



SPRING 2019 DEPARTMENT NEWSLETTER





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and keep in touch!

Please let us know if your address or contact information changes. Write or call the Physics & Astronomy Department Manager, Suann Reese:

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Cover Photo:

Prof. Chris Crawford's research on the capture of neutrons by protons has revealed, for the first time, the nature of the parity-violating weak interaction between protons and neutrons in a nucleus.

Image Courtesy of Andy Sproles/Oak Ridge National Laboratory, U.S. Dept. of Energy.

Greetings from the Department Chairs

Dear Friends of the Department of Physics and Astronomy,

Since our previous newsletter in Fall 2017, the Department of Physics and Astronomy has undergone significant changes due to the recently commenced renovation of the Chemistry-Physics Building. This renovation (https://uknow. uky.edu/campus-news/uk-transform-modernize-chemistry-physics-building) will modernize and transform the building, constructed in 1962, into a modern research facility with upgraded research laboratories, open-floor-plan meeting and collaboration spaces, and modern technological classrooms. The first phase of the renovation, slated to be completed in late 2021, will include a transformation of the third floor and the addition of a new exterior façade; lower floors of the building will be renovated in later years.

As a result of the need to vacate the third floor, more than half of our department has been relocated from the Chemistry-Physics Building to temporary offices in the Blazer Dining Hall building, located on the north side of campus near the brand-new Gatton Student Center. Experimentalists with research laboratories have remained in the Chemistry-Physics Building, while theorists and astronomers have been relocated to Blazer. Although the renovation and physical separation of our department have introduced several challenges, we still regularly get together for the weekly colloquium and the seminar series, and most of our teaching still takes place in the Chemistry-Physics Building.

The department continues to grow. We now have nearly 90 graduate students enrolled in our Ph.D. program and have recently grown the size of our faculty to 31, with the recent hiring of two new assistant professors, William Gannon and Yuanyuan Su. Prof. Gannon, who will join the faculty this fall, is currently a postdoctoral fellow at the University of British Columbia and is an experimental condensed matter physicist studying quantum magnetic fluctuations in low-dimensional correlated electronic systems. Prof. Su, who joined us in January, was a postdoctoral fellow at the Harvard-Smithsonian Center for Astrophysics prior to arriving at UK and is an astronomer with interests in the astrophysics of clusters of galaxies, the largest gravitationally bound systems in the universe, as probed using multiple types of telescopes. We could not be more pleased with the recent additions of these two new dynamic young faculty members, and we look forward to the growth of their research programs.

We continue to be optimistic about what the department will accomplish in the coming years. Our immediate priorities include redesigns of our undergraduate and graduate curricula, in order to better meet the diverse needs of our students; continued efforts to recruit the highest quality graduate students, who form the core of our research mission; and efforts to cultivate an inclusive and welcoming environment for all students at the undergraduate and graduate levels.

We are eager to share the exciting developments featured in this newsletter and welcome any input or ideas that you may have.

With best wishes,



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Research Highlight

Profs. Renbin Yan and Ron Wilhelm Lead Efforts to Create the World's Largest Stellar Library of the Milky Way

By Jenny Wells and Jordan Raddick

Want to learn everything there is to know about a subject? Go to the library. Want to learn everything there is to know about stars? Go to the stellar library.

Professors Renbin Yan and Ron Wilhelm, along with a team of astronomers from the Sloan Digital Sky Survey (SDSS), recently announced the opening of a new "stellar library" containing spectra of thousands of stars in the Milky Way galaxy. Having access to this library will help astronomers understand not only our own galaxy, but galaxies across the universe.

The announcement came at the annual meeting of the American Astronomical Society (AAS) in Seattle. The new library is known as the "MaNGA Stellar Library," named after the SDSS's Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) survey it was designed to support. MaNGA's goal is to understand the detailed internal structure of galaxies — but of course galaxies are made of stars, so understanding a galaxy requires understanding the stars that compose it. For decades, astronomers have been trying to figure out what unique mix of stars best explains the light that we see from every distant galaxy.

