Physics and Astronomy
Communiqué
Autumn 2018

Deepak Singh's Research Could Lead to Better Battery Life

Battery life could extend a hundredfold

By Jeff Sossamon, MU News Bureau

Among the chief complaints for smartphone, laptop, and other battery-operated electronics users is that the battery life is too short and—in some cases—that the devices generate heat. Now, a group of physicists led by Associate Professor Deepak K. Singh has developed a device material that can address both issues. The team has applied for a patent for a magnetic material that employs a unique structure—a "honeycomb" lattice that exhibits distinctive electronic properties.

"Semiconductor diodes and amplifiers, which often are made of silicon or germanium, are key elements in modern electronic devices," said Singh, who also serves as the principal investigator of the Magnetism and Superconductivity Research Laboratory at MU. "A diode normally conducts current and voltage through the device along only one biasing direction, but when the voltage is reversed, the current stops. This switching process costs significant energy due to dissipation, or the depletion of the power source, thus affecting battery life. By substituting the semiconductor with a magnetic system, we believed we could create an energetically effective device that consumes much less power with enhanced functionalities."

Singh's team developed a two-dimensional, nanostructured material created by depositing a magnetic alloy, or permalloy, on the honeycomb-structured template of a silicon surface. The new material conducts unidirectional current, or currents that only flow one way. The material also has significantly less dissipative power compared to a semiconducting diode, which is normally included in electronic devices.

The magnetic diode paves the way for new magnetic transistors and amplifiers that dissipate very little power, thus increasing the efficiency of the power source. This could mean that designers could increase the life of batteries by more than a hundredfold. Less dissipative power in computer processors could also reduce the heat generated in laptop or desktop CPUs.

"Although more works need to be done to develop the end product, the device could mean that a normal five-

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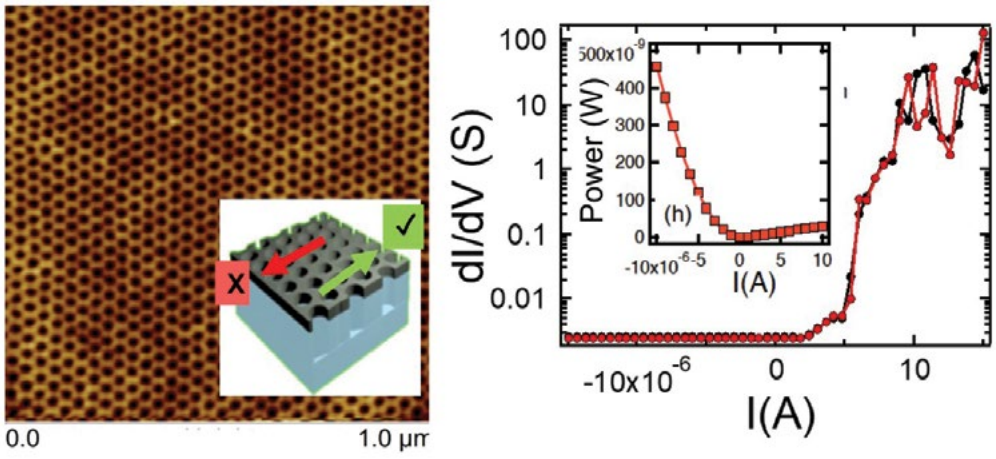


The left shows the atomic force micrograph, exhibiting honeycomb-structure pattern behind a magnetic device. Inset shows the schematic of current flow direction. On the right: electrical data reveals diode-type behavior of current flowing in one direction. Inset shows that the dissipative power is of the order of nano-watt in the current flowing direction, which is at least three orders of magnitude smaller than the semiconductor diode. Credit: Deepak Singh

From the Chair

Dear Physics Alumni and Friends,

The physics department continues to thrive in spite of continued budget challenges, and we remain cautiously optimistic for the future. Mizzou's freshman class showed a decided uptick in number, going up from 4,000 last year to 4,700 this year. We have new campus leaders in place including **President Mun Choi, Chancellor Alexander Cartwright, Provost Latha Ramchand,** and our own **Dean Patricia Okker,** all coming on board within the span of the last couple years. They bring new perspective to Mizzou and a fresh and forward-looking vision.

I am happy to report that our faculty search last year was successful, and **Se Kwon Kim,** formerly a postdoctoral fellow at UCLA, joined the department this fall as an assistant professor. Se Kwon is a theoretical condensed-matter physicist who has been investigating novel topological phenomena in magnetism and utilizing them for spin-based information processing. **Karen King** was promoted to associate teaching professor, and her position also became full time in the department. This year we have been given the go-ahead to recruit a tenure-track faculty member in the area of experimental biophysics. The new hire will provide critical mass to our highly successful biophysics program.

Our graduate student number has remained stable, fluctuating between 50 and 55 students over the past decade. This year, the number has dipped a bit due to the graduation of an unusually high number of doctoral students. Fourteen graduated last year, and eight new students joined this semester, bringing the total number of students to 46 for the current academic year. We have 112 declared undergraduate physics majors this year, which is about the same as last year (110). The department has around 10 postdoctoral fellows. The faculty size, currently 30 including four non-tenure-track faculty members, has remained more or less stable despite the recent budget turmoil that the university has faced.

We have redoubled our efforts in improving the quality of our undergraduate programs, driven in part by the rapid rise of the number of physics majors over the past decade and by a desire to make the education more relevant to the modern-day world. **Silvia Bompadre,** the director of undergraduate studies, spearheads that effort. Karen King has just been appointed as the coordinator of student internship, both for graduate and undergraduate students, and we hope to place some of our students as summer interns in the industry and government labs.

The productivity of our faculty and students remains high, much of which is listed in the body of this newsletter. Mizzou has just embarked on the ambitious effort to double our research presence in terms of publications, citations, grant dollars, etc., within the next five years. The department's productivity has always been strong, we have very talented faculty, and I see no reason why, as a department, we cannot double our research productivity, at least in terms of the number of publications. This I give as a challenge to the faculty, including myself. This year, the faculty was especially successful in receiving new grants and contracts from external agencies such as the NSF, NIH, DOE, the Wipro Foundation, etc., with the amount of new grant dollars received exceeding $3 million. This is a remarkable achievement in light of the tight funding situation.

