Missouri University of Science and Technology
Physics Department

Matter 'n Motion

March 2015

For alumni, friends, faculty, and staff of the MSM-UMR-Missouri S&T Physics Department

Physics Students Achieve Nuclear Fusion

A team of three undergraduate students from Missouri University of Science and Technology have achieved nuclear fusion of deuterium into helium. The reaction was achieved as part of the students' final project for their senior research laboratory class.

Missouri S&T students **Brock Ebert**, **Sheldon Harper** and **Jaykob Maser** constructed an inertial electrostatic confinement device where deuterium-2, a type of hydrogen that has an extra neutron attached to the nucleus, was heated to the point that the nuclei overcame electrical repulsion, collided and fused. The collision bound them together to form a new nucleus of helium and a neutron.

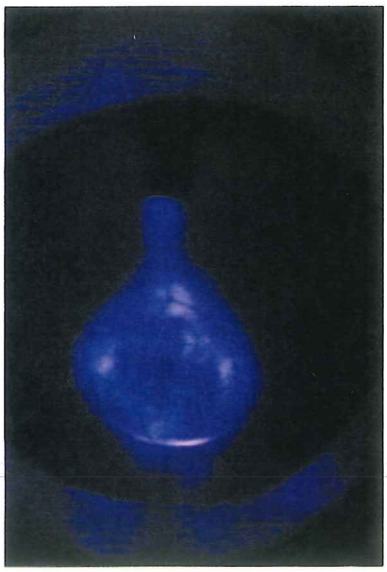
In the students' device, the deuterium atoms were ionized and then accelerated by a potential difference between two grids. A few thousand volt potential difference can produce ions with kinetic energies equivalent to temperatures of tens of millions of degrees, so this is an example of a "hot fusion" device. This nuclear fusion reaction is the same process as the one that powers the sun.

The students, working under the supervision of Dr. **Greg Story**, associate professor of physics, confirmed that they had achieved fusion by detecting the production of the neutrons. The three students conducted the semester-long research project in collaboration with the nuclear engineering department and the Missouri S&T Nuclear Reactor Facility faculty and staff.

"I never thought it would happen because the experiment is so complicated," says Story. "It is an incredible accomplishment for undergraduate students who built their apparatus entirely on their own. Now that they have achieved fusion, their next goal is to try to optimize the process by adjusting things like the pressure of the gas in the plasma."

Ebert, Harper and Maser, all seniors in physics, met in a pre-college prep course and have remained friends since then. They all plan to attend graduate school once they graduate from Missouri S&T.

Sheldon Harper, Brock Ebert, and Jaykob Maser (left) and their fusion device (below)



In this issue:

Memo from the Chair

This past year we welcomed a new administrative structure with the hiring of a new Provost, Dr. **Robert Marley**, and two new Vice Provost/Deans for our new colleges of Arts, Science, and Business, and of Engineering and Computing. The new Deans are Dr. **Stephan Roberts** for the College of Arts, Science, and Business, and Dr. **Ian Ferguson** for the College of Engineering and Computing. In addition, the Physics Department welcomes two new faculty members, Drs. **Cihan Kurter** and **Daniel Fischer**. We are delighted to have them join the department, and look forward to the new enthusiasm and exciting research expertise they bring. Cihan is profiled in depth later in this newsletter, and Daniel, who joined us in January 2015, will be the subject of an article in next year's newsletter. Finally, **Richard Sankovich** retired after 37 years of service, and has been hired back part-time to continue to oversee lecture demonstrations. Rich will also be profiled in next year's newsletter.

This year was another outstanding year for faculty achievements. Profs. **Yew San Hor** and **Thomas Vojta** received Faculty Research Awards, and Prof. **Greg Story** received a Faculty Teaching Award. Prof. Hor was also recognized by Thomson Reuters as one of the most highly cited scientists (all fields) in the past decade for his seminal work on topological insulators and superconductors. He was the only faculty member at Missouri S&T to be so recognized. Prof. Story also won an Outstanding Teacher Award. **Alexey Yamilov** was promoted to Associate Professor with tenure. Prof. **Julia Medvedeva** was named Senior Investigator at the Materials Research Center, and Prof. **Don Madison** was named a Distinguished Referee by the European Physical Journal.

Not to be outdone, our students also had an outstanding year. Over 85% of our majors graduated with honors, and over 60% of our undergraduate majors were named to the Academic Scholars List. Graduate student **Hatem Barghathi** was one of four finalists for the American Physical Societies Topical Group on Statistical and Non-linear Physics Student Speaker Award. **Krista Limmer** (Materials Science and Engineering) and **Hari Chaluvadi** placed first and second respectively in the 2014 Missouri S&T Council of Graduate Students Research Showcase. Krista is advised by Prof. Julia Medvedeva, and Hari by Prof. Don Madison. These and more stories of student and faculty accomplishments can be found elsewhere in this newsletter.

Thanks to your generosity, our department was able to acquire $100,000 for upgrading our teaching laboratories. Half of this money came from donations to the department and half from university funds. This money will allow us to begin to address serious issues of dated and poorly functioning equipment in our teaching labs. We are extremely grateful for the financial assistance, but remind you that laboratory maintenance and upgrade is an ongoing process, and one that requires constant support. Please continue to consider designating some or all of your phonathon or departmental contributions to laboratory funds so that our students can benefit from an improved laboratory environment.

I want to thank all of you for your continued and generous support. The department clearly is doing well, and this is primarily due to the quality and dedication of our faculty, students, staff, and alumni.

– Dan Waddill

Dan Waddill

Endowments: Gifts that Continue to Give

Many generous donors have found that creating an endowment, a fund established with cash, securities or other assets which provides income in perpetuity, offers a significant, long-term impact on Missouri S&T. Endowments can be unrestricted or restricted for a specific purpose such as scholarships, department programs, faculty support, etc. Endowments can be started with as little as $15,000 and additional funds can be added at any time in the future.

The Missouri S&T Physics Department has several donors that have been adding to their endowment for several years, including endowments established by **Ed** and **Mary Sue Sickafus**, and by the estates of **Richard Anderson** and **Richard Hannum**. Our most recent endowment came from **John** and **Patty Rogers**.

The ongoing nature of an endowment provides a way to support your alma mater and give them the financial strength to do things that might not otherwise be possible. If you want to learn more about the Missouri S&T endowment program and how you can participate, please call 1-800-392-4112, or e-mail *giving@mst.edu*.

Physics Department Awards 2014-2015 Scholarships and Fellowships

The following scholarships have been endowed through the generous gifts of the friends of the Missouri S&T Physics Department. Please contact the Physics Department if you would like to add to the endowment fund of these scholarships or would like to establish a new one.