"It's a bit like hearing a symphony," said Yan, who serves as principal investigator of the MaNGA Stellar Library project, or MaStar for short. "We hear the sound from the entire orchestra at once, but we can only understand the music if we know which instruments are playing."

For galaxies, the "music" is the light coming from the mix of stars that make up a galaxy, along with its detailed history of star formation. The problem is that other galaxies are so far away that astronomers cannot distinguish individual stars in them. The solution is to study thousands of stars in our own Milky Way. Once they identify all of the possible "instruments" using stars in the Milky Way, they can decipher the "music" of distant galaxies.

In a symphony, the sound of each instrument has its own unique tone; in the case of galaxies, the light of each type



A graphical summary of all stars currently in the MaNGA Stellar Library, plotting the stars' temperature vs. luminosity (brightness), along with information on their chemical makeup. Photo courtesy of SDSS collaboration.

of star has a unique spectrum. A spectrum measures how much light a star gives off at different wavelengths, a pattern unique to each type of star. Like sheet music shows how a song will sound, "reading" a spectrum gives important information about a star, like its temperature, size and chemical composition. By observing thousands of stars of all types, astronomers can build up a "library" of stellar spectra. Thus, when they measure the spectrum of a distant galaxy, they can try to build the spectrum by putting together different combinations of stars from the stellar library until they find a combination that fits.

"To reconstruct the spectrum of a galaxy, you need to get good spectra for the widest range of stars you possibly can," said Karen Masters, spokesperson for the SDSS project. "This allows you to estimate the mass the galaxy has in stars, and reconstruct its star formation history, both crucial to complete the goals of the MaNGA survey part of SDSS-IV. As astronomers often say, this is just like reconstructing a piano from the sound it makes falling down the stairs."

Those accurate spectra come from the spectrograph of the MaNGA program. MaNGA spends most of its time observing galaxies, but over the last three years, it has also measured spectra for more than 3,000 stars of all colors and sizes. These spectra have been collected into MaStar.

MaStar began out of necessity. At the beginning of the fourth phase of the SDSS in 2013, the MaNGA team realized that there was no suitable library of stellar spectra for their survey. Rather than be stymied by the lack of such a library, the team realized they had an opportunity to create such a library by working with the other survey programs that make up the SDSS.

"We needed a new stellar library, meeting not only certain specifications in wavelength coverage but also covering more types of stars," said Yan, who works closely on the project with UK doctoral student Daniel Lazarz. "I planned and led a team of people to carry out the project — it was a huge amount of effort."

Yan says what makes the MaStar project possible is the parallel observing capability in the SDSS.

"At the same time as our colleagues use the infrared spectroscope to observe stars in our galaxy, we can use the MaNGA instrument to simultaneously observe other stars in optical," Yan said. "This is enabled by the way SDSS uses fibers to observe the light from many stars at once. We basically get the observations for free."

Thus, with this strategy of "piggybacking" on other SDSS observations, researchers from the MaNGA team were able to get the right spectra for the right stars to create the stellar library they so desperately needed. All the spectra for all these stars have been released as part of the SDSS's Data Release 15, and are available online through the project's website at www.sdss.org.

Once astronomers have a library that includes the light spectra for as many types of stars as possible, they can figure out how many of each type of star add up to make the galaxy spectrum, and thus understand the galaxy's history of star formation. In Yan's analogy, they can understand which instruments are making the music. The key is to include as many types of stars as possible in the library.

"MaStar is the most inclusive stellar library ever created," Yan said. "That inclusivity is our biggest strength: the more instruments we can recognize, the better we can understand the symphony."

And the MaNGA Stellar Library will just keep growing. With observations continuing at Apache Point Observatory until at least 2020, it will become the biggest and most inclusive stellar library ever made.



Renbin Yan



Ron Wilhelm

Research Highlight

Prof. Christopher Crawford and the NPDGamma Experiment

By Jenny Wells and Sara Shoemaker

Prof. Christopher Crawford and many of his current and former students are contributing co-authors on a groundbreaking paper that was recently featured as the Editor's Choice in Physical Review Letters, the American Physical Society's premier scientific journal.

