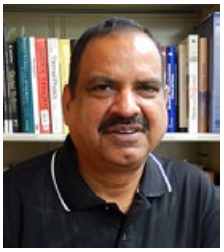
Physics and Astronomy
Communiqué
Autumn 2014

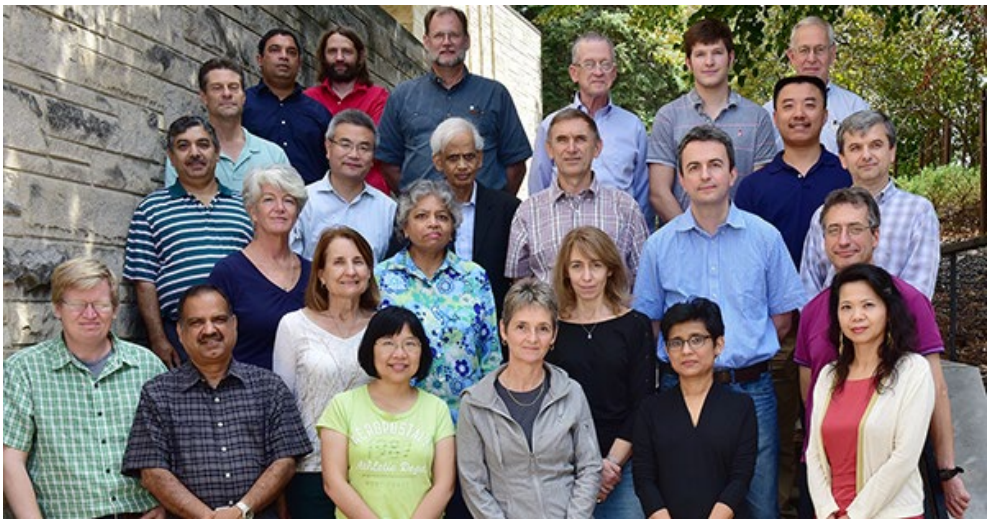
From the New Chair

By Sashi Satpathy, Department Chair



I start my role as the new chair of the department with deep gratitude to my predecessors, Professors Peter Pfeifer and H. R. Chandrasekhar and Professors Emeritus Henry White and David Cowan. Due to their leadership, our department has made tremendous progress during the 25 years that I have been here. I will do my best to accelerate this progress, to nurture an intellectual atmosphere in the department, and to encourage an environment in which all of us can function to the best of our abilities.

The department has achieved considerable success this past year. The newsletter details some of this impressive progress, but I will mention a few of the highlights. Associate Professor Gavin King received the Innovation Award from the Microscopy Society of America for developing the first 3-D microscope. Professor Meera Chandrasekhar won the prestigious Robert Foster Cherry Award for Great Teaching awarded by Baylor University. Funded by Science Without Borders, Professor Suchi Guha will collaborate with scientists in Brazil to establish collaboration in the area of nanoscience. Professor Paul Miceli visited the University of the Western Cape in South Africa to teach a course and to develop a collaboration that uses x-ray scattering to study Si solar cells. The department hosted a workshop organized by Professor Angela Speck, with participation from all over the world, in preparation for the forthcoming solar eclipse in August 2017.



Physics and astronomy faculty, September 2014. For an identification key, please see Page 3.

This year, a major renovation of the teaching labs for the undergraduate introductory physics courses allowed a substantial increase in the number of students we can teach. Additionally, we developed a Research Experiences for Undergraduates program in the area of materials and modeling this summer, funded by the NSF and run primarily by Assistant Teaching Professor Karen King. This not only helps us carry out the critical mission of undergraduate student training but it will also, hopefully, help us to recruit graduate students for our department.

This year, two of our faculty members were promoted: Gavin King to associate professorship and Ping Yu to professorship. Our congratulations to them, and we wish them continued success in the future.

Last but not least, we are grateful to our Leaders, a select group of our alumni, for their continued support of the department both at the intellectual and financial levels. During the past several years, many of our endowment funds have grown considerably, and the Leaders have created new funds, as well. Recently, with the Leaders' financial support, we established two student scholarship funds, the Gerry Fishman Graduate Student Travel Fund and the Carl Anderson Graduate Student Award Fund. We deeply appreciate supports like these, since they go a long way in making our department better in the face of declining state support for higher education. Finally, I encour-

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Innovation Award for King Lab

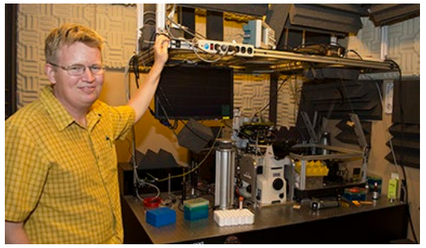
By Kristi Galloway, College of Arts and Science

Gavin King, associate professor of physics, and Krishna Sigdel, a postdoctoral associate in King's lab, received the Innovation Award from the Microscopy Society of America for developing the first three-dimensional microscope that allows scientists to study membrane proteins to see how they interact on the cellular level. *Nano Letters,* the journal of the American Chemical Society, published King and Sigdel's research on the project, "Three-dimensional Atomic Force Microscopy: Interaction Force Vector by Direct Observation of Tip Trajectory."

Until recently, the microscopic study of these complex proteins had been restricted because of force microscope limitations. Normally, force microscopes measure the compression of a needle against the specimen by bouncing a single laser off the cantilever, or arm, that holds the microscopic needle in place. As the cantilever moves, it deflects light. The deflections are measured and the data is processed to give researchers an idea of how the membrane proteins are interacting with the cell. Usually, to determine membrane protein structure in detail, specimens must be frozen, which means the specimen cannot be studied in the primarily liquid environment found in the body.

King first encountered force microscopes as a graduate student while working in a low-temperature physics lab. "I began to wonder," King says, "could the precision and power of low-temperature force microscopes be extended into biological conditions?" Determined to find out, King built a new force microscope that is able to study membrane proteins at room temperature. He used the traditional force microscope as a guide but then added an additional laser that measures the second and third dimensions of tip movement. The microscope has one laser that measures the deflection of the cantilever, one that measures exactly where the tip is located, and one that measures the back-scattered light to show precisely where the sample is placed. These lasers give three-dimensional data about the membrane protein and dynamic changes in its structure using a real-time data stream.

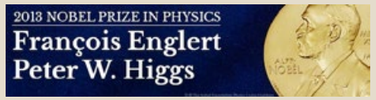
The possibilities are bright with this new microscope. King says, "One of my long-term goals is to use the force microscope to directly measure the effects of drug binding on the single molecule level." Because the microscope will allow scientists to see how the shape of proteins change when they interact with different drugs, they will be able to determine how drugs bind and interact with cells, which may lead to significant pharmaceutical breakthroughs.



Gavin King stands next to the three-dimensional atomic force microscope in his lab.