The department has been able to maintain its activities thanks to new revenue streams such as the supplemental fees, online teaching income, and generous donations from alumni and friends, too numerous to mention here, but for every one of which we are deeply grateful. One noteworthy item is the establishment of the annual Boain Dissertation Award for the best doctoral dissertation, made possible by the support of Physics Leader **Ronald Boain** and his spouse **Catherine Rangel-Boain.** On behalf of the department, I express our sincere gratitude to the physics alumni, leaders, and friends for their continued support, and for their time, interest, and commitment to the department.

Wishing everyone another successful year full of intellectual activities and excitement.

Sashi Satpathy

Sashi Satpathy
Department Chair and Curators' Distinguished Professor

MU Physics Receives a Wipro Science Education Fellowship Grant

By Meera Chandrasekhar

Three faculty from the physics department, **Meera Chandrasekhar, Dorina Kosztin** and **Karen King,** and **Marcelle Siegel,** from the College of Education, received a four-year $1.1-million grant to support 60 mid-Missouri K–12 science teachers in their science teaching through leadership and collaboration. The grant is funded by Wipro, a global information technology, consulting, and business process services company that is heavily invested in educational priorities in India and the U.S. The University of Missouri is one of three new sites chosen for the Wipro Science Education Fellowship (SEF) project. The other two sites are the University of South Florida and Stanford University. The new sites are part of a collaboration of seven WiproSEF sites led by Arthur Eisenkraft of the University of Massachusetts Boston (UMB). **Doug Steinhoff** is MU's project coordinator.

The fellowship is a two-year program for experienced teachers, which uses a model of teacher support and development to increase the quality of teaching and leadership in science throughout several districts. This model includes a comprehensive set of activities designed to improve teacher practice, focusing on the outcome of increased achievement in science for all students.

Teachers from Eldon and Jefferson City, from left, Steve Henderson, Jacqueline O'Donnell, Quincy Carver, Jennifer Hoecker, Taylor Mislevich, and Amylia Hayes.

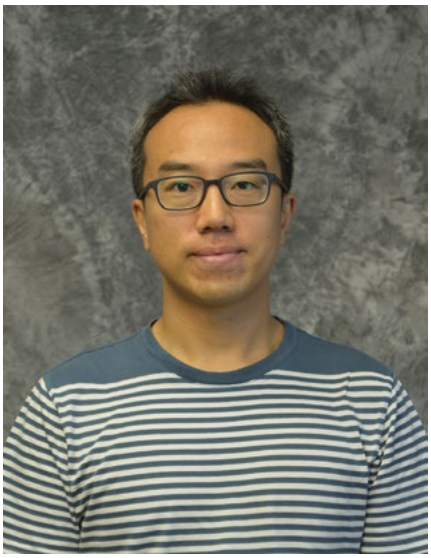
Three cohorts of 20 teachers each will be recruited from school districts in Boone County and adjacent counties. One cohort will begin participation in 2018, with the other two following in 2019 and 2020, respectively. Large districts in the area will send 12 teachers, approximately one from each grade, to the program over the three cohorts, while small districts will send four to six teachers. An administrator from each district is also part of the team. Each teacher will stay in the project for two years. In the first year, teachers will collaborate in subject-based groups of five teachers each across all K–12 grade levels in the fall semester. In the spring semester, they will collaborate in grade-band groups across subjects. Teachers will choose a research topic to apply to their teaching, videotape their classes, and receive feedback from others in their group. They will also come to monthly meetings with MU faculty. In the second year, teachers will conduct independent study projects. Teachers from Boonville, Columbia, Community R-VI, Eldon, Jefferson City, and Hallsville school districts comprise our first cohort.

Physics faculty, clockwise from top left, Dorina Kosztin, Meera Chandrasekhar and Karen King, and project coordinator Doug Steinhoff, in back.

Through these interactions, teachers will establish connections between grades and subject areas to build continuity across grades and science subjects. School districts will be able to utilize these teachers as science leaders throughout their districts.

The project's activities began with an induction ceremony on May 8, 2018, attended by all teachers; several university administrators, including President Mun Choi, Interim Provost Jim Spain, Dean of Education Kathryn Chval and A&S Associate Dean Chris Pires; chairs and faculty; the CEO of Wipro's Azim Premji Foundation Anurag Behar; and Arthur Eisenkraft from UMB. Academic activities of the project began on Aug. 11, 2018.

Welcome Se Kwon Kim!



Assistant Professor Se Kwon Kim

The department is very pleased to welcome Se Kwon Kim as the George Vineyard Assistant Professor. He obtained his doctorate from Johns Hopkins University in 2014. Before joining MU, he worked as a postdoctoral scholar at the University of California, Los Angeles (UCLA). Kim was a recipient of an Outstanding Young Researcher Award in 2016, awarded by the Association of Korean Physicists in America.

As a theoretical condensed-matter physicist, he has been studying fundamental physics of magnetism and superconductivity as well as their technological applications in practical fields such as spintronics and quantum computation. The common theme of his research topics is topology in physics, which includes the dynamics of topological solitons and the identification of novel topological phases. Kim has been actively collaborating with spintronics experimental groups in several institutions across the world such as UCLA in the U.S., Kyoto University in Japan, Korea Advanced Institute of Science and Technology and Korea University in Korea, and Chinese Academy of Sciences in China, to name a few.

In the future, he will explore the interplay of charge, spin, and energy degrees of freedom in quantum materials with a particular focus on topological quantum phenomena. He is also looking forward to collaborating with other faculty members in the department.

Battery Life

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Associate Professor Deepak Singh

hour charge could increase to more than a 500-hour charge," Singh said. "The device, which reduces power flowing through an electronic device, could also act as an 'on/off switch' for other peripheral components such as closed-circuit cameras. We have applied for a U.S. patent and have begun the process of incorporating a spin-off company to help us take the device to market."

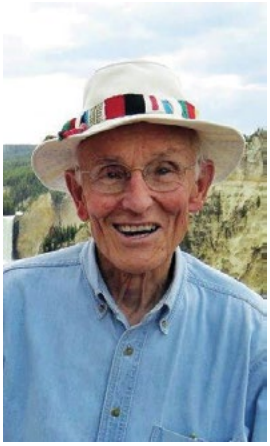
The proposed startup company associated with this research highlights the university's impact on the state's economic development efforts, including commercialization of research conducted at Mizzou, workforce development and job growth, quality-of-life improvements for residents, and attracting corporations and businesses to the state. Companies commercializing MU technologies have secured hundreds of millions of dollars in investments and grants to advance their commercialization efforts. In 2017, the Office of Technology Management and Industry Relations reported that 31 U.S. patents were issued to members of the MU community.