In an experiment carried out at the Department of Energy's Oak Ridge National Laboratory, a multinational group of physicists was able for the first time to measure the weak interaction between protons and neutrons in the nucleus of an atom. The project culminates decades of work performed on the experiment known as NPDGamma.

Crawford has been contributing to the NPDGamma experiment since 2005, commissioning the experimental apparatus and collecting data at Los Alamos National Laboratory before the experiment was moved to Oak Ridge National Laboratory. UK has been involved in the Oak Ridge effort since Crawford was hired in 2007.



Christopher Crawford

"We have been involved in many aspects of the experiment, from computer simulations of neutrons to developing software and data acquisition programs used by the collaboration for data analysis," said Crawford, who is the principal investigator from UK on the experiment. "Our group helped recondition the gamma-ray detectors and calibrated their acceptance for the Oak Ridge measurement. UK graduate student Elise Tang (now a postdoc at Los Alamos National Lab) analyzed the first batch of data at Oak Ridge and determined how to characterize background noise from signatures in the data."

Crawford's team which participated in the NPDGamma experiment includes postdoctoral scholar Mark McCrea, graduate students Aaron Sprow, Elise Tang and Latiful Kabir, and undergraduate students Kayla Craycraft, Charles Fieseler, Forest Simmons and Robert Milburn.

Sumit Das Named Distinguished Professor

The Distinguished Professor Award Committee has named Professor Sumit Das as the 2019–20 Distinguished Professor in Arts & Sciences, the highest honor bestowed by the College to one of its faculty. The College annually grants this award on the basis of three criteria: outstanding research, unusually effective teaching, and distinguished professional service. Dr. Das will receive one semester's research leave at full salary and a monetary award of \$5,000, and he will present a formal public lecture.

A former department chair at UK and a University Research Professor in 2010, Dr. Das holds a B.Sc. (Hons.) and an M.Sc. in Physics from the University of Calcutta, and a Ph.D. from the University of Chicago (Physics), where he studied with Nobel laureate Yoichiro Nambu. In 2002, he moved to UK from the Tata Institute of Fundamental Research in Mumbai, where he was a senior faculty member. He was elected a Fellow of the Indian Academy of Sciences in 1997 and received the Bhatnagar Prize in 1998, the highest honor awarded by the Indian government to scientists, for his work on black hole entropy. Professor Das has published over 150 articles and proceedings on String Theory, black holes, non-perturbative field theory, and other subjects in theoretical physics, and his research has been funded continuously by NSF since 2003.



Sumit Das

Graduate Student Achievements

Huffaker Fellow Aaron Jezghani Develops New Instruments and Technologies in His Experimental Work in Neutron Decay

By Eliana Shapere

Aaron Jezghani is an inventor — although he wouldn't call himself that. He is pursuing a Ph.D. in precision nuclear physics, focusing on neutron decay, and is fascinated by the hands-on nature of experimental physics. Jezghani spends his days designing, building, and testing all types of equipment — everything from high-voltage instruments to computer data systems.

An important part of Jezghani's doctoral experience has been the many opportunities he has had to give talks at national and international conferences thanks to receiving travel grants from the UK Graduate School, the American Physical Society, and the Huffaker Travel Scholarship Fund established by Milton Huffaker (B.S. Physics '57, honorary doctorate '13).

"I just look back in awe at everything that has transpired after coming to UK for grad school," he said. "Without funding opportunities like these travel grants, there's no way I'd have been able to present at conferences as much as I have."

His most memorable talk was at the Division of Nuclear Physics meeting in Santa Fe, where the audience was so big that it was standing room only. "I had more audience feedback than I'd ever had," Jezghani said. "After my talk, I was approached by a few scientists from other countries who were interested in my ideas and work."



