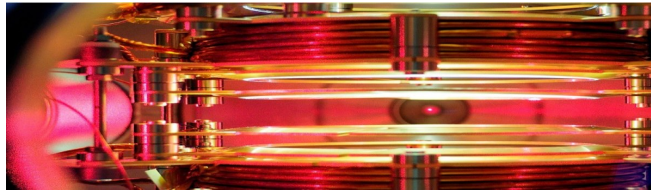


# Matter 'n Motion

January 2021



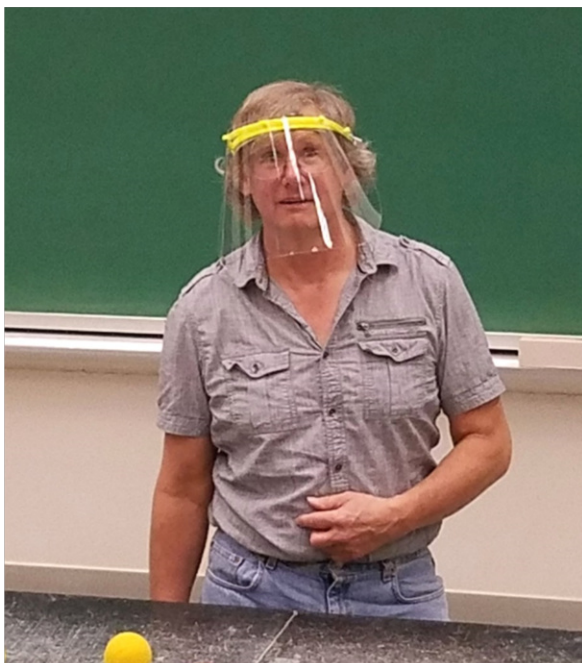
Missouri University of  
Science and Technology  
PHYSICS DEPARTMENT

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

## The Show Must Go on: Teaching during the Pandemic

When the 2020 St. Pat's festivities were cancelled, we knew: Covid had come to Missouri S&T. Two days later, it was announced that classes would have to move online in the middle of the following week. We started to prepare. The instructors who had experience with online teaching helped their colleagues setting up the technology. On Saturday, another email: all courses had to be online already by Monday.

With two days notice, our faculty scrambled through a crazy weekend, and come Monday, we were ready to teach online. For the first week, we were still permitted to use the campus facilities. Professors were teaching in empty classrooms, writing equations on Wacom tablets or on papers under document cameras or had their cameras aimed at the chalkboard, while the students watched on Zoom. At the end of that week, campus closed completely, and faculty were sent to teach from home for the remainder of the semester. Nonetheless, no courses were canceled and we successfully finished the semester.



With the fall semester, we were finally able to return to campus – with masks and face shields, and with limited classroom occupancy. Our classrooms in the physics building that normally hold 35 students were now permitted to seat ten; our lecture hall for 140 now seated just 27. Rows were blocked off with trash bags or yellow tape to leave only seats six feet apart from each other. The university converted the gymnasium into a makeshift lecture hall for large classes like our engineering physics. Some courses remained online. And many instructors now had to juggle hybrid classes with half the students attending in person and the other half on Zoom at the same time. Colloquium, group meetings, help sessions, and advising all happened on Zoom.

Thanks to the safety precautions and the comprehensive contact tracing and quarantine procedures, Missouri S&T was able to remain open throughout the semester, and no Covid infections were traced to any classes or labs. While we can't wait for things to return to normal, we found new ways to engage with our students, and our students have been learning and progressing towards their degrees.

## Memo from the Chair

The year 2020 was definitely one for the history books and brought, dare I say it, unprecedented challenges for the department and the university, as I am sure it did for all of you. In March, the Covid-19 pandemic closed the campus and forced us to switch to online instruction on a two days' notice. I am proud of our students, faculty, and staff for mastering this difficult transition and completing the semester successfully. Nonetheless, we were happy to return to campus for the fall semester despite occupancy limits and social distancing requirements because we could finally see each other mask-to-mask again. Read more about the Covid-19 response in the article "The show must go on" on the front page. As you peruse this newsletter, you will also notice that there are hardly any pictures showing more than one person, and the few that do were taken before the pandemic started.

Despite the difficult circumstances, our faculty continued to excel in their research and teaching. Prof. **Daniel Fischer** was promoted to Associate Teaching Professor with tenure. Prof. **Julia Medvedeva** is part of a team winning a \$20 million Army Research Laboratory grant. Profs. **Marco Cavaglia**, **Michael Schulz**, and **Alexey Yamilov** received major new NSF awards. The strong performance of our faculty was recognized by the college and the university as well as by the international community. Profs. **Marco Cavaglia** and **Ulrich Jentschura** won campus Faculty Research Awards, while Prof. **Daniel Fischer** received a research award from the College of Arts, Sciences, and Business. Prof. **Greg Story** received both a campus Faculty Teaching Award and an Outstanding Teaching Award (his 18<sup>th</sup> so far). Profs. **Alexey Yamilov** and **Thomas Vojta** received Outstanding Teaching Commendations. Prof. **Yew San Hor** was once again listed as one of the nation's most "highly cited researchers" in his field. Profs. **Ulrich Jentschura**, **Thomas Vojta**, as well as emeriti **Bob Dubois**, **Don Madison** and **Ron Olson** were listed in a database of the top 2% scientists across all areas of science.

We welcomed several postdocs and visiting scientists. Dr. **Bishal Bhattarai** joined Prof. **Julia Medvedeva**'s group from Washington University. Dr. **Christopher Moore** came from Clemson university to work with Prof. **Ulrich Jentschura**, as did **Albert Wienczek** from Poland. **Jin Wang** and **Huangwu Lyu** came from China to work with Prof. **Aleksandr Chernatynskiy**.

The enrollment in the physics department continues to be strong, and the quality of the new students is excellent. Two National Merit finalists, **Steven Karst** and **Daniel Ripp**, are involved in research internship in the department. In total, we currently have about 80 undergraduates and 29 graduate students. In 2020, 17 students graduated with a BS degree, and four students received a PhD degree.

The year 2020 also was a complex year for the university financially. On the one hand, the pandemic led to significant budget cuts for the campus and the physics department. On the other hand, the university received a \$300 million gift from June and Fred Kummer, the largest single gift in the history of Missouri higher education. Much of this gift is directed at specific projects, and its impact on the physics department is not yet clear.

