



AMEP News

Applied Mathematics, Engineering, and Physics
Degree Program
University of Wisconsin - Madison

2025



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Photo credit: University Communications

Letter from the Coordinators

Dear Friends of AMEP,

Welcome to our 2025 newsletter assembled and produced once again by our multi-tasking AMEP advisor/coordinator Morgan Adams. Morgan is also a huge help in daily advising as well as organizing the get-togethers, among other program management issues. Thank you, Morgan, for your steadfast dedication to the program and keeping us on task!

The 10-year academic program review mandated by the UW Regents was completed for the BS-AMEP degree program this past Spring. The review committee formed by the Dean reviewed the self-study document written by the program managers in Spring 2024. The committee interviewed separately the faculty coordinators, the advising and administrative staff, and AMEP faculty advisors from mathematics, physics and engineering. All AMEP students were invited to meet with the committee and several did provide in-person feedback on the program. The committee also read a program support letter crafted by AMEP alumni Craig Heberer, Dan Koellen, Tom Dillinger and Lloyd Hackel. Craig, Tom, Lloyd and Dan have formed an AMEP subcommittee of the Physics Department Board of Visitors. Jeremiah Holzbauer has recently joined them. You can read more about Jeremiah later below in this newsletter.

It will not be a surprise to you that the committee noted that:

"AMEP attracts academically strong students to UW Madison that are seeking an 'applied math' program, many graduates pursue graduate school or secure jobs in industry, and the broad, and interdisciplinary training is a unique advantage. There is a strong connection with alumni of the program, some of whom are faculty members at UW. In some cases, the major was cited as a reason for selecting UW."

The AMEP program review and self-study were discussed by the L&S Academic Planning Council (APC) in April 2025. The APC provided comments and recommendations with respect to the UW Guide and the AMEP website, recruitment of women and the need to see annual reports on assessment of student learning, as required by campus policy. This 10-year review is now complete and the process of improving the program continues.

This newsletter features long time AMEP faculty advisor, Professor Leslie Smith, now 100% in the Mathematics Department since 2020, after many years with 25% appointments in Mechanical Engineering first, then in Engineering Physics. Leslie served as chair of the Mathematics Department in 2005-2008 and again in 2012-2014, while still employed 25% in engineering. She has enjoyed meeting and teaching AMEP students in Math 320, 322, 703 and 705 as well as NE/EP 548. She is a fellow of the American Physical Society and of the American Mathematical Society.

Our alumni spotlight features Jeremiah Holzbauer (AMEP 2006) who is a senior scientist at Fermilab

after a postdoc at Argonne National Lab. Jeremiah re-connected with AMEP after receiving last year's newsletter. He joined us for our Fall 2024 AMEP get-together in the Van Vleck lounge and is now part of the AMEP subcommittee of the Physics Board of Visitors.

Many AMEP students are involved in various research projects across UW. This newsletter features a few examples including Michael Zhao who is working with Professor Saverio Spagnolie in the AMEP Lab and Spencer Kwan working with Professor and AMEP alumnus Cary Forest in WHAM, the Wisconsin High-temperature superconducting Axisymmetric Mirror.

The three recipients of the AMEP leadership prize, created and endowed by AMEP alumnus Dan Koellen, are juniors Arushi Patil, Henry Miller and Spencer Kwan. Arushi has been involved in research in advanced manufacturing with Mechanical Engineering Professor Krishnan Suresh, and she is now doing a co-op with Domtar Paper Co. this summer and fall. Henry Miller is doing an internship at Extreme Engineering Solutions (X-ES) this summer and fall. Spencer has been working with WHAM, as featured below. Arushi, Henry and Spencer have demonstrated leadership in AMEP, mentoring and guiding other students and serving as effective ambassadors for the program.

Our newsletter concludes with a brief introduction to research in quantum computing from Patrick Walsh (AMEP 2025) and recipient of an AMEP leadership prize in 2024. Patrick is moving on to the PhD program in Physics at Stanford University. He worked with Physics Professor Mark Eriksson at UW and earned an NSF Graduate Research Fellowship to pursue his PhD studies.

We hope you enjoy reading about this year's sample of our student and faculty activities.

Best wishes,

Fabian Waleffe
Professor of Mathematics
Professor of Mechanical Engineering

Deniz Yavuz
Professor of Physics

Faculty Feature

Interview with AMEP Faculty

Prof. Leslie Smith, Mathematics



Professor Leslie Smith has been a member of the AMEP community for upwards of 20 years, participating in AMEP activities as an instructor, advisor, and administrator.

The AMEP program is a perfect fit, because she has an undergraduate degree in physics and a PhD in applied mathematics, which

led to faculty appointments in departments of mathematics and engineering. For much of her time at UW-Madison, she held a joint appointment in the Department of Mathematics and the Department of Nuclear Engineering and Engineering Physics. Her current research areas include atmospheric dynamics with clouds and storm formation, oceanic energy transfer between large-scale eddies and submesoscale waves, and internally-driven convection.

Leslie is “grateful to UW-Madison and AMEP for giving her the opportunity, support and space to create her own identity in teaching and research.”

She has always been an interdisciplinary scientist who gravitates towards teamwork within small groups of researchers of complementary backgrounds. She naturally grew into the broad area of fluid dynamics, an area which allows her to combine asymptotic and numerical analysis with physics, engineering applications, and atmosphere/ocean science. Some of her main collaborators at UW-Madison have been Nan Chen (Mathematics), Jon Martin (Atmospheric and Oceanic Sciences), Chris Rutland (Mechanical Engineering), Sam Stechmann (Mathematics) and Fabian Waleffe (Mathematics and Mechanical Engineering).