The ***Dr. John R. and Patty Rogers Endowed Scholarship*** provides scholarships to academically proficient physics majors who demonstrate financial need. The 2014-2015 Rogers scholarship were awarded to **Trenton Briggs** from Strafford, Missouri; **Victoria Kraemer** from Richland, Missouri; and **Brendan Hruby** from Maryland Heights, Missouri.

Recipients of the ***Harold Q Fuller Scholarship-Loan*** were **Paul Somers** from Springfield, Missouri; **Nicholas Beebe** from Rolla, Missouri; **Giannino Lusicic** from Ballwin, Missouri; and **Joshua Sutter** from Florissant, Missouri. This scholarship-loan was endowed by the late Dr. **Harold Q Fuller**, chair of the Physics Department from 1948 to 1970 and former Dean of the College of Arts and Sciences, to recognize outstanding achievements among juniors and seniors in physics. One quarter of the scholarship is an interest-free loan that students begin to repay when they start their first jobs.

The recipient of the ***Burke H. Miller Memorial Scholarship*** was **Cory Karle** from Saint Charles, Missouri. This endowed scholarship was established by the Miller family to commemorate the academic achievements of their son, **Burke**, who graduated with a bachelor's degree in physics in 1969 and later died during the Vietnam War. The award is for promising and dedicated students in physics.

Wyatt Parsons from New Haven, Missouri; **David Owen** from Saint Louis, Missouri; and **Juan Remolina** from Saint Charles, Missouri were awarded the ***Ed and Mary Sue Sickafus Endowed Scholarship/Fellowship***, established by **Ed** (BS '55, MS '56) and **Mary Sue Sickafus** in conjunction with the Ford Motor Company and awarded to physics students on the basis of their performance at Missouri S&T.

David Owen from Saint Louis, Missouri and **Juan Remolina** from Saint Charles, Missouri received the ***Leon E. Woodman Memorial Scholarship***. This scholarship was established by the Woodman family in honor of Dr. **L. E. Woodman**, Chair of the Physics Department from 1919 to 1948. It is offered to students in physics who are of good moral character, maintain a satisfactory grade point average, and are in financial need.

The ***Richard W. Hannum Endowed Development Fund*** was established through a bequest by **Richard Hannum** (PhD '66). The fund is currently used to provide scholarships for outstanding students in Physics. **Joshua Sutter** from Florissant, Missouri received the Hannum Scholarship for 2014-2015.

The ***Richard Anderson Scholarship Fund*** is an endowment established in memory of Dr. **Richard Anderson**. **Katherine Overend** from Lansing, Kansas and **Sawyer Scheer** from Hamilton, Ohio received the Anderson Scholarship for 2014-2015.

In addition to endowed scholarships, which are usually awarded to juniors and seniors, the department awards special ***Physics Department Scholarships***, funded from the annual phonathon and development fund, to students who earn a grade point average of 3.5 or higher. This past year, these scholarships of were awarded to **Nocona Kyle Sanders** from Poplar Bluff, Missouri; **Robert Branson** from Butler, Missouri; **Jason Mao** from Springfield, Missouri; **Mason Proffitt** from Saint Louis, Missouri; **Patricia Huestis** from Abilene, Texas; **Alexander Mark** from Manchester, Missouri; and **Clayton Craig** from Manchester, Missouri.

Additional department scholarships were awarded to **David Gillcrist** from Kansas City, Missouri; **Austin McCoy** from Lynchburg, Missouri; **Rachel McCormick** from Maryland Heights, Missouri; **Sawyer Scheer** from Hamilton, Ohio; and **Cory Karle** from Saint Charles, Missouri.

Report from the SPS

2014 was another outstanding year for SPS.

The year began with election of new officers for the semester. Except that no new officers were elected because all of the Fall 2013 officers retained their positions. **Nelson Shreve** was re-elected President, **Frank Marshall** Vice President, **Andrew Cudd** returned as treasurer, and **Josey Stevens** continued as secretary.

Spring activities included the usual game and movie nights, and GRE review sessions. SPS heard talks by Physics Professors **Paul Parris** and **Barbara Hale**. SPS ran several events at the regional Science Olympiad competition in February, and members served liquid nitrogen ice cream to 70 students, as well as their parents and siblings, at Rolla Middle School's Family Fun Night. SPS debuted its quantum locking train, and of course the semester closed with the mandatory liquid nitrogen ice cream celebration.

The fall 2014 semester began with elections and a new roster of officers. Josey Stevens was elected President, **Allison Smith** became Vice President, **Katherine Overend** was elected Secretary, and **Rachel McCormick** assumed the duties of Treasurer.

In addition to more movie and GRE review nights, fall SPS meetings included Professor **Dan Waddill's** annual talk on "How to get into graduate school." Fifteen SPS members made the trek to Argonne National Laboratory for the undergraduate research conference. SPS finalized its new constitution, and heard a talk by Mathematics Professor **David Grow** on tensor analysis, and a talk by Economics Professor **Greg Gelles**, who seems to spend as much time thinking about black holes and dark matter as he does ecnomics. As you can predict by now, the fall semester closed with the now-mandatory liquid nitrogen ice cream party.

Alumnus **Mark Herrera** (BS '08) and several others created a Facebook page for S&T Physics Graduates. All alumni are invited to join https://www.facebook.com/groups/mstphysics/.

SPS thanks alumni who have made events like the Argonne trip possible through their donations at the Physics phonathon.

Yew San Hor CAREER Grant

Professor **Yew San Hor** recently received the National Science Foundation's most prestigious award for young faculty members for his condensed matter research and physics education and outreach.

Yew San (left) and Yunsheng Qiu (right, BS'14)

Hor received the NSF's Faculty Early Career Development CAREER Award, the "most prestigious award in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations."

A member of the Missouri S&T faculty since 2010, Hor will use the CAREER Award funding to continue his research on growing new topological insulator and superconductor crystals and exploring surface properties of these materials. Topological insulator surfaces contain electrons with unusual spin transport properties. The surface current flows without dissipating, while the interior of the material prevents the flow of current. Coupled with a superconductor, topological insulators could be used to create fault-tolerant quantum computers.

According to Hor, condensed matter and particle physicists also believe the study of topological insulators will help in the search for Majorana fermions, which could be key to solving quantum computing applications. The research might also help to confirm the existence of axions, hypothetical particles that may provide clues to the mystery of dark matter in the universe.

Hor also expects to continue to develop a course that debuted in 2013 at Missouri S&T. The course integrates basic concepts with experimental techniques in condensed matter physics.

"I'd like to show students that physics is in their daily lives," says Hor. "Learning about it makes them good problem-solvers and creative thinkers. It requires some imagination."

Hor will receive $538,000 in CAREER funding over five years to continue his research. The award took effect on April 15, 2013.

Rastko Sknepnek

Alumnus **Rastko Sknepnek** (PhD '04) recently moved to Scotland in the UK to join the faculty of the University of Dundee as a Lecturer (equivalent to an Assistant Professor in the US). He also holds a prestigious Dundee Fellowship which provides extra support for his research program.