I close, as always, by thanking our alumni for their dedication and generous donations without which the department's success in its teaching, research, and service missions would be impossible. I know that we can count on your continuing support. Thank you very much!

I hope that the pandemic will subside soon so you will be able to visit us in Rolla to see the exciting things happening in the physics department and to share with us what you have been doing since graduation.

*Thomas Vojta*



### 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 email [giving@mst.edu](mailto:giving@mst.edu).

## Physics Department Awards 2020-2021 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.

**Dr. John R. and Patty Rogers Endowed Scholarship** recipients were **Harold Baker** from Hollister, MO; **Tucker Mattson** from Blue Springs, MO; **Lily Smith** from Maryland Heights, MO; **Samuel Clodfelter** from Saint Charles, MO; and **Alexander Love** from Ellisville, MO.

**John L. & Betty L. McDaniels Scholarship** recipient was **Jonathan Evans** from Lamar, MO.

**Gerrie Fletcher Endowed Scholarship in Memory of Dale Shull** recipients were **Jodie Hermann** from Arlington, IL and **Caroline Beshears** from Kansas City, MO.

**Richard Anderson Scholarship Fund** recipients were **Ian Smith** from Saint Joseph, MO; **Nicholas Theodorou** from Saint Louis, MO; **Reece Beattie-Hauser** from Wildwood, MO; and **Keith Miller** from Malden, MO.

**Harold Q Fuller Scholarship-Loan** recipients were **Joshua Maechler** from O'Fallon, MO; **Sean Anderson** from Warrensburg, MO; and **Ravi Shastri** from Fenton, MO.

**Richard W. Hannum Endowed Development Fund** recipients were **Javier Franco Hernandez** from Chesterfield, MO and **Mcgowan Toombs** from Arnold, MO.

**Burke H. Miller Memorial Scholarship** recipient was **Kenneth Distefano** from Kansas City, MO.

**Allan Pringle Endowed Scholarship** recipients of the award were **Benjamin Edwards** from Rolla, MO and **Caroline Beshears** from Kansas City, MO.

**Pringle IMM Miner Match money** was awarded to **Mason Toombs** from Arnold, MO; **Kathryn Zychinski** from Saint Louis, MO; **Emily Richardson** from Saint Peters, MO and **Steven Karst** from Ballwin, MO.

**Ed and Mary Sue Sickafus Endowed Scholarship/Fellowship** recipients were **Rebecca Campbell** from Saint Charles, MO; **Kenneth Distefano** from Kansas City, MO; **Samuel Halladay** from Mount Vernon, IA and **Aaron Silvus** from Lee's Summit, MO.

**Leon E. Woodman Memorial Scholarship** recipients were **Jose Padron** from Springfield, MO and **Colton Helms** from Fredericktown, MO.

**Physics Department Scholarship** recipients were **Joshua Dalton** from Saint Peters, MO; **Zachary Driemeyer** from House Springs, MO; **Joseph Franz** from Kansas City, MO; **Samuel Halladay** from Mount Vernon, IA; **Jodie Hermann** from Saint Louis, MO; **Alexander Hoffman** from Wildwood, MO; **Andrew Janes** from O'Fallon, MO; **Keith Miller** from Malden, MO; **Zachary Miller** from Saint Peters, MO; **Nathaniel Page** from Springfield, MO; **Ravi Shastri** from Fenton, MO; **Seth Stubblefield** from Saint Peters, MO; **Zachary Szatkowski** from Saint Louis, MO; **Jacob Thiel** from Rolla, MO; **Mcgowan Toombs** from Arnold, MO; and **Timothy Van Hoose** from Rolla, MO.

**Physics Scholarships for Academic Access** recipients were **Samuel Halladay** from Mount Vernon, IA; **Brock Hinton** from Hindsville, AR; **Jordan Stevens** from Bonne Terre, MO and **Cole Rischbieter** from Barnhart, MO.

## DONATIONS 2020

Your donations help make it possible to continue to attract quality undergraduate and graduate students in our department. Currently we have approximately 80 undergraduates and 29 graduate students, and we have a goal of growing these numbers in 2021. Every dollar you can give for scholarship and graduate fellowships will greatly assist the department in its aggressive recruitment plan, and will be greatly appreciated.

Your continued generosity with Phonathon donations and other private donations has allowed us to increase teaching laboratory capacity by up to 50% over the past years.

Last year's donations to the department totaled \$26,194.53 from 70 donors.

We greatly appreciate your generosity in helping us support scholarships and student activities such as the Society of Physics Students.

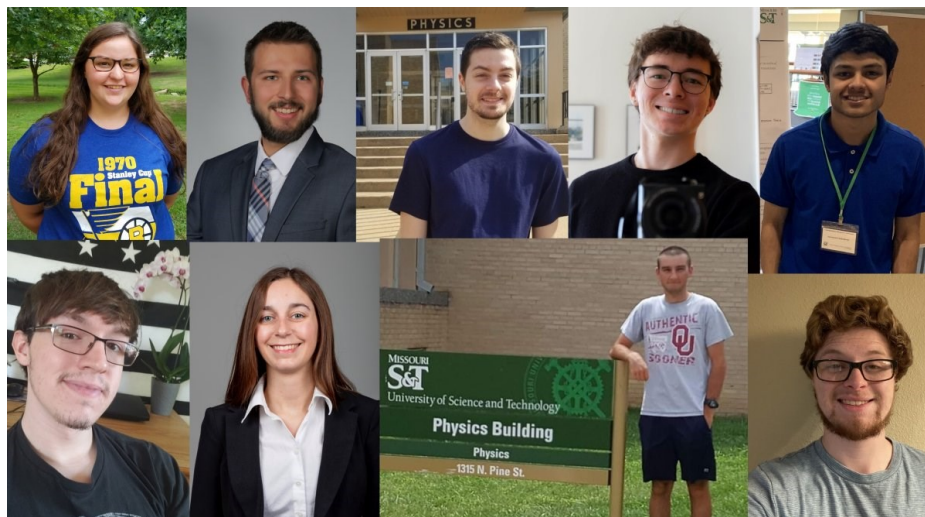


## Congratulations to 2020 Physics Degree Recipients

### May 2020

#### *Bachelor of Science*

Brett Ballard  
Jonas Buxton  
Elizabeth Caputa-Hatley  
Anzumaan Chakraborty  
Dominic Dalba  
Michael Ellis  
Zenon Klok  
Cameron Maupin  
Kyle McMillen  
Mark Myers  
Vince Preis  
Ashley Pruett



Top left to right: Elizabeth Caputa-Hatley, Cameron Maupin, Kyle McMillen, Vince Preis, Anzumaan Chakraborty. Bottom left to right: Dominic Dalba, Ashley Pruett, Brett Ballard, Zenon Klok.

