

MATTER 'N MOTION



Physics Department | Missouri University of Science and Technology
Spring 2025

Predicting crystal
structures 7

Symmetry matters 8

Helium recycling 11

ENDOWMENTS: GIFTS THAT CONTINUE TO GIVE

We are grateful for the generosity of the donors who funded the following endowed scholarships and prizes that helped so many students this academic year.

Dr. Richard Anderson

Dr. Harold Q Fuller

John L. & Betty L. McDaniels

Dr. Donald and Lona Packwood

Dr. John R. and Patty Rogers

Ed and Mary Sue Sickafus

Gerrie Fletcher

Dr. Richard W. Hannum

Burke H. Miller

Dr. Oran Allan Pringle

Dr. Laird D. Schearer

Dr. Gerald Wilemski

Dr. Gerald Wilemski, professor emeritus of physics, added \$45,000 to his Graduate Research Fund. Thank you, Gerry!

CHARLES W. and BARBARA J. MYLES GRADUATE SCHOLARSHIP

We thank Charles and Barbara Myles for their generous donation of \$25,000 establishing a new endowment. The Charles W. and Barbara J. Myles Graduate Scholarship will provide scholarships for graduate students who pursue research in condensed matter physics.

Charles Myles earned his BS from our department in 1969, followed by MS and PhD degrees in physics from Washington University in St. Louis in 1971 and 1973, respectively. He was a professor at Texas Tech University for 42 years.

Donations for Lab Enhancements

We received a generous \$40,000 gift from Stephen Christiansen. In addition, Kul and Charlotte Basin donated \$25,000 in honor of the exceptional teaching and mentorship by Professors Ralph Alexander and Robert Bell. We will use these funds for a long-overdue upgrade of our Intermediate and Advanced Labs. The Advanced Lab gives our students the opportunity to conduct hands-on research over the course of two semesters. It is our capstone course and one of our major's favorite classes. The donation will allow us to modernize the equipment and expand the labs to serve more students.



GARY and SHARON KOVENER PLC GIFT

We are immensely grateful to Gary and Sharon Kovener for establishing a \$100,000 endowment to support the Physics Learning Center. More on page 10.

DEAR ALUMNI AND FRIENDS,

Once again, the past year was a year of many changes. We are mourning the passing of Professor Emeritus Don Sparlin on December 20, 2024. We remember him as a passionate teacher with an irrepressible sense of humor. Prof. Jerry Peacher retired in September 2024 after a record-breaking 55 years in the department. I would like to thank Jerry for his dedication to the department and wish him the best for his well-deserved retirement.

Our faculty continues to do excellent work in teaching and research. Dr. Shun Saito received a Faculty Excellence Award, and Dr. Marco Cavaglià was honored with a Post Tenure Review Excellence Award and a Faculty Service Award. Dr. Agnes Vojta was the recipient of the 2024 Dean's Medal. Dr. Jim Musser was promoted to Teaching Professor. Drs. Hyunsoo Kim and Yew San Hor won new major NSF grants. Drs. Alexey Yamilov and Simeon Mistakidis had articles in prestigious Nature journals. Profs. Marco Cavaglià, Yew San Hor, Ulrich Jentschura, Julia Medvedeva, and Thomas Vojta, as well as emeriti Bob Dubois, Don Madison, and Ron Olson were listed in a database featuring the top 2% cite scientists in their fields.

Our undergraduate enrollment continues to be strong. We currently have 83 undergraduate and 24 graduate students. In 2024, 11 students graduated with a BS degree, and we awarded 3 PhDs and one MS degree. Our students are

active in numerous research projects. Samuel Schrader, Gabriel Riddle, and Mason Toombs won prizes at the Undergraduate Research Conference, and Joshua Santy was named a Fellow of the Opportunities in Undergraduate Research Experience (OURE) program. 37% of our first-year physics majors participated in the First Year Research Experience (FYRE) program of our college, and the department's Fuller Competition saw many promising entries. Graduate students Tuhin Das, Reece Beattie-Hauser, and Logan Sowadski are the first authors, respectively, of articles published in prestigious physics journals.

On the following pages, you can read more about the accomplishments of our faculty and students.

As always, I would like to close by thanking our alumni and friends for their dedication and generous donations without which the department's success in teaching, research, and service would not be possible. We are enormously grateful for several sizable donations that the department received in 2024. They allow us to support promising undergraduate and graduate students, improve the Physics Learning Center, and upgrade the teaching laboratories for physics majors. I know that we can count on your continuing support.