The studies, "Magnetic Diode Behavior at Room Temperature in 2D Honeycombs" and "Spin Solid versus Magnetic Charge Ordered State in Artificial Honeycomb Lattice of Connected Elements," were published in *Advanced Electronic Materials* and *Advanced Science,* respectively. The U.S. Department of Energy, Office of Basic Energy Sciences (DE-SC0014461) provided funding for this research. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding agencies.

Read more at munews.missouri.edu/news-releases/2018/0516-new-device-could-increase-battery-life-of-electronic-devices-by-more-than-a-hundred-fold/.

In Memoriam

Guy Schupp passed away Nov. 25, 2017, at the age of 84. He was a professor in the department for 40 years, beginning in 1964. He performed his research at the University of Missouri Research Reactor and taught and mentored numerous students. Many former students will recall his passion for tennis. He competed in tournaments across the Midwest, achieving a national ranking of 24 in the men's 55-year age bracket.



The department awards funds annually from the Guy Schupp Scholarship to one or more full-time undergraduate or graduate students who have shown exceptional promise in the study of physics.

David Cowan passed away on Dec. 17, 2017, at the age of 81. He came to the university in 1968 from Sandia Laboratory and worked in the department as a professor and researcher until his retirement in 2000. He served as department chair during his tenure and, in 1996, invited a cross-section of alumni to become part of a newly formed Physics Leaders group, setting in motion a very successful and enduring interface between our Physics Leaders and our department.

These two professors represented over 70 years of experience, research, and teaching in the department and will be greatly missed by faculty and former students.

News from our Alumni

Rowan University has appointed **Cristian Botez** as dean of its College of Science & Mathematics and School of Health Professions, effective Aug. 1. Botez, MS '99, PhD '02, had most recently served as chair of the physics department at University of Texas at El Paso. His adviser at MU was **Professor Paul Miceli.**

Michael Gramlich, PhD '11, was hired as an assistant professor in physics this fall at Auburn University. His adviser at MU was **Professor Paul Miceli.**

Romanus Hutchins, BS '18, has been admitted as a graduate student by the University of Maryland Fischell Department of Bioengineering. He also has been awarded a National Graduate Education for Minorities Fellowship for his graduate studies. Hutchins worked in **Professor Ping Yu's** laboratory doing undergraduate research for three and a half years. His research was mainly on the design, characterization, and analysis of Airy and Bessel beams for optical scattering and biomedical applications. During his undergraduate studies, he presented his work in several national and international conferences, including the Conference on Laser and Optoelectronics in 2016 and 2018. He successfully applied for several fellowships and internships on and off campus. He was selected as a WAVE fellow twice at California Institute of Technology. He also served as an undergraduate ambassador and undergraduate research representative for the Undergraduate Research Day at the Capitol in Jefferson City, Missouri.

Romanus Hutchins and Professor Ping Yu.

Faculty Updates

Guang Bian's proposal, Design and Characterization of Novel Superconducting Topological Semimetals, was accepted for funding by NSF. The more than $444,000 award is valid for three years.

Shi-Jie Chen's lab, in collaboration with Andrew Gu's lab in the Department of Bioengineering at MU, recently published a paper in *Nature Communication:* www.nature.com/articles/s41467-017-01588-z. An article reporting on this important research and publication is included in this newsletter.

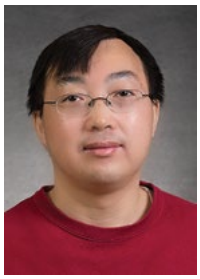
Suchi Guha received the 2018 MU Provost's Award for Leadership in International Education. This award recognizes MU faculty who have provided outstanding leadership in strengthening MU's international dimension. She also has four active simultaneous grants from the National Science Foundation (NSF) for her research on organic electronics, biosensors, and hybrid perovskites. Her NSF grant for about $400,000, awarded in August 2018, Tuning the Spin Texture in Organic-inorganic Halide Perovskites, has a collaborative component with the University of Western Cape in South Africa.

Yicheng Guo has been working on understanding the formation and evolution of distant low-mass galaxies whose stellar mass is 100–1000 times smaller than our own Milky Way. He will study the size and morphology of low-mass galaxies in the five Hubble Legacy Fields, where Hubble Space Telescope has taken its deepest view of the universe. He was also awarded the Dr. Richard Wallace Faculty Incentive Grant by the Mizzou Alumni Association to set up a workstation for undergraduate students to analyze the spectroscopy of low-mass galaxies taken by the Keck Telescope, one of the largest optical telescopes in the world.

Gavin King's laboratory has had a productive 2018, with a book chapter and five peer-reviewed papers accepted for publication in such high-profile journals as *Science Advances.* The laboratory was happy to welcome alumnus **Brendan Marsh,** BS '17, back to Columbia for summer research. Marsh headed to Stanford to complete his doctorate this fall.

Karen King was promoted to teaching associate professor. She was recently appointed as the coordinator of student internship, for graduate and undergraduate students in the department.

Sergei Kopeikin, together with J. Mueller of theUniversity of Hanover in Germany, has organized a first international workshop on Spacetime Metrology, Clocks and Relativistic Geodesy: www.issibern.ch/teams/spacetimemetrology/. The workshop was held at the International Space Science Institute (ISSI) in Bern, Switzerland, March 19–23, 2018. The workshop team discussed the reproducibility of atomic optical clocks measurements coming from independent absolute frequency comparisons made in different laboratories and how to achieve the remote comparison of clocks in consistency with their challenging accuracy level. A second workshop is in preparation and will be held at ISSI in 2019. Funding for the workshop is provided by ISSI.