There is still much work to be done, but the instrument is promising, thanks to its precision. "I think the future of single-molecule techniques is in precision measurements," says King. "Initial experiments can be revisited with a much higher degree of precision, and new conclusions can be drawn in a firmer light with the help of this tool."

MU Hosted the APS Prairie Section Fall 2013 Meeting



The Department of Physics and Astronomy hosted the annual meeting of the American Physical Society Prairie Section on Nov. 7–9, 2013. The conference chairs, Professors Carlos Wexler, Silvia Bompadre, and Paul Miceli, hosted approximately 200 participants from Illinois, Indiana, Iowa, Minnesota, Missouri, Wisconsin, Kansas, Nebraska, and North and South Dakota.

The program started with a public lecture "Higgs Boson and Beyond: the Big Questions in Particle Physics," by Professor Mark Neubauer from the University of Illinois at Urbana–Champaign at Monsanto Auditorium, which was attended by approximately 150 people. Neubauer participated in the ATLAS project, which was one of the two that worked at CERN's Large Hadron Collider to locate the Higgs.

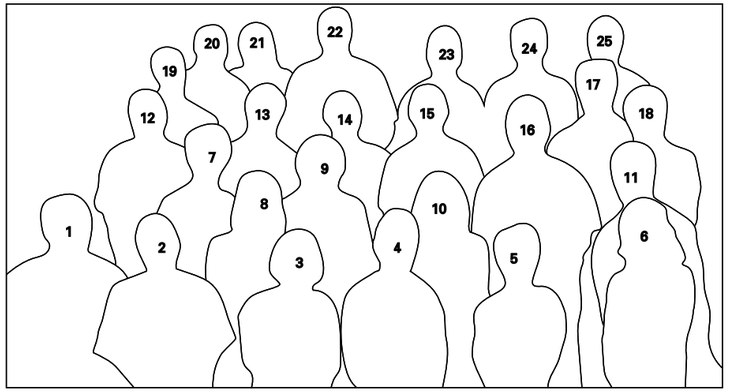
In addition, 12 invited lectures, 50 contributed lectures, and over 40 posters were presented encompassing all areas of physics, including condensed matter, biological, nuclear, astrophysics, cosmology, space science, physics education and outreach, industrial, nuclear, atomic, molecular, optical, and multidisciplinary physics. On Nov. 8, over 50 students were invited for a boxed lunch and a tour of the research laboratories at the Physics Building and at the MU Research Reactor.

The conference was funded in part by the Office of Research, the College of Arts and Science, and the Department of Physics and Astronomy. Generous contributions from the Physics Leaders funded the registration of all MU students.

Conference chair: Professor Carlos Wexler

Conference co-chairs: Professors Silvia Bompadre and Paul Miceli

Scientific advisory and local organizing committee: Professor Silvia Bompadre, Professor Linda Godwin, Professor Michael Roth (University of Northern Iowa), Professor Sashi Satpathy, and graduate student Matthew Connolly.



Faculty identification key for picture from front page: 1. Gavin King, 2. Sashi Satpathy, 3. Xiaoqin Zou, 4. Dorina Kosztin, 5. Suchi Guha, 6. Yun Zhang, 7. Sarah Hill, 8. Linda Godwin, 9. Meera Chandrasekhar, 10. Sylvia Bompadre, 11. Giovanni Vignale, 12. Jagat Lamsal, 13. Ping Yu, 14. H.R. Chandrasekhar, 15. Sergei Kopeikin, 16. Carsten Ulrich, 17. Haojing Yan, 18. Ioan Kosztin, 19. Paul Miceli, 20. Deepak Singh, 21. Wouter Montfrooij, 22. Rod Schlotzhauer, 23. Peter Pfeifer, 24. Daniel Lynch, and 25. Haskell Taub.

From the New Chair

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age our alumni to keep us informed about milestones in their career and personal lives. In the future, we would like to devote a part of the newsletter to news about them. Alumni are asked to send an e-mail with updates to the department office at umcasphysics@missouri.edu.

We have many challenges ahead and tasks to accomplish. I look forward to an invigorated intellectual atmosphere in the department, where our students receive the best education possible and where the members of our faculty flourish as accomplished researchers and teachers.

Laboratory Makeovers

Enrollment in introductory physics courses has increased steadily over the past several years. To be able to offer every student in the introductory physics courses a seat in the lab, the laboratory rooms had to undergo a makeover. As shown at right, the labs could accommodate at most 20 students per lab section. After the renovations, shown above, the number increased to 30 students per lab section. Overall, the number of seats for the four introductory physics courses was increased by 760 seats. New stools for the labs were bought with funds provided by the Student Fee Capital Improvement Committee, and thanks, also, to the dean's office for providing some of the funds for the renovations.

IGERT Update

By Haskell Taub

In September 2011, MU's Department of Physics and Astronomy received a five-year, $3-million grant from the National Science Foundation for a project titled "Neturon Scattering for the Science and Engineering of the 21st Century." It is a prestigious award—there were only 18 grants made out of over 400 submissions—and it remains the only IGERT grant MU has ever received. Our project involves training doctoral students in interdisciplinary research using neutron scattering. A core feature of our project is the use of MU's unique Research Reactor facility (MURR) for research and training of graduate students in neutron-scattering techniques.

Our interdisciplinary project includes nine graduate students and their mentors in the MU departments of Physics and Astronomy, Biochemistry, Mechanical and Aerospace Engineering, and Biological Engineering. In addition, we have a partnership with three universities: Indiana University and North Carolina State University, which each have one trainee, and Fisk University, which has had two master's students in our project. Two national laboratories, Oak Ridge and the National Institute of Standards and Technology, are also partnering with us. Our trainees perform experiments at their facilities as well as at MURR.

The past year has been a busy one for our IGERT trainees. Their research topics range from the structure of hydrogen storage materials and lithium battery electrodes to fundamental studies of how water freezes on a bilayer lipid membrane and the dynamics of the ribosome. Three trainees have been engaged in experiments at MURR so that, for the first time in a while, we have had to schedule time carefully on the triple-axis spectrometer and the neutron powder diffractometer. Eight MU trainees have participated in neutron-scattering experiments at our partnering national labs. We have received praise from our IGERT program director for our wonderful achievements in research, the trainees' contributions to our research projects, and for preparing our trainees in professional skills. This year, two of our trainees received their doctorates. Matthew Connolly is a recipient of a prestigious postdoctoral National Research Council Fellowship at NIST/Boulder, and Andrew Miskowiec is now a postdoctoral fellow at Oak Ridge National Laboratory, one of the world's premier neutron-scattering facilities.

NSF IGERT–supported research was recently recognized by the journal *Europhysics Letters* with the selection of an article by Miskowiec *t* as one of its highlighted articles of 2014. David Robertson, MURR's director of research and education, has noted the impact of our NSF IGERT grant on building interdisciplinary research both on the MU campus and with researchers at the National Institute of Standards and Technology and Oak Ridge National Laboratory.

