Institutes of Health (NIH). His work in experimental biophysics is featured on the front page of this newsletter. Congratulations also to **Assistant Professor Sowjanya Gollapinni** for winning her first Department of Energy (DOE) award. During our academic program review several years ago, I expressed my concern that physics faculty were funded exclusively by the National Science Foundation (NSF) and DOE. Now, we enjoy(ed) funding from DOE, NSF, NIH, the Office of Naval Research (ONR), and the Defense Advanced Research Projects Agency (DARPA), as well as smaller agencies. Meanwhile, our annual research expenditures increased to **$12.8M**, an all-time high and higher than that of any department at the University of Tennessee, Knoxville. Our students are increasingly successful at winning external fellowships, mostly through the DOE graduate fellowship program. This is a big success story, and it attests to the quality of our faculty, students, and staff.

Special thanks to **Assistant Professor Nadia Fomin** and colleagues for organizing the annual meeting of the Southeastern Section of the APS (SESAPS) here in Knoxville. With close to 400 participants, this meeting was a great success. In addition, I would like to extend my appreciation to **Assistant Professor Steve Johnston**, who hosted the annual ONR Energy & Power Management Program review. This meeting also went very well. Bringing these meetings to Knoxville does well for our reputation and helps build networks.

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 2019.

Undergraduate Scholarship Profile

Waikoloa Had to Wait

Ian Cox could have gone to Hawaii but he decided on Japan instead.

With class and research commitments, only one trip would fit his schedule.

Cox, a junior, has spent the past year or so balancing his academic requirements with work in **Professor Robert Grzywacz's** research group. As such he is learning about neutron spectroscopy, the properties of nickel and tin, troubleshooting experiments, and navigating multiple time zones. He travelled to Japan this summer and again this fall to help set up an experiment using VANDLE (Versatile Array of Neutron Detectors at Low Energy), along with HAGRiD (Hybrid Array of Gamma Ray Detectors) to measure the decay of nickel-78 and neighboring nuclei. The research is located at the Radioactive Isotope Beam Factory at RIKEN, the largest comprehensive research institution in Japan.

The group set up the experiment this summer, and although beam problems caused delays, things were up and running in the fall. While he said he didn't get to see much of the experiment, Cox did gain firsthand knowledge of adapting when things don't go to plan.

Ian Cox with the VANDLE (Versatile Array of Neutron Detectors at Low Energy) array at the RIKEN Radioactive Isotope Beam Factory in Japan.

"There were a couple of problems, so we spent some time making sure everything was working well and just how we wanted it," he said.

A November trip to RIKEN meant he had to make some choices about managing his calendar. Cox had submitted a poster to a joint meeting of the American Physical Society Division of Nuclear Physics (DNP) and the Physical Society of Japan. The conference was scheduled for late October in Waikoloa, Hawaii. But with research and coursework, he chose to sit it out.

"I figured I'd focus more on the experiment than on the conference," he said.

Physics is a family tradition for Cox, who grew up in East Tennessee spending time at his grandfather's business: Spectrum Techniques in Oak Ridge. The company sells radioactive sources for teaching, training, research, radiation protection, and up-and-coming technologies. Following in his grandfather's footsteps as a physics major, the Hardin Valley Academy graduate chose UT for a variety of reasons.

"I went to high school in Knoxville and I had been around the university for a while," he said. "I really liked the atmosphere and the campus. I was getting a pretty good deal with scholarships and obviously physics here is good, so I thought it was a good fit."

Cox was accepted into the Chancellor's Honors Program and won the physics department's Bill Bugg Faculty Scholarship. His campus life involves following UT sports, playing sports in his own right, spending time with friends, and membership in the Society of Physics Students. The latter is ultimately how he found out that Grzywacz was looking for an undergraduate to join his group. Cox sent an email, met with Grzywacz, and that was that.

He's done hands-on work and travelled abroad, and he did in fact attend a DNP meeting: the 2017 conference where he presented a poster on studies of tin-133 in the beta-decay of indium-133. Cox advocates getting experience outside the classroom for all physics majors.

"If you study physics I think you should do undergraduate research," he said. "I think it's very important and it's great because you learn a lot more that way. From classes you learn a lot about the math and the theory behind everything, but in my research it's really good to get practice with this kind of stuff and see how it applies; see what grad school's like because you work with graduate students a lot. You can see if that's really what you want to go into."

Where are they now?