Aigen Li is working on nano particles in the space between stars, focusing on how they interact with electromagnetic radiation and their astrophysical effects and implications. This work is supported by a NASA Hubble theory grant (2017), a NASA Chandra theory grant (2018), and an NSF/AST grant (2018). Li has also been vigorously involved in scientific services: he co-organized the focus meeting "Nano Dust in Space and Astrophysics" in the 30th General Assembly of the International Astronomical Union held in Vienna Aug. 20–31, 2018. He serves on the scientific organizing committee (SOC) of the international symposium Dusting the Universe to be held in Tucson, Arizona, on March 4–8, 2019. He continues to serve on the SOC of the annual Cosmic Dust meeting since 2006. One of Li's graduate students, **Ajay Mishra,** PhD '16, published four first-author papers in *The Astrophysical Journal* and has joined the faculty of Lincoln University. **Bradley Mills,** an advisee of Li who will receive his doctorate in December, has joined the faculty of Trinity College.

R. Bowen Loftin is conducting research on the future challenges that must be overcome to support the widespread and routine use of adaptive instructional technology (AIS) for training and education. This work is sponsored by the U.S. Army Research Laboratory's (ARL) Human Research and Engineering Directorate, in cooperation with the U.S. Air Force Research Laboratory and Aptima, Inc. Loftin is collaborating with scientists and engineers from other universities as well as industry and government agencies. He is charged with recommending specific research investments for the ARL to make over the next decade. The results of these research investments will be of value, not only to the Army, but to the wider defense community, public education (K–12), higher education, and private sector training.

Paul Miceli was recognized for his 25 years of service to MU. Among other things, he is a William T. Kemper Fellowship for Teaching Excellence winner and a recipient of the Governor's Award for Teaching Excellence in the recent years.

David Singh was named a Curators' Distinguished Professor of Physics, and he received a grant from the Department of Energy, Basic Energy Sciences, for his proposal "Frontiers in Magnetic Materials."

Angela Speck has been appointed a presidential engagement fellow by University of Missouri President Mun Choi. In this capacity, she will be representing the UM system in several speaking events around the state. She was also recently appointed to serve as a faculty fellow in the A&S dean's office with a focus on outreach and engagement.

Carsten Ullrich received a Cottrell SEED (Singular Exceptional Endeavors of Discovery) Award from the Research Corporation for Science Advancement: rescorp.org/cottrell-scholars/career-advancement-awards/seed-award. The award is more than $50,000 and runs through September 2019. The award specifically targets former Cottrell Scholars and supports exceptionally creative new research or educational activities with potentially high impact. Ullrich's SEED research is "Femtomagnetism with Time-dependent Density-functional Theory: Exchange-correlation Torques and Exact Benchmarks." Ullrich also received a three-year NSF grant for $370,079 that began in August for "Time-dependent Density-functional Approaches for Excitons: Linear Response Versus Real Time." He also received a 33-month $365,000 DOE grant that began in September for "Time-Dependent Density-Functional Approaches for Spin-Dependent Nonequilibrium Phenomena."

Haojing Yan was recognized as a recipient of the Provost's Junior Faculty Award for Research and Creative Activity. Yan graduated three of his doctoral students this past May: **Marat Musin, James Runge,** and **Zhiyuan Ma.** Musin started his postdoc in August at the National Astronomical Observatories of China, Chinese Academy of Science. Ma accepted a postdoctoral position at the University of Massachusetts, Amherst, which started in September.

Marat Musin, James Runge, Haojing Yan, and Zhiyuan Ma.

Check the department website for department news and updates:

- A frequently updated Recent Faculty Publications list with links to articles (new feature)
- Updated Physics Leaders page
- Department news and calendar
- Alumni: Please visit physics.missouri.edu/alumni-and-friends to learn how to update your contact information or submit an online profile that will be added to the page.
- Visit often: physics.missouri.edu

Shi-Jie Chen Uses Computational Models to Study RNA

Working with postdoctoral and doctoral students, Shi-Jie Chen uses theoretical and computational biophysics to study ribonucleic acid (RNA)—a polymer that plays a critical role in transporting genetic material around in a cell.

An RNAmazing Research Breakthrough

By Ryan Owens, strategic communications associate, College of Engineering [edited for style]

Understanding ribonucleic acid (RNA) and its chemical properties and biological mechanisms is a key area of focus in health research. RNA is critical in the processing and movement of genetic information and gene expression.

The way RNA folds into various tertiary structures determines its biological function, and being able to dissect and alter that process could lead to prevention of a multitude of retrovirus-induced diseases, including certain types of cancer. An interdisciplinary team of Mizzou researchers is one step closer to that goal.

Professor of Bioengineering **Li-Qun (Andrew) Gu** and **Shi-Jie Chen,** professor of physics and biochemistry, and their team recently published "Nanopore Electric Snapshots of an RNA Tertiary Folding Pathway," in the prestigious journal *Nature Communications.* Gu is affiliated with the Dalton Cardiovascular Research Center, and Chen is an affiliated researcher in the MU Informatics Institute.

The paper outlines how the team used nanopore snapshots to determine RNA structures at various phases of the folding process and, based on the nanopore signal, used computer simulations to understand important points that allow researchers to eventually derive the entire folding pathway and predict how a given strand of RNA will fold.

"Once they go through this nanopore, molecules can generate different signals," Gu says. "Different domains of this RNA will generate quite different signals. From this current signal, you can discriminate which domain it is, and then we have a clue that the molecule may fold in a particular way."

Being able to map the folding pathway of RNA has the potential to allow researchers to predict which molecules may fold in such a way that will cause adverse health effects. The specific RNA investigated by the team begins in an unfolded state before moving to an intermediate state, then into a pseudoknot structure—a compact bundling that approximates a knot but untangles when stretched out rather than tightening.

Understanding this process has the potential to allow pharmaceutical experts to design drugs that can intercept RNA at the intermediate stage, keeping it from folding into a potentially harmful structure, or even altering it in a way that allows the molecule to fold into a non-harmful structure.

"In order to go to the final structure, you have to unfold the misfolded structure first," Chen says. "This can potentially tell us how to sabotage the folding of this molecule."

Many of the students working alongside Gu and Chen on this groundbreaking research came to Mizzou as part of MU Engineering's 2+2 and 3+2 programs. Students in these programs come from partner universities abroad, where they study for the first two or three years, then they come to Mizzou to finish their degrees. The 2+2 program culminates in a bachelor's degree, while 3+2 culminates in a master's.

Professor of Bioengineering Li-Qun (Andrew) Gu and Shi-Jie Chen, professor of physics and biochemistry, and their team recently published "Nanopore Electric Snapshots of an RNA Tertiary Folding Pathway," in the prestigious journal *Nature Communications.* Photo by Amy Parris.