Rastko obtained his PhD in 2004 working with Prof. **Thomas Vojta**. After that, he was a postdoc at McMaster University in Canada and at Ames Laboratory in Iowa. There, his research interest shifted to soft matter and biophysics. He further explored this area at Northwestern University and the University of Syracuse before accepting a faculty position in Dundee in summer of 2013.

Dundee is a city of about 150,000 people which dates back to a charter by King William in the 12th century. It is located in the eastern Lowlands of Scotland on the north bank of the Firth of Tay, which feeds into the North Sea. The university was founded in 1881 as University College, Dundee. After gaining its independence from the nearby University of St. Andrews in 1967, the university has grown to become an internationally recognized research university.

Rastko reports that he is settling in well and that he really loves his new home. Rastko looks forward to building his research program focusing on topics such as biological and artificial membranes, active self-propelled particles, and DNA-guided assembly of materials. He also plans to teach a Computational Physics class similar to the one he took at S&T. Rastko is also happy to report that he managed to solve his "two-body problem." His wife, **Soko Matsumura** who is an astrophysicist, also got a faculty position at Dundee.

Rastko's office is in the lower right corner of the Harris Building, pictured below. Congratulations to S&T Physics major **Robert Branson** for answering the challenge in last year's newsletter by being the first to correctly identify the building.

Congratulations to S&T's 2014 Physics Degree Recipients!

May 2014

Bachelor of Science

Derek Murphy Anderson
Andrew Bruce Cudd
Christian Kenneth Dzurny
Timofey Golubev
Nicholas Ryan Hugenberg
Yunsheng Qiu
Jaimie Shelton

Master of Science

A Tiat Alsaaideh
Anthony Bonnes
Simin Khatibi

Master of Science Teaching

Amanda Celina McBee

Doctor of Philosophy

Adam David Scott

December 2014

Bachelor of Science

Zachary Erik Burgdorf
Ian Nicholas Denaro
Brock Alan Ebert
Scott Alan Ketcherside
Jaykob Neil Maser

Master of Science

Sultan Saleh Alhassan
Khulaif Naif Alshammari
Majed Mutlaq Alshammari
Jonathan Howard Noble
Thusitha Priyantha WK Arthanayaka Mudiyanseleage

Doctor of Philosophy

Sachin Sharma

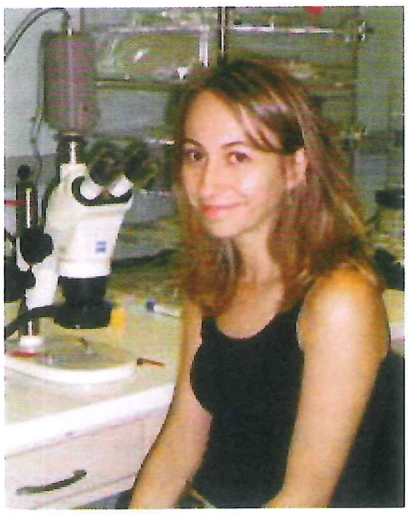
To Contact S&T Physics

If you would like to contact us for any reason, you can reach us by phone at **(573) 341-4781** and by e-mail at **physics@mst.edu**. You might also be interested in checking out our web page, *http://physics.mst.edu*.

New Faculty Cihan Kurter

Cihan Kurter grew up in Izmir, Turkey, one of the the oldest settlements of the Mediterranean basin. After receiving her MS degree in Physics in Turkey, she moved to Chicago in 2005 to study for her PhD at Illinois Institute of Technology. She says that after Izmir, Chicago felt so exotic; how interesting it was to wake up to a covering of snow for the first time in her life.

Cihan's PhD work began as point contact tunneling spectroscopy studies of cuprates and unconventional superconductors. However, she soon started to collaborate with colleagues at Argonne National Laboratory and got involved in various projects in the materials science division. Her graduate research there was primarily on detecting coherent and tunable terahertz (THz) radiation from high temperature superconductors. Due to their layered structure, these materials naturally form stacks of Josephson junctions. Application of an external dc-voltage along the stack direction leads to high frequency oscillations spanning a frequency band in the electromagnetic spectrum known as the THz gap.



Cihan's project was not only the first experimental demonstration of a solid state THz source utilizing the Josephson effect, but also improved the quality factor and radiation power of the THz emission reported earlier with semiconductors. The latter is extremely important for practical applications in sensing, imaging and spectroscopy across the physical and biological sciences.

In 2009 she moved to College Park for postdoctoral research at the University of Maryland, followed by a second postdoc at the University of Illinois in 2011. Cihan says she benefited from both postdocs significantly and gained a lot of experience. At the University of Maryland, she had a chance to merge superconductivity into metamaterials, which are subwavelength structures smaller than the waves they propagate, and which create an effective medium for electromagnetic waves. Metamaterials can have a negative refractive index which is especially sensitive to ohmic losses. The use of superconductors in metamaterial devices can not only minimize the ohmic losses, but also eases the tunability. Metamaterials can be a true route to achieve some fantastic-sounding proposals such as flat lenses or invisibility cloaking devices.

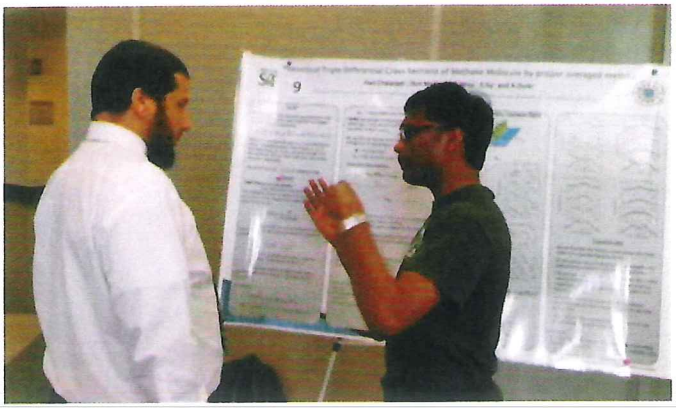
At Illinois, Cihan studied topological insulator/superconductor hybrid structures, which potentially host zero energy bound states, known as Majorana fermions. A pair of Majorana modes defines a two-level system, i.e. a qubit which can store and process quantum information non-locally through its non-abelian exchange statistics; therefore they are key components in developing a fault-tolerant topological quantum computer.

In August 2014, Cihan became an assistant professor in the Missouri S&T's physics department. She plans to develop topological systems that could include Majorana modes, and continue her study of metamaterials along with new materials or hybrids.

Chaluvadi Receives Graduate Research Showcase Award

Congratulations to **Hari Chaluvadi**, advised by Professor **Don Madison**, who won second prize in the 2014 *Graduate Research Showcase* morning session. The title of Hari's poster was "*Theoretical triple differential cross sections of methane molecule by proper averaged method.*"

There were 64 student participants in the Graduate Research Showcase. Their posters were judged by Missouri S&T faculty and staff. **Krista Limmer**, the first place winner, while not a physics student, was advised by Professor **Julia Medvedeva**.