An update on a few of our scholarship alumni

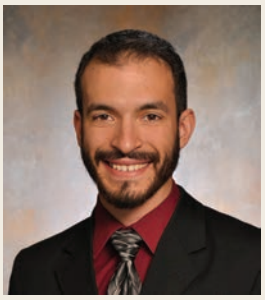
A. Brooke Carter

Bachelor's Degree, 2017
James W. McConnell Scholarship
Additional Degrees/Certifications: Teaching License for Physics
Currently: Science Teacher, L&N STEM Academy, Knoxville

Eric Martin

Bachelor's Degree, 2012 (Engineering Physics)
William Bugg Faculty Scholarship
Additional Degrees/Certifications: MS, Physics, University of Colorado Boulder; PhD, Applied Physics, University of Michigan
Currently: Research Fellow, University of Michigan Department of Physics and Co-Founder, Monstr Sense Technologies

"The Bugg scholarship was actually one of my motivators freshman year to start out majoring physics, and I'm very glad I did." —Eric Martin



Adrian Sanchez

Bachelor's Degree, 2010
Physics General Scholarship
Additional Degrees/Certifications: PhD, Medical Physics, The University of Chicago
Currently: Enrolled in the Medical Innovators Development Program, Vanderbilt University School of Medicine (PhD to MD Program)

SESAPS 2018

UT Physics hosted the 85th annual meeting of the Southeastern Section of the American Physical Society (SESAPS) November 8-10. More than 350 people attended, with 90 poster presentations and close to 200 oral presentations. Denise Kiernan, author of the national bestseller *Girls of Atomic City,* delivered a public lecture at McClung Museum on the eve of the meeting. Attendees also enjoyed a lecture on local history by Jack Neely during the conference banquet. Faculty members **Nadia Fomin (Chair), Steve Johnston, Sowjanya Gollapinni, and Miguel Madurga** were part of the local organizing committee, along with undergraduate physics major **Peyton Nanney.** Congratulations to UT's own **David Perryman** (pictured right), a junior physics and computer science major, who won the SESAPS prize for best undergraduate oral presentation. The prize was a copy of *The Feynman Lectures on Physics*.

Remembering John Quinn

The physics department was deeply saddened by the October 8 passing of John Quinn, professor and chancellor emeritus. Quinn was a distinguished administrator over decades in higher education as well as a titan in condensed matter physics theory. Yet he almost didn't become a physicist at all.

"I thought I would be a mathematician," he once said. It was his older brother who convinced him that all the exciting developments would be in physics, and that conversation steered him down a path where he would make an indelible mark on the way we understand how particles behave.

Born in New York in 1933, Quinn earned a bachelor's degree in physics at St. John's University in 1954. He enrolled in graduate school at the University of Maryland, where he discovered the study of electrons in a solid, an area that would become his specialty. He also became acquainted with a bright young assistant professor named Dick Ferrell.

When Ferrell went to the Rand Corporation in California for the summer, he left Quinn with a problem. Ferrell was interested in positron annihilation and asked him to find electron density at the position of the positron. Quinn used the lowest-order of what he called self-consistent perturbation theory. The work was the basis of his first paper, which turned into a presentation at the 1956 American Physical Society January meeting. It was also the foundation of Quinn's doctoral dissertation, "Self-Energy Approach to Correlations in a Degenerate Electron Gas," which presented a new method for calculating the correlation energy of a degenerate electron gas. It launched a career where he would go on to become an expert in many-body theory and help set apart two-dimensional electron systems as a sub-field in condensed matter studies. His method later became known as the GW approximation, which is often used in electronic structure calculations.

When he finished the PhD in 1958 Quinn accepted a postdoctoral appointment at Maryland, then joined RCA Laboratories in 1959, working in the general solid state research group. With time to pursue his own interests, he gave lectures on electron-electron interactions on solids. At the time there was great interest in why the Sommerfeld model worked as well as it did. His work showed it was possible to treat the electrons in a solid like a Fermi liquid, where interacting and non-interacting electron states are mapped one-to-one. He was the first to calculate the electronic mean free path in metals, which later became known as the "universal mean-free-path curve," which appeared in many textbooks and is still being used extensively in experimental research.

In 1965 Quinn moved to academia, accepting a position at Brown University where he would over time serve as professor, associate provost, Ford Foundation Chair, and dean of the faculty. He was especially proud of his efforts to attract and keep outstanding faculty members. He evaluated faculty performance for 485 faculty members every year, and by the time he left Brown he knew all of them by name.