In fall 2014 we welcomed our second cohort of seven IGERT trainees.

IGERT students preparing for one of their bi-weekly sessions with the IGERT trainees off campus.

Nathan Rhodes, a physics and education major, in his role as learning assistant is helping high school students explain Cartesian divers.

PhysTEC Update

By Karen King

Tomorrow's Outstanding Physics (TOP) Teachers program, directed by Assistant Teaching Professor Karen King, is in its second year of PhysTEC funding from the American Physical Society. Given physics teacher shortages in Missouri and across the country, the program seeks to increase the number of highly qualified high school physics teachers. Recruiting efforts include a "Learning Assistant" program, which hires physics and engineering majors to assist in local high schools. The University of Missouri now expects to graduate approximately four new teachers with physics and education degrees per year in the next few years, compared to less than one per year before TOP Teachers began. This greater graduation rate will place MU's Department of Physics and Astronomy among the top 7 percent of all physics departments that offer secondary physics certification.

Director of Astronomy Thinks Big as Solar Eclipse Draws Near

By Bell Johnson

Angela Speck, professor of astrophysics at MU, has high hopes to outfit the whole country with over 300 million pairs of eclipse glasses. In a move to raise awareness about the total solar eclipse on Aug. 21, 2017, Speck began planning a workshop over a year ago. The two-day workshop was held this past August and drew astronomers and other scientists from all over the world to discuss how to best showcase a once-in-a-lifetime opportunity.

"If we don't start working on it soon, we're going to miss a lot of opportunities to take advantage of it," Speck says. "The idea was to bring together lots of people who have an interest in anything to do with the solar eclipse in 2017."

The eclipse, with a total duration of 90 minutes, will span from Oregon to South Carolina, occurring in Columbia, Mo., for only two minutes at 1:12 p.m. Yet, Columbia will have one of the longest time frames to observe the eclipse.

The workshop was modeled after a similar one held in Maryland two years ago. Speck hopes to generate a renewed interest in science by planning educational events leading up to the eclipse.

"My biggest hope is that it really has the impact it can have. That is people get so excited that we have a resurgence in interest in science," Speck says. "I think that's doable. It will just take effort."

The whole country will see at least 75 percent eclipse (20 million live in the path of totality) but Speck wants to make Columbia a hot spot for residents and tourists alike. By talking to Columbia City Council and the mayor, Speck has been brainstorming ideas to raise awareness from partnering with local artists to create an art exhibit to reaching out to national sponsors like Eclipse Gum.

"There are lots of things involved," Speck says. "I predict, if we do this right, this will be as big as the Apollo missions."

By filling Faurot Field and other designated watch areas around Columbia, Speck wants to feed in live streams to track the eclipse's movement across the country while sending out a feed of what is happening in Columbia at the same time.

Workshop flyer created by Tyler Nordgren.

"There are all these things we need to be thinking about, and we need to be doing it now," Speck says.

Much of Speck's desire to foster a national presence about the event begins with her goal of connecting both the sciences and the arts.

"There are all these things that cross over not just in the STEM fields but also in the humanities and the arts—we could do something awesome," Speck says.

She sees a connecting thread about solar eclipses through art, music, religion, literature, and engineering. She hopes other departments will host events centered on solar eclipses to raise awareness a year before the actual event.

"If we do this right, and if we get the publicity right, this will be amazing for astronomy. It will be amazing for science in general, and I think it will just get people excited, but it will also—I hope—achieve this idea that we shouldn't try to separate out all our disciplines so much," Speck says. "There's so much overlap that I would really like to get people realizing that just because you think of yourself as arty doesn't mean you can't get involved in this."

Recent Graduates

Fall 2013

Bachelor of Science: Cody Allard, Christopher Blessing, Tyler Cary, Maximillian Copeland, Curtis Ewen, and Sean Sweany
Master of Science: Nagaraju Chada and Tina Rezaie Matin
Doctorate: Danish Adil, Tianyu Liu, Matthew Mower, Mohammad Sherafati, and Yuan Wang

Spring 2014

Bachelor of Science: Michael Andrade, Nathan Frey, Robert Gear, Andrew Gillespie, Travis Hurst, Colby Johnson, Paul Schnase, Jedidiah White, and Lucie Williams
Master of Science: Grant Knotts, Bradley Mills
Doctorate: Andrew Miskowiec and Dhanashree Moghe

Summer 2014

Bachelor of Science: Thomas Kirkpatrick
Master of Science: Elmar Dohnke
Doctorate: Yonghui Li and Xiaojun Xu

Science Quest
Teaching the Love of Science to the Younger Generation

By Linda Godwin

Science Quest is a newly established program at Mizzou dedicated to increasing science awareness and initiating a life-long love of science in the younger generation. It is the result of a new outreach effort by Lanika Ruzhitskaya, MA '03 journalism, EdSp '05, PhD '11 Inf Sci, who, since July 2014, is the director of the Science Outreach Center at Saint Francis University, in Loretto, Penn.

The first Science Quest was held May 21–22, 2014, and was a collaboration between the departments of Physics and Astronomy, Chemistry, and Geology, and the Columbia Public Schools. The event centered around the animated 3-D movie *Quantum Quest: A Cassini Space Odyssey* written and directed by Harry Kloor. Kloor holds doctorates in physics and chemistry, is an author, educator, and producer, and he traveled to Columbia for the event to introduce his movie and meet and interact with the students.

Almost 400 fifth-grade students from several of the Columbia elementary schools participated. Each day the students were able to meet Kloor and watch the movie at Forum 8 Theater, followed by a panel discussion and many hands-on activities in and around the Physics Building on the MU campus.

Alan Whittington, E.B. Branson Professor of Geology, demonstrates volcanic-like activity to the students.

Panel discussion members, Dawn Cornelison, MU associate professor of biology, James Schiffbauer, MU assistant professor of geology, and Linda Godwin, MU professor of physics and astronomy, discussed topics ranging from how to determine if an animal or organism is alive to space flight. Kloor encouraged the students to study hard, noting that they will be living in a world that will be much different than any other before it due to the rapid increase in technology.

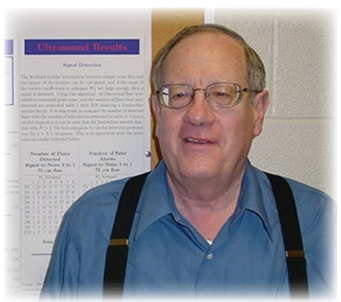
Professors and graduate students from the collaborating departments provided additional information and numerous hands-on experiences involving chemistry, geology, physics, and solar viewing.

For more information, check out our Science Quest Facebook page, https://www.facebook.com/ScienceQuestMU. This event was partially funded by a grant from Mizzou Advantage.

In Memoriam

Brian DeFacio, professor emeritus and valued colleague, died at age 77 on March 25, 2014.