### December 2020

#### *Bachelor of Science*

Kenneth Distefano  
Nathaniel A. Page  
Ravi S. Shastri  
Elizabeth Triller  
Alex Warhover

#### *Doctor of Philosophy*

A. H. Nishshanka C. De Silva  
Madhav Dhital  
Pauf Neupane  
Matt Wentzel-Long



Left to right: Kenneth Distefano; top: Nathaniel Page, Elizabeth Triller; bottom: Ravi Shastri and Alex Warhover.

## Congratulations to the 2020 Physics Academic Scholars

Students who maintained at least a 3.50 GPA for twelve hours or more of coursework

### Spring 2020

Sean Anderson, Brett Ballard, Elizabeth Caputa-Hatley, Joshua Dalton, Kenneth Distefano, Zachary Driemeyer, Andreas Ellinas, Joseph Franz, Samuel Halladay, Colton Helms, Jodie Hermann, Ethan Hisle, Charles Kropp, Taylor Lindenbusch, Cameron Maupin, Kyle McMillen, Dillon McNamara, Keith Miller III, Zachary Miller, Jose Padron, Nathaniel Page, Ashley Pruett, Nicholas Razo, Cole Rischbieter, Brandon Robinson, Jordan Stevens, Seth Stubblefield, Zachary Szatkowski, Nicholas Theodorou, McGowan Toombs, and Benjamin Yingling.

### Fall 2020

Sean Anderson, Reece Beattie-Hauser, Samuel Clodfelter, Joshua Dalton, Kenneth Distefano, Andreas Ellinas, Joseph Franz, Samuel Halladay, Jodie Hermann, Ethan Hisle, Andrew Janes, Steven Karst, Charles Kropp, Mason Labrot, Keith Miller III, Zachary Miller, Winston Penrod, Cole Rischbieter, Ravi Shastri, Zachary Szatkowski, Mason Toombs and McGowan Toombs.

## Julia Medvedeva Studies Hydrogen in Amorphous Oxide Semiconductors

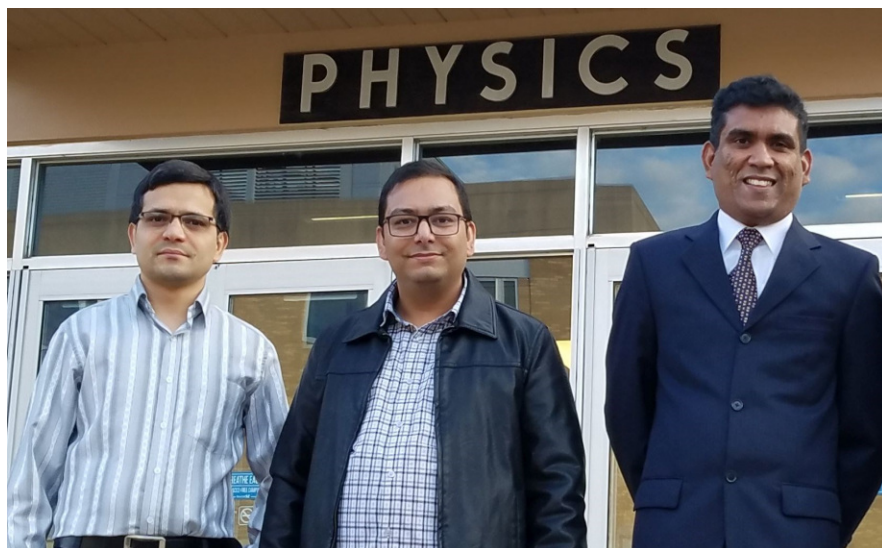
For decades, hydrogen has been known to play a key role in defect passivation, doping, crystallization, and improved transport properties in Si-based semiconductors. Despite tremendous progress, hydrogen remains a mysterious ion in materials chemistry and physics owing to its bipole nature, moderate electronegativity, lack of  $p$ -orbitals, flexible ionic size, and the ability to form covalent, metallic, or ionic bonding depending on the electronic characteristics of the surrounding atoms. Revealing the microscopic behavior of hydrogen in amorphous oxide semiconductors that recently became competitive with silicon as an active transistor layer in large-area and flexible displays, presents a more formidable problem. Weak metal-oxygen bonding, ionic in nature, renders strong structural disorder even in the short, nearest-neighbor range of the amorphous oxide, dramatically increasing the number of possible locations for H defects in the structure that determines the concentration, stability, and diffusion of hydrogen as well as the resulting macroscopic properties of H-doped oxides.



Medvedeva employed computationally-intensive ab-initio molecular dynamics simulations combined with accurate density- and hybrid-functional calculations and analyzed the results using statistical time- and temperature-dependent tools developed in her group. Given the wide structural distributions in amorphous oxide semiconductor, such simulations require large computer power and were performed using the Foundry, the high-performance computer cluster that was commissioned at Missouri S&T in winter of 2020, thanks to a \$2 million Major Research Instrumentation (MRI) grant from National Science Foundation, on which Medvedeva served as co-Principal Investigator.

The results of her studies have revealed a stark difference between H-passivation in covalent Si-based semiconductors and the ionic metal oxides: remarkably, hydrogen doping triggers an extended bond reconfiguration in the oxide and this structural rearrangement results in energy gains that outweigh passivation of dangling O- $p$ -orbitals. This H-induced structural transformation in the morphology results in a more uniform distribution of the conduction paths in the amorphous material. Along with the increased H mobility, the findings helped explain the observed 70-fold increase in the carrier mobility of H-doped In-Ga-O. Together with her colleagues from Northwestern University, Medvedeva published her work in the prestigious *Proceedings of the Academy of Science*, as well as in *Journal of Materials Chemistry C*. Moreover, she was invited to present her work at Display Week 2021, the International Symposium and Exhibition by the Society of Information Display to be held in May 2021 in San Jose, California.