Collaborating with physicists around the world has allowed Jezghani to refine his research and gain perspective on how it fits into the

Aaron Jezghani standing next to a neutron decay spectrometer magnet at Oak Ridge National Laboratory.

universe of scientific progress. "Being able to travel and engage with physicists from around the world has been one of my favorite parts about graduate school. I can't put a value on how much I've learned from their insights," he said. "The funding that Huffaker provided to the Physics Department has allowed me to seek out exposure beyond our campus in a way that wouldn't have been possible otherwise."

Within the local physics community, Jezghani has helped to foster a love for science among young people. "I've spoken to middle schoolers about pursuing careers in science and I've volunteered my time as a guest scientist for STEM activity days. These experiences were ultimately my favorite, because I want to share my passion for physics, and science in general, with others," he said.

Surprisingly, Jezghani didn't originally plan on going to graduate school. Instead, he intended to pursue a teaching certification. Thanks to the encouragement of his advisor, Dr. Ram Rai of Buffalo State University, who received a Ph.D. from UK, Jezghani decided to apply for graduate school. He ended up accepting UK's offer of admission after being impressed with the physics program and professors, and also with the cultural environment of UK and Lexington.

"As part of my tour of the department, I was able to attend the 2012 Van Winter Memorial Lecture, 'Once Upon a Time in Kamchatka,' which, to this day, is one of the most enjoyable colloquia I've experienced. Then I was driven around downtown and that reminded me of my hometown in Maryland. Of course, the best experience was being able to be in Lexington the night we beat Indiana in the Sweet 16 - by the time we won the title, I knew I was going to UK."

For Jezghani, being at UK has been a wonderful experience, academically and socially. "As for the academics, I've really enjoyed being able to engage with the physics faculty; I've always found their doors open, and I've really enjoyed bouncing ideas off of them," he said. "I think the other part that I really took away from UK was the camaraderie of the

physics grad students. I've heard students from other universities talk about exclusivity and cut-throat competition in their program, but I can say that isn't the case at UK."

Originally, Jezghani planned to study chemistry in college, never having taken physics in high school. He soon realized that chemistry was not his true passion, and ended up earning a degree in mathematics. After graduation, he worked a few different jobs while looking for a career that would spark his interest. Within a couple of years, however, Jezghani realized he wanted more.

"I considered my options, decided to go back to school to get another degree, and found that I just really enjoyed physics," he said. "It's hard for me to say what it is that I like so much, but I can readily lose myself in a problem or idea, and to me, that's something special."

Jezghani's experience has included opportunities that many physics researchers and students only dream of. Not least among them, he has developed several new technologies and instruments while pursuing his Ph.D. "I developed a new digital signal processing filter for high-efficiency, low-threshold triggering on pulses, and accurate online timing and energy determination. Also in collaboration



Ph.D. candidate Aaron Jezghani is charting an unusual path to his doctorate in physics.

with National Instruments, I created a new data acquisition platform for flexibility with simple customization and powerful debugging capabilities," he said.

"That's the beauty of working towards a Ph.D.—you come up with ideas that have never been considered before, and experiments that have never been done, and you acquire the skills and confidence to implement these solutions yourself."

Ph.D.s Recently Awarded

The department congratulates the following doctoral students who have earned their Ph.D. since our previous newsletter in fall 2017:

Joshua Abney

"Studies of Magnetically Induced Faraday Rotation by Polarized Helium-3 Atoms" Advisor: Wolfgang Korsch

Michael Brown

"Determination of the Neutron Beta-Decay Asymmetry Parameter A Using Polarized Ultracold Neutrons" Advisor: Brad Plaster

James Ryan Dadisman

"Magnetic Field Design to Reduce Systematic Effects in Neutron Electric Dipole Moment Measurements" Advisor: Brad Plaster

Gemunu Ekanayake

"Determination of Stellar Parameters Through the Use of All Available Flux Data and Model Spectral Energy Distributions" Advisor: Ronald Wilhelm

John Gruenewald

"Tuning the Effective Electron Correlation in Iridate Systems Featuring Strong Spin-Orbit Interaction" Advisor: Ambrose Seo

