DEPARTMENT OF
Physics & Astronomy
WINTER 2016-17
MSU College of Natural Science | Newsletter for Alumni and Friends

From the Department Chair...

Despite the financial stresses facing higher education and the diminishing rates at which federal grants are being funded, I am happy to report that the past year has been a very strong one for our department.

Student numbers continue to grow, the faculty members are winning competitive awards, our teaching programs are in the process of renewal and the planetarium and other outreach programs are performing very well. It is also a pleasure to announce a new endowed position—the Wu-Ki Tung Professorship in Elementary Particle Physics—that is funded by the Tung family in honor of Wu-Ki Tung, who was a faculty member in our department from 1992 – 2007 (see page 7).

Our programs have been re-invigorated by the arrival of eight new faculty members, two of whom have their tenure home in our department and the other six having majority appointments in either the Facility for Rare Isotope Beams, Lyman Briggs College or the new department of Computational Mathematics, Science and Engineering. Four of these hires are in elementary particle theory, with three of the four specializing in the area of lattice quantum chromodynamics. This is a new direction for our department and is really exciting for fundamental studies of elementary particle physics, especially given the emerging possibility of calculating nuclear interactions directly from the standard model of high energy physics. The other four new hires include two in accelerator physics, one in condensed matter theory and one in physics education research. Read more about these new faculty on page 3.

"We are very appreciative of the endowments and gifts given to our department . . . These resources allow us to do things that are otherwise very difficult to do."

Several of our early career faculty members have received very competitive awards this year, including a SLOAN Fellowship to Kendall Mahn and DOE Early CAREER Awards to Chris Wrede and Sean Couch. Our senior faculty continue to be very successful, with Megan Donahue and Brian O'Shea being elected fellows of the American Physical Society and Joey Huston being designated as an MSU Foundation Professor. Read more about these and other faculty honors on page 4.

Also of note, Sekhar Chivukula has taken the position of associate provost for undergraduate education, and Elizabeth Simmons was appointed the associate provost for faculty and academic staff development, continuing the strong contributions of our faculty to senior administration at MSU.

Our students have won several competitive graduate student awards (see page 4). The importance of graduate and undergraduate students to our success and research progress cannot be overstated. They are also very engaged and supportive of our teaching and outreach programs and are driving positive change in several directions.

This year, Wayne Repko officially retired after 35 years on the faculty (see page 3). Wayne has always been one of the best teachers in our department, a wise man on the faculty and the leader of a well-known research activity in elementary particle theory. The good news is that he remains very active in research and in the department.

We are very appreciative of the endowments and gifts given to our department, which fund many of our student fellowships and awards, staff awards, research initiatives and endowed faculty positions. These resources allow us to do things that are otherwise difficult to do. Thanks for your continuing support and I wish you the best for the holiday season. Enjoy the newsletter!

Phillip Duxbury
Chair
Department of Physics and Astronomy

ALUMNI CLASS NOTES

Frederick G. Krauss, M.S., physics, '66, is enjoying his 13th year of retirement from a 16-year career in nuclear engineering at Consumers Power Company (now known as Consumers Energy), followed by an 18-year career as an associate professor of physics at a community college. He and his family spend their summers in Michigan and winters in Raleigh, N.C., where his son and three grandsons live.

Craig Barrows, physics, '67, recently retired (for the second time) after teaching physics at Highland Community College in Wamego, Kansas. He and his wife, Dianne, moved to Bend, Ore., to be closer to their daughter, and he is now volunteering as a physics tutor at Central Oregon Community College.

Keith Emery, physics, '76; M.S., electrical engineering, '79, is retiring after more than 36 years at the National Renewable Energy Lab, Golden, Colo., as a principle engineer and group manager, with more than 340 photovoltaic-related publications and conference presentations. Emery has been listed as a highly cited researcher by Thomson Reuters for the past three years.

Mike Miller, physics, '98, is the founding general partner of Liquid 2 Ventures, Seattle, Wash., a new venture fund focused on early-stage technology development. He has one set of fraternal twins and another on the way.

Joshua Roebke, physics, '01, teaches writing at the University of Texas at Austin, where he is also a visiting research associate at the Institute for Historical Studies. In October, he won the inaugural Whiting Creative Nonfiction Grant to help him complete his first book, *The Invisible World*, which provides a social and cultural history of particle physics. The book will be published in the United States by Farrar, Straus & Giroux, and the rights have been sold in more than a dozen other countries.

Carlos O. Maidana, M.Sc., physics, '02, owner and managing director of MAIDANA RESEARCH, and his technical team were awarded a 2016 Small Business Innovative Research Award in Advanced Technologies for Nuclear Energy by the U.S. Department of Energy for the development of computational tools for the design and fabrication of complex liquid metal reactors' magnetohydrodynamic components. Maidana was also appointed as treasurer and chair of the Liaison Subcommittee by the American Institute of Aeronautics and Astronautics Nuclear and Future Flight Propulsion Technical Committee.

Mike Litos, physics, '03, is an assistant professor of physics at the University of Colorado, Boulder. He is also part of the Center for Integrated Plasma Studies at UC-Boulder, and intends to continue his research in plasma wakefield acceleration and start his own local research group.

Laura Chapin, physics, '04, just started a new job as the STEM teacher at the Discovery Academy of Science in Dunedin, Fla. She works with 2nd- to 6th-grade students with hands-on experiments and projects.

Ankur Warikoo, M.S., astrophysics, '04, is currently an Internet entrepreneur. He started Groupon's India Business in 2011 and in August 2015 did a buyout and made Groupon India independent. It is now called nearbuy.com and is India's largest marketplace for retail services.

Elias Garratt, physics, '06, is a research physicist at the National Institute of Standards and Technology in Gaithersburg, Md.

Jeremy Armstrong, Ph.D., physics, '07, is an assistant professor of physics and astronomy at the University of Nebraska at Kearney.