DeFacio was the department's principal mathematical physicist and standard-bearer in inverse-scattering theory. He was a valued member of the physics department until his retirement in 2005, when he and his wife, Chris, moved to Laredo to live among her family after 37 years away from Texas.



DeFacio graduated from Palestine High School in 1953 and from Texas A&M University in 1967. Having received his bachelor's, master's, and doctorate from Texas A&M, he selected the University of Missouri as home base for his teaching and research in physics and mathematics.

He was invited to speak on his research on four continents as well as to edit professional journals, but he enjoyed teaching most of all.

A lifelong athlete, he played football for the legendary Bear Bryant at A&M. And later in life, he embraced running, completing several marathons before switching to long walks with his dogs.

DeFacio is survived by his wife, Chris; daughter, Patricia, of Laredo; and son, John, of St. Louis; as well as two sisters and five nephews, all of Tyler, Texas.

Robert Kost, an alumnus and a past Physics Leader, passed away on March 5, 2014.

He had been battling esophageal cancer for many years

Kost, MS '67, PhD '71, held a variety of academic and industrial positions in his career.

Following graduation, Kost taught for a while at what is now Missouri Western University. He left academia

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NSF Research Experience for Undergraduates in Materials and Modeling

This year marks the beginning of a National Science Foundation–sponsored Research Experience for Undergraduates in physics at the University of Missouri. The nine-week program, hosted by the Department of Physics and Astronomy, engages students in high-quality research on topics that play to MU's strengths in astrophysics, condensed matter, and biophysics. The program draws from a national pool of applicants, as well as students from Missouri and from partner institutions that serve underrepresented students.

In addition to working on research projects, which is the primary aim of the program, participants also attend science and academic-life seminars organized by the Office of Undergraduate Research and a weekly small group seminar on physics research topics. To further their enthusiasm for physics research, the group toured Jordan Valley Innovation Center in Springfield, Mo., and the MU Research Reactor in Columbia. Each student presented his or her research findings at the end of July in a talk for the physics community and at a poster session for all of MU's summer research interns. The award of $325,471, directed by Curators' Professor of Physics and Astronomy Sashi Satpathy and Assistant Teaching Professor Karen King will support 10 students each summer from 2014 to 2016.

The group enjoyed a fun stop at Bridal Cave in Camdenton, Mo., on their way to an afternoon industry tour of Jordan Valley Innovation Center in Springfield, Mo. Front: Clayton Craig, Francis Afzal, Juan Remolina, Kevin Reece, James Loy, and Karen King. Back: Jacob Ohlhausen, Jason Emming, Jacob Freyermuth, Ryan Goul, Gavin Hester, G.W. McElfresh, and Graham Deutsch.

Alumnus Profile: Robert Cunningham

by Linda Godwin

With his roots in Missouri, Robert Cunningham, MS '65, PhD '70, graduated from Lamar High School in 1959 and from William Jewell College in Liberty, Mo., in 1963 with a major in physics. He spent the following summer working at the NASA satellite tracking station in Santiago, Chile, doing electronic maintenance, where he notes he encountered transistor circuit boards for the first time.

In fall 1963, Robert began graduate school at the University of Missouri with a physics department assistantship. He spent summer 1964 working again for NASA, but this time at NASA Langley Research Center in Hampton, Va., designing rocket test equipment.

1965 was a milestone year as Bob received his master's degree in physics, and, most importantly, he married Linda Kay Kulmus. Robert had met Linda in French class when he was a student at William Jewell. He talked her into taking German (she was an excellent student and already taught French and Spanish) at MU so she could teach it to him, enabling him to pass the language requirement for his doctorate. Summer employment was closer to home as he taught physics in summer school at William Jewell College and also began preparing the new double-axis and triple-axis neutron diffractometer at the MU Research Reactor for his research work in neutron scattering.

Robert's research in in-band resonant modes in chromium-tungsten alloys using the diffractometers led to his doctorate in 1970. He commemorated the blue glow of the Cherenkov radiation in the reactor pool by publishing his thesis with a blue cover.

With his doctorate in physics, Robert was able to choose between several potential jobs, including Brookhaven National Labs, being a professor at a college in Texas, and setting up new experiments at a new reactor in Venezuela. He chose to accept a job at McDonnell Douglas in St. Louis, and, with his experience, quickly moved into management, where he was involved in the design of the F-18 for the Navy, and thereafter in the Phantom Works Research Center.

Retiring from Boeing in 2006 after 33 years, Robert became administrator at a rapidly growing church in Maryville, Ill., for five years, and currently is chairman of the board for a large weekday preschool program in the church.

During his busy life and career, Robert has remained connected with his alma mater, including his long-time involvement in Physics Leaders and serving as a past president of the group. Thank you, Robert, for your years of support.

A TIME for Physics First—Doubling Physics Course-taking in High School

One hundred twenty-three Teachers, 53 Missouri School Districts, Eight Years, and Two Grants Later

By Meera Chandrasekhar

When we started the A TIME for Physics First project to prepare Missouri's ninth-grade science teachers to teach a yearlong freshman physics course in high school, we were often asked, "Why physics in ninth grade?" While the rest of the world typically teaches all three science courses simultaneously over a three-year period, the U.S. high school course sequence is usually biology in 10th grade, chemistry in 11th, and physics in 12th grade. This sequence was instituted by the Committee of Ten in 1893 (MU President Richard Jesse was a member of that committee). With the B-C-P sequence, only 36 percent of high school students take physics[i], compared with 70 percent in chemistry and 98 percent in biology. One would, of course, like the entire high school population to take courses in all three subjects, and be prepared for college-level STEM courses.

Around the early 1990s The Physics First movement was getting under way nationally, spearheaded by the Nobel Laureate, Leon Lederman. The blueprint was to teach physics in ninth grade, followed by chemistry and biology. The rationale was that this inverted sequence leads the student from the simple to the complex, an approach that is in harmony with how the brain learns. The sequence also allows optional courses to be taken in 12th grade.

In order to teach physics in ninth grade, a cadre of physics teachers has to be developed. Over two project periods (2006–08 and 2009–14) the A TIME for Physics First program offered professional development to teachers from 53 Missouri school districts—rural, suburban, and urban. They attended summer academies and participated in academic year activities for multiple years. It is, by definition, an intensive program. While we only accepted science teachers who were teaching ninth grade, their background and teaching assignments spanned the range from general and earth science to physical science and physics. Some teachers taught special-education students, while others taught honors or regular classes. Some teachers were quite comfortable teaching algebra-based problems, while others had not taught quantitative content. Some teachers were the only science teachers in their school, while others taught at large high schools with three or four other ninth-grade science teachers.

Teachers conduct lab experiments and classroom discussions during the summer academy.