Jeremy Huber

"Multispectral Observations and Analysis of the Rosette Nebula" Advisors: Gary Ferland and John Kielkopf (U. of Louisville)

Ehsan Jafari

"η' Decay to π+π-π+π" Advisor: Bing-An Li

Stacy Long

"RR Lyrae Calibration Using SDSS, Single-Epoch Spectroscopy" Advisor: Ronald Wilhelm

Mohsen Nasseri

"Nanoscale Devices Consisting of Heterostructures of Carbon Nanotubes and Two-Dimensional Layered Materials" Advisor: Doug Strachan

Suvarna Ramachandran

"Probing the Low-x Gluon Helicity Distribution with Dijet Double Spin Asymmetries in Polarized Proton Collisions at $\sqrt{s} = 510 \text{ GeV}$ " Advisor: Renee Fatemi

Jessica Short-Long

"Correlation Between Emission Lines and Radio Luminosities of Active Galactic Nuclei" Advisor: Renbin Yan

Maryam Souri

"Electronic and Optical Properties of Metastable Epitaxial Thin Films of Layered Iridates" Advisor: Ambrose Seo

Justin Thompson

"Structural, Transport, and Topological Properties Induced at Complex-Oxide Hetero-Interfaces" Advisor: Ambrose Seo

UK Society of Physics Students Win Chapter and Research Awards

By Ellie Wnek



(L to r) Dany Waller (SPS president), Henry Colburn (SPS vice president), Alex Blose (SPS secretary) and Kris Andrew (SPS treasurer)

The University of Kentucky Society of Physics Students (SPS) chapter has won an Outstanding Chapter Award and a Chapter Research Award from the SPS National Office. The Chapter Research Award is a competitive financial grant for a yearlong research project.

With the Outstanding Chapter Award, SPS chapters are recognized for high levels of interaction with the campus community, the professional physics community, the public and with SPS national programs. The outstanding chapter designation is given to less than 10 percent of all SPS chapters in the United States and internationally. Although this is the second time the UK chapter has received this award, it has been almost 25 years since UK was initially recognized as a top-tier student-led physical sciences organization.



Joseph Feliciano (front) and Ben Kistler (back) assemble a monitor for a supercomputer, which will be used for physics demonstrations, programming competitions and interdepartmental game nights.

For the Chapter Research Award, chapters submit research proposals with the top five percent receiving the financial grant. The title of their proposal is "Data Analysis and Accuracy: Small Supercomputer versus a Desktop Dinosaur." Students will build a mini-supercomputer following the Tiny Titan building plan from Oak Ridge National Lab. Once built, it will be used for research projects, experiments and simulations. The students presented their supercomputer during the SPS Open Lab Day this spring. The chapter's president, Dany Waller, said, "This recognition is a high honor for the University of Kentucky and for science achievement at the higher education level in Kentucky. We are so thrilled to be recognized and look forward to doing even more work in our community."

The UK Society of Physics Students chapter is a professional and social organization for physics majors and minors, as well as for students with a general interest in physics. SPS operates within the American Institute of Physics (AIP), an umbrella organization for professional physical science societies. Each semester the chapter hosts interactive presentations during which professors speak about their research and provide students with the opportunity to interact outside of a traditional classroom setting. Additionally, SPS also hosts an open lab day to promote education in physics and showcase the research occurring in the department.

A Stand-Out in Undergraduate Research: Tom Shelton '20

By Julie Wrinn



Tom Shelton with the project beamline for the Nab collaboration at Oak Ridge National Laboratory, where he completed an internship in summer 2018 and will return in summer 2019.

Like most physics majors, Tom Shelton is drawn to a challenge. "In high school, the calculus-based physics class was the most challenging," Shelton explained, "so I figured why not do that as a major." Not everyone sees the logic in such thinking, but physics students tend to be a breed apart. This class of 2020 double major in physics and math has been fortunate to find like-minded peers at UK through the Society of Physics Students (see story on p. 9). "Easily the best part about the department is the students," said Shelton. "There are some great professors as well who are extremely helpful in their office hours."