Hari Chaluvadi

Dan's Birthday

It has long been a newsletter tradition to use this space to celebrate a prank, typically executed by undergraduate physics majors, in honor of department chairman **Dan Waddill**.

Now that's just cruel.

So this year, to break that tradition, we remember Dan's birthday in 2014 with pictures of birthday-present sports memorabilia celebrating the feats of his last-place Boston Red Sox.

Construction Zone!

During the first nine months of 2014, the Physics building became a construction site while it underwent renovation of its heating and cooling systems in preparation for connection to Missouri S&T's geothermal energy system.

During those months, Physics faculty and staff were temporarily relocated to various buildings across campus.

On completion of the geothermal project the university's power plant was decommissioned. The Physics building's heating and cooling needs are now met by campus geothermal plants.

The picture below shows the second floor hallway, looking west, at the height of the renovation.

Alumni Notes

We need your stories to liven up our newsletter! Unfortunately, anything we might have received on paper disappeared during our 2014 construction shuffle.

Please send us your stories, pictures, and musings for our 2016 newsletter. The best way to do this is by email to *physics@mst.edu*.

Outstanding GTA's

This past year we again presented graduate teaching awards to honor the outstanding accomplishments of our graduate teaching assistants. The awards are determined by a combination of student evaluations and teaching performance assessed by the faculty overseeing the teaching laboratories. The 2014 winners were **Susmitha Akula**, **A Tiat Alsaaideh**, and **Nishshanka DeSilva**. Congratulations to all the winners for helping to advance the department's commitment to excellence in teaching.

Barbara Hale receiving Chi Omega award

Faculty Recognized With Awards

Professor **Greg Story** was selected yet again as one of Missouri S&T's outstanding teachers. Greg was one of 36 S&T faculty to receive an Outstanding Teaching Award, which is given each year to faculty members based on student teaching evaluations. Greg was also one of eight S&T faculty to receive a 2014 a Faculty Teaching Award. This $1000 award is given to faculty who "have demonstrated excellence in teaching and teaching-related activities."

Professors **Thomas Vojta** and **Yew San Hor** who both received Faculty Research Awards for 2014. They represented two out of the eight S&T faculty who received this $1000 award for demonstrating excellence in research during the previous two years.

Professor **Barbara Hale** received a Chi Omega Lifelong Service Award, presented at the national Chi Omega convention in Orlando FL. June, 2014. Some of Barbara's accomplishments include helping to found the Rolla Chi Omega chapter in 1979; advising the chapter every year since; serving as House Corporation treasurer for the Rolla chapter for 28 years; helping purchase the chapter house, home to 48 student members; serving on the National Chi Omega scholarship selection committees; serving as House Corporation treasurer for the Syracuse University Chi Omega chapter house; saving the Syracuse chapter house for future generations; and being a Chi Omega for 57 years. Barbara also won the Missouri S&T Greek Advisor Award in 2014.

Professor **Bob DuBois** was one of the two recipients awarded honorary membership to the Roland Eötvös Physical Society in Hungary (the Hungarian equivalent of the American Physical Society) in 2014. Bob has collaborated with scientists at the Institute for Nuclear Research of the Hungarian Academy of Sciences (ATOMKI), located in the city of Debrecen since the 1980's. Bob was presented his membership in November when he gave a talk at the Hungarian Academy of Sciences in Budapest.

Congratulations to 2014 Physics Academic Scholars

Students who maintain at least a 3.50 GPA for twelve hours or more of coursework are honored for their outstanding accomplishment by being named Academic Scholars.

Spring Semester 2014

Derek Anderson, Robert Branson, Clayton Craig, Jack Crewse, Andrew Cudd, Christian Dzurny, David Gillcrist, Timofey Golubev, Patricia Huestis, Nicholas Hugenberg, Howard Johnson, Cory Karle, Giannino Lusicic, Jason Mao, Alexander Mark, Rachel McCormick, Katherine Overend, David Owen, Wyatt Parsons, Mason Proffitt, Yunsheng Qiu, Juan Remolina, Anna Sakach, Kyle Sanders, Nelson Shreve, Owen Smith, Paul Somers, Joshua Sutter, Brandon Yokeley.

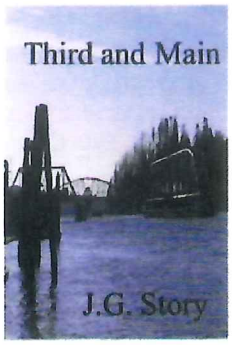
Fall Semester 2014

Rachel Birchmier, Robert Branson, Albert Chua, Jacob Cook, Clayton Craig, Brian Ford, David Gillcrist, Kent Gorday, Patricia Huestis, Jacob Hume, Casey Jameson, Cory Karle, Aaron Lemmermann, Jason Mao, Alexander Mark, Jaykob Maser, Joshua Maxwell, Rachel McArthur, Rachel McCormick, Kathryn McNabb, Jack Moore, Sara Newman, Wyatt Parsons, Mathew Pollard, Mason Proffitt, Juan Remolina, Kyle Sanders, Sawyer Scheer, Nelson Shreve, Paul Somers, Josey Stevens, Joshua Sutter, Skye Tackkett, Alexander Watson

Third and Main

People who return to a small town after 20 years away may not find the local shops they expect to see, but they can easily identify the landmark buildings. A new book by Professor **Greg Story** contemplates the changes that occur to small town buildings and the way those buildings' roles change over time.

Story's novel, "*Third and Main*," was unveiled at a launch party last May at the Public House Brewery, located at 600 N. Rolla St., in Rolla.



The novel, published through Bookmasters, tells of the reincarnations of a certain building on the corner of Third and Main streets in a fictional Oregon-coast town, and the people that impact the building as they come and go. Story, himself a character in the novel, learns the history of the building and comes to better understand the town as a whole through his discoveries.

"I was inspired by downtown Rolla and Pine Street," explains Story. "I was looking through a Rolla history book and realized that the buildings all look the same as they did 50 years ago on the outside, but there have been a dozen different companies operating in them during that time."

"Third and Main" is the sixth novel Story has written, but the first one he has published. He hopes it will not be the last one to reach the public. His wife, **Lisa**, took the cover image.

"I really enjoy the creative process and the editing that goes into writing a book," says Story.

Story earned a bachelor of science degree in physics from the University of Oregon and a Ph.D. in physics from the University of Southern California in 1984 and 1989, respectively. In 1994, he joined faculty at Missouri S&T, where he teaches quantum mechanics and laser physics.

Following the launch party, Story, who is also a local musician, performed in concert on the Public House stage. He performs the first Friday of each month, playing a variety of instruments, including guitar, mandolin and banjo among others.