Nathan Wasylewski, physics/actuarial science, '13, is a mechanical and proposal engineer at Mark One Corporation, Gaylord, Mich. The company creates innovative and custom machines mostly for the automotive industry through parametric modeling, designing and prototyping.

Contact Us

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CONNECT WITH NATSCI

New Faculty

The Department of Physics and Astronomy (PA) welcomed eight new faculty members, seven of whom started in August 2016, and one who started in January 2017:

Bazavov

Alexei Bazavov, assistant professor, studies strongly coupled theories, particularly quantum chromodynamics. He received his Ph.D. in physics from Florida State University and most recently was a research associate at the University of California, Riverside, and the University of Iowa. He holds a majority appointment in the Department of Computational Mathematics, Science and Engineering (CMSE) and a partial appointment in PA.

Hao

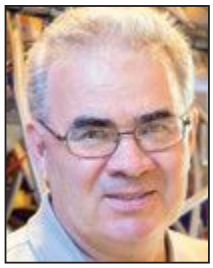
Yue Hao, associate professor, studies beam dynamics effect in various types of accelerators with theoretical models and simulation with high performance computing resources. Hao received his Ph.D. in accelerator physics from Indiana University, Bloomington. Prior to joining MSU, Hao was a physicist at Brookhaven National Laboratory and an adjunct professor at Stony Brook University. He is appointed in MSU's Facility for Rare Isotope Beams (FRIB), with a joint appointment in PA.

Hinko

Katie Hinko, assistant professor, focuses her research in physics education and experimental biophysics. Hinko received her Ph. D. in physics from the University of Texas at Austin and most recently was a senior research associate in the Physics Education Research Group at the University of Colorado Boulder and director of Educational Community Partnerships for JILA. Hinko holds a majority appointment in Lyman Briggs College and a partial appointment in PA.

Lin

Huey-Wen Lin, assistant professor, uses high-performance supercomputers to nonperturbatively calculate physical quantities at the quark and gluon level. Lin received her Ph.D. in physics from Columbia University. Before coming to MSU, she was a visiting assistant professor at the University of California, Berkeley. She holds a majority appointment in PA and a partial appointment in CMSE.



Ostroumov

Peter Ostroumov, professor, is appointed in FRIB—where he is associate director of the Accelerator Systems Division—and holds a joint appointment in PA. Ostroumov received a doctor of science degree from the Moscow Engineering Physical Institute. Prior to joining MSU, he was a senior physicist and chief of the accelerator development group at the Argonne National Laboratory.

Maghrebi

Mohammad Maghrebi, assistant professor, will join the department in January 2017. Maghrebi, who earned his Ph.D. in physics at MIT, is interested in quantum many-body systems, specifically their dynamics far from equilibrium. Before coming to MSU, Maghrebi was a postdoctoral researcher at the Joint Quantum Institute, affiliated with the Department of Physics at the University of Maryland.

Shindler

Andrea Shindler, associate professor, is appointed in FRIB, with a joint appointment in PA. Shindler's research area is theoretical nuclear physics. He received his Ph.D. in physics from the University of Rome Tor Vergata, Italy. Prior to joining MSU, Shindler was a theorist at the Forschungszentrum Jülich Institute for Nuclear Physics.

von Manteuffel

Andreas von Manteuffel, assistant professor, focuses his research on precision predictions for collider observables. He received his Ph.D. in physics from Heidelberg University in Germany. Prior to joining MSU, von Manteuffel was a postdoc at the Institute for Physics at the University of Mainz, Germany.

Retirement

Repko

Wayne Repko, Professor Emeritus, retired in May 2016. His research focused on theoretical high energy physics. Repko received his Ph.D. in physics from Wayne State University, Detroit, Mich. He served as a research associate at Wayne State University and Johns Hopkins University, Baltimore, Md., before coming to MSU as an assistant professor in 1970. He became a full professor in 1979. Repko is a fellow of the American Physical Society.

Faculty Honors

Sean Couch and **Christopher Wrede,** both assistant professors and astrophysicists, have been selected by the U.S. Department of Energy Office of Science to receive research funding as part of the DOE's Early CAREER Research Program. Couch and Wrede will each receive at least $150,000 per year for five years.

Megan Donahue, professor, and Brian O'Shea, associate professor, were named fellows of the American Physical Society. Donahue was nominated for advanced cosmological observations and analyses of galaxy clusters. O'Shea was nominated for outstanding contributions to the study of cosmological structure formation using large-scale supercomputing, and leadership in the development of computational science research and education.

Joey Huston, professor, was named an MSU Foundation Professor in recognition of his exceptional contributions to research and instruction. His investiture will take place in spring 2017. Huston is an expert in experimental high energy physics and physics phenomenology. He received his Ph.D. in experimental high energy physics from the University of Rochester. Huston came to MSU in 1985 as a visiting assistant professor and formally joined the faculty in 1986. Huston is a fellow of the American Physical Society.

Kendall Mahn, assistant professor, was selected to receive a 2016 Alfred P. Sloan Research Fellowship. The two-year, $55,000 fellowships are awarded yearly by the Sloan Foundation to early career scientists in recognition of distinguished performance and potential to make substantial contributions to their fields of research. She joined the department's faculty in 2014 as a high-energy particle experimentalist.

Reinhard Schwienhorst, associate professor, is co-convener of the top quark working group on the ATLAS experiment at the Large Hadron Collider (LHC). He is responsible for all analyses involving the top quark, the heaviest of all elementary particles. The LHC is the most powerful particle accelerator built to date, providing large datasets to study the top quark in detail. It collides two beams of protons at an energy of 13 TeV. The LHC is based at the European particle physics laboratory, CERN, near Geneva, Switzerland.

Mark Voit, professor and associate dean for undergraduate studies in the College of Natural Science, received a 2016 William J. Beal Outstanding Faculty Award. His research involves understanding the formation and evolution of the large-scale building blocks of the universe. Voit is also co-author of the leading introductory textbook in astronomy and astrophysics.