Quinn came to UT in 1989 as chancellor and professor of physics. Even as chancellor he kept a board in his office where he scribbled equations while meeting with his students, always intrigued by the elegant mysteries of physics. In 1992, he returned to the physics faculty full-time as the Willis Lincoln Chair of Excellence. Since then, Quinn tackled one of the biggest challenges in theoretical physics related to the fractional quantum Hall effect, an emergent phenomenon in a highly correlated state of quantum matter. He had a stellar and highly productive career, in which he published more than 250 papers and, most recently, a graduate level textbook on *Solid State Physics*. He was also very active in the condensed matter physics community and served as Chair of the Division of Condensed Matter Physics of the American Physical Society and as Divisional Associate Editor of *Physical Review B*. When he retired in 2015 he was named chancellor emeritus to honor his distinguished service to the university. It's one of many honors he claimed over the years, including two from the University of Maryland: the Physics Department Outstanding Graduate Alumnus Award and the Distinguished Alumnus Award from the College of Computer, Math and Natural Sciences.

Of all his accomplishments, Quinn often said that he was most proud of "turning out a number of extremely fine research scientists." His motto for fellow theorists was: "Try and write a paper that an experimentalist will read."

Even in retirement he continued to work, collaborating with faculty from the math department and keeping an eye on the direction of condensed matter physics research. He clearly was among UT's finest scholars. He was a true gentleman with a big heart and was liked and admired by so many people around him. We will miss him dearly.

PHYSICS FAMILY NEWS

New Physics Faculty Fellows for APS, AAAS

The department has another name to add to its list of American Physical Society (APS) fellows with the election of **Professor Kate Jones**. Elected by their peers, fewer than half of one percent of APS members are chosen for fellowship each year. She is the 12th member of the current physics faculty to be named a fellow and was cited for "important contributions to understanding the structure of neutron-rich and weakly bound nuclei, in particular from neutron transfer reactions with radioactive ^{132}Sn beams."

Jones has taught courses on Introductory Astronomy, Elementary Nuclear Physics, and the Modern Physics Laboratory. This fall she is teaching Physics for Future Presidents as part of the First-Year Studies program. She also serves as associate department head in physics. Jones earned both bachelor's and doctoral degrees from the University of Surrey in England and joined the faculty in 2006.

Congratulations also to **Adjunct Assistant Professor Gaute Hagen** on his election to the 2018 class of APS Fellows. He is a staff research scientist at Oak Ridge National Laboratory.

Professor Adriana Moreo has been elected a Fellow of the American Association for the Advancement of Science (AAAS), the fourth member of the current physics faculty to earn this honor. AAAS Fellowship is a lifetime honor recognizing extraordinary accomplishments in advancing science. Moreo was cited "for contributions to condensed matter physics, in particular for the development of advanced computational techniques for strongly correlated electronic systems such as manganites and cuprates." She is also a fellow of the American Physical Society.

Moreo joined the physics faculty in 2004 and teaches the department's graduate-level physics course on Statistical Mechanics. She also plays a leadership role in UT's "Women in Physics" events. She holds a joint position at Oak Ridge National Laboratory and earned a Licenciada en Fisica and PhD in physics at the Instituto Balseiro (Bariloche, Argentina).

Graduate Student Research Earns Awards

Josh Barrow

Phil Dee

Graduate Students **Josh Barrow, Philip Dee, and Andrew Lopez** have all won Science Graduate Student Research (SCGSR) awards from the U.S. Department of Energy. Barrow will go to Fermilab to study fundamental particle physics and nucleon instability as it applies to the imbalance of matter and antimatter in the universe. Dee will work in the computational materials science group at ORNL. Lopez will work at LANL running a variety of physics simulations as part of an ongoing project to search for neutrinoless double-beta decay.

Andrew Lopez

Sean Burcher

Graduate Student **Sean Burcher** won two awards for his work on "Constraining the ^{30}P(p,γ)^{31}S Reaction Rate, via a Measurement of the ^{32}S(p,d)^{31}S* Reaction." At the 10th International Conference on Direct Reactions with Exotic Beams (DREB2018) he was recognized with the Asian Nuclear Physics Association & Association of Asia Pacific Physics Societies Division of Nuclear Physics Award for Young Scientists. At the Nuclear Structure 2018 (NS2018) meeting he won second place for best poster presentation.

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We were pleased to host students from Bearden High School, Berean High School ISP, Halls High School, and Oak Ridge High School for our Fall 2018 Open House. This was our seventh open house to introduce our undergraduate program to area students.

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