## Three Graduate Students Defend PhD Theses



Three physics graduate students **Pauf Neupane** successfully defended their doctoral theses:

**Madhav Dhital:** “Fully differential study of higher-order contributions to the few-body dynamics of simple atomic systems”. (Advisor: Michael Schulz)

**Pauf Neupane:** “Molecular dynamics study of temperature dependent wetting in alkane-water systems”. (Advisor: Gerald Wilemski)

**Aruma Handi Nishshanka DeSilva:** “Symmetry-breaking in the multi-photon ionization dynamics of oriented atoms”. (Advisor: Daniel Fischer)

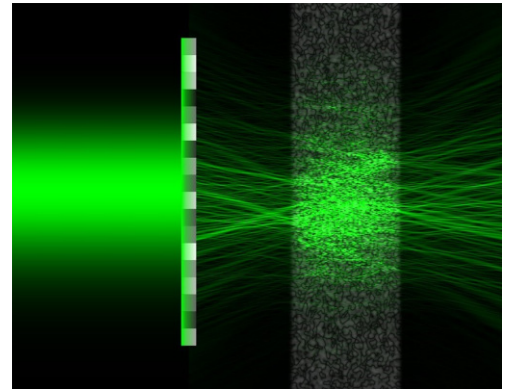
They all continued as postdocs in the department.



## Alexey Yamilov publishes in prestigious Nature Photonics

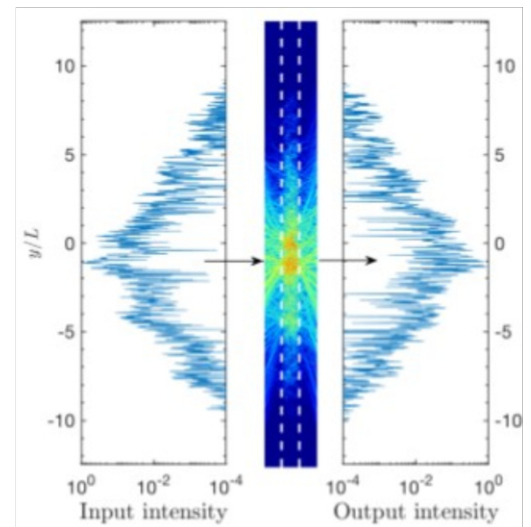


It is commonly thought that optical beams, propagating through a scattering medium such as fog, spread laterally and that one has no control over this process. In collaboration with the experimental group of Prof. Hui Cao from Yale University, Alexey Yamilov demonstrated in a recent Nature Photonics paper “*Transverse localization of transmission eigenchannels*” that it is possible to select special input wave patterns that would travel without spreading.



The concept of such transmission eigenchannels was conceived in the 1980s in context of mesoscopic physics to explain experiments with electron waves in small metal wires at very low temperatures. However,

because it is not possible to precisely control input wave for electrons, the eigenchannels could not be observed directly. The Nature Photonics paper comes on the heels of the first experimental demonstration of the existence of eigenchannels for light waves by Yamilov’s and Cao’s groups “*Control of energy density inside disordered medium by coupling to open or closed channels*,” published in Physical Review Letters. Having achieved such an unprecedented level of control of optical waves opened up exciting opportunities to investigate unusual properties of eigenchannels, including a possibility to steer them, as shown by the collaborators in another Physical Review Letters “*Angular memory effect of transmission eigenchannels*” These studies not only have imaging and communication applications in the field of optics, but also lead to profound implications in condensed matter physics, acoustics, and other fields involving wave propagation and scattering.



## Daniel Fischer promoted to Associate Professor



Daniel Fischer was promoted to Associate Professor with Tenure starting September 1st. Congratulations Daniel!

Daniel was also selected to receive the Missouri S&T College of Arts, Sciences, and Business (CASB) Research Award 2020. The award honors faculty who do research with undergraduate and graduate students, and Daniel is recognized for his large impact on the students in our department.

Research on chiral symmetry breaking performed in Daniel’s lab was published in prestigious Physical Review Letters. (An object, such as an atom or molecule, is chiral when it cannot be superimposed onto its mirror image.)

## Report from the SPS

Despite the difficulties of student life during the pandemic, the Society of Physics Students held meetings in person for half of the spring semester and virtually during the fall semester. Our officer board during the spring semester included Zachary Miller as President, Zach Driemeyer as Vice President, Cole Rischbieter as Secretary, Teddy Caputa as Treasurer, Nick Razo as Historian and Brett Ballard as Student Council Representative. For the fall semester, the officer board consisted of Zachary Miller as President, Samuel Halladay as Vice President, Cole Rischbieter as Secretary, Alex Warhover as Treasurer, Nick Razo as Historian, and Jose Padron as Student Council Representative.

We hosted virtual talks from Dr. Joseph Graham and Dr. Syed Alam from the Nuclear Engineering Department, Dr. John Gal from the Nuclear Engineering Department at Mizzou, Dr. Jason Murphy from the Math Department, Dr. Daoru Han from the Mechanical Engineering Department, Dr. Katie Shannon from the Biology Department, Drs. Marco Cavaglia, Daniel Fischer, Ulrich Jentschura, Dan Waddill, and Shun Saito from the Physics Department. We also broadened our outreach to the Nuclear Engineering Department because a number of students in that department show significant interest in physics.

This has certainly been a challenging year for SPS because of the limited number of in-person meetings. Hopefully next year, SPS may have its best yet and continue our celebration of the world of physics.

*Zachary Miller, SPS President*

## Sigma Pi Sigma Inductees

The 2020 Inductees were: Sean Anderson, Zachary Driemeyer, Nicholas Theodorou, Caroline Beshears, Reece Beattie-Hauser, Charles Knopp, Andreas Ellinas, Samuel Halladay, and Zachary Miller.

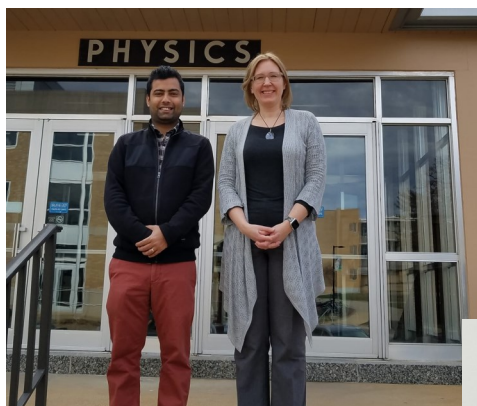
## Observatory



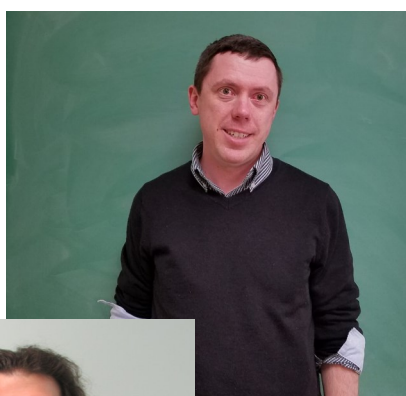
2020 has shaken things up for the observatory. In the spring semester, we held two observatory events. The viewing objects for these nights were Venus and The Orion Nebula. There was only one observatory night for the fall semester. Due to the many COVID regulations, the event was limited to members of STARS. Those who attended were able to look at amazing images of Saturn and Jupiter!