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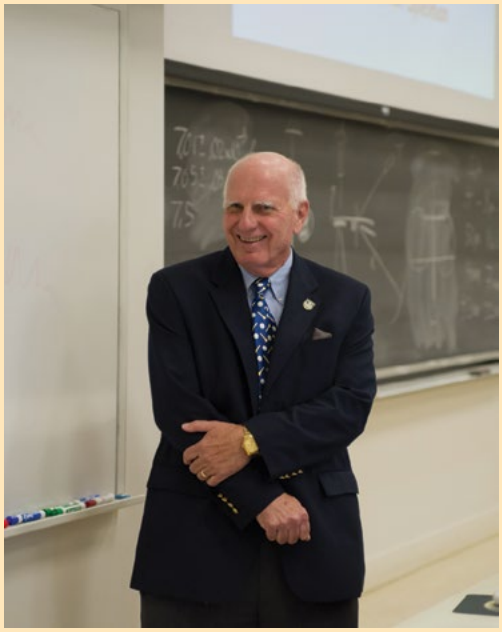
Werner Receives the Clifford G. Shull Prize

Samuel Werner, Curators' Professor Emeritus of Physics, is the recipient of the Clifford G. Shull Prize of the Neutron Scattering Society of America (NSSA) with the citation:

"For his seminal contributions to the observation of the fundamental quantum mechanical nature of spins through the effects of rotation and the gravitational field, using neutron interferometry, including the observation of the Aharonov-Casher effect, for his extensive work with neutron scattering on the magnetic properties of transition metals and their alloys, for his critical role in the NSSA, particularly as its Founding President, and for his wide and lasting influence on the neutron community, including nurturing of many neutron scientists."

The NSSA established the Clifford G. Shull Prize in Neutron Science to recognize outstanding research in neutron science and leadership promoting the North American neutron scattering community. The prize is named in honor of Clifford G. Shull, who received the Nobel Prize in 1994 with Bertram Brockhouse for seminal developments in the field of neutron science.

Werner received the award at the 2018 ACNS in College Park, Maryland, June 24–29, 2018.



Curators' Professor Emeritus of Physics Samuel Werner.

Chen

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The opportunity to work on projects such as this and earn high-ranking journal credits are a key recruiting tool for potential undergraduates and graduate students alike. The researchers get much-needed assistance, while students earn the opportunity to build up their résumés for future employment with a co-author credit in a major journal—a big feather in the cap for both undergraduate and graduate students.

"We set a goal," says Dave Grant, Mizzou engineering career and recruitment coordinator. "When I meet with these students, we set a goal for them, and I talk to Andrew, too. … Andrew has been really good at saying, 'If you come to my lab, we will publish.'"

Good Luck, Marianne!

Marianne Friedman, the department's administrative associate and business support specialist, accepted a well-deserved promotion and new position with the College of Agriculture, Food and Natural Resources at MU on April 1. We will miss the knowledge, skill, guidance, and expertise that kept the department running smoothly for the past 10 years but wish her the very best in her new role on campus.

Alumni Spotlight

By Linda Godwin and Robert Cunningham

Don Packwood is one of our distinguished alumni and a strong supporter of our Department of Physics and Astronomy for many years. He earned his bachelor's degree and master's in physics from the University of Missouri–Rolla, now Missouri University of Science and Technology (MUS&T) in 1963 and 1965, respectively. He began his doctoral work at MU, conducting research in the electronic properties of oxygen vacancies in calcium oxide crystals, and received his doctorate in 1971. This work formed the basis for a successful career at Hewlett-Packard Corporation in semiconductor research and development for a wide range of silicon devices, including computer chips, microwave cell phone chips, and infrared detectors. He retired from HP in 1998 as an engineering manager of integrated circuit process development and manufacturing.

Packwood received an A&S Distinguished Alumni Award in 2004 and also an honorary professional degree in physics from MUS&T. Besides being a founding member of the A&S Strategic Development Board, he is also a founding member and second president of our Physics Leaders.

Packwood has made numerous contributions to the department with his time and talents and has returned for many years for the annual Physics Leaders meeting. He and his wife, Lona, established the Donald & Lona Packwood Endowed Scholarship in Physics, which has provided many undergraduates with assistance in their education at MU. He has also supported our College of Arts and Science and served on that alumni advisory board for many years and continues to do so.

Lona and Don Packwood in front of flat-topped mountain Cerro Pedernal in northwest New Mexico during their 2009 five-week trip exploring southeast Arizona and New Mexico, mostly living in their modified (by Packwood) Toyota truck.

Packwood's hobbies have included a range of outdoor physical activates and travel. Many faculty and friends have heard him relate stories from these adventures. Evidently he has long had the travel and adventure bug as Physics Leader Robert Cunningham recalls:

"In the late 1960s, some of the graduate students had to have a break from physics—from courses, teaching, grading, research, and thesis writing. Their break was exploring, and the Grand Canyon was one of the main targets. Don Packwood, Paul Reichart, Phil Klamm, and Robert Cunningham made the trip. Finding the trail was not easy, the trails had drop offs of hundreds of feet, and the water was so alkaline that it built up on your lips.

Don Packwood holding the winner's trophy at his running club's handicapped (meaning starting time depends on running speed) race in 2016.

"The next year, nine graduate students went on a different Grand Canyon trip. It was rattlesnake heaven. You could hear them rattle as you walked along. One person found a nice ledge to sit down on and came very close to sitting down on a sleeping rattle snake. Along the way, the group found a note about two days old that a father needed help. He had been stung by a scorpion, and his two sons were sick. The students got them back on their feet, and the father left a thank you note on the students' car window that he and his sons had made it out of the canyon in good shape.

"When Packwood moved to California, he and Lona found many trails to follow. Their Christmas letters were always interesting to read because of their many adventures."

We are glad that among his many life adventures, Packwood continues to include our Department of Physics and Astronomy in his priorities, as we are much the better for it.

Physics Leaders 2017 Fall Meeting

By Linda Godwin

The Physics Leaders fall meeting for 2017 was held October 13 and 14. We welcomed several leaders to the department including special guest and Physics Leader **Bill Brinkman.**

In addition to updates on the department by the chair and faculty, new **Assistant Professor Yicheng Guo** explained his research focus and presented "Measuring the Early Growth Chart of Our Milky Way."