Frank Marshall Leads Mars Landing Team

Physics major **Frank Marshall**, along with another Missouri S&T student and a recent S&T graduate were part of a team that was selected as a finalist to design part of a Mars landing mission in 2018.

The MARA-DS team, comprised of five students from four universities, was one of 10 finalists who proposed a Mars mission payload as part of Mars One's University Competition. The payloads had to be deemed feasible and meet all requirements and restrictions as outlined by Lockheed Martin, the company that will build the 2018 unmanned Mars lander.

The team's project, "*MARA-DS: Material Radiation Degradation Study*," was designed to protect human explorers on Mars from hazardous cosmic rays and solar radiation. The team planned to develop instrumentation to record the energy and impact of galactic cosmic ray and solar particle concentration level changes on the surface of Mars.

The payload would establish a baseline control for the radiation environment and measure the massed radiation changes. The collected data would help future explorers develop structures that shield them from radiation.

The other MARA-DS team members were current Missouri S&T student **Ian Lee**, **Michael Bouchard**, who earned a BS degree from Missouri S&T in 2014, **Nick Orenstein**, a Ph.D. student at University of Southern California, and **Charles Parrish**, an undergraduate at North Carolina State University. The team's faculty advisor was Dr. **Robert Binns**, Research Professor of Physics at Washington University in St. Louis.

You can read about the mission that eventually won the competition at mars-one.com.

In addition to working on the MARA-DS team, Frank is involved in undergraduate research in Fourier transform microwave spectroscopy and is an active member on the Missouri S&T Mars Rover Design Team, where he has served as the Interim Chief Technical Officer among other positions. In 2014, S&T's Mars Rover finished second among finalists from 23 universities representing 7 different countries in the University Rover Challenge.

S&T's Mars Rover, presented by Chancellor Cheryl B. Schrader

The Physics Department gratefully acknowledges the support of the following alumni and friends.

Donations over $100:

Harro Ackermann
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Gerald Wilemski
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Kyle Williams
David J. Wolters
Paul C. Yue

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Melva Crocker
Richard L. Dalrymple
Vibhakar R. Dave
David L. Dotson
Kevin B. Edwards
Suzanna Edwards
Carol V. Hanrahan
John A. Hocken Jr.
Theodore C. Huff
Jared F. Hund
Leonard A. Huneke
Harris C. Jones
Amanda Kinney
Ryan Kinney
Terrence A. Leigh
Suzanna Long
Hulen H. Luetjen
Havva Malone
Joel W. Mansell
Kanishka Marasinghe
Madhavi Marasinghe
Daniel B. Marsh
John W. McGuire
William Meyer
Steven A. Mezines
Christian G. Michel
Harvey P. Nixon
Frank L. Ollinger
Larry D. Oppliger
Raymond E. Paul
Donald G. Rathbun
Emmett R. Redd
John R. Reiter
Gena C. Robertson
Gary S. Sammelmann
Richard S. Schwentker
Morgan P. Slusher
James G. Smith
Zachary Stegen
Kenneth M. Stephens
Michael X. Strebler
James J. Strohmeyer
Terry R. Tucker
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Gary K. Woodward
Gary G. Wooley

Physics Department Acknowledges Corporate Support

The Physics Department gratefully acknowledges the support of the following corporations:

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Missouri University of Science and Technology Students & Alumni: In Press

The following journal articles which appeared over the last year feature work by Missouri S&T undergraduate students,[1] graduate students,[2] or alumni[3] under the supervision of Missouri S&T faculty.

"*Controlling diffusion inside a disordered nanophotonic waveguide using geometry*," R. Sarma, T. Golubev,[1] A. Yamilov, and H. Cao, Appl. Phys. Lett. **105**, 041104 (2014).

"*Probing long-range intensity correlations inside disordered photonic nanostructures*," R. Sarma, A. Yamilov, P. Neupane,[2] B. Shapiro, and H. Cao, Phys. Rev. B **90**, 014203 (2014).

"*Position-dependent diffusion of light in disordered waveguides*," A. Yamilov, R. Sarma, B. Redding, B. Payne,[3] H. Noh, and H. Cao, Phys. Rev. Lett. **112**, 023904 (2014).

"*Dynamical (e,2e) studies of tetrahydropyran and 1,4-dioxane*," J. D. Builth-Williams, G. B. da Silva, L. Chiari, D. B. Jones,[3] Hari Chaluvadi,[2] D. H. Madison, and M. J. Brunger, J. Chem. Phys. **140**, 214312 (2014).

"*Theoretical triple differential cross sections of methane molecule by proper averaged method*," Hari Chaluvadi,[2] C. G. Ning and D. H. Madison, Phys. Rev. A **89**, 062712 (2014).

"*Fully differential cross sections for electron impact excitation-ionization of aligned D_2*," E. Ali,[2] A. L. Harris,[3] J. Lower, E. Weigold, C. G. Ning, and D. H. Madison, Phys. Rev. A **89**, 062713 (2014).

"*Theoretical and experimental investigation of (e,2e) ionization of argon 3p in asymmetric kinematics at intermediate energy*," S. Amami, M. Ulu, Z. N. Ozer, M. Yavuz, S. Kazgoz, M. Dogan, O. Zatsarinny, K. Bartschat, and D. H. Madison, Phys. Rev. A **90**, 012704 (2014).

"*Effect of the center-of-mass approximation on the scaling of electron-capture fully differential cross sections*," A. L. Harris[3] and D. H. Madison, Phys. Rev. A **90**, 022701 (2014).

"*Triply differential (e,2e) studies of phenol*," G. B. da Silva, R. F. C. Neves, L. Chiari, D. B. Jones,[3] E. Ali,[2] D. H. Madison, C. G. Ning, K. L. Nixon, M. C. A. Lopes, and M. J. Brunger, J. Chem. Phys. **141**, 124307 (2014).

"*Triple differential study of ionization of H_2 by proton impact for varying electron ejection geometries*," A. Hasan,[2] S. Sharma,[2] T. P. Arthanayaka,[2] B. R. Lamichhane,[2] J. Remolina,[1] S. Akula,[2] D. H. Madison and M. Schulz, J. Phys. B **47** 215201 (2014).

"*Theoretical and experimental (e,2e) study of electron-impact ionization of laser-aligned Mg atoms*," S. Amami, A. Murray, A. Stauffer, K. Nixon, G. Armstrong, J. Colgan, and D. H. Madison, Phys. Rev. A **90**, 062707 (2014).

"*Fine-structure constant for gravitational interactions*," U. D. Jentschura, Phys. Rev. A **90**, 022112 (2014).

"*From Dirac theories in curved space-times to a variation of Dirac's large-number hypothesis*," U. D. Jentschura, Ann. Phys. (Berlin) 526, A**47** (2014).

"*Foldy-Wouthuysen transformation, scalar potentials and gravity*," U. D. Jentschura and J. H. Noble,[2] J. Phys. A **47**, 045402 (2014).