*Nick Fuller, STARS President*

## New postdocs and visiting scholars



**Dr. Bishal Bhattarai** from Washington University St. Louis, postdoc with Julia Medvedeva.



**Dr. Christopher Moore** from Clemson University, postdoc with Ulrich Jentschura.



**Albert Wienczek** from Poland working with Ulrich Jentschura.

**Jing Wang** and **Huangwu Lyu** from China were working with Aleksandr Chernatynskiy.





## Ulrich Jentschura speaks on two continents on the same day



The year 2020 was a successful one for faculty member Ulrich Jentschura, despite all the interesting boundary conditions.

In the summer, Ulrich gave four invited talks at conferences, among these, two on the same day (9th of July), on two different continents. At the RADCOR (radiative corrections) workshop at Stony Brook (N.Y.), he presented a talk on quantum electrodynamic effects and their overlap with possible new fifth-force effects in atomic physics, which would open the door to a new level of understanding of fundamental physical forces.

In Europe, the virtual conference on “Physics Beyond the Standard Models” took place at the same time, with many participants from CERN and NORDITA in Copenhagen (two of the most prestigious particle physics laboratories in the world). Traveling at hypersonic speeds via Zoom between the two continents, Ulrich virtually traveled to Stony Brook from the beautiful resort of Bled, in Slovenia, where the workshop on physics beyond the Standard Model was held, and where Ulrich gave two invited talks. In order to accomplish the feat, Ulrich got up at 2am to join the European meeting, which concluded at around 9am Central Standard Time, at which point the meeting at Stony Brook started.

The program of talks was completed on the 1st of October, with a talk on medical topics, at the Madridge Cancer Research Conference, virtually held from the Marriott Hotel in Orlando, FL. At that conference, Ulrich reported on a therapy approach for cancer which he developed and by which he managed to successfully address health issues that had affected his life in recent years.

Late last year, a new addition to his family made Ulrich very happy. On the 17th of December, a date which happened to coincide with the 250th birthday of the famous composer, Ludwig van Beethoven (who was born on the 17th of December, 1770), Ulrich’s son, Theodore Lowell, was born in Springfield, Missouri.

## Shun Saito visits South Africa



In February 2020, faculty member Shun Saito and his postdoctoral researcher, Dr. Siddhartha Gurung-Lopez, visited the University of the Western Cape (UWC) in South Africa for two weeks. The trip was supported through the University of Missouri South African Education Program (UMSAEP). Its goal was to initiate a collaboration on cosmology and the large-scale structure of the universe with Prof. Roy Maartens and Prof. Santos.

Shun and his postdoc visited the observatory facility at the South African Radio Astronomy Observatory, gave a seminar talk, and had fruitful discussions with local researchers at UWC. It was interesting to experience power failures scheduled a few times per day as well as an evacuation from the UWC campus due to serious protest activities. On the day they flew back to the U.S., Shun and his postdoc had a chance to visit the famous Cape of Good Hope.



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

### **CORPORATE:**

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Timothy J. Sommerer  
Nancy Stepp  
Gerald Wilemski

### **Donations \$1,000 to \$2,499**

Junfang Jeff Gao  
Xiaoqian Liu  
Ulrich D. Jentschura  
Don Packwood  
Agnes Vojta  
Thomas Vojta

## 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 \$25,000 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, John and Patty Rogers, John and Betty McDaniels, L.E. Woodman** and by the estates of **Richard Anderson** and **Richard Hannum**. Our most recent endowment was established in memory of **Dr. Oran Allan Pringle**.

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 email [giving@mst.edu](mailto:giving@mst.edu).

## Faculty awards

**Marco Cavaglia** (top left) and **Ulrich Jentschura** (top right) received 2020 campus Faculty Research Awards, recognizing faculty members who have demonstrated excellence in research and scholarship during the last two years.

**Daniel Fischer** (bottom right) won a College of Arts, Sciences, and Business Research award which honors faculty who do research with undergraduate and graduate students

**Greg Story** (bottom left) received both a Faculty Teaching Award and an Outstanding Teaching Award.

**Thomas Vojta** and **Alexey Yamilov** received Outstanding Teaching Commendations.

**Agnes Vojta** won second place in the S&T Advising Center's "We Love Your Class" award. **Joel Peacher** received a nomination.



## Faculty Notes

**Ulrich Jentschura**, **Thomas Vojta** and emeriti **Bob DuBois**, **Don Madison**, and **Ron Olson** are listed in the database of the top 2% scientists across all areas of science that was released by a team of researchers led by John P.A. Ioannidis from Stanford University. The list is based on a number of citation metrics that reflect the career-long impact of a scientist's work.

**Marco Cavaglia** won a major new NSF award for the project "WoU-MMA: Enabling Multi-Messenger Astrophysics with Advanced LIGO: from Detector Calibration to Interpretation of Gravitational-Wave-Signals".

**Marco Cavaglia** continues to co-chair the "Burst Sources" working group, the second largest observational group in the international LIGO Scientific Collaboration.

**Michael Schulz** received a major NSF award for the project "Coherence Effects: A Sensitive Tool to Study the Few-Body Dynamics in Simple Atomic Systems".

**Thomas Vojta** performed supercomputer simulations to support a pilot study at USC's California Nanosystems Institute that seeks to understand the distribution of serotonin carrying fibers in the brain and the role this distribution plays in the many neurological disorders. The work is published in the journal *Frontiers in Computational Neuroscience*.

**Alexey Yamilov** won a major grant from the NSF for his project "Wave transport via eigenchannels of complex media" which is a collaboration between Dr. Yamilov and Dr. Hui Cao's group at Yale.

**Julia Medvedeva** delivered an invited virtual presentation on her latest research on amorphous oxide semiconductors at the Thomas Young Centre (TYC) Symposium in London. TYC is the London Centre for the Theory and Simulation of Materials and Molecules with over 120 researchers from several area universities. The symposium brought together experimentalists and modelers to discuss challenges in understanding and predicting the properties of disordered and amorphous functional materials.