Graduate Student Honors

Physics and astronomy graduate students who recently received awards include:

Andrew Cudd and **Jacob Morrison,** students of Assistant Professor Kendall Mahn, received National Science Foundation East Asia and Pacific Summer Institutes for U.S. Graduate Students (EAPSI) awards and spent last summer in Japan.

Bob Doering, a student of Professor Emeritus Aaron Galonsky, was awarded the George E. Pake Prize last March. The award is named after physics and astronomy Professor Emeritus Pake, who is a nuclear physicist.

Jie Guan, a research assistant interested in nanotechnology and nano-materials, received the 2015 Chinese government award for Outstanding Self-Financed Students Abroad.

Stephanie Hamilton, a doctoral student of Professor Joey Huston, discovered a new dwarf planet.

Amy Lowell, a student of Associate Professor Filomena Nunes, received a fellowship from the National Nuclear Security Administration Graduate Fellowship Program, a full-time, salaried position sponsored by the U.S. Department of Energy (DOE).

Zachary Matheson, a student working with University Distinguished Professor Witek Nazarewicz on a microscopic description of nuclear fission, received a U.S. DOE Office of Science Graduate Student Research award.

C. Konrad Gelbke Graduate Research Award

Gelbke

In appreciation of Konrad Gelbke and his career of research, leadership and service to Michigan State University, former students and colleagues established the **C. Konrad Gelbke Graduate Research Award.** The fund will be used to establish an advanced graduate seminar within the Department of Physics and Astronomy and the National Superconducting Cyclotron Laboratory. Gelbke is honored that his former students and colleagues have recognized him with this award fund. In appreciation, he has agreed to match any funds* generated by this mailing. Donations can be made either by using the envelope included in this newsletter (note "Gelbke Award" on the check's "Memo" line) or online at http://natsci.msu.edu/gelbke-2016/.

**up to a predetermined amount.*

PERL: Where physics and learning meet

The Physics Education Research Lab (PERL) at Michigan State University was started in 2013 by physics education researcher Danny Caballero as an interdisciplinary collaboration to study how students learn physics, particularly related to how tools affect student learning in physics and the conditions and environments that support or inhibit this learning.

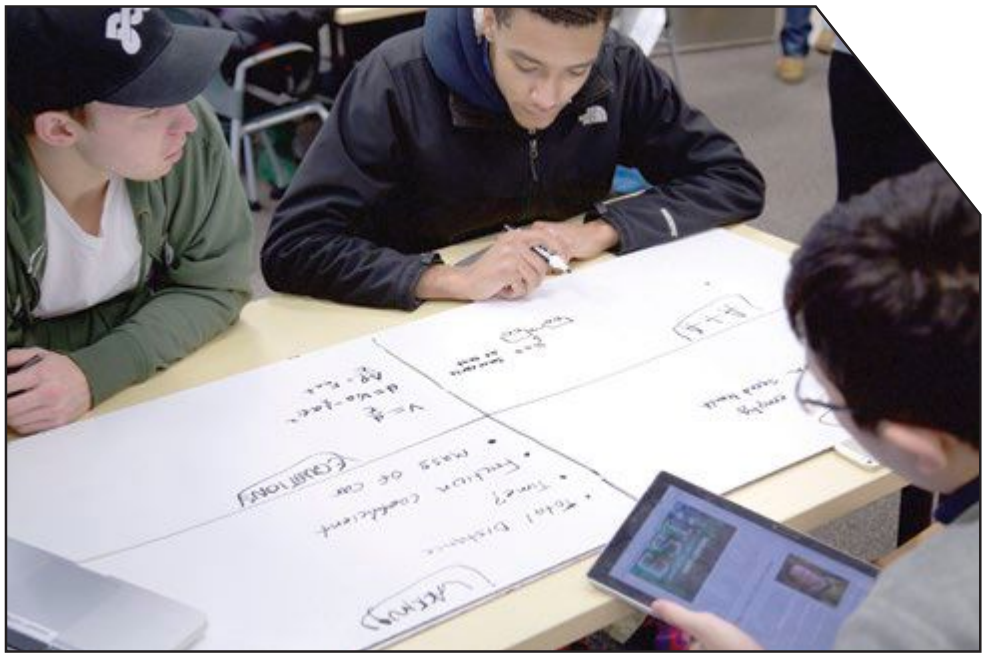
In 2014, Vashti Sawtelle, a physics education researcher who studies how learning environments support or inhibit students from diverse backgrounds in their learning of physics, joined Caballero as a co-director of PERL. Today, the program has blossomed into a set of vibrant projects for students, and the research team is gaining valuable information on how students learn about, and engage with, physics.

To keep pace with its growth, PERL recently added two faculty members—Kathleen (Katie) Hinko, assistant professor of physics, Lyman Briggs College; and Paul Irving, assistant professor of physics. Both are involved in redeveloping introductory physics courses to be more focused on the authentic practices of physics.

The lab also has five research associates, seven graduate researchers and six undergraduate researchers.

PERL researchers are currently working on several projects:

- **Transforming experiences for science and engineering students—Integrating scientific practices into introductory calculus-based mechanics:** The Projects and Practices in Physics (P3) course is a community-based learning environment for introductory mechanics that investigates how students learn to engage with scientific practices while learning physics content.
- **Exploring cross-disciplinary connections—Physics for life scientists:** In this area, the PERL team is exploring the intersection of physics and the life sciences to understand how to build successful learning strategies from physics education to create successful interdisciplinary learning environments.



The PERL research team studies and assesses how students learn in physics and engage in physics practice, the social and contextual factors that promote student learning and engagement, and educational technology use and practice.

The program has blossomed into a set of vibrant projects for students, and the research team is gaining valuable information on how students learn about, and engage with, physics.