During the lunch break, Physics Leaders conducted an informal panel discussion for the benefit of our students with discussion and Q&A concerning their career experiences ranging across academia, government, and industry.

Joe Schaeperkoetter, left, receives congratulations from Physics Leaders Chair David Rainwater and department Chair Sashi Satpathy.

The leaders were pleased to meet with A&S **Dean Patricia Okker** on Friday afternoon to hear about recent events at the university and to discuss issues for the department and College of Arts and Science.

Undergraduates **Pierce Bloebaum, Patrick Mooney,** and **Chandler Osborne** and graduate students **Zachary Buck, Alec Pickett, Joe Schaeperkoetter,** and **Milica Utjesanovic** presented their research to the leaders and faculty on Friday afternoon.

Alumni, faculty, retired faculty, students, and family members gathered at the Reynolds Alumni Center on Friday evening to visit and enjoy the dinner and award presentations.

Graduate student Joe Schaeperkoetter and undergraduate Pierce Bloebaum were recipients of Physics Leaders Awards for their research presentations made earlier in the day. The awards were presented by Physics Leader **Chair David Rainwater.** Schaeperkoetter's presentation was "Adsorption-induced Pore Expansion in Graphene Oxide Frameworks," and Bloebaum presented "Cran- and Acai-berry Synthesized Gold Nanoparticles: Anti-cancer Properties Against Prostate Cancer."

Faculty, students, and alumni attended the department gathering at Reynolds Alumni Center on Friday evening.

Bill Brinkman graciously accepting his alumni award.

Angela Speck and **Suchi Guha** received the Alumni Faculty Fellow Awards sponsored by the Physics Leaders.

For the highlight of the evening, Bill Brinkman, PhD '65, a highly distinguished condensed-matter physicist, was presented a Distinguished Alumni Lifetime Career Award by department **Chair Sashi Satpathy.**

Following the final meeting on Saturday morning, Rainwater and **Vice Chair John Shumway** "passed the gavel" to the newly elected chair and vice-chair, **Vann Priest** and **Shadi Shahedipour-Sandvik.**

PAGSA News

By Sean Fayfar, PAGSA president

Public Outreach

On March 15, 100 students from Rockbridge High School in Columbia, Missouri, visited the physics department at Mizzou where PAGSA members held a booth with interactive displays. These students were able to see introductory physics demonstrations and discuss the physical concepts with graduate students.

On July 18th, PAGSA hosted a two-hour physics segment with MU IGNITES, which is a summer camp for about 20 high school students who are all children of immigrants. The students took a tour of the observatory and had a competition to build the longest candy bridge over a gap.

Journal Club

Journal Club provides students the opportunity to practice giving presentations to their peers in an informal setting and receive feedback on how to improve. Students give presentations that range from physics research prepared for the APS March meeting to topics covering community service opportunities in Columbia. This allows students to focus on developing their presentation skills on any topic imaginable. The presentations from the past academic year included:

Yuanzhe Zhou: "Machine Learning and Convolutional Neural Networks"

Matt Prosniewski: "Effective Networking Strategies" and "Craps, How to not Lose Your Pants"

Travis Hurst: "Research and Productivity Tips from Terence Tao" and "Emergent Gravity: Erik Verlinde's Perspective"

Lisa Shepard: "Evidence for a Flat Earth: Exposing the Round-Earth Hoax"

Griffin Johnson: "The Ethical Knob"

Amrit Bal: "The Physics of Earthquakes"

Alec Pickett: "Oxygen Vacancies in Sol-Gel Processed ZnO Films"

Sean Fayfar: "The Largest 'Useful' Finite Numbers"

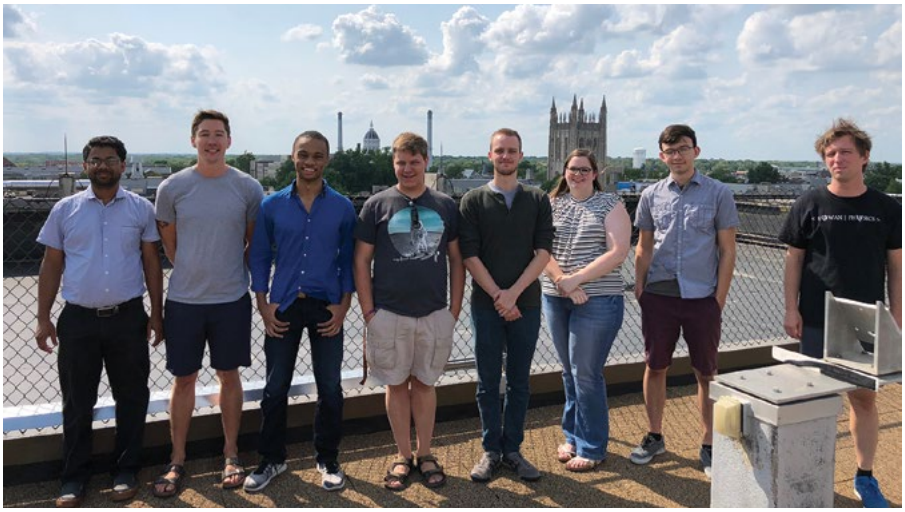
Todd Lombardi: "How Columbia Takes on Homelessness: Catholic Workers"

At Epoch Escapes: Nikki Genovese-Bretana, Alex Bretana, Travis Hurst, Sean Fayfar, Anna Spyrison, and Alyson Heimsath.

Presentations Outside of the Department

Graduate students once again participated in the Graduate Professional Council's Annual Research and Creative Activities Forum where they presented their academic projects to an audience of professors, colleagues, and visiting faculty from other institutions. PAGSA congratulates **George Yumnam, Tu Chattrakun,** and Alec Pickett for receiving first, second, and third place, respectively in the physical sciences category.

Members also attended the annual APS March meeting, which was held in Los Angeles this past year. We had 12–15 graduate students and several postdoctoral fellows who attended and gave presentations on their research. This was a beneficial opportunity for students to view current research in their fields and present their work in a professional setting.



New graduate students, from left: Vishal Jayswal, Ryan Smith, Randy Burns, Jared Williams, Jacob Cook, Sarah Parker, Charlie Winborn, and David Zwick.