**Julia Medvedeva** is a co-Principal Investigator of a new cooperative agreement with the Army Research Laboratory that will bring nearly \$20 million to Missouri S&T over five years. Medvedeva leads the Integrated Computational Materials Engineering area that aims at a materials-by-design approach for ultra-high-strength steels for the military.

The Foundry, Missouri S&T's newest High Performance Computing (HPC) cluster, is now operating. The project was funded to a large part by a \$1.96 million NSF award won by a team of Missouri S&T faculty consisting of Richard Dawes, Chemistry, **Julia Medvedeva** and **Thomas Vojta** from Physics, Stephen Gao from Geosciences and Geological & Petroleum Engineering, and Serhat Hosder, Mechanical & Aerospace Engineering.



## Institute of Multi-messenger Astrophysics and Cosmology takes off

The Institute of Multi-messenger Astrophysics and Cosmology (IMAC) led by Dr. Marco Cavaglia had many accomplishments even during the COVID pandemic.

By the end of 2020, just over a year after its inception, IMAC had grown to 16 members and published over two dozen articles in peer-reviewed journals on astrophysics and cosmology. Several of these publications received international media attention as major discoveries in the field. One of these publications by the Laser-Interferometer Gravitational-wave Observatory (LIGO) Scientific Collaboration (LSC), and co-authored by several IMAC researchers and students, was about a signal from the most massive black hole merger yet observed in gravitational waves. Other notable LIGO publications with IMAC contributions were about the detection of the second collision between neutron stars ever measured, and the discovery of what may be an entirely new population of astronomical objects, including possibly the merger of a neutron star with a black hole.

The cosmology group led by Dr. Shun Saito created cosmological simulations representing the distribution of neutrinos in the early universe that was published in *The Astrophysical Journal*.

IMAC researchers were also active in promoting science to the general public. Cavaglia gave public lectures at the Saint Louis Astronomical Society, at the S&T Global Learning Speaker Series, and a pre-pandemic stage talk at the Saint Louis Science Center 2020 SciFest Engineering Expo, where the LIGO group participated in the event as an exhibitor. Cavaglia and Saito gave the Physics Department Nobel Prize lecture colloquium in November celebrating the 2020 Nobel Prize in physics which was awarded for discoveries in astrophysics and black holes. IMAC researchers and students presented their work in many invited talks and colloquia at national and international venues, from Columbia, MO, to Cape Town.

### Meet Ashini Modi



Meet the youngest member of Missouri S&T's Institute for Multi-Messenger Astrophysics and Cosmology! **Ashini Modi** is a Sophomore at Caddo Parish Magnet High School in Shreveport, Louisiana. She has been working with Marco Cavaglia and already published a paper; it presents the first ever estimate of the spatial correlation of cosmic black hole collisions.

"It has always been a dream of mine to be a part of the science that goes on at LIGO", says Ashini, "and that was finally made possible last year when I met Dr. Cavaglia at an AAS conference. ... Being able to conduct astrophysics research as only a 10th grader has shown me that astronomy is a field open to anyone, no matter how young you are."

### Dripta Bhattacharjee featured on Humans of LIGO



Graduate Student **Dripta Bhattacharjee** was featured in the September issue of "Humans of LIGO" in recognition of her work as a LIGO Scientific Collaboration Fellow at the LIGO-Hanford Observatory. Dripta is working with faculty member Marco Cavaglia on the calibration of gravitational-wave interferometers. She believes the most challenging part of working with LIGO, no matter how foolish this sounds, is to understand all the acronyms and abbreviations. In her free time, Dripta likes to practice Bharatanatyam, an Indian classical dance form. She also loves to read books, usually fiction (*A Thousand Splendid Suns* by Khaled Hosseini is her favorite).

## Frontiers in Physics Colloquium Series

### Physics Colloquium Series in Spring 2020:

- ◆ Dr. Carlos Trallero (University of Connecticut) talking about *“New time and energy scales for attosecond science”*
- ◆ Dr. Sergei Sheludiyakov (Texas A&M) *“Search for quantum phenomena of hydrogen and deuterium in solid molecular hydrogen”*
- ◆ Dr. Chien-Lung Huang (Rice University) *“Emergent quantum states close to the boundary between magnetic order and disorder phase”*.

Campus closed down due to COVID, and the remaining spring colloquia were held on Zoom:

- ◆ Dr. Binod Rai (Oak Ridge National Laboratory) *“Complex magnetic textures in quantum materials”*
- ◆ Dr. Kaya Wei (National High Magnetic Field Laboratory-Florida State) *“Quantum Materials Research for Potential Energy Conversion Applications”*
- ◆ Dr. Hyunsoo Kim (University of Maryland) *“Quantum materials research and high-spin superconductivity”*
- ◆ Virtual poster session for the 49th Annual Harold Q Fuller Prize Competition

### The fall colloquium series continued by zoom:

- ◆ Dr. Daniel Gruen (SLAC National Accelerator Center) *“Cosmology from galaxies and lensing in the Dark Energy Survey”*
- ◆ Dr. Robin Smith (University of Sheffield) *“Nuclear structure and astrophysics with TPC detectors and gamma beams”*
- ◆ Dr. R. Weiss (MIT on behalf of the LIGO Scientific Collaboration) *“The beginnings of gravitational wave astronomy: current state and future”*
- ◆ Dr. Andrew A. Geraci (Northwestern) *“Searching for ‘Fifth forces’, Dark Matter, and Quantum Gravity in the Lab”*
- ◆ Drs. Marco Cavaglia and Dr. Shun Saito (Missouri S&T Physics Department) *“Public Lecture—The 2020 Nobel Prize in Physics: Black Holes and the Milky Way’s Darkest Secret”*
- ◆ 27th Annual Laird D. Scheerer Prize Competition

We concluded the year with Dr. Ryan Quitzow-James (Institute of Multi-messenger Astrophysics and Cosmology-Missouri S&T) *“Search for Gravitational Waves from Magnetar Bursts”*.

## Professor emeritus William F. Parks passed away



Dr. William Frank Parks, of Rolla, passed away Sunday, November 1, 2020 at the age of 82. He was born in Pittsburgh, PA on June 1, 1938 to the late Lee and Frances (Gaito) Parks. On December 29, 1956 he married Carol (Newman) Parks, who survives. Bill first graduated from Central High School in Philadelphia, PA in January of 1956 with a Bachelor of Arts degree. He earned a Bachelor of Science degree from Lehigh University in 1960 in Engineering Physics and his PhD in Physics from Iowa State University.