One of those is Professor Chris Crawford, who has served as Shelton's research mentor since his freshman year. "Prof. Crawford has been invaluable in the opportunities he has provided for me. From the direct research under him to the acquisition of an internship next summer, Dr. Crawford has been a wonderful resource and a great mentor." Last summer Shelton earned a Chellgren Center summer research fellowship to study at Oak Ridge National Laboratory under the direction Dr. Crawford. They worked on digital signal processing for the Nab collaboration, a project involving 14 different universities.

The Nab collaboration carries out precise measurements of how neutrons undergo beta decay to a proton, electron, and an anti-neutrino. The decay electrons and protons are measured in silicon detectors. As Shelton explains, his work on digital signal processing was to "develop algorithms that were tailored to the architecture of graphical processing units (GPU's) in order to perform real-time analysis of the data collected by the experiment. The implementation of these algorithms allows upwards of 5000 events per second to be fully analyzed."

Next summer, in 2019, Shelton will complete another internship, this time under Oak Ridge staff physicist Dr. Leah Broussard. "My work will be within the same collaboration and will partially be continuing and expanding upon my work from last summer," explained Shelton, "but there are also some really exciting new aspects such as learning how to simulate the charge collection in the silicon detector." In recognition of his outstanding work in undergraduate research, Shelton was recently awarded a Goldwater Scholarship, one of 496 STEM majors at U.S. colleges and universities who were named Goldwater Scholars this year.

Shelton grew up in Oregonia, Ohio, just north of Cincinnati, but his family is originally from Williamsburg, Kentucky, where his grandparents still live, and both his father and grandfather have degrees from UK.

After graduation in May 2020, Shelton plans to continue doing what he loves. "My goal is to continue my studies in graduate school for experimental nuclear physics," said Shelton. "I would love to try to become a staff scientist at a national lab or something similar." He is well on his way.

Faculty Awards

Congratulations to the following faculty who were recently recognized for their exemplary research, teaching, or service:

Chris Crawford

Arts and Sciences Outstanding Undergraduate Research Mentoring Award, 2018

Terry Draper

Arts and Sciences Outstanding Teaching Award, 2018; and an award from the Disability Resource Center for "his outstanding efforts to assist UK students in overcoming barriers to accessibility"

Susan Gardner

Named a University Research Professor for 2019–20

Tim Gorringe

Arts and Sciences Outstanding Teaching Award, 2019

Keh-Fei Liu

Recipient of the 2018 Albert D. and Elizabeth H. Kirwan Memorial Prize, given each year to a faculty member in recognition of outstanding contributions to original research

Brad Plaster

Provost's Outstanding Teaching Award, 2018

Support the Physics and Astronomy Development Fund

Your gift to the Physics and Astronomy Development Fund will provide critical resources to respond to student needs, attract world-class faculty, and provide innovative opportunities to enable our students to compete in the global marketplace. You can support the Physics and Astronomy Development Fund at https://www.as.uky.edu/givetoas.

If you'd like to give to another fund that is not listed, please use the search box in the upper right of the page and type in the desired fund to make your gift.

By mail, please send to: University of Kentucky Gift Receiving 210 Malabu Drive, Suite 200 Lexington, KY 40502

For questions please contact Debra Gold (debra.gold@uky.edu or 859-257-8124).



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Upcoming SkyTalks

On the second Thursday of each month, we welcome alumni, friends of the department, and the public to the MacAdam Student Observatory. A 50-minute presentation on a specific aspect of astronomy is followed by a trip to the observatory, where guests are invited to view the sky through our 20-inch telescope (weather permitting).

All talks take place in the UKAA Auditorium, Young Library, and free parking is available on the top floor of Parking Structure #2, next to the observatory:



If you are interested in attending a SkyTalk, please contact the department at (859) 257-6722 for any schedule updates or visit https://pa.as.uky.edu/skytalk.