Warm Regards,
Thomas Vojta
Chair

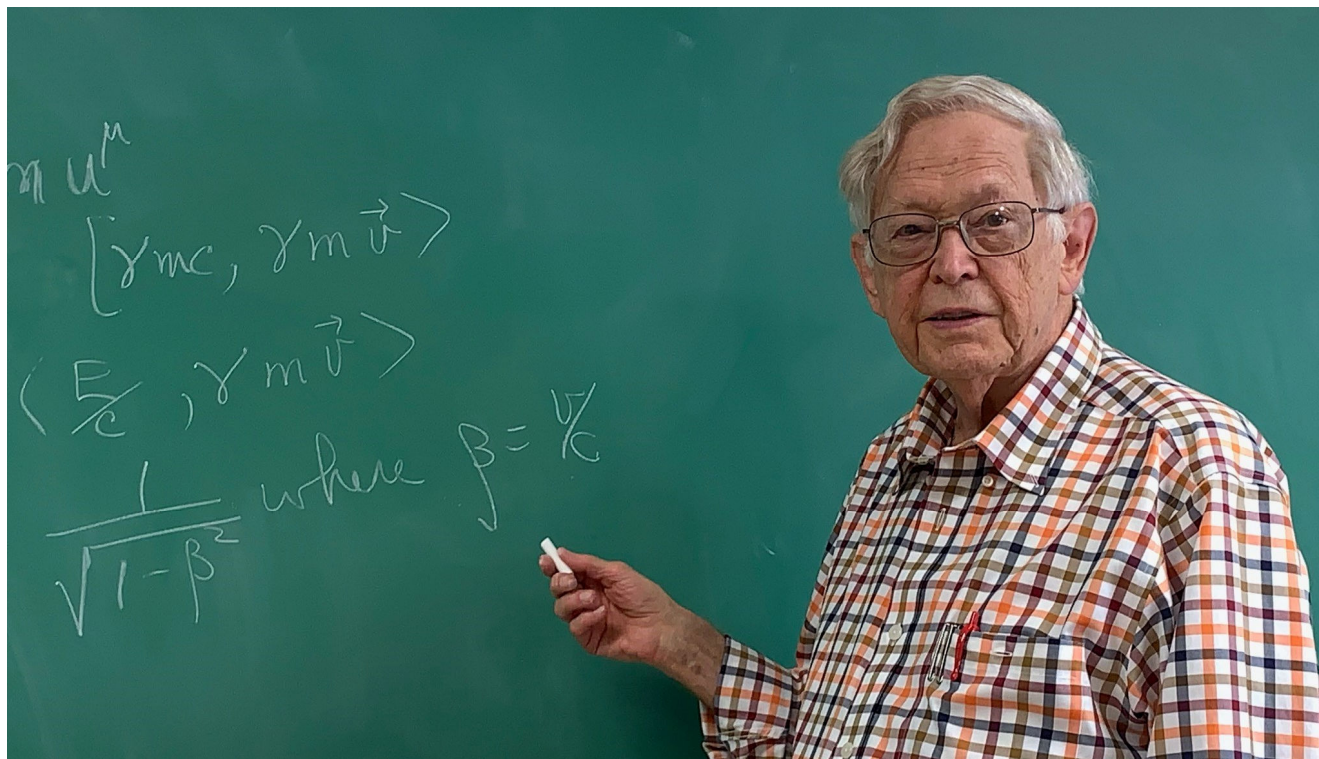


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Front cover:
Snapshot of the magnetization correlation function depicting the distribution of the population imbalance between different modes of an atomic spinor gas.
Credit: Dr. Simeon Mistakidis.
See article on pg. 8.

THE END OF AN ERA: JERRY PEACHER RETIRES



After a record-breaking fifty-five years in our department, Dr. Jerry Peacher retired at the end of the spring semester. Jerry joined Missouri S&T in 1969 as assistant professor from the University of California, Berkeley, where he was an assistant research physicist in the Space Sciences Laboratory. His research interests have focused on atomic and molecular collision theory, the topic of his postdoctoral work at the University of California, San Diego. Prior to that he worked as a physicist at the Naval Ordnance Test Station in China Lake, California, after earning his Ph.D. in physics at Indiana University. In addition to his successful research and teaching career, Jerry served as Associate Department Chair and undergraduate advisor for more than 20 years. He embodied the institutional knowledge of our department. After five and a half decades in the department, Jerry starts off his retirement by facing the momentous task of cleaning out his office. We wish him the best.



SHUN SAITO RECEIVES FACULTY EXCELLENCE AWARD

Dr. Shun Saito, assistant professor of physics, received a Missouri S&T Faculty Excellence Award for demonstrating sustained excellence in teaching, research and service.

Dr. Saito is a theoretical astrophysicist working on observational cosmology and galaxy evolution, focusing on galaxy redshift surveys.

DON SPARLIN PASSED AWAY



We are mourning the loss of Dr. Don Sparlin, professor emeritus of physics, who passed away at the age of 87 on December 20, 2024. Don earned his BS in Engineering Physics from Kansas University in 1959 and his PhD in Physics at Northwestern University in 1964. In 1968, Don came to Rolla and joined the Physics Department as an assistant professor.

Don was a condensed matter experimentalist and a passionate teacher. He was honored with seven Faculty Excellence Awards and an Outstanding Teacher Award. One of Don's many contributions to the department was to change the advanced lab from a traditional form into the format we still use today: students work in teams and design their own research projects, present at midterms and finals, and prepare a written report. This makes a real-life research experience part of the physics curriculum. Don enjoyed introducing physics to audiences of all ages, particularly grade schoolers, through his Uncle Don's Magic Show.