"*Neutrino helicity reversal and fundamental symmetries*," U. D. Jentschura and I. Nandori, Eur. Phys. J. H **39**, 591 (2014).

"*Neutrino helicity reversal and fundamental symmetries*," U. D. Jentschura and B. J. Wundt,[3] J. Phys. G **41**, 075201 (2014).

"*Weighing the neutrino*," U. D. Jentschura, D. Horvath, S. Nagy, I. Nandori, Z. Trocsanyi and B. Ujvari, Int. J. Mod. Phys. E **23**, 1450004 (2014).

"*Numerically optimized regulator and functional renormalization group*," I. G. Marian, U. D. Jentschura, and I. Nandori, J. Phys. G **41**, 055001 (2014).

"*The structure and properties of amorphous indium oxide*," D. Buchholz, Q. Ma, D. Alducin, A. Ponce, M. Jose-Yacaman, R. Khanal,[2] J.E. Medvedeva, and R.P.H. Chang, Chem. of Mater. **26**, 5401(2014).

"*Exploring new aspects and practical applications of capillary guiding of charged particle beams*", M. Alshammari, K. Alshammari, A. Cudd,[1] R. D. DuBois, and K. Tokési, Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms (in press).

"*Enhanced rare-region effects in the contact process with long-range correlated disorder*," A. K. Ibrahim,[2] H. Barghathi,[2] and T. Vojta, Phys. Rev. E **90**, 042132 (2014).

"*How random is topological disorder? Phase transitions on random lattices*," H. Barghathi[2] and T. Vojta, Phys. Rev. Lett. **113,** 120602 (2014).

"*Rare regions and Griffiths singularities at a clean critical point: the five-dimensional disordered contact process*," T. Vojta, J. Igo[3] and J.A. Hoyos: Phys.Rev. E **90**, 012139 (2014).

"*Numerical method for disordered quantum phase transitions in the large-N limit*," D. Nozadze[3] and T. Vojta, Phys. Stat. Sol. B **251**, 675 (2014).

"*Strong-randomness infinite-coupling phase in a random quantum spin chain*," F. Hrahsheh,[3] R. Narayanan, J.A. Hoyos and T. Vojta, Phys. Rev. B **89**, 014401 (2014).

"*Contact process on generalized Fibonacci chains: infinite-modulation criticality and double-log periodic oscillations*," H. Barghathi,[2] D. Nozadze[3] and T. Vojta, Phys. Rev. E **89**, 012112 (2014).

Vojta Visits Natal and Sao Carlo in Brazil

In July, 2014, faculty member **Thomas Vojta** visited the International Institute of Physics on the campus of the Federal University of Rio Grande do Norte in Natal, Brazil. Natal is a city of about a million people located at the northeastern tip of South America, facing the Atlantic Ocean. It is renowned for the natural beauty of its beaches. The International Institute of Physics was established 5 years ago to create a research center for theoretical physics that would attract scientists from all over the world.

Thomas attended a two-week workshop on "*Quantum criticality in correlated materials and model systems*" which brought together theorists and experimentalists working in diverse fields of physics including magnetism, superconductivity, ultracold gases and even high-energy physics. Thomas gave an invited talk entitled "*Criticality and quenched disorder: rare regions vs. Harris criterion.*" The schedule also left some time for sightseeing. Thomas took a buggy ride across Natal's remarkable sand dunes; visited the largest cashew tree in world; and explored Pipa Beach, one of the most famous beaches of Brazil.

sand dunes of Genipabu near Natal

After the workshop, Thomas traveled south to visit **José Hoyos** in Sao Carlos. José was a postdoc in Thomas' group at Missouri S&T from 2006 to 2007; he is now a professor at the Institute of Physics Sao Carlos of the University of Sao Paulo. Thomas and José spent a week working on research projects on phase transitions in disordered systems. In addition, Thomas gave a seminar as well as a colloquium entitled "*Quantum phase transitions and novel phases in condensed matter.*"

After this successful visit, Thomas plans to return to Brazil this year. He applied for and won a grant from the Brazil-U.S. Exchange Program sponsored by the Sociedade Brasileira de Física and the American Physical Society. He will use this grant for a month-long visit to Sao Carlos and Belo Horizonte during the coming summer.

We don't have a picture of Thomas in the mountains this year. Instead, we give you a view of the sand dunes of Genipabu near Natal.

Planned Giving:

Leaving a Legacy to Missouri S&T

Many alumni and friends have realized that a future gift – one arranged through their will or trust – allows them to give back to their alma mater more than they ever thought possible. With careful planning, charitable estate giving can reduce your estate tax liability or transfer assets to your family at a lower gift tax cost.

Making a planned gift shows your loyalty to Missouri S&T, an institution that played a significant role in shaping your future. For more information about giving a current or planned gift, contact the Office of Development at 1-800-392-4112 or e-mail *giving@mst.edu*.

Phonathon 2015

For last year's Phonathon you helped us meet the goal of matching $50,000 to improve our instructional labs. Your donations will go to modernizing the equipment used by our majors and by all students on campus in STEM disciplines. We are very grateful for your support.

Your assistance also helps us to recruit and retain the quality undergraduate and graduate students in our department. Currently we have approximately 80 undergraduates and 30 graduate students, and we have a goal of growing these numbers to 90 and 40 respectively by 2020. Every dollar you can give for scholarships and graduate fellowships will greatly assist the department in its aggressive recruitment plan, and will be greatly appreciated.

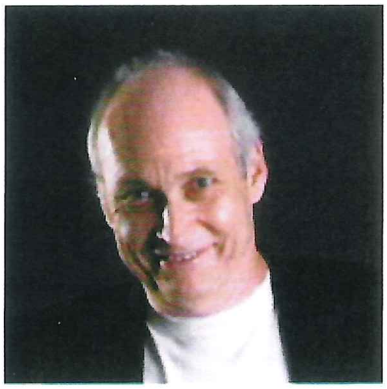
Alumni and other donors committed $37,108 in donations to the MSM-UMR-Missouri S&T Physics Department last year. Last year's fundraising Phonathon raised $37,085 with an average gift of $244 from 152 donors. The department greatly appreciates your generosity, which helps to support scholarships and student activities like the Society of Physics Students.

Frontiers in Physics Colloquium Series

The Spring 2014 *Frontiers in Physics Colloquium Series* was coordinated by Professor Ulrich Jentschura. The series began in January with a talk on "*Production and properties of thin film ceramics for applications*" by **Vladimir Vishnyakov** from Manchester Metropolitan University.