Social Events

This past year, PAGSA hosted a few social events for its members. In fall 2017, PAGSA held its annual Welcome Picnic where the new graduate students met with current students and the professors who would be teaching their classes.

The spring picnic was held at the end of the academic year, giving students an opportunity to discuss their progress in classes and research.

A few graduate students participated in an escape room at Epoch Escapes in Columbia. They used their problem-solving abilities to find clues and solve puzzles and escaped with a few minutes remaining. PAGSA hopes to host more of these events in the next year and test its members' ability to solve puzzles and use team work.

Scholarship Recipients

Many scholarships, awards, and other funds have generously been established and supported by our alumni. The students below are the recipients of those funds and awards for summer 2018 and academic year 2018–19.

Undergraduate Students

Donald L. and Lona Lewis Packwood Endowed Undergraduate Scholarship in Physics
Michael Dotzel and Noah Schwartz

Clifford W. Tompson Scholarship in Physics
Sean Burke, Spencer Griffin, Maria Howell, Matthew Snyder
Zach Valleroy

Paul E. Basye Undergraduate Scholarship
Jordan Asmus, Quinn Cunningham, Phillip Hegeman, Tyler Kling, Joshua Miles, Matt Soehngen, Andrew Tait, Sarah Van Hoesen
Jack Weakly

O.M. Stewart Scholarship
Madison Schwinn

Ferguson Fellowship
Johnathan Williams

Laws Scholarship
Savannah Feterl and Tyler Kling

Graduate Students

Harry E. Hammond Prize in Physics
Alex Daykin and Li Lee

O. M. Stewart Scholarship
John Barron, Payal Bhattacharya, Alex Brentana, Kanokporn Chattrakun
Ashutosh Dahal, Alexander Daykin, Sean Fayfar, Jaisen Guo
Rodney Helm, Erica Hroblak, Travis Hurst, James Jones, Scott Kissenger
Ernest Knight, Amrit Laudari, Li Ean Lee, Chenxiaoji Ling
Todd Lombardi, Qiangsheng Lu, Zhiwei Ma, Eddie Maldonado
Alessandro Mazza, Alec Pickett, Anna Pittman, Edward Pluhar
Matthew Prosniewski, Aditya Putatunda, Pratik Kumar Sahu
Katie Schaefer, Lisa Shepard, James Torres, Milica Utjesanovic
Mitchel Vaninger, George Yumnam

Ferguson Fellowship
Matthew Anderson, Randy Burns, Jaisen Guo, Rodney Helms
Amrit Laudari, Alec Pickett, Edward Pluhar, Aditya Putatunda

Gerald Fishman Travel Awards
Matt Anderson, Zack Buck, Tu Chattrakun, Ashutosh Dahal
Jesse Kremenak, Amrit Laudari, Marat Musin, Alec Pickett, Anna Pittman
Eddie Pluhuar, Matt Prosniewski, Joe Shaeperkoetter

Society of Physics Students

By Michael Dotzel, SPS president

The Mizzou chapter of the Society of Physics Students was particularly active during the 2017–18 school year. SPS convened meetings weekly instead of monthly, which saw the regular attendance of MU physics students and enthusiasts alike. The purpose of our increased meeting frequency was to foster familiarity and build camaraderie with one another in the context of informal discussions about physics topics, courses, activities, and summer programs and Research Experience for Undergraduates (REU) for those so motivated.

Our various activities involved a number of staples: creating our own liquid nitrogen ice cream, informal student discussions on physics research and career development, creating and playing with non-Newtonian fluids (e.g. Oobleck), and the occasional science fiction movie night. In addition, SPS hosted a number of student lectures on certain interesting physical topics. Some examples of topics covered in lectures in spring 2018 were dynamical billiards (general theory), the Bunimovitch stadium, and variants of the basic formulation demonstrating such properties as turbulence produced by the Magnus effect, and string theory (including theory of orbifolds, compactification of extra dimensions, and application of formalism to the entropy of black holes and their dimensional density). We hope to increase involvement with the student lectures. While popular with the SPS members and those in attendance, we will encourage more students to give their own talks on physics topics, provided they are thoroughly explained for a more colloquial presentation.

We have participated in a number of new activities. With the MU Math Club, SPS has implemented several

Continues on Page 14

Graduate Student News

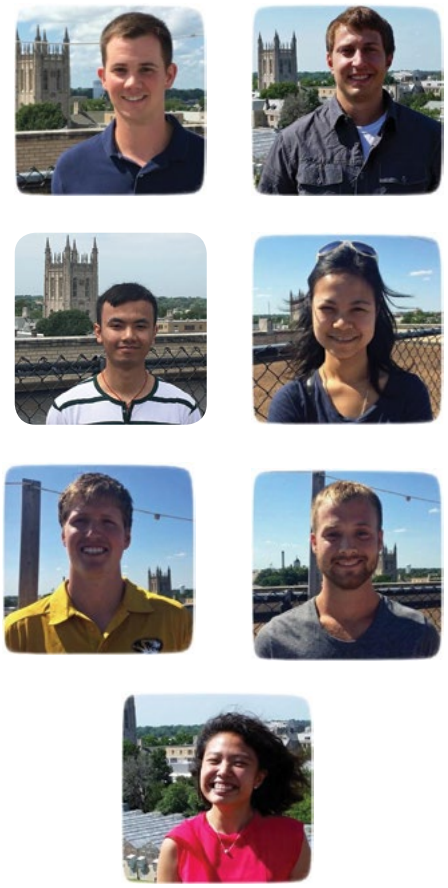
Travis Hurst received the prestigious NSF Graduate Research Fellowship. We believe he is the first student in the history of our department to receive this award. His adviser is **Shi-Jie Chen.**

"His selection for the fellowship was based on his demonstrated potential to contribute to strengthening the vitality of the U.S. science and engineering enterprise. Receiving an NSF Graduate Research Fellowship is a significant accomplishment, and we wish Travis success in his graduate studies, and continued success in achieving his career aspirations" says Chen.

Alec Pickett received an MU Dissertation Year Fellowship Award in a campuswide competition. It is a one-year award that begins this semester. Pickett's advisor is **Professor Suchi Guha.**

Congratulations to **George Yumnam, Tu Chattrakun,** and **Alec Pickett** for receiving first, second, and third place respectively in the category of physical sciences, for their presentations to an audience of professors, colleagues, and visiting faculty from other institutions at the Graduate Professional Council's Annual Research and Creative Activities Forum in March.