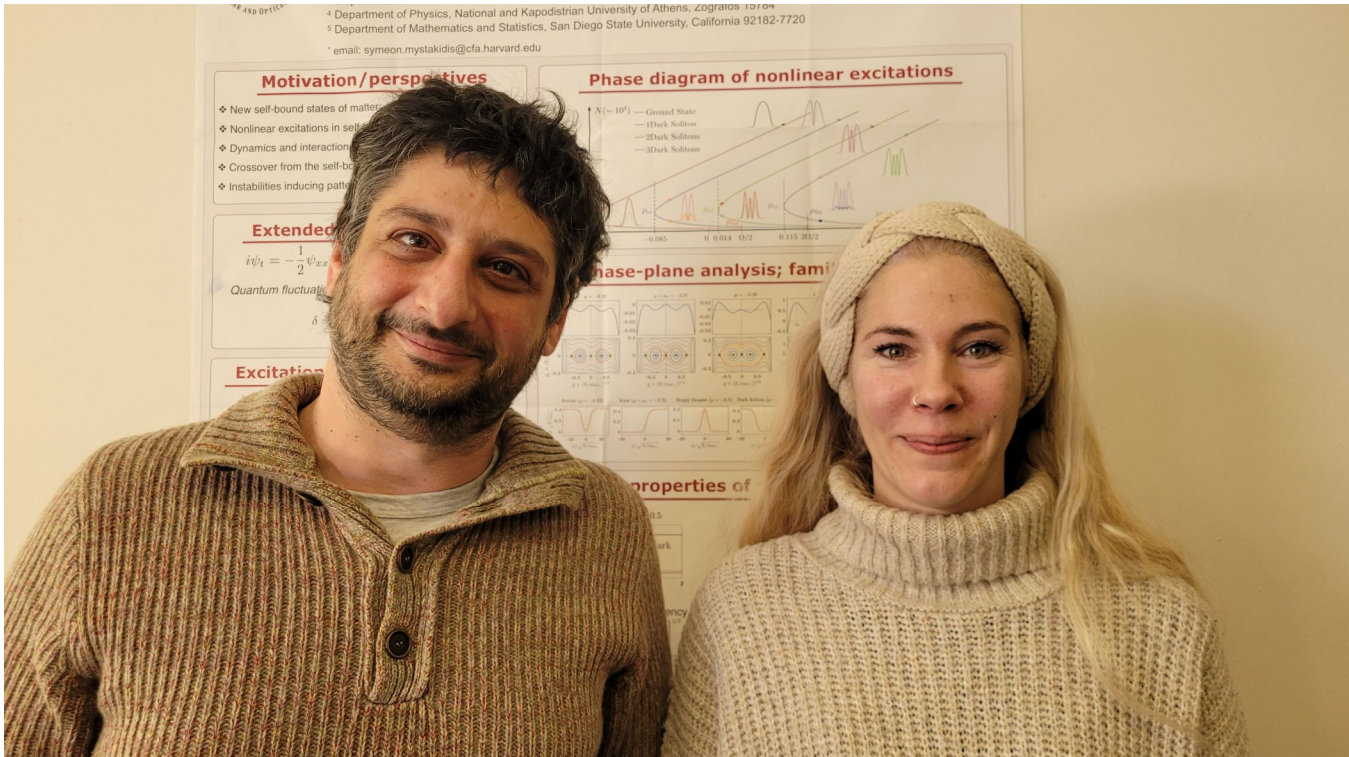
After his retirement in 2001, his passion for teaching kept him in the classroom, and he continued to teach physics and math for another 14 years. Don was active in Rolla area theater and men's choir and co-founded the World's Finest Rolla German Band. He will be remembered for his gregarious nature, his irrepressible sense of humor, and his large and loving personality. If you have stories and memories to share with the family, send an email to MegBrady100@gmail.com or a letter to Meg Brady, PO Box 508, Rolla MO 65402.

TRISH ASTON RECEIVES STUDENT SERVICE AWARD

Our front office would not run without **Trish Aston**. She cares deeply for the students, and some of the graduate students affectionately call her Mama Trish. For her dedication to student wellbeing she was honored with a Student Service Award of the College of Arts, Sciences, and Education. "I love our students", Trish says. "They're our whole purpose for being here."



NEW FACULTY: Simeon Mistakidis and Lia Katsimiga



At the beginning of the year, we welcomed two new faculty members: assistant professor Dr. **Simeon Mistakidis** and assistant teaching professor Dr. **Lia Katsimiga**.