Dr. Parks had a distinguished career as a Professor of Theoretical Physics, first at Kansas State University from 1964-1966 and then at UMR, now Missouri S&T from 1966 until retiring in 2000. Outside his professional career, his interests included being an avid outdoorsman and lover of nature, exploring its beauty through hiking, mountain climbing, bicycling, camping, and snow skiing. His maintained priority was always his love and devotion to family.

In addition to his parents, Mr. Parks was preceded in death by a daughter, Stefanie Maria Elder and one brother, John Parks. He will be deeply missed by his surviving family which includes his wife, Carol Parks, of Rolla; his daughter, Jennifer Heberlie and husband Joe, of Rolla; four grandchildren, Justin Eli Heberlie, of Rolla, Jacob Sinclair Heberlie, of St. Louis, MO, Kane C. Meek and Jace Robert Elder, both of Rolla; other extended family members and dear friends.

Memorial contributions in his memory are suggested to the Ozark Rivers Audubon Chapter Nature Center or the Rolla High School Science Department. Services will be set for a future date to be determined. You can show your support by planting a tree in memory of Dr. Parks.



## 27th Annual Schearer Prize Competition

The Twenty-Seventh Annual *Laird D. Schearer Competition for Graduate Research* was held on December 5, 2019.

The competition is held in memory of Laird D. Schearer, the department's first Curators' Professor of Physics. In keeping with Professor Schearer's longtime interest in enhancing the quality of research performed at the university, the Prize, established by the Schearer family, rewards graduate students of the Department of Physics for outstanding research.



The 2020 Schearer Prize Committee, Drs. **Dan Waddill** (Chairman), **Jerry Peacher** and **Alexey Yamilov** (Judges) selected three finalists who gave oral presentations about their work in a departmental colloquium:

- First place (\$500) — **Jack Crewse**, “*High-harmonic generation in Dirac metals: Application of the semiconductor—Bloch formalism to topological systems*” Advisor: Thomas Vojta
- Second place (\$300) — **Bishnu Acharya**, “*A complete experiment on multi-photon ionization of ultra-cold and polarized atoms*” Advisor: Daniel Fischer
- Third place (\$200) — **Gaurav Khairnar**, “*Phase boundary near a magnetic percolation transition*” Advisor: Thomas Vojta

The cash awards were made possible by the generous donations of the Schearer family.

### From the Schearer Prize Winner Jack Crewse

I am deeply honored to have been named the winner of the 27th annual Schearer Prize. As an undergraduate I strove to one day achieve something worthy of such a prize, and now I am beyond delighted to have done it for a second time. Of course, none of this achievement would be possible if it weren't for the numerous people who provided their support along the way. For this year's competition I presented work that was done on a six-month visit to the University of Regensburg in Germany. I thank my advisor, Dr. Thomas Vojta, whose support and guidance not only made such a research experience possible, but also provided me with the tools to make it quite successful. I equally thank Ferdinand Evers of the University of Regensburg, who hosted me as a visiting researcher in his group and provided valuable guidance in making this project a success. Additionally, I give thanks to the members of the Evers research group for being so welcoming, especially Jan Wilhelm and Patrick Groessing. Lastly, I would like to thank my loving and supportive fiancé, Shay, who accepted my proposal while visiting me in Germany, even after putting up with me being gone for half a year!

The work I presented for this year's competition concerns the generation of high-harmonic radiation resulting from the interaction of intense, terahertz-frequency light waves with electrons in a solid. Recent advances in time-resolved spectroscopy have allowed experimentalists to observe these interesting radiation responses which contain rich details of ultra-fast (femtosecond scale) dynamical properties of the studied material. Motivated by the rising interest in this high-harmonic generation (HHG) the group of Ferdinand Evers asked the question: what happens in a topologically non-trivial material? To answer this question, we developed a numerical simulation of the so-called “semiconductor-Bloch” equations that models the time-evolution of the electrons as they are accelerated by an external electric field (the laser). By comparing calculated emission spectra of these accelerated electrons for both a typical semiconductor and a topological insulator material (i.e. Bismuth Telluride), we can study the effects of band structure topology on the HHG process. The results of our simulations show the HHG is significantly more “efficient” in topological surface states and effects from topological invariants such as the Berry curvature can be observed in the polarization of the emitted radiation. Additionally, our results indicate that the “carrier-envelope phase” of the perturbing laser pulse exhibits some control over these high-harmonic peaks in the emission spectra. The physical origin of the carrier-envelope phase control of the HHG is a subject of continuing debate, but this observation may still provide experimentalists with another tool to further advance investigations.

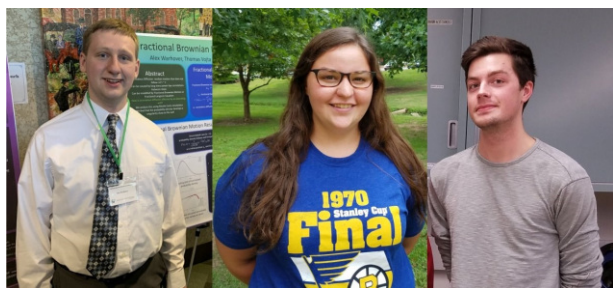
Thank you to both the Schearer family as well as the Schearer Prize committee for making this competition a possibility.

*Jack Crewse*

## 49th Annual Fuller Research Seminar

Six undergraduate students presented posters about their research projects at the 49th *Annual Harold Q Fuller Undergraduate Research Competition*, held on May 7, 2020. The posters were judged by the Fuller Prize Committee: Drs. **Paul Parris** (Chair), **Yew San Hor** and **Jim Musser**.

- ◆ First place (\$400): **Alex Warhover**, “Anomalous Diffusion with an Absorbing Wall”. Advisor: Thomas Vojta
- ◆ Second place (tie, \$300): **Elizabeth Caputa-Hatley**, “Highly non-stoichiometric amorphous oxide semiconductors: the structure and electronic properties of defects in a  $-\text{In}_2\text{O}_{3-x}$ ”. Advisor: Julia Medvedeva
- ◆ Second place (tie, \$300): **Kyle McMillen**, “Characterization of Supersonic Gas-Jet Targets from Laser Wakefield Accelerators”, Advisor: Daoru Han



## Alumni Achievement Awards



Congratulations to two physics alumni who received the Alumni Achievement Awards at the 2020 homecoming.