Two aspects of Physics First were new to most teachers: the level of physics content, and the methodology used to teach the content. The content covered fundamental principles of classical physics—motion, forces, energy, waves, and electricity. The pedagogy was based on the modeling method, developed by D. Hestenes[ii] and collaborators over the past two decades. The core of the modeling pedagogy is to organize content around scientific models and have students work through building and understanding the models themselves through a variety of classroom activities.

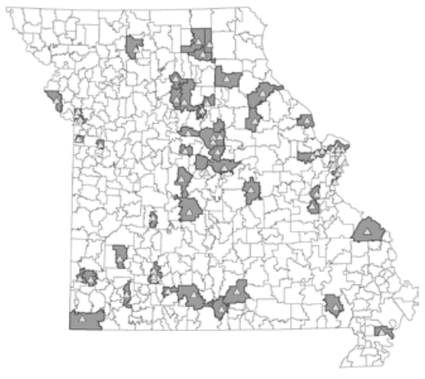
The modeling cycle is divided into a model-construction and a model-deployment phase. In the model-construction phase, teachers (and in their classrooms, their students) construct models of phenomena by conducting experiments, discussing results and misconceptions, and justifying conclusions. Class involves active participation by students, is hands-on, and highly collaborative—and it has very little lecture. The model-deployment phase involves doing practice problems, readings, a lab practicum, or making further refinements of the model. Several tools are used during the implementation of modeling, including group work, hands-on labs, presentation and discussion, and whiteboarding.

An important aspect of the modeling pedagogy is the use of multiple representations. Ninth-grade students might be taking algebra simultaneously—thus, relying exclusively on mathematical representations, as we do in our traditional physics classes, and would make a physics course seem opaque, even insurmountable. Thus verbal, pictorial, and graphical representations are used along with mathematical representations. Translating between representations is an integral part of the method, and allows students who learn in different ways to achieve a higher level of understanding.

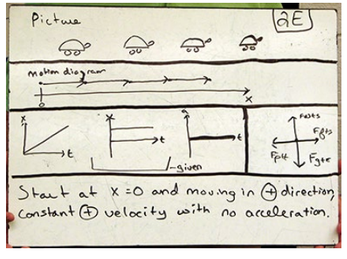
We found that teachers and students showed gains in learning physics. Teachers also reported gains in leadership skills. Asked about the future of ninth-grade physics, over 90 percent of the project's school district administrators reported that they were likely or very likely to continue ninth-grade physics in their schools five years from now.

Ninth-grade physics has helped double the number of high school physics courses taken in Missouri over the past seven years. In 2007, about 1200 students across Missouri took ninth-grade physics. In 2013, that number is over 13,000, of whom 10,000 students are in districts that came to our project. In comparison, the enrollment in 11th/12th grade physics courses has remained approximately flat, near 12,500 over the past 10 years. Nationwide, 84,000 students took ninth-grade physics in 2013—thus Missouri students comprise fully 15 percent of that total.

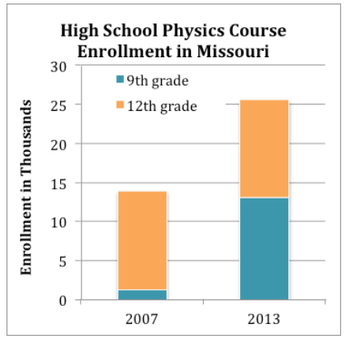
Several MU faculty, staff, and students are involved in this project: the co-principal investigators are Teaching Professor Dorina Kosztin, Assistant Teaching Professor Karen King, Associate Professor Debi Hanuscin (also of the Department of Learning, Teaching and Curriculum), and Professor Dorina Mitrea (Department of Math). Sarah Hill is the project director, and Professors Paul Miceli and Angela Speck help teach summer classes. Several physics and astronomy graduate and undergraduate students have helped out as teaching assistants. The partnership has benefitted from collaboration with school districts and other Missouri universities: Jaimie Foulk (Camdenton and MU), Dennis Nickelson (William Woods University), Sunder Balasubramanian (Lincoln University), Douglas Steinhoff and Marsha Tyson (Columbia Public Schools), Ann Wallenmeyer (Springfield Public Schools), and Sara Torres (Arizona Science Teachers' Association) have helped teach classes and organize the program.



Distribution of participants in the A TIME for Physics First project, 2006–14. Image courtesy of the MU Assessment Resource Center.



Pictorial, diagrammatic, graphical, and verbal representations of $v=\Delta x/\Delta t$.



Enrollment in ninth-grade physics has nearly doubled between 2007 and 2013. About 10,000 of the 13,000 students who take ninth-grade physics are in districts that participated in the A TIME for Physics First program.

Endnotes

[i] http://nces.ed.gov/fastfacts/display.asp?id=97. Also, S. White and C.L. Tesfaye, (Aug 2010) "High School Physics Courses and Enrollments," *Focus On, Report by American Institute of Physics.*

[ii] J. Jackson, L. Dukerich, D. Hestenes, *Science Educator* 17 (2008) 10–17.

Professor Paul Miceli was invited to teach a course, X-ray and Neutron Scattering Methods for Studying the Surfaces and Interfaces of Nanocrystalline Materials, at the University of the Western Cape in South Africa. The course was given as part of their National Nanoscience Platform, which is a collaborative venture among four campuses: Nelson Mandela Metropolitan University, The University of the Free State, the University of Johannesburg, and the University of the Western Cape (UWC). He has presented his course twice, in May 2013 and May 2014. Given the availability of user programs at synchrotron x-ray and neutron sources around the world, the course seeks to introduce students to new techniques that are accessible but not currently in use in South Africa. During his travels, Miceli gave seminars at several universities and national laboratories in South Africa. A collaborative project was also started with Professor Christopher Arendse from the physics department at UWC, who will visit Miceli's lab at MU for two months during fall 2014 where they will use x-ray reflectivity to study nanostructured Si for solar cell applications.

PAGSA 2013–14

By PAGSA President Grant Knotts

The Physics and Astronomy Graduate Student Association (PAGSA) elected new officers in 2014 including President Grant Knotts, Vice President Marat Musin, Secretary Tina Matin, and Treasurer Ashutosh Dahal. The 2014 executive board also includes Faculty Adviser Carsten Ullrich as well as the committee chairs: Harrison Knoll (social events), Alex St. John (teaching excellence) and Jacob Brown (public outreach). The PAGSA webmaster is Erica Hroblak, and the 2013–14 PAGSA representatives to the Graduate Student Assocation (GSA) and the Graduate Professional Council (GPC) were Aayush Dahal and Zack Buck, respectively.

Mohammad Sherafati and his adviser, Sashi Satpathy, were the Arts and Science doctoral marshal at the fall 2013 Graduate School commencement.

PAGSA serves many roles in organizing department events and helping its members develop skills that help them to excel as educators and researchers. In 2013–14 they organized the New Graduate Student Orientation, the Teaching Assistant Training Workshop, the fall and spring picnics, as well as the Thanksgiving dinner. Also, the Teaching Excellence Committee worked to improve the teaching skills of the department's graduate teaching assistants, while Journal Club helped students hone their presentation skills.