Simeon obtained his Masters degree in Theoretical Physics from the University of Athens, Greece. He moved for his PhD at the University of Hamburg (Center for Optical Quantum Technologies). His research was devoted to the correlated nonequilibrium quantum dynamics of many-body atomic systems with a particular emphasis on excitation processes in optical lattices, pattern formation and the physics of polarons. He received the Lenz-Ising Award for outstanding junior scientists. Following his PhD, Simeon was an ITAMP postdoctoral Harvard fellow working on engineering entanglement based processes and magnetic phenomena appearing in many-body multicomponent systems ranging from quasiparticles and droplets to long-range settings. His theoretical tools are based on ab-initio approaches, beyond mean-field frameworks and the construction of effective Hamiltonian models. His research interests are focused on quantum many-body dynamics. Simeon has co-authored more than 100 scientific publications, serves as a reviewer in over ten international peer-reviewed scientific journals, and is a topic editor in two of those. You can read more about his research on page 8.

Lia received her Ph.D. in Nuclear and Particle Physics from the University of Athens, Greece. Her research was on classical solutions in field theory providing, for instance, the bounds for the mass of the Higgs boson. She was a Post Doctoral Researcher with a focus on AMO physics at the University of Hamburg. Before moving to Rolla, she taught as a visiting assistant professor in the Department of Mathematics & Statistics at the University of Massachusetts (UMass) Amherst. Her research interests are centered around AMO theory on nonlinear excitations in the form of matter-wave dark and bright solitons, admixtures thereof as well as vortices and rogue waves.

Besides co-authoring currently 20 scientific publications, Lia and Simeon share their passion for music. They enjoy theater and cinema nights and playing cards and boardgames with friends.

FULLER PRIZE 2024

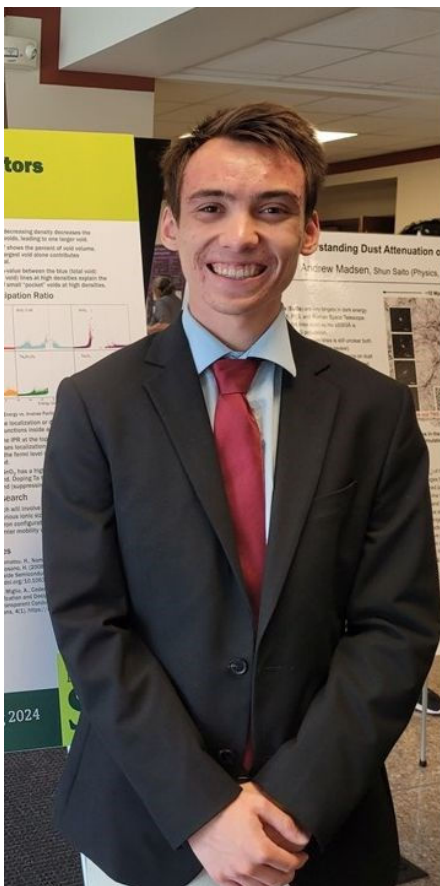
The Fuller Prize Competition for Undergraduate Research honors the memory of Dr. Harold Q. Fuller, former chair of the physics department.

1st place: Joshua Santy

"Amorphous Transparent Metal Oxide p-type Semiconductors (advisor: Dr. Julia Medvedeva) and

Samuel Schrader "Visualization of Ultracold Atomic Samples" (advisor Dr. Daniel Fischer).

3rd place: Andrew Madsen "Towards Understanding Dust Attenuation of Emission lines with Illustris TNG Galaxies " (advisor Dr. Shun Saito).



Physics majors win at S&T Undergraduate Research Conference

Samuel Schrader received 3rd place for his project "Visualization of Ultracold Atomic Samples."

Gabriel Riddle and **Mason Toombs** received 3rd place for their group project "Application of T Gates for Anti-concentration in Clifford Circuits" in Computer Science.

Joshua Santy was awarded the prestigious OURE Fellowship for 2024-2025. Joshua will work on a project entitled "Amorphous Transparent Metal Oxide p-type Semiconductors for All-oxide Microelectronics" with Dr. Julia Medvedeva.

SCHEARER PRIZE 2024

The Schearer Prize Competition for graduate research is held in memory of Laird D. Schearer, the department's first Curators' Professor of Physics, and rewards graduate students for outstanding research performed during the course of their graduate study.

First prize:

Gaurav Khairnar

“Can Helicity Modulus Be Defined For Boundary Conditions With Finite Twist?”

(advisor: Dr. Thomas Vojta)

Second prizes:

Tuhin Das

“Temperature-Dependent Dielectric Function of Calcium Fluoride (CaF₂): Infrared and Ultraviolet Contributions”

(advisor: Dr. Ulrich Jentschura)

and

Shruti Majumdar

“Multiply differential study of vibrational dissociative capture in p + D₂ collisions”

(advisor: Dr. Daniel Fischer)



Tuhin Das, Gaurav Khairnar, and Shruti Majumdar

From Schearer Prize winner Gaurav Khairnar:

The Schearer Prize Competition is one of the most outstanding programs in our department, and winning this year's Schearer Prize brings me immense joy. I am deeply grateful to Dr. Vojta for his mentorship and guidance, which have been instrumental in shaping me as a researcher. I also extend my thanks to my fellow graduate students for the invaluable discussions that brought me new insights and enriched my work. Also, I want to thank Dr. Laird Schearer and his family for their visionary support of graduate students through this initiative.