Dr. **Frederick Baganoff**, Phys’85, is a research scientist at MIT’s Kavli Institute for Astrophysics and Space Research and a member of the Event Horizon Telescope Collaboration that captured the first black hole image in 2019.

Dr. **John Asher Johnson**, Phys’99, is a professor of astronomy at Harvard University’s Harvard-Smithsonian Center for Astrophysics and the founder and director of Harvard’s Banneker Institute, an astronomy program for minority undergraduates.

## From Fuller Prize Winner Alex Warhover

I am deeply honored to have been awarded first prize in the 49th Annual Fuller Competition. I would like to thank Dr. Vojta for his incredible guidance and support as my research mentor, the Prize Committee and all other faculty involved for their hard work making sure this competition could happen despite the pandemic, and the Fuller family for their support that made this competition possible in the first place.

My project can be summarized as a computational investigation into different specific types of random walks. The major aspects to our investigation were changing the behavior of the random walk based on previous steps and introducing non-trivial boundary conditions, then investigating the effects of these modifications near these boundaries. Throughout the project, I have enjoyed the process of analyzing data from a computational model, then using this analysis to refine the model to best capture the phenomenon you are researching. I have also enjoyed several opportunities to discuss and present my research, which are important experiences for any researcher to become familiar with.

My experience on this project has led me to pursue a graduate degree in computational condensed matter physics. I am certain that the experience I have working on this project will be vital for my success as a graduate student. My research experience has been my favorite aspect of my undergraduate career, and I would encourage all undergraduate students who are not already a part of a project to start communicating with professors to get involved in one as soon as you are able to!

*Alex Warhover*

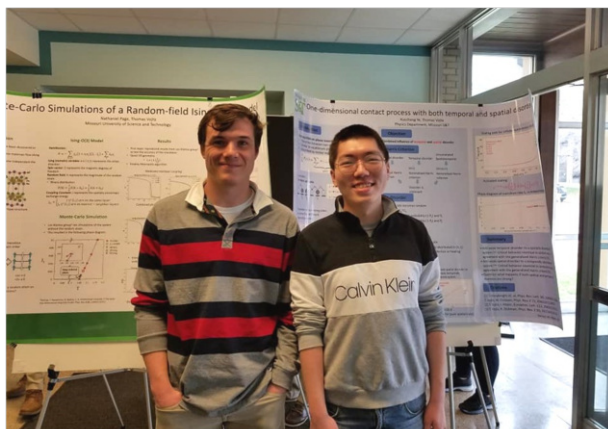
## Agnes Vojta’s book published



**Agnes Vojta**’s second poetry collection “The Eden of Perhaps” was published by Spartan Press in March.



## Instead of the APS March meeting



Undergraduate **Nathaniel Page** and graduate student **Xuecheng Ye** from the Vojta group.

The students and postdocs of Julia Medvedeva's group and Thomas Vojta's group were packed and ready to leave for the APS March Meeting when the conference was cancelled at the last minute because of the worsening Covid situation.

To give them an opportunity to present their work, the department organized an informal poster session in the lobby. Little did we know that this would be the last in-person event in the department for a long time; the Fuller Competition for undergraduate research in May was held on Zoom.



**Julia Medvedeva** and her postdoc **Bishal Bhattarai** exploring the posters



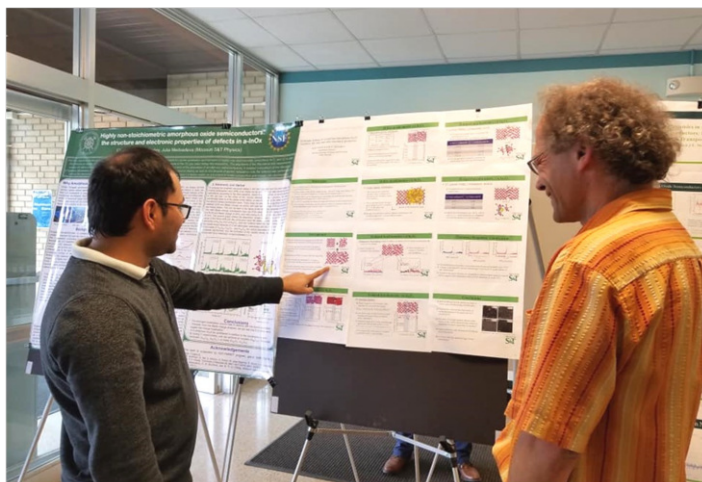
Graduate student **Gaurav Khairnar** (Vojta group) presenting his work.



Undergraduate **Elizabeth Caputa-Hatley** (Medvedeva group) explains her poster to **Jim Musser**.



Postdoc **Hatem Barghathi** (Vojta group) shows his work to **Madhav Dhital**, **Sam Halladay**, and **Gaurav Khairnar**.



Graduate student **Kapil Sharma** (Medvedeva group) discussing with **Thomas Vojta**.

### Missouri S&T Students and Alumni: In Press

Are you missing the annual list of publications involving S&T students and alumni? Last year this list contained 31 publications; it has grown too long to be included in the newsletter.

## Physics Department

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## Come Back for Homecoming 2021

Plans are tentative due to the pandemic. If possible the Missouri S&T Physics Department warmly invites you to return to Rolla for the **S&T Homecoming 2021** on **October 8 & 9, 2021**. On Friday afternoon, October 8th, 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, Shella Keilholz, (BS 1997) will deliver the Homecoming Physics Colloquium at 4PM on Friday, October 8, 2021.

Contact us at [physics@mst.edu](mailto:physics@mst.edu) for specific information about physics department activities, or [alumni@mst.edu](mailto:alumni@mst.edu) for general homecoming information. Come home to your college roots, and help us celebrate our past as MSM-UMR, as we work to dig deeper into our future at Missouri S&T!

### So What's News with You?

We hope you enjoyed this year's edition of **Matter 'n Motion**. We would like to know what is happening in the lives of our alumni to include in next year's newsletter. Send us stories, pictures and musings by mail to the **Physics Department, Missouri University of Science and Technology, 1315 N. Pine St., Rolla MO 65409-0640** or e-mail at [physics@mst.edu](mailto:physics@mst.edu). Thanks for keeping in touch. It's always good to hear from old friends. If you would like to contact us, you can reach us at (573) 341-4781. You might also be interested in checking out our web page, <http://physics.mst.edu> and our facebook page *SandT Physics*.