Additionally, multiple PAGSA members have served in student-advocacy roles and leadership positions at the university and national levels. Jesse Kremenak was elected to his third term as director of national affairs for GPC and is also serving as the national director of legislative affairs for the National Association of Graduate-Professional Students. Matt McCune is serving as the GPC director of state affairs and as the GSA public relations officer.

Several of the department's graduate students have been recognized for their achievements by both the department and the university. Yiyao Chen and Jesse Kremenak were awarded the Harry E. Hammond Award for Excellence in Undergraduate Teaching in fall 2013. Matt Reel and Dave Stalla won the award the following semester. David Arrant, in fall 2013, was the recipient of the department's Public Outreach Award.

Fall 2014 new graduate students: Li Lee, Kiandokht Amiri, Eddie Pluhar, Lisa Shepard, James Torres, Zhiwei Ma, Chenhan Zhou, Alec Pickett, Ernest Knight, and Matt Anderson (Alessandro Mazza not pictured).

Jesse Kremenak, at right, shown with Professor Carsten Ullrich, was inducted into the Rollins Society this past spring.

At the university level, Mohammad Sherafati was selected as the doctoral marshal for the fall 2013 Graduate School commencement ceremony. Jesse Kremenak was inducted into the Rollin's Society, the prestigious honor society for MU graduate and professional students, and, additionally, was the recipient of GSA's highest award: the Superior Graduate Student Award. Dave Stalla was selected by undergraduate students to receive the Missouri Students Association (MSA) TA Choice Award while both Ashkan Shafiee and Zack Buck received awards for their presentations at GPC's Research and Creative Achievements Forum.

Outreach was another large component of PAGSA's service in 2014. Many of our students participated in the Missouri Science Olympiad State Tournament, assisting Professor Yun Zhang in the running of multiple events: shock value and circuit lab. Additionally, Jacob Brown coordinated the robo-cross event. Harrison Knoll recently joined the *Big Electron* radio

Continues on next page

Bits and Pieces

Professor Wouter Montfrooij and alumna **Lanika Ruzhitskaya,** MA '03 journalism, EdSp '05, PhD '11 Inf Sci, have written an introductory astronomy textbook titled *Astronomy! A Conceptual Introduction from the Big Bang to that Asteroid Heading Right for Us.* The book accompanies the redesigned self-paced course Introduction to Astronomy and is aimed at non-science majors and astronomy enthusiasts. The book is published by Mizzou Media and will be available as an e-book from Amazon.

The Physics and Astronomy Department at MU has recently bought into the partnership of the 3.5-m WIYN telescope, located at Kitt Peak, Tucson, Ariz. **Professor Haojing Yan's** group has just finished their very first observing run (Sept. 23–25) at this telescope, which jump-started their long-term survey project, MizzouWINS (Mizzou WIN Survey). This survey aims to complete full optical coverage (300–1000 nm) of 121 square degrees in the Herschel very wide fields where the Herschel space telescope has obtained precious far-IR/sub-mm data but are still lacking optical images for comprehensive analysis. The group will spend the next five years at this telescope to carry out MizzouWINS.

A fundamental problem of modern astrophysics and cosmology is the existence and nature of dark matter. Most of the matter in the universe is currently assumed to be in the form of weakly interacting particles of unknown nature that have eluded detection despite many efforts over the past four decades. On the other hand, there may be no dark matter, in which case the law of gravity must be modified. In collaboration with his colleagues, Friedrich W. Hehl and Carmen Chicone, Professor **Bahram Mashhoon** has developed a nonlocal generalization of Einstein's theory of gravitation, in which nonlocality simulates dark matter. In fact, it is shown in the recent Rahvar-Mashhoon paper that this theory can account for gravitational physics from the scale of the solar system to that of galaxy clusters without invoking dark matter[1]. It remains to be shown that the nonlocal gravity theory can properly account for gravitational lensing observations and for structure formation in cosmology.

[1]S. Rahvar and B. Mashhoon, "Observational Tests of Nonlocal Gravity: Galaxy Rotation Curves and Clusters of Galaxies," *Physical Review D* 89, 104011 (2014).

This summer, **Professor Carsten Ullrich** held a two-month visiting position at the Ecole Polytechnique in Palaiseau, France. He conducted research at the European Theoretical Spectroscopy Facility, which develops fundamental condensed-matter theory in close contact with experiment and applications. The specific goal of his visit was to conduct research on developing new methods for calculating excitonic properties in insulators and semiconductors.

Continued from previous page

show as a host. The show airs live at 5 p.m., Sundays on 88.1 FM.

PAGSA once again received the Chancellor's Award in Public Outreach in 2014 at the Mizzou Adventures in Graduate Education event. This year they won second place with a large group of graduate and undergraduate students led by Matt McCune with a booth titled "May the Force Be with You." Before the event, Matt was interviewed on the NPR show *Radio Friends with Paul Pepper,* along with Graduate School Dean Leona Rubin, where they discussed Graduate Education Week at Mizzou. Many graduate students volunteered at the inaugural Science Quest event, organized by alumna Lanika Ruzhitskaya, Professor Linda Godwin, and Matt McCune.

Deepika Menon and Matt McCune standing behind about $900 worth of holiday gifts for children at Great Circle (formerly Boys & Girls Town) purchased with donations from the physics and astronomy faculty, staff, postdocs, and graduate students.

These achievements would not have been possible without the support and advice of the faculty leadership within the Department of Physics and Astronomy. PAGSA says a big "Thank you!" to Director of Graduate Studies Carsten Ullrich, Associate Chair and former Director of Undergraduate Studies Dorina Kosztin, lab coordinator Yun Zhang, and former Department Chair Peter Pfeifer.

MU Builds a Partnership with Brazil

By Bell Johnson

Two years ago, Professor Suchi Guha was awarded a visiting professorship by the American Physical Society to teach a summer course at the Federal University of ABC (UFABC) in Brazil. There, Guha met Professor Wendel Alves, who specialized in peptide chemistry. Together they submitted a proposal and were awarded a grant through the U.S. National Science Foundation (NSF).

Guha, who specializes in organic electronics, and Alves created a partnership through the grant to improve device performance functionality. Essentially, nanopeptides act as "scaffolds" to make conducting polymers more efficient in organic solar cells and other devices. Guha describes these nanopeptides as the "building blocks" to improve the function of flexible electronic devices.

"For instance, you can have a solar cell or entire electronic circuits in the fabric you are wearing," Guha says. "If you want to charge your cellphone, you have the circuit inbuilt."

The NSF grant began in December 2013 and runs for a year ending this December. Through the grant, a graduate student from Brazil worked in Guha's lab for two months and a graduate student from the Department of Physics and Astronomy at MU recently visited Alves' lab in Brazil.