- **Understanding the development of disciplinary identities:** Retention and persistence is a critical issue facing the science community. Studies have shown a student's sense of self is a key factor influencing retention. PERL is exploring the ways that students develop these perceptions of belonging to the science community.
- **Students' use of mathematics in upper-division physics:** This project focuses on students' written responses to open-ended assessment items to identify individual student approaches, and the difficulties they experience with specific models and tools.
- **Characterizing and developing the next generation of physics assessments:** As part of ongoing transformations, a cross-disciplinary team of discipline-based education researchers has developed a new instrument to characterize assessments in physics, chemistry and biology. The Three-Dimensional Learning Assessment Protocol (3D-LAP) is a set of criteria that can be used to determine if an individual assessment item (or cluster of items) aligns with a scientific practice, crosscutting concept, or disciplinary core idea. PERL members have collected exams and homework sets from each introductory physics course, and are now characterizing those assessments using the 3D-LAP.

Other initiatives include creating a coherent gateway for STEM teaching and learning at MSU and transforming introductory physics laboratories to discovery-based experiences.

For more information on PERL, visit http://perl.pa.msu.edu

MSU researchers ask: What does the Higgs boson tell us?

Almost five years ago, the physics world celebrated the discovery of the Higgs boson. This has naturally led to new questions. How does it interact with other particles? Has it unlocked a door to new physics? A team of MSU physicists has set out to find the answers.

Wade Fisher, an associate professor who played a role in the 2012 discovery of the Higgs boson at the Large Hadron Collider (LHC) just outside of Geneva, Switzerland, is part of that team with the ATLAS collaboration. Fisher and three of his colleagues in MSU's Department of Physics and Astronomy are now studying the Higgs boson and its potential links to new physics. Upgrades to the LHC and the particle detectors will help accomplish this.

"It required technological advances, but we have doubled the particle collision energy, which takes us to a new energy frontier," Fisher said.

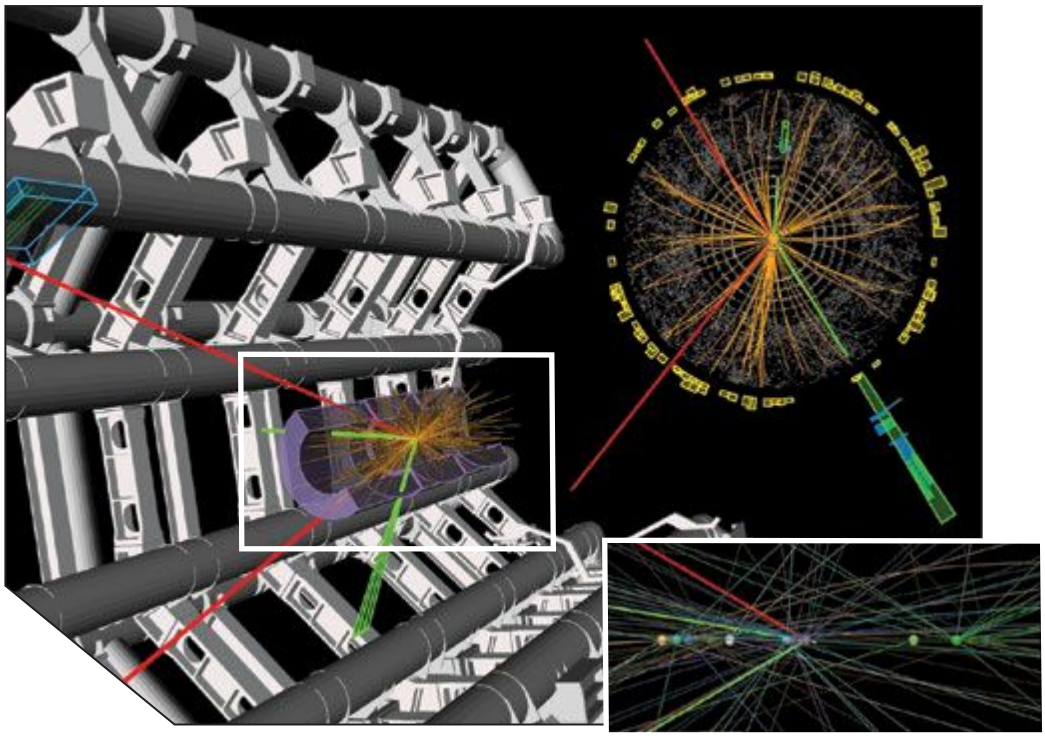
However, he pointed out, they are limited by the number of protons they can crash together and actually get the data out. He compared it to the amount of light coming from a light bulb; it can be turned up only to the limit of that light bulb.

"So what we try to do is make the machine brighter in terms of protons—which is known as luminosity. The more protons we collide, the more data we can collect."

As a result, the researchers are now able to gather a year's worth of data in just a month.

"This changes the game because when looking for something rare, we need a huge amount of data. We sift through trillions of interactions using pattern-recognition algorithms and statistical analysis," Fisher said.

Upgrades are also being done on the ATLAS detector, which Fisher said is about the size of MSU's Biochemistry Building. The particles interact at the center of the detector and move outward, which Fisher likened to the layers of an onion.



Pictured above is a candidate Higgs boson event recorded by the ATLAS detector exhibiting four reconstructed leptons originating from the decay of the Higgs boson. Lepton tracks are colored red (muons) or green (electrons). The two insets show zoomed views into the tracking detector.

> *"Why are we doing what we're doing? It's the drive to understand the origin of the universe."*

"As the particles enter the detector we make measurements that tell us where the particles are going and what their energy is. We then apply energy and momentum conservation, allowing us to infer what happened in that particular event."

The most recent upgrades were installed in 2015, with the next round scheduled for 2018. The team is also researching algorithms and hardware to be included in a future upgrade—in 2024.

The MSU constituency includes four physics faculty, seven graduate students and six postdoctoral researchers, as well as six engineers. The MSU group works with universities from around the globe, and that ATLAS collaboration comprises about 5,000 researchers.