In February, **Maria Baldini** from Argonne National Laboratory gave a talk on "*Inhomogeneity driven giant magneto-resistance in compressed $LaMnO_3$*," and **Yang Liu**, also from Argonne National Laboratory, followed the next week with his presentation "*Probing interfacial electronic reconstruction by angle-resolved photoemission and synchrotron x-ray scattering.*" **Seung Ho Baek** from Technische Universität Dresden told us about "*Mapping electron dynamics using tailored ultrafast tabletop x-ray sources*," and **Cihan Kurter** of the University of Illinois at Urbana-Champaign discussed "*Anomalous Josephson current in superconductor/topological insulator devices.*"

Because of spring recess for St. Pat's and spring break, there were only three colloquia scheduled for March. **Deepak Singh**, from Missouri University, spoke about "*Exploration of magnetic crystals*," and **Guillaume Laurent** of MIT described "*Generation and application of attosecond pulses for real-time observation of atomic processes.*" Perhaps the highlight of the spring colloquium series was a visit by former American Physical Society President **Michael Turner**, from the University of Chicago. Professor Turner, who coined the term "dark energy," gave a fascinating talk on "*The dark side of the Universe.*"



Michael Turner

In April, **He Wang** from the University of Florida lectured on "*Mapping electron dynamics using tailored ultrafast tabletop x-ray sources*," **Predrag Ranitovic** of Lawrence Berkeley National Laboratory reported on "*Laser-matter interactions: from strong field ionization to attosecond XUV coherent control of molecular dynamics*," **Daniel Fischer** of the Max Planck Institute, Heidelberg spoke about "*Controlling and analyzing ultra-cold, atomic few-body quantum systems*," and **John H. Page**, Distinguished Professor at the University of Manitoba, reviewed "*Waves in complex media.*"

The Spring Colloquium Series concluded in May with poster presentations by undergraduate Physics majors at the Forty-Third Annual **Harold Q Fuller** Prize Colloquium. Details of the Fuller competition appear in a separate article on page 15.

Professor **Julia Medvedeva** took charge of the *Frontiers in Physics* series for the Fall 2014 semester. On the last Thursday in August, **Oscar de Lucio** of the National Autonomous University of Mexico (UNAM--home to an astonishing 340,000 students) presented "*Applications of the 5.5 MV Van de Graaff accelerator at IF-UNAM for ion beam analysis techniques.*"

Due to several faculty meetings scheduled with new S&T administrators, there was only one talk in September. **Alexander Goldberg** from Schrödinger Inc. reviewed the use of "*Schrödinger high-throughput atomic scale simulations to discover new materials for industrial applications.*"

The colloquium series resumed full scale operations in October with talks by **Risheng Wang** of Missouri S&T's Chemistry Department on "*DNA engineering: from structure to application*," and **Pouyan Ghaemi**, from The City University of New York who acquainted us with the "*Electronic world on the edge.*" Our homecoming speaker was **Matthew Foster** (PhD '06), who gave us his personal account "*Aircraft carriers, bytes, and physics: the fate of a Missouri S&T physicist.*" Matt discussed his transition from a budding atomic physicist into a rebellious operations research scientist.

Matt Foster and son

Our October colloquia continued with a talk by **David Hseih** of the California Institute of Technology on "*Quantum states of matter in crystals*," and a report by **Otmar Schmid** (PhD '00) from the Institute of Lung Biology and Disease, Helmholtz Zentrum München on "*Aerosol science in health research –or– what the heck can you do with cloud and aerosol science?*"

We heard from three speakers in November. **Nicholas Butch** of the NIST Center for Neutron Research told a tale of "*Adventures in electron correlations*," **Aaron Finck** from the University of Illinois at Urbana-Champaign reviewed "*Searching for majorana fermions in hybrid topological insulator devices through interferometry*," and **Reuben Collins** from Colorado School of Mines summarized "*Hot carrier transfer in nanocrystalline silicon.*"

Frontiers in Physics 2014 concluded in December with presentations by four finalists at the Twenty-first Annual **Laird D. Schearer** Prize Colloquium. Details are in the article on page 14 of this newsletter.

21st Annual Schearer Prize Competition

The Twenty-First Annual *Laird D. Schearer Competition for Graduate Research*, established by the family of Dr. **Laird D. Schearer** to recognize research performed by a graduate student, was held on December 4, 2014.

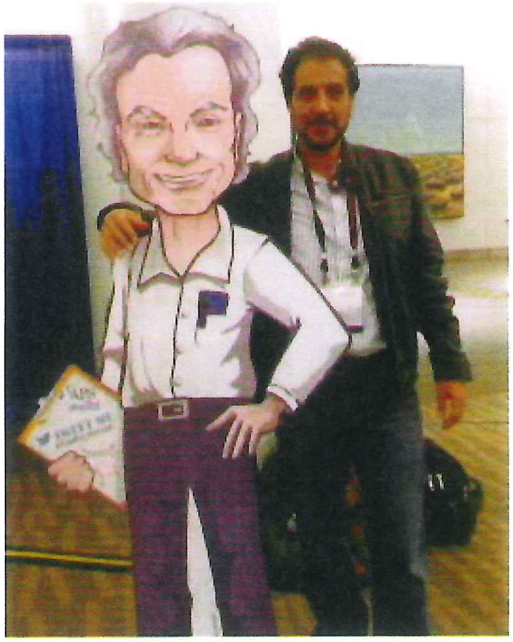
Eight students submitted applications for the competition. The applications consisted a short description of their research, copies and lists of any publications and presentations they have made, plus a résumé. Based on these applications, the judges, Professors **Julia Medvedeva**, **Greg Story**, and committee chair **Barbara Hale**, selected four finalists who gave oral presentations of their work in a departmental colloquium. The finalists were **Hatem Barghathi**, advised by Professor **Thomas Vojta**; **Hari Chaluvadi**, advised by Professor **Don Madison**; **Jonathan Noble**, advised by Professor **Ulrich Jentschura**; and **Milan Koirala**, advised by Professor **Alexey Yamilov**.

During the colloquium on December 4, Mr. Chaluvadi discussed "*Theoretical M3DW (molecular 3-body distorted wave) proper average calculations for electron-impact inonization of molecules*," Mr. Barghathi talked on "*Phase transitions of random lattices: how random is topological disorder?*" Mr. Noble described "*The Foldy-Wouthuysen transformation and generalized Dirac equations*," and Mr. Koirala presented "*Critical states embedded in the continuum.*" All students gave excellent talks.

After considering the finalists' contribution to the research, knowledge of the area and presentation effectiveness the committee awarded first prize and $700 to Hatem Barghathi, second prize and $300 to Hari Chaluvadi and Jonathan Noble, and third prize and $200 to Milan Koirala. The Schearer Prize committee would like to congratulate Hari, Hatem, Jonathan and Milan on the excellent quality of their oral presentations and thank all eight applicants for participating in the Schearer Prize competition. The cash awards were made possible by the generous donations of the Schearer family. Following the presentations, the finalists and numerous faculty members had a wonderful dinner at a local restaurant.