Guha describes the partnership established through the grant as "the first of its kind."

This past March, Alves and Guha submitted another proposal through Science Without Borders, which funds scientific collaborations between South American countries and the U.S. Only a few were selected, and Guha's was one of them. This program aims to attract internationally recognized senior foreign researchers to conduct projects with Brazilian research groups. By securing a visiting scientist position at UFABC, Guha will divide her time between Brazil and MU for the next two years.

MU already has an initiative to establish partnerships with universities in Brazil, and Guha has been in contact with the Office of International Studies to create more opportunities for other students to go abroad.

"We don't know if it will materialize, but it's something I'm also working on," Guha says. "Hopefully we can make it into a bigger program."

Through her visiting scientist position, Guha hopes to continue to create complimentary systems between the two labs and become more comfortable with scientific disciplines outside her comfort zone.

"It's been a lot of fun because it's always nice to see things from a different perspective," Guha says. "What has really helped me is the fact that we have been able to exchange ideas across disciplines very efficiently."

Magnetism at the Crossroad

By Deepak Singh

Magnetic materials are pervasive in everyday life, from electric motors to hard disc data storage. From a theoretical point of view, well-defined microscopic Hamiltonian models can often describe magnetic materials. Such a symbiotic relationship between experiment and theory has been particularly useful in the context of the exploration of new magnetic material of technological importance. My research program investigates new magnetic material or magnetic phenomena that are at the cross-road of fundamental science and strong technological implications. In this quest, my group utilizes various sample preparations and measurement techniques that include nanofabrication of magnetic devices; synthesis of single-crystal magnetic material using optical-floating-zone technique; and onsite electrical, thermal, and magnetic characterizations of the home-grown samples and neutron-scattering measurements.

One of the research projects my group is pursuing involves the exploration of a new class of materials, topographical nanoengineered magnetic materials, in which the coupling between the magnetic and the thermal properties can be tuned for potential applications in areas such as the spin (magnetic) caloritronics. Magnetic caloritronics is a newly discovered research arena that is concerned with spin, charge, entropy and energy transport in magnetic devices. The collective nature of the effect depends on the coupling between the spin wave, phonon propagation, and electrons near the Fermi surface. In a recent research, they have used in-situ nanoengineering to develop a new material consisting of locally hexagonal periodic array of ultra-small cobalt dots in direct multi-directional contact with an encapsulating polycrystalline thin copper film. A host of interesting properties that includes the coexistence of giant thermal hysteresis and anomalous magnetoresistance behavior are found in the electrical transport measurements on these nanoengineered materials, which opens a new avenue to explore magnetic caloritronics.

Jagat Gunasekera, Harrison Knoll, Deepak Singh (in back), and Ashutosh Dahal.

Electronics Lab Gives Students the Chance to Be Creative

Professor Wexler helping students debug their counter/display encoder design.

By Bell Johnson

Professor Carlos Wexler developed an electronics lab course while brainstorming how to create more engaging laboratories. He says he was tired of seeing students use research lab equipment without understanding how it worked.

The electronics lab was first offered in spring 2013 with only 10 students to give it a trial run. Many improvements were made to the course before it was offered again this past spring. This time, Wexler had to cap the number of students in the course to 20 because of a lack of space in the room.

The course starts with the basics of electronics—how individual components such as diodes and transistors work by building circuits with one or two transistors. From there, the course continues to build upon itself as students understand the internal circuit and use of operational amplifiers, which consist of dozens of transistors.

Wexler describes the beginning of the course as analog and the second half as digital, as students comprehend how individual components form into more complex systems, ultimately leading to students using microcontrollers with millions of internal parts!

Students learn to use open-source hardware and associated software libraries to build systems of increased complexity. While the students have the knowledge and skills to develop systems from scratch, to do so would be too time consuming. "By using the open-source libraries, we stand on the shoulders of previous developers and deal with complex systems as LEGO blocks," Wexler says. "Students learn how to interface with these libraries and create a much more sophisticated system, for instance, involving complex communication protocols, than they could otherwise."

Wexler equates the process to understanding the structure of the inside of a car. While you don't necessarily need to know how to do everything, you do need to know when to inflate a tire. "It's important that you know how the individual components work—how different systems interface with one another," Wexler says.

The electronics lab is accomplishing everything Wexler hoped it would. One student fixed a broken-down piece of equipment that would have cost $1,000 in replacement cost for only $20 just by thinking through how the system worked and creating a new system using open-source components. Wexler describes the new equipment as far superior to the commercial equipment.

"This is how the real world operates. The problems that you face in your professional life are not 'here is a system, do it as we tell you.' It's how do you achieve something in an 'open problem,'" Wexler says.

He says that students who take the course are that much more marketable in future employment situations because they can understand how a system works from basic terms into the more complex concepts. The lab has an open-door policy, which allows students to check out a key and come in to work on their projects whenever they want. Wexler attributes much of the success of the course to this feature.

"I don't tell them to build 'this particular thing.' I give them some basics and say 'This is what we have, and here are some ideas.' Then they take some of the ideas they proposed and build on top of that," Wexler says. "I give them building blocks, and then they create their own 'toys.'"

Wexler will teach the course again in spring 2015 and has high hopes for the future of the lab. He hopes to see it grow with more students from the physics department and other interest areas.

"The model for having this open-door policy where students can check out materials and work on their own in groups without adult supervision," he says, "I think that's where you get their creativity flowing."

In Memoriam

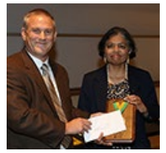
Continued from Page 6

to work for Seagate in their Scott's Valley, Calif., plant and later transferred to their Minneapolis location.

After he retired from Seagate, Kost returned to teaching physics, this time at Normandale Community College in Bloomington, Minn. He loved teaching the students and continued to do so until his health would no longer permit. Even after having to resign, he would occupy himself designing and building physics lab experiments to be used by the college.

Department Kudos

Faculty



Curators' Teaching Professor of Physics and Astronomy **Meera Chandrasekhar** was named the recipient of the Baylor University Robert Foster Cherry Award for Great Teaching. The $250,000 Cherry Award is the only national teaching award presented by a college or university to an individual for exceptional teaching. She has also been named a recipient of the 2014 Columbia Public School Science Hero Award.

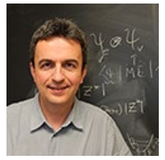
Professor **Suchi Guha** has been selected as a special visiting researcher by the Brazilian National Science Foundation under the program Science Without Borders.

Associate Professor **Deborah Hanuscin** holds a joint appointment in the MU College of Education and was named the 2014 Outstanding Science Teacher Educator of the Year.

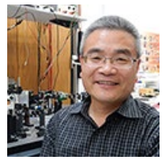
Professor of Physics and Radiology **Kattesh Katti,** was appointed director of the Green Nanotechnology Center, at the University of the Western Cape, South Africa.