The recipients of the Harry E. Hammond Prize in Physics for best teaching assistant (TA) were **James Jones** and **Tu Chattrakun** for fall 2017 and **Alex Daykin** and **Li Lee** for spring 2018. This award is given to graduate students for their excellence in undergraduate teaching and going out of their way to help students excel in physics. Teaching assistants work as lab instructors, classroom assistants, discussion instructors, or as head TA, which is a position that includes supervising other TAs and working closely with the students and professor.



Graduate students, left to right, Travis Hurst, Alec Pickett, George Yumnam, Tu Chattrakun, James Jones, Alex Daykin, and Li Lee.

SPS

Continued from Page 13

intra-club competitions such as the Integration Bee, the Series Bee, and the Order-of-Magnitude Competition. Last year's president, **Patrick Mooney,** arranged for a visit to the Museum of Art and Archaeology to learn about archaeometry and the role physics and chemistry play in determining the age/composition of artwork of several centuries or millennia ago.

SPS hopes to reach out to local high schools to give colloquial physics presentations to students and to field questions regarding undergraduate research/coursework/physics. Notably, SPS has arranged (via contact through **Professor Paul Miceli**) for a trip to Argonne National Laboratory for this fall.

The main goal of SPS for this year is more fun, cohesive, and consistent integration of physics into the mindsets of both its members and students/enthusiasts at Mizzou and in Columbia. I believe that the combination of the above, along with occasional hands-on activities to demonstrate particularly powerful physics notions, will serve this purpose brilliantly.

SPS, from left: Lucas Chandler, Philip Hegeman, Patrick Mooney, Chandler Osborne, Michael Dotzel, Sarah Van Hoesen, and Blake Gohmann.

Congratulations, Graduates!

Fall 2017 PhD in Physics

Sean Baldridge
Nagaraju Chada
Shahrzad Karimi
Mohammad Madhi Valizadeh

Spring 2018 PhD in Physics

Zachary Buck
Hannah Groom
Soma Khanra
Gregory (Scott) Kissinger
Jesse Kremenak
Zhiyuan Ma
Marat Musin
James Runge
Joe Schaeperkoetter
Brook Summers

Fall 2017 MS in Physics

Sean Baldridge (received concurrently with his doctorate)

Spring 2018 MS in Physics

Griffin Johnson

For reference: To receive Latin honors from the College of Arts and Science requires at least 54 of the student's last 60 hours to be from MU and:
3.7–3.799 GPA for cum laude
3.8–3.899 GPA for magna cum laude
3.9–4.0 GPA for summa cum laude
Department honors requires > 3.5 GPA in physics courses, completion of six credit hours of research, and a publication or presentation (oral or poster).
A certificate of general honors from the MU Honors College requires students to complete 24 hours of courses for honors credit and maintain a 3.5 cumulative GPA.

Fall 2017 BS in Physics

Zachary Jermain, *summa cum laude*
Richard McClure, *magna cum laude*

Spring/Summer 2018 BS in Physics

Amrit Kaur Bal, *certificate in general honors*, *department honors*
Samuel James Barker
Pierce Lee Raskas Bloebaum, *cum laude*, *department honors*
Michael Robert Buikus
Nicholas Patrick Corkren, *emphasis in astronomy*
Matthew David Graham, *summa cum laude*
Romanus Joshua Hutchins
Kein Christopher Kelly, *emphasis in astronomy*
Kylie Suzanne Kollmeier, *emphasis in biophysics*
Jessica Laura Lucero
Patrick Michael Mooney
Chandler Todd Osborne, *cum laude*, *emphasis in astronomy*
Sarah Virginia Poor
Abrianna Porter
John Michael Rogers
Adam Dudley Smith, *department honors*, *emphasis in material science*
Abigail Catherine Warden, *summa cum laude*, *certificate in general honors*, *department honors*

Spring 2018 BA Physics

Zeb Joseph Charlton, *cum laude*

Doctoral graduates and their professors. Front: Suchi Guha, Brock Summers, Soma Khanra, Hannah Groom, Joe Schaeperkoetter; back: Paul Miceli, Carlos Wexler, Jesse Kremenak, James Runge, Zachary Buck, Gregory (Scott) Kissinger, Marat Musin, and Helmut Kaiser.

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Editorial Office
Department of Physics and Astronomy
223 Physics Building
Columbia, MO 65211
Phone: 573-882-3335
E-mail: umcasphysics@missouri.edu
Web site: physics.missouri.edu

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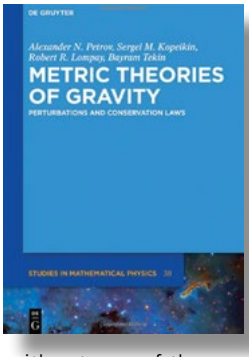
The department appreciates hearing from alumni and friends. Send announcements or milestones to the address listed above.

Book Corner



Alexander N Petrov, Sergei M Kopeikin, Robert R Lompay, and Bayram Tekin. Metric Theories of Gravity: Perturbations and Conservation Laws. *Mathematical Physics* 38. De Gruyter.

Sergei Kopeikin has written and published a book, *Metric Theories of Gravity,* on the conservation laws in metric theories of gravity with a team of three co-authors from Russia, Ukraine, and Turkey (Petrov, Lompay, and Tekim). This monograph aspires to give a unified description and comparison of various ways of constructing conserved quantities for perturbations and to study symmetries in general relativity and modified theories of gravity. The main emphasis lies on the field-theoretical covariant formulation of perturbations, the canonical Noether approach, and the Belinfante procedure of symmetrisation. The general formalism is applied to build the gauge-invariant cosmological perturbation theory, conserved currents, and superpotentials to describe physically important solutions of gravity theories. The book has been published under the De Gruyter series *Studies in Mathematical Physics,* which is devoted to the publication of monographs and high-level texts in mathematical physics.

The book is available on Amazon.

Congratulations, Undergrads!

Physics and astronomy undergraduates, May 2018. From left, front: Amrit Bal, Dr. Silvia Bompadre, Abigail Warden Sarah Poor; back: Chandler Osborne, Pierce Bloebaum, Patrick Mooney, Adam Smith, and Romanus Hutchins.