"Why are we doing what we're doing? It's the drive to understand the origin of the universe," Fisher said. "Studying the laws of physics, at the most fundamental levels and at the highest energies, gives us a way of more accurately turning back the clock so we can inch our way closer to the conditions of the Big Bang. This could not only reveal something about our nature and our existence, but it gives us insight into how we might harness the laws of the universe for ourselves

Wu-Ki Tung Endowed Professorship in Particle Physics: Honoring a true pioneer

Internationally known particle physicist Wu-Ki Tung (1939-2009) was born in Yunan, China, educated at Yale, served on the faculty of the University of Chicago, and as department chair at the Illinois Institute of Technology. But Michigan State University was his spiritual and academic home from 1992 until his retirement in 2007.

Wu-Ki Tung

Shortly before he came to MSU, Tung created the Coordinated Theoretical Experimental Project on Quantum Chromodynamics (CTEQ). This project blended particle physicists from two cultures—experimentalists and theoreticians—to common scientific goals. CTEQ is still one of only a handful of such groups in the world.

"This middle ground of active teamwork between theory and experiment was not mainstream, but Wu-Ki saw the need and made it the centerpiece of the second half of his career," said Raymond Brock, MSU University Distinguished Professor, one of the original two dozen CTEQ members.

"When Wu-Ki came here, MSU became the center of this world," Brock continued. "He saw that measurements of fundamental parameters in particle physics were going to be limited by uncertainties inherent in the theoretical models used to interpret these results. To avoid this problem, he created a scheme to properly combine the thousands of experimental inputs to these models into a template which experiments could in turn apply to new results. Furthermore, he made this scheme flexible so it could evolve—as the inputs to the models improved, new CTEQ templates would be fit and made available. This was, and continues to be, a huge computational effort that requires unusual skill, painstaking care, and unlimited energy—Wu-Ki's approach to everything he did! We all tried to live up to his standards."

Now every particle physicist in the world knows of and appreciates CTEQ, probably his most treasured legacy.

To honor Tung's legacy and continue his work, his wife, Beatrice; sons Lei and Bruce; daughter-in-law-Cecilia; and grandchildren Max and Allie established the Wu-Ki Tung Endowed Professorship in Particle Physics with a $1 million gift to the university. The professorship will support future faculty members who share his passion for particle physics research combined with scientific collaboration and collegiality.

"My father believed that science and academics were generational," Lei Tung said. "To him, the cycle of learning, applying and teaching was noble and enduring. He was honored to contribute to collective knowledge and progress through sharing and open discourse. He believed in, and loved, the process.

> *"He would love that his legacy will inspire future faculty to the kind of science that he loved most: learning about nature collaboratively."*

"We had talked about this endowment even before he retired in 2007," Lei Tung continued. "He wanted it established at MSU, where he found such strong support for his principles and aspirations. We are delighted to help extend that support to future generations of physicists, and ensure continuity of his work."

"The department is so grateful to Wu-Ki's family," Brock added. "Wu-Ki loved academia, the freedom of university science, and the high standards that colleagues create for themselves. He would love that his legacy will inspire future faculty to the kind of science that he loved most: learning about nature collaboratively."

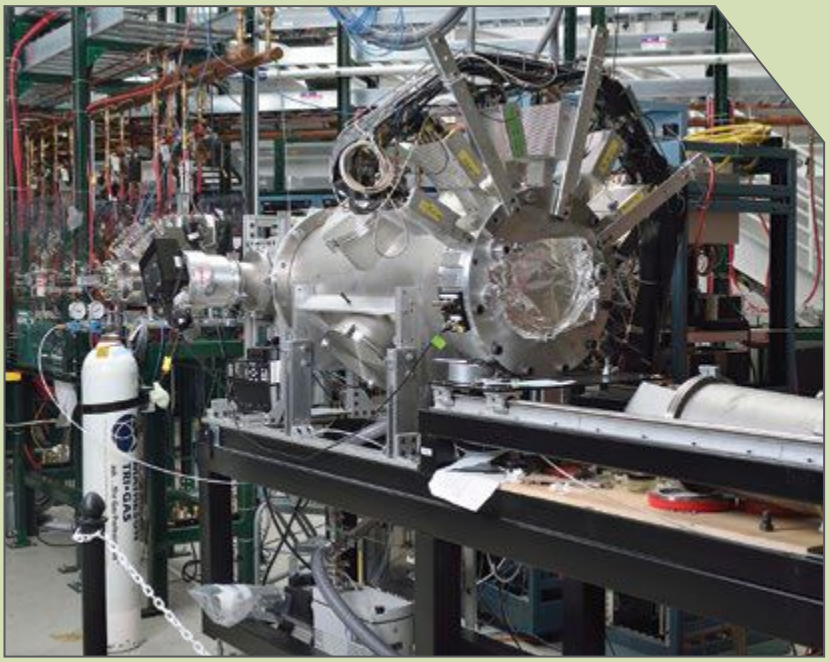
MSU receives $122.5 million for cyclotron laboratory

A cooperative agreement between Michigan State University and the National Science Foundation will result in up to $122.5 million in continued funding over five years for the National Superconducting Cyclotron Laboratory.

The agreement will fund forefront research in nuclear and accelerator science and continue operation of NSCL as one of the world's flagship nuclear science research facilities. The agreement will also provide funding to operate a newly built, smaller linear accelerator that will allow researchers to "re-accelerate" rare isotopes.

"This cooperative agreement allows us to continue enabling cutting-edge scientific research into the nature and origin of atomic nuclei," said Brad Sherrill, University Distinguished Professor of physics and NSCL director. "We are excited about what this means for our users."

"It is incredibly important to both the nation's leadership in nuclear science and to our scientific user community that rare isotope research continue in a strong way at NSCL" added Thomas Glasmacher, University Distinguished Professor of physics and FRIB laboratory director.



The National Superconducting Cyclotron Laboratory is one of the world's flagship nuclear science research facilities. Funded by the NSF, its mission is to provide beams of rare isotopes for researchers from around the world.

The Physics Division of the National Science Foundation has supported NSCL operation at MSU since the mid-1980s. The new funding will cover the period until the under-construction Facility for Rare Isotope Beams becomes operational, which is expected to be in 2021.