Teaching Professor **Dorina Kosztin** was awarded the MU President's Award for Innovative Teaching. The award recognizes faculty who are outstanding teachers and who employ novel and innovative teaching methods to achieve success in student learning.

The ALL-CRAFT team in Professor **Peter Pfeifer's** lab (Alliance for Collaborative Research in Alternative Fuel Technology) was selected for a Sustainable Steward Award by the MU Environmental Affairs Sustainability Committee for "developing new, cleaner renewable ways to fuel our vehicles as we move into the future."



Professor **Carsten Ullrich** was awarded the Chancellor's Award for Outstanding Research and Creative Activity. This award gives special recognition to MU faculty members who are still in the developmental phases of their careers, have made outstanding contributions in research and/or creative activity, and have great promise for achieving wider recognition.



Professor **Ping Yu** was elected a senior member of the International Society for Optics and Photonics.

Associate Professor **Xiaoqin Zou** won first place in the scoring category and seventh place in the predicting category for overall docking out of 63 international teams in the fifth international CAPRI (Critical Assessment of PRediction of Interactions) competition on predicting protein–protein complex structures, 2011–2013. She also won third place on modeling of structural water at the protein–protein interface. Zou was awarded a $143,000 American Heart Association (Midwest Affiliate) grant for 2013–2015.

Graduate Students

Graduate student **Jesse Kremenak** has been selected as a winner of the Graduate Student Association Superior Graduate Student Award and was inducted into the Rollins Society, one of MU's prestigious honor societies, for having "advanced the well-being of self-defined communities beyond the scope of their academic work."

Graduate students **Matt McCune** and **Deepika Menon** recently presented a poster titled "The Nuts and Bolts of Running a Graduate Student-led Science Outreach Program" covering the successes of the Physics and Astronomy Graduate Student Association's Public Outreach Committee at the 2013 American Society for Biochemistry and Molecular Biology's Science Outreach and Communication Symposium.

Graduate students **Yiyao Chen, Jesse Kremenak, Matthew Reel,** and **David Stalla** received the Harry E. Hammond Award in recognition of their excellence in undergraduate teaching.

Graduate student **David Stalla** has been selected as a winner of the Missouri Student Association TA Choice Award for his exemplary work in Physics 1220.

Graduate students from the Department of Physics and Astronomy won the 2014 Chancellor's Award in Public Outreach: Second Place at the Mizzou Adventures in Education event on April 12.

David Arrant was the recipient of the department's Public Outreach Award.

Mohammad Sherafati was selected as the doctoral marshal for the fall 2013 Graduate School commencement ceremony.

Graduate student **Shawn Hayden** and **Lacey Daniels,** an undergraduate student, received first prize for their research presentations at the Leaders Meeting, fall 2013.

Alumni

Arjuna Flenner, PhD '04, has been named one of 21 Dr. Delores M. Etter Top Scientists.

Your Next Car

It Might Well Run on Natural Gas and Be Ready for Hydrogen when It Comes Along

by Professor Peter Pfeifer

During the past six years, the Alliance of Collaborative Research in Alternative Fuel Technology (ALL-CRAFT, http://all-craft.missouri.edu/), under the leadership of Peter Pfeifer, had over $6 million of grants and contracts to develop low-pressure, high-capacity storage technologies for natural gas and hydrogen as alternative fuels for advanced transportation. The objective is to replace bulky, cylindrical compressed natural gas (CNG) tanks in current natural gas vehicles by a lightweight, flat-panel (conformable), low-pressure tank, with storage as adsorbed natural gas (ANG), in next-generation natural-gas vehicles, and similarly for hydrogen in hydrogen fuel-cell vehicles. The flat tank, made possible by the low pressure in the ANG tank, is central to a tank that can be integrated into the chassis or other unused space of a car (conformable tank), options that are not possible with heavy-walled high-pressure CNG tanks. The tank will make NG vehicles a widely attractive alternative to gasoline and diesel vehicles. The low pressure also reduces fueling costs (public stations, home fueling appliances) by reducing compression of NG from 250 bar (CNG) to 35 bar (ANG).

The research has been funded by the U.S. Department of Energy, U.S. Department of Defense, California Energy Commission, and Southern California Gas Company. The physics underlying this research and development program is to create high-surface-area, nanoporous carbons with high-binding energies for methane or hydrogen in the form of a dense film, less than a nanometer thick, in a minimum of macroscopic solid volume. Principal achievements of the ALL-CRAFT team in 2013–14 include:

- Completion of an advanced flat-panel ANG tank, which has an internal volume of 39 liters, holds 21 kg of carbon monoliths developed and manufactured in the physics department, and stores a record amount of 4.1 kg CH_4 at 35 bar and 23° C). This gives a tank whose outside volume is comparable to a CNG tank, but is conformable and weighs 20–30 percent less than the CNG tank.
- Two licenses for commercialization of the ANG technology have been executed between MU and two companies.
- A patent, "High-surface-area carbon and process for its production," U.S. Patent No. 8,691,177, was issued April 8, 2014.
- High-surface-area carbons have been successfully doped with boron so as to increase the binding energy for hydrogen from 5 kJ/mol to 10 kJ/mol. This is an important milestone toward achieving the 2017 DOE targets for hydrogen storage capacity in light-duty vehicles and portable power equipment.

Meet some of the students who make things happen in the Pfeifer lab. From left: Matthew Beckner, David Stalla (in back), Michael Kraus, Jimmy Romanos, Peter Pfeifer, Yuchoong Soo, Elmar Dohnke, and Tyler Rash.

The QuEST program held its first summer workshop for third grade teachers July 14–25. Teachers learned about magnetism in sessions facilitated by faculty members **Deborah Hanuscin,** who is principal investigator of the project, and **Karen King**, and graduate student **Jesse Kremenak.** The QuEST program (PI: Deborah Hanuscin) is funded by the NSF DRK12 program and is investigating the impact of a unique professional development model on teachers' classroom practices and student learning in elementary science.

Shelby Davison, an elementary education major, participated in the program.

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The department appreciates hearing from alumni and friends. Send announcements or milestones to the address listed above.

MU's new chancellor's academic home is the physics department. This past spring, Chancellor R. Bowen Loftin, center, visited the department and conducted a Q&A session with graduate and undergraduate students in the physics department.

2014–15 Undergraduate Scholarships

Newell S. Gingrich Physics and Astronomy Undergraduate Scholarship
Kaylina Breig, Gregory Jenkins, Aylecia Lattimer, Abuzar Mahmood, Joshua Russell, Kara Schrand, Alexander Sun, and Daniel Van Hoesen

Donald L. and Lona Lewis Packwood Scholarship
Richard Barber and Angelynn Simenson

Clifford Tompson Scholarship in Physics
Christian Boyd, Brendan Marsh, and Dylon Register

Paul E. Basye Undergraduate Scholarship
Ian Crawford-Goss, Lacey Daniels, and Richard McClure