In my presentation, I explored the effects of boundary conditions on thermodynamic properties, focusing on the helicity modulus. While developing numerical techniques to evaluate the helicity modulus under twisted boundary conditions, we observed unexpected behavior as the twist angle varied. This work investigates the nature and cause of this effect, its phenomenology, and its broader implications. Our findings contribute valuable insights for experimental studies on mesoscopic systems and large-scale numerical simulations.

Finally, I encourage all graduate students to take part in this competition. It is a great opportunity to share your exciting research and learn from each other in our department.

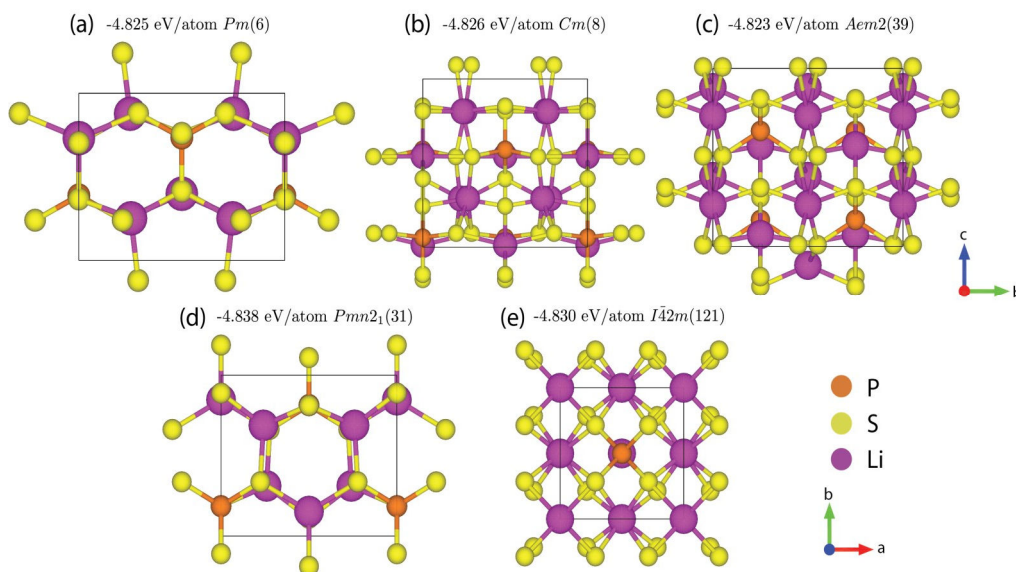
GUIDED BY SYMMETRY: Predicting Crystal Structures for Next-Generation Materials

Researchers in the group of Dr. Aleksandr Chernatynskiy have developed an innovative crystal structure prediction (CSP) method, marking a significant advancement in materials science. This approach, tailored for materials featuring rigid molecular units, combines symmetry principles with advanced computational techniques to predict complex crystal structures efficiently.

The team applied their method to two metal chalcogenides, Li_3PS_4 and $\text{Na}_6\text{Ge}_2\text{Se}_6$, widely studied for applications in solid-state batteries and other advanced technologies. Treating molecular groups like PS_4 and Ge_2Se_6 as rigid building blocks, their approach accurately identified known crystal phases and revealed previously unknown structures. Notably, a new metastable configuration for Li_3PS_4 and a novel phase of $\text{Na}_6\text{Ge}_2\text{Se}_6$ with significantly lower energy were discovered.

Using their symmetry-guided method, the researchers outperformed traditional genetic algorithm-based CSP tools like USPEX in identifying low-energy metastable configurations. This efficiency stems from strategically limiting atomic configurations to those compatible with predefined space group symmetries.

“This work demonstrates how symmetry can simplify the daunting complexity of crystal structure prediction,” said researcher Dr. Qi Zhang. “By focusing on the most probable configurations, we’ve made it feasible to uncover both stable and metastable structures with higher accuracy and less computational effort.”



Dr. Aleksandr Chernatynskiy, associate professor of physics, is a condensed matter theorist.

Figure: Predicted metastable structures (a,b,c,e) and ground state (d) structures in LiPs_4 system



Dr. Simeon Mistakidis, assistant professor of physics, is one of the authors of a groundbreaking paper in Nature Physics.

Huh, S., Mukherjee, K., Kwon, K. et al. Universality class of a spinor Bose-Einstein condensate far from equilibrium. Nat. Phys. 20, 402–408 (2024)



This article was selected as the cover of Nature Physics in March 2024 and received a dedicated Nature Physics News & Views entitled "Symmetry Matters".

SYMMETRY MATTERS:

Universality in Spinor Bose-Einstein Condensates

Phase transitions, such as the melting of ice, have always intrigued people. Particularly interesting are second-order phase transitions like the Curie transition in ferromagnets where one phase changes into the other continuously. These transitions lead to critical phenomena associated with strong large-scale fluctuations with diverging correlation lengths. Their qualitative behavior depends only on dimensionality and the symmetries of the system. This makes it possible to classify different systems with the same qualitative behavior into universality classes.

While phase transitions in thermal equilibrium are well understood, much less is known about phase transitions far from equilibrium. One important question is whether the organizational principles that govern equilibrium phase transitions remain relevant for non-equilibrium transitions.

A promising pathway to study these questions is through programmable quantum simulators. These are experiments designed to mimic specific quantum phenomena. Ultracold atoms trapped with lasers or magnetic fields allow unprecedented control of the parameters and can provide new insights into emergent quantum many-body dynamics.

Dr. Simeon Mistakidis and his colleagues from Harvard and the Korea Advanced Institute of Science & Technology (KAIST) use ultracold Lithium atoms that form a two-dimensional spinor Bose-Einstein condensate. The atoms are placed in three different hyperfine states that are utilized to mimic spins, i.e. magnetic degrees of freedom. By controlling the interactions between the atoms and the external magnetic fields, the researchers can quantum-simulate different magnetic phases and phase transitions. They discovered that the non-equilibrium phase transitions in this system display behavior that is independent of microscopic details and is determined only by the dimensionality and the symmetries of the underlying Hamiltonian. These in turn dictate the universality class that they belong to, similarly to equilibrium phase transitions. Specifically, they found that the long time-evolution of the magnetic correlation functions is self-similar and obeys power law scaling.

These results represent a stepping stone for categorizing far-from-equilibrium dynamics in quantum many-body systems in terms of universality classes and may be exploited to unveil unseen far-from-equilibrium phenomena.

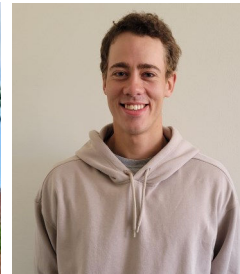
Our cover image shows a snapshot of the magnetization correlation function depicting the distribution of the population imbalance between different modes of an atomic spinor gas. The gas of atoms evolves in time after crossing a second-order quantum phase transition boundary featuring universal dynamics.

CONGRATULATIONS TO OUR 2024 GRADUATES



Bachelor of Science in Physics:

Fall 2024: Harold Baker (right) and Benjamin Edwards (not pictured)



Spring 2024: From left: Samantha Thompson, Zachary Alton, Ethan Pham, Steven Karst, Sadrad Gamez, Mason Labrot, Mason Toombs, Samuel Schrader, and Jeppe Thybo

PhD in Physics:



Qi Zhang, Jack Crewse, Chemedra Ejata (not pictured)

MS in Physics:



Reece Beattie-Hauser



Dr. Agnes Vojta, teaching professor of physics, is the recipient of the 2024 Dean's Medal for Outstanding Commitment to Undergraduate Student Success in the College of Arts, Sciences, and Education.

She is the head instructor for Engineering Physics 1 and teaches the College Physics sequence as well as the First-Year seminar for the new physics majors.



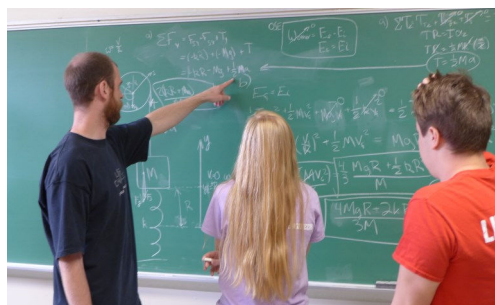
Dr. Jim Musser was promoted to teaching professor of physics effective September 2024. He is the head instructor for Engineering Physics 2 and also teaches several upper level courses.

TEACHING THE MULTITUDES

Each semester, around 900 students take introductory physics at S&T. Engineering Physics 1 and 2 as well as the College Physics sequence constitute the bulk of our department's teaching responsibilities. Teaching professors Dr. **Agnes Vojta** and Dr. **Jim Musser** are the head instructors for Engineering Physics 1 and 2, respectively. The courses combine traditional lectures, small-group recitations devoted to problem solving, and hands-on laboratory sessions. The head instructors teach all lecture sections for their respective course and coordinate a team of faculty and graduate TAs who teach the recitations. Each course has common assignments and exams to ensure a uniform learning experience for students across sections.

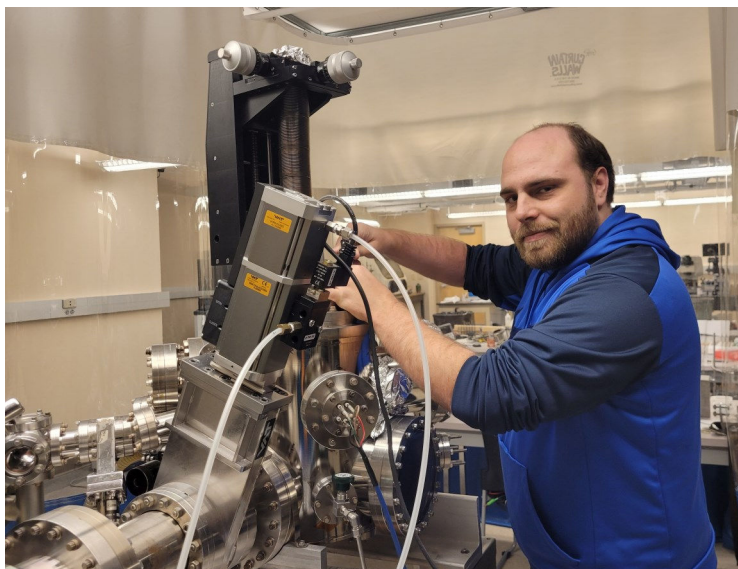
In addition, Dr. Musser and Dr. Vojta serve as academic advisors for our physics majors. They meet with every student at least once a semester and are the first faculty of the department to interact with incoming first-year and transfer students at Advising & Registration events.

The introductory courses offer the **Physics Learning Center (PLC)**. For twenty hours a week, two classrooms are staffed with faculty and Peer Learning Assistants, and students can drop by to get help with their homework. The students enjoy the relaxed, informal atmosphere and the knowledgeable staff. Working in groups and teaching each other not only enhances learning, but makes it fun, and many regulars come back week after week.



GARY AND SHARON KOVENER PLC ENDOWMENT

One of our Physics alumni, Dr. Gary Kovener (PhD, Physics, 1974) pledged \$100,000 to enhance and expand the Physics Learning Center. The funds will be used to attract and train the best possible Peer Learning Assistants, extend the hours, and offer the PLC for additional courses. We are grateful for this generous gift that will allow us to provide academic support to the students enrolled in foundational physics courses.



Graduate student Mat Pollard working in the lab

HELIUM RECYCLING BOOSTS QUANTUM MATERIALS RESEARCH

Scientists in Dr. Yew San Hor's lab grow single crystals and analyze their electrical, magnetic, and thermal properties at temperatures as low as 2 K and in magnetic fields up to 9 T. To reach such low temperatures, liquid helium is used as a coolant due to its extremely low boiling point of around 4.2 K at atmospheric pressure. Helium is rare and expensive, and once it boils off into the atmosphere it cannot easily be recaptured.

A recent grant from the National Science Foundation enabled the lab to acquire a helium reliquifier for their Physical Property Measurement System. The reliquifier captures evaporated helium, compresses it, and cools it below the liquefaction point. The liquid helium is then returned to the cryogenic system. This allows the researchers to run their experiments continuously and reduces their expenditure on liquid helium.

Among the systems that Dr. Hor and his team study are topological materials which have garnered a lot of attention because of their potential applications in quantum computing and spintronics. Due to the topology of the band structure, these materials exhibit different behavior on their surface than in the bulk. In topological insulators, strong spin-orbit coupling leads to surface states that can conduct electricity while the bulk is insulating. In contrast, in topological superconductors, the bulk is superconducting. Besides their promising applications, these materials are prime candidates for the discovery of Majorana quasiparticles which are their own antiparticles, offering potential for a tabletop experimental platform in particle physics.



Dr. Yew San Hor, associate professor of physics, specializes in experimental condensed matter physics. His expertise is in crystal growth and synthesis of quantum material systems.

CUWiP 2024

We kicked off the year with an event we had been preparing for extensively: the APS Conference for Undergraduate Women in Physics (CUWiP). S&T had been selected as one of the fifteen locations for regional conferences. Despite single-digit temperatures, one hundred physics students from across the Midwest traveled to our campus for two days of panel discussions, invited talks, networking events and poster presentations.

The participants got to hear from an inspiring lineup of speakers, including a former astronaut, scientists from the National Geospatial-Intelligence Agency and the US Army Research Laboratory, and college professors. Panel discussions explored careers in academia and industry, professional skills, and funding opportunities. A workshop on the Impostor Syndrome and stress management resonated deeply with many attendees. Students from different institutions were able to connect with each other, meet mentors and role models, and learn about the physics graduate program at Missouri S&T

The CUWiP was a tremendous success thanks to the immense efforts of the organizing committee led by Dr. Marco Cavaglia and all the students and faculty members who helped run the events.



We are grateful for the support of these alumni and friends in 2024:

CORPORATE:

Experimental & Mathematical Physics Consultants
Harvey Hubbell Foundation
Shell Oil Company Foundation

Over \$ 5,000

Charlotte A. Bhasin
Kul Bhasin
Stephen Christiansen
Gary Kovener
Charles Myles
Gerald Wilemski

\$1,000 - \$2499

Thomas K. Gaylord
Timothy H. Kaiser
Nathaniel McClure
Kevin Moll
Michael Noble
Dorcas and John Park
Sawyer Scheer
Agnes and Thomas Vojta

\$500 - \$999

Harro Ackerman
Andrew and Tessa Baughman
Junfang Gao
Wayne Holland
Xiaoqian Liu
Amy and Casey Morriss
Donnie Priest
Frederick Rambow
Frank Salter
Richard D Thom
Terrence Ward
August C. Weisler, Jr.

\$250 - \$499

Elizabeth Black
James Canner
Harry Hardebeck
Jon Holdman
Ulrich D. Jentschura
Thomas Jordan

REACHING FOR THE STARS

There is hardly another physics topic that intrigues the public more than galaxies, gravitational waves, and black holes, and our astrophysicists are in high demand for public outreach activities that capture a broad audience across the state and across age groups. Their events include planetarium shows for hundreds of K-12 children on the S&T campus; telescope viewings of the solar eclipse for 1900 high school students in Jackson, MO; demonstrations and TEDx-style talks for thousands of visitors at the St. Louis Science Center; presentations at schools, public libraries, and the Missouri State Fair. Our volunteers give generously of their time and devote many evenings and weekends to educating the public and inspiring a new generation of scientists.

The 2024 physics department Outreach Award which recognizes outstanding contributions to outreach activities that promote physics to children, S&T students, and the general public, went to postdoctoral researcher Dr. Hasti Khoraminezhad and Prof. Marco Cavaglià with his LIGO group. Marco Cavaglià was also honored with an S&T Faculty Service Award.



\$250 - \$499 ctd

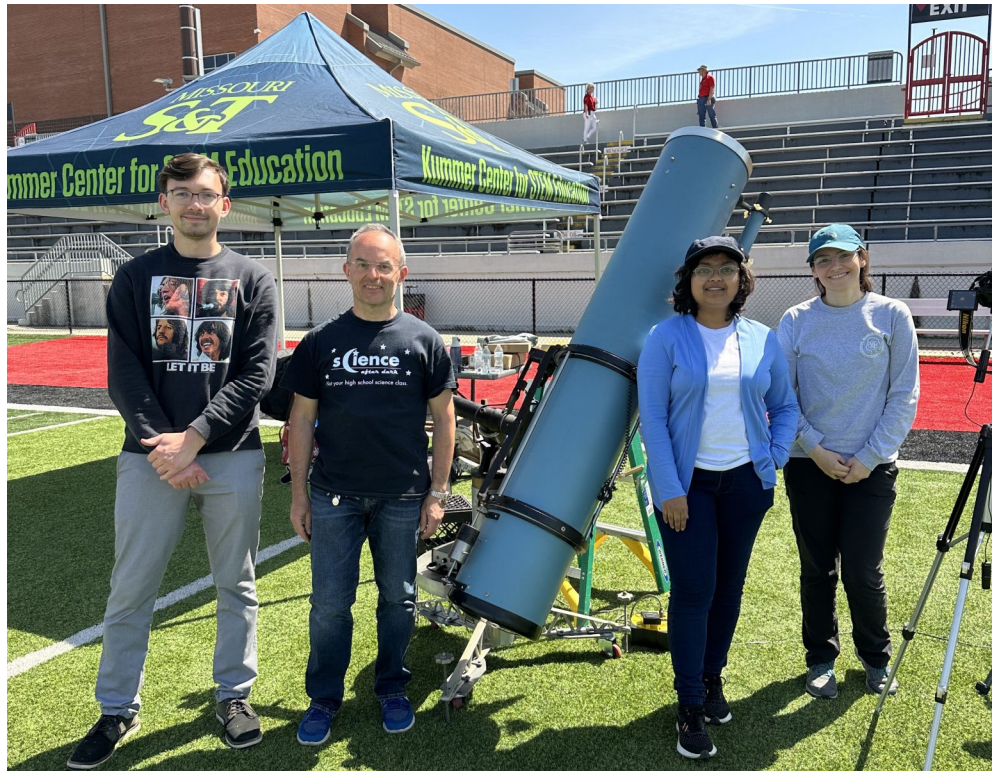
Thomas McMahon
Brian G Millburn
Mark Morris
Jon R Nance
Daniel Payton
Andrew Prideaux
Kathy Rages
Betty and Carl Reichert
Bart Wayne Smith
Robert Thurman
David J Wolters
Gary Woodward

\$100-\$250

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George Caudle
Robert and Kay Dubois
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Eric J Norman
Larry Oppliger
John Reagan
Lauren Rich
Gary S Sammelmann
Thomas Schmit
Richard Slusher
Gregory Upchurch

Under \$100

Gary D Bickel
Hava Malone
Morgan P Slusher



Top: Dr. Yanyan Zhang demonstrating space-time curvature.
Bottom: Charlie Winborn, Prof. Marco Cavaglià, Dishari Malakar, and Dr. Hasti Khoraminezhad at the solar eclipse viewing in Jackson, MO.



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Keep in touch!

Drop us an email at physics@mst.edu, visit the campus when you are in town, or plan a special trip for Homecoming 2025. We would love to show you what we have accomplished

Tell us what you're doing with your physics degree, and what you've been up to since you left Rolla. We love to hear from our graduates!

You can follow us on facebook at **SandTPhysics** or on LinkedIn at

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