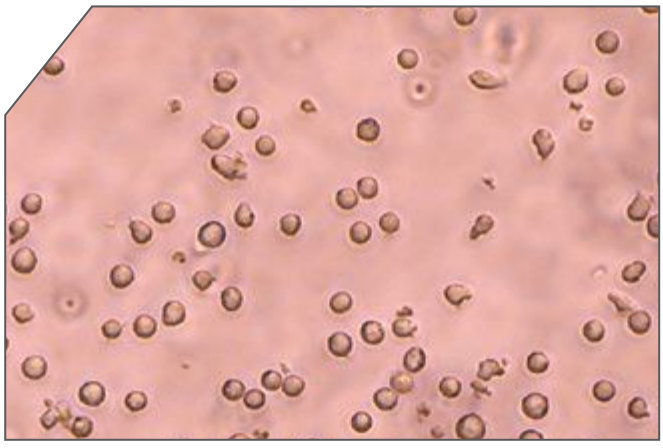
Developing a model to enhance understanding of cell differentiation

A research team headed by Carlo Piermarocchi, professor of physics and astronomy, received a five-year, $1.7 million NIH National Institute of General Medical Sciences grant for a research project that seeks to better understand cell differentiation in blood.

The goals of the project are to: develop a signaling model based on statistical physics able to reproduce blood lineage differentiation using spin associative memories to represent single-cell states; develop a mathematical model for an ensemble of different hematological cells, under co-culture conditions; and verify the predictions of the mathematical modeling to assess cellular differentiation via flow cytometry and performing RNA-seq on pools of cells and on single cells.

The experimental validation of the models will be carried out at the Sanford Burnham Prebys Medical Discovery Institute in La Jolla, Calif.

The proposed methodology will enhance general understanding of biological processes and diseases where cell differentiation plays a key role. In particular, this project could provide new biomedical insight in stem cell biology, immunology, hematology and human development.



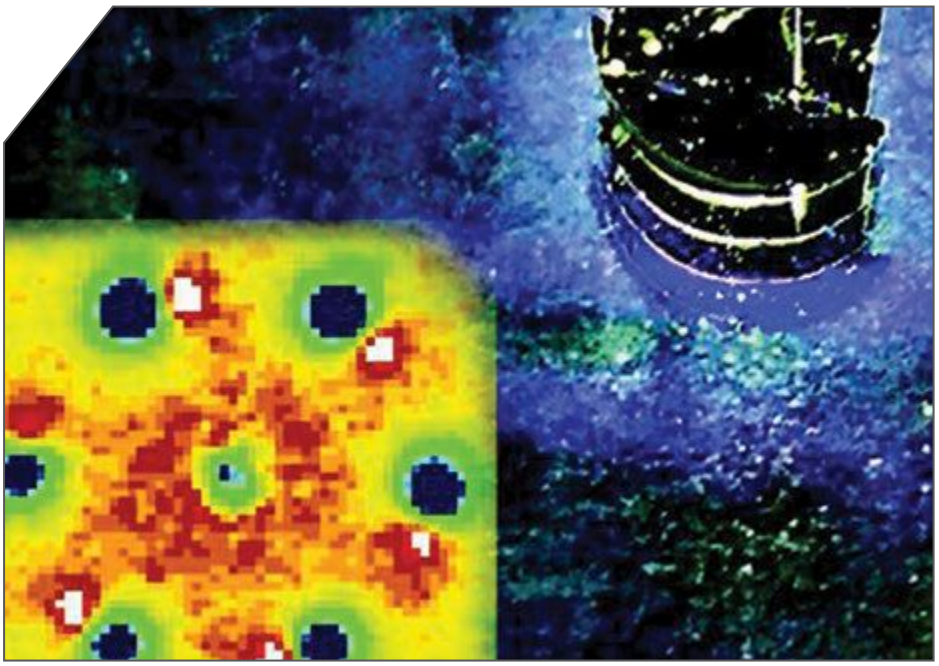
The myeloid progenitor blood cells pictured above are one of the lineages being studied by Piermarocchi and his team.

Developing ultrafast electron microscopes

A research team headed by Chong-Yu Ruan, professor of physics and astronomy, received a $972,000 National Science Foundation major research instrumentation (MRI) award for the continued development of an ultrafast electron microscope for probing the dynamics of the electronic and atomic structure of materials. The project could lead to the development of new and improved semiconductors.

In 2011, Ruan and other researchers were awarded a National Science Foundation grant to begin building the device. Ruan and his team subsequently developed a method to change the electronic properties of materials in a way that will more easily allow an electrical current to pass through.

This new project could lead to the development of new and improved semiconductors—substances that conduct electricity under some conditions but not others, making it a good medium for the control of electrical current. They are used in any number of electronics, including computers.



MSU researchers have found that by shooting an ultrafast laser pulse into a material, it can change its properties, a process that can lead to the development of new and improved semiconductors.

The project could lead to new understanding of materials dynamics at the most fundamental scales, and to the development of new materials based on this understanding.

Integrating computation into undergraduate physics

The Partnership for Integration of Computation into Undergraduate Physics, or PICUP, is working toward transforming physics curricula across the country.

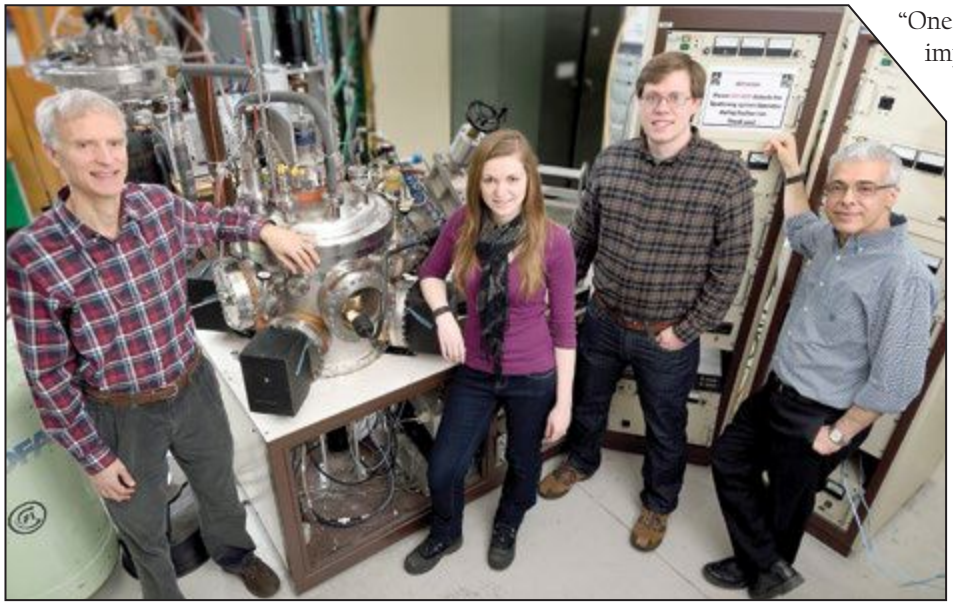
A research team headed by Danny Caballero, assistant professor of physics and astronomy, received a four-year, $503,977 National Science Foundation collaborative research grant to support the development and study of a community of instructors across the United States who will incorporate computational physics into their existing courses.

The group, known as Partnership for Integration of Computation into Undergraduate Physics (PICUP), will undertake a project that includes the creation of a professional development program to bolster computational physics instruction in U.S. colleges and universities, as well as studying the factors that support or inhibit how faculty take up computational physics instruction. Broader impacts include the opportunity for more students to engage with the modern practices of computational physics, developing a core community of computational physics instructors and developing a knowledge base around enacting essential changes to physics curricula across the country.

This grant builds on two previous NSF collaborative grant awards, one related to fostering a "grass roots" approach to integrating computational practices into physics courses, and a second that involved creating a survey to assess the state of computational instruction courses for physics majors across the United States.

Collaborative research leads to new technologies

As you're updating your cover photo on Facebook, or plotting out your next trip using Google Maps or purchasing something on Amazon, probably the last thing on your mind is how much computer memory and energy you're using as you're accessing these massive computing installations. But it's uppermost on the minds of scientists and researchers who work in the energy field.



(L to R): Physics and astronomy professor Norman Birge, graduate students Bethany Niedzielski and Joseph Glick, and Scientific Instrument Facilities Coordinator Reza Loloee, Ph.D., stand next to the high-vacuum sputtering system used in the project.

In a research project funded through the Intelligence Advanced Research Projects Activity (IARPA) organization, several Michigan State University researchers, as well as scientists from Northrop Grumman Systems Corporation, developed a superconducting magnetic memory element that has greatly reduced heat generation and power consumption compared to conventional alternatives.

"Supercomputers consume enormous amounts of power in exchange for their computational abilities," said Norman Birge, professor of physics and astronomy.

According to the Natural Resources Defense Council, data centers are one of the largest and fastest growing consumers of electricity in the United States. In 2013, U.S. data centers consumed an estimated 91 billion kilowatt-hours of electricity and are on track to reach 140 billion kilowatt-hours by 2020.

When IARPA projected what larger-scale computers might look like in the future, it seemed they would become almost energy prohibitive. It became evident that new computer technology would need to display much more energy efficiency than current technologies in order to reduce world electricity use.

> *"For most of my career, I've been working on things that are . . . a little bit esoteric. Now, I'm working on a project that could have an impact on a much broader scale in society."*

"This novel scalable memory element can be controllably switched into two distinct phase states to act as the 1's and 0's of computer language," said Bethany Niedzielski, a physics Ph.D. student who aided in fabrication and completed all measurements of the devices. "Memory like this is an essential piece in work toward developing a fully superconducting computer."

This study is the first demonstration that using these types of devices for computer memory is actually feasible.

"One of the major impediments to superconducting computing technology had been the lack of an efficient memory that took advantage of the superconducting state," said Eric C. Gingrich, a physicist at Northrop Grumman who was the lead student on this project while he was at MSU. "This project has demonstrated experimentally a solution to that problem, and brings the technology one step closer to being realized."

IARPA hopes the superconducting circuits developed based on this new magnetic memory element will use 10,000 times less power than conventional semiconductor circuits, so that after the cooling is taken into account, the final efficiency will be 100 times less power for the superconducting supercomputer.

The research team now has enough data for Northrup to begin fabrication of the device, which would then be incorporated into the whole cell. The goal is to have a working device by early 2017. Birge said the next step in his lab is to hone the materials research.

"For most of my career, I've been working on things that are very interesting to the fundamental physicist, but they're a little bit esoteric," Birge said. "Now, I'm working on a project that could have an impact on a much broader scale in society."

Additional MSU researchers contributing to this project are Joseph A. Glick, Reza Loloee, William P. Pratt, Jr. and Yixing Wang.

A quantum leap

Two physics faculty members are taking a quantum leap.

Mark Dykman, professor, and Johannes Pollanen, assistant professor and the Jerry Cowen Chair of Experimental Physics, have teamed up to investigate the quantum behavior of an electron system that could lead to the development of a large, scalable quantum computer.

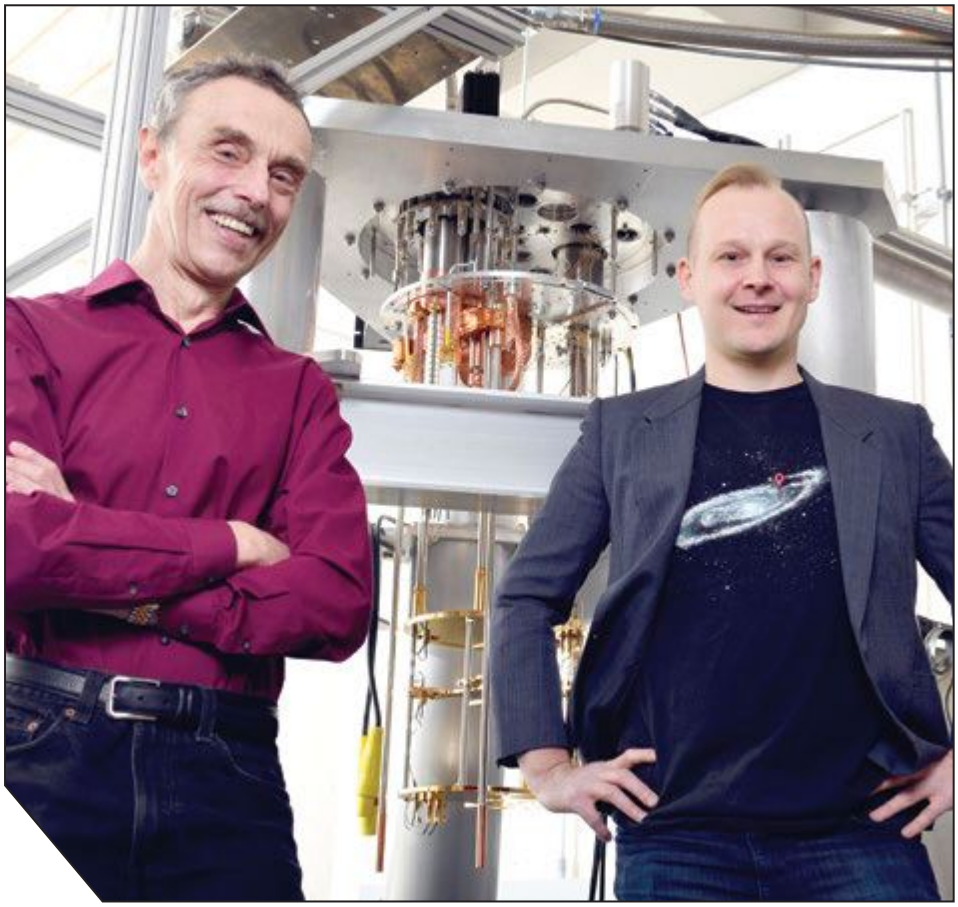
This system, they explained, is electrons hovering in free space a few nanometers above the surface of liquid helium. It constitutes one of the most ideal systems that scientists are able to create in the lab. Being free from defects, it provides a platform for studying many-body phenomena unimpeded by the disorder inherent to other condensed-matter systems, including the effects of strong electron correlations and the quantum many-body dynamics away from thermal equilibrium.

"Johannes is an experimentalist and I am a theorist," said Dykman, who has been at MSU since 1995. "We are looking at the phenomena that are of common interest to us; the dynamics of electrons on liquid helium provide a multitude of such phenomena."

"A synergy between experiment and theory, like the one Mark and I have here at MSU, really moves physics forward," said Pollanen, who joined the MSU faculty in January 2016. "Our collaboration stimulates the development of both the experiment and the theory. It puts the experimental observations on strong theoretical footing and also pushes the theory into a new and unexplored terrain."

"Our collaboration stimulates the development of both the experiment and the theory."

Understanding the behavior of strongly interacting particles is a major problem in physics as a whole, Dykman explained.



Mark Dykman, a physics theorist (left), and Johannes Pollanen, an experimental physicist, are combining their expertise to investigate the quantum behavior of an electron system that could ultimately lead to the development of a large, scalable quantum computer.

It brings with it a potential for new concepts and technologies.

"Physicists are searching for systems that have no defects, those that are as close to ideal as possible. Electrons on helium are such a system," Dykman said.

"Making the connections between what we see in the lab when we do experiments and what the theory predicts should happen can be difficult in the presence of disorder and defects," Pollanen said. "But this system is fantastic, as it allows us to address a multitude of the problems of condensed matter physics that could not be addressed in a clean way otherwise. Familiar examples include commensurate-incommensurate transitions, many-electron polaronic effects and the dynamics of Wigner crystals to mention but a few."

In terms of applications, electrons on helium provide a route to quantum computing.

"There are other researchers who are trying to make a quantum computer, but we have a different take," Dykman said. "I think we can compete with them."

According to Pollanen, they are focusing on these electrons because of their potential for scalability and also because the absence of disorder means that the quantum behavior of the electrons is long-lived, which is vital for performing computations.

"These are the long-term kinds of things that we think about," he said.

"This is a highly demanding area," Dykman said. "But we have a very clear direction for our research. We hope it will finally be possible to answer some questions that have been around for decades.".

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36th International Symposium on Lattice Field Theory set for MSU

The 2018 International Symposium on Lattice Field Theory will take place July 22–28, 2018, at the Kellogg Hotel and Conference Center on the Michigan State University campus.

This annual conference showcases the latest developments and results in lattice gauge theory, including particle physics, nuclear physics and computation physics. Conference attendees from around the world include theoretical particle physics researchers, experts in the study of strongly interacting systems, such as quantum chromodynamics, the theory describing the strong interactions of quarks and gluons.

New ideas and collaborations are often inspired by the presentations and discussions at this annual gathering.

The MSU Department of Physics and Astronomy is one of the sponsors of the event, and faculty members Huey-Wen Lin, Alexei Bazavov and Andrea Shindler are chair and co-chairs of the local organizing team. This conference series rotates between the U.S., Europe and Asia/Pacific every year. It has been more than a decade since the last conference was held in the Midwest when the 2003 conference was held at the Fermi National Accelerator Laboratory near Chicago.

"For MSU, being selected to host this conference is special," explained Lin, an assistant professor in the department. "Prior to 2016, there were no local faculty in this subfield of physics. By winning the bid to host Lattice 2018, the international community has given a strong vote of confidence to the newly hired lattice group at MSU."

The planning committee hopes to attract at least 400 participants and, in addition to the program, introduce participants to MSU's active development and investment in high-performance computing as well as the Facility for Rare Isotope Beams.

For more information about the conference, visit http://www.pa.msu.edu/conf/Lattice2018/.