From Schearer Prize Winner Hatem Barghathi

It is a great pleasure and particular honor to win the Schearer Prize for the second time. I am very thankful to my advisor, Professor **Thomas Vojta**, for his patient guidance and continuous support. Also, I would like to thank the Prize Committee for providing me with the opportunity to present my research work. The greatest thanks and deepest appreciation go out toward my family for their support and patience.



My PhD research is about the effect of random disorder on phase transitions. In last year's Schearer prize talk, I showed how a non-equilibrium phase transition survives a random field disorder. This result is important for biological systems such as bacterial growth. This year's talk was about phase transition on lattices with random connectivity. My results solve a puzzle that has been around for at least 15 years regarding the effect of such topological disorder on phase transitions. We identified a class of random lattices on which surprisingly, the phase transition behaves identical to that on a perfect periodic lattice.

Also, I would like to thank the Schearer family for making this competition possible. It is a great opportunity to improve our presentation skills and to learn about the work of other graduate students.

Come Back for Homecoming

The Missouri S&T Physics Department warmly invites you to return to Rolla for **S&T Homecoming 2015** on **October 23-24, 2015**. On Friday afternoon, October 23, the department will hold an open house and special programs for its alumni and friends. Tours of laboratories and educational facilities will be offered and there will be opportunities for interaction with current Missouri S&T physics students. Come see what we have done since you received your degree.

In keeping with a long-standing tradition, an S&T alum will deliver the Homecoming 2015 Physics Colloquium at 4 PM. on Friday, October 24. Later that evening, Professors **Ed** and **Barbara Hale** will host a homecoming reception in their lovely home. Contact us at **physics@mst.edu** for specific information about physics department activities, or **alumni@mst.edu** for general homecoming information. Come home to your college roots, and help us celebrate our past as UMR, even as we work to shape our future as Missouri S&T!

Faculty Notes

Ulrich Jentschura published an article on possible connections of the fine-structure constant and the gravitational coupling constant, which generated a lot of interest, including a "fan mail letter" from acclaimed MIT physicist Prof. **Roman Jackiw**.

Congratulations to **Don Madison** who has been named a Distinguished Referee by the European Physical Journal for 2014.

Don Hagen has been awarded two new USDOT grants, "*Examination of engine to engine variability using an ARP reference sampling and measurement system*," funded for $500,000, and "*Ambient conditions corrections for nvPM emissions measurement*," funded for $383,932.

Yew San Hor was the only person from Missouri S&T noted in Thomson Reuters "*The most influential scientific minds 2014*," which identified the most cited scientists over the past decade in 21 different fields.

In September of 2014, **Julia Medvedeva** became a Senior Research Investigator of the Graduate Center for Materials Research (MRC) at Missouri S&T. The role of a Senior Research Investigator is to facilitate MRC seed funding for young investigators, to advise campus-wide multidisciplinary initiatives and to further materials-related graduate education and research at Missouri S&T.

Alexey Yamilov was promoted in September 2014 to Associate Professor with tenure. Congratulations, Alexey!

Ulrich Jentschura received a grant from NIST for "*IPA - special functions*."

Dan Waddill and **Julia Medvedeva** are part of the best-in-class signature area "*Enabling materials for extreme environments*" at Missouri S&T. For this signature area, three new tenure-track faculty positions (in physics, chemistry, and nuclear engineering) have been open this year, with two additional faculty positions in the materials science to be open in the year of 2016.

Michael Schulz has been awarded a new grant "*Coherence effects and few-body dynamics in atomic fragmentation processes*," funded for $200,411 by the NSF.

Julia Medvedeva gave three invited talks this year: "*Wide band-gap oxides*," at the US Army Night Vision Lab; "*First principles theory of transparent crystalline and amorphous oxide conductors and semiconductors*," at the 6th Forum on New Materials in Montecatiny Terme, Italy; and "*Long-range structural correlations in amorphous In-X-O from ab-initio molecular dynamics*," at the annual NU-MRSEC meeting at Northwestern University.

Thomas Vojta gave invited talks at the *International Conference on Coherence and Correlations on Different Scales*, Ustron, Poland; the *Workshop on Quantum Criticality in Correlated Materials and Model Systems*, Natal, Brazil; and the *Workshop on Recent Progress and Perspectives in Scaling, Multifractality, Interactions, and Topological Effects Near Anderson Transitions*, Dresden, Germany.

43rd Annual Fuller Research Seminar

An unprecedented total of seventeen undergraduate students presented posters about seven different research projects at the 43rd annual **Harold Q Fuller** Undergraduate Research Competition, held on May 1, 2014.

The Fuller Awards are given to the students whose projects are judged to be the most outstanding on the basis of accomplishment, presentation, and response to the questioning of the judges.

The 2015 presenters were **Alexander Mark**, **Paul Somers**, Brandon Yokeley, **Jack Crewse**, **Stephen Kraus**, **Timofey Golubev**, **Sam Stephens**, **Scott Ketcherside**, **Nelson Shreve**, **Ryan Gibbs**, **Clayton Craig**, **Giannino Lusicic**, **Andrew Cudd**, **Brock Ebert**, **Sheldon Harper**, **Jaykob Maser**, and **Yunsheng Qiu**. The Physics department applauds your efforts!

The posters were judged by the Fuller Prize Committee, Dr. **Paul Parris** and Dr. **Michael Schulz**, chaired by Dr. **Barbara Hale**.

The three winning research projects were "*Analysis and experimentation in plasma physics*," by Brock Ebert, Sheldon Harper and Jaykob Maser, advised by Dr. **Greg Story**; "Exploring gluon polarization in the proton with STAR jet data and the NNPDF polarized parton distributions," by Andrew Cudd, a summer research project advised by Dr. **Carl Gagliardi** of Texas A&M; and "Magnetization of transition metal doped topological insulators," by Jack Crewse and Yunsheng Qiu, advised by Dr. **Yew San Hor**.

Brock, Sheldon, and Jaykob each received $400 and are recognized in an article on the front page of this newsletter. Andrew, Jack, and Yunsheng each received $300. Congratulations to the winners!

Ulrich Jentschura was awarded a $75,000 grant from the National Science Foundation for "*Quantum vacuum and atoms: exploring QED and atom-surface interactions with the help of advanced numerical methods.*"

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So What's News with You?

We hope you enjoyed this year's edition of **Matter 'n Motion**. We enjoy keeping you informed about what is going on at Missouri S&T, but we'd also like to know what's new with you, both personally and professionally. Any information you send will be circulated in the department and, if appropriate, inserted in the next physics newsletter unless you request otherwise.

Please print or type your information, and include your mailing address so that we can update our records. Mail to: **Physics Department, Missouri University of Science and Technology, 1315 N. Pine St., Rolla MO 65409-0640**. Or, if you would prefer, you can e-mail us your comments at **physics@mst.edu**. Thanks for keeping in touch. It's always good to hear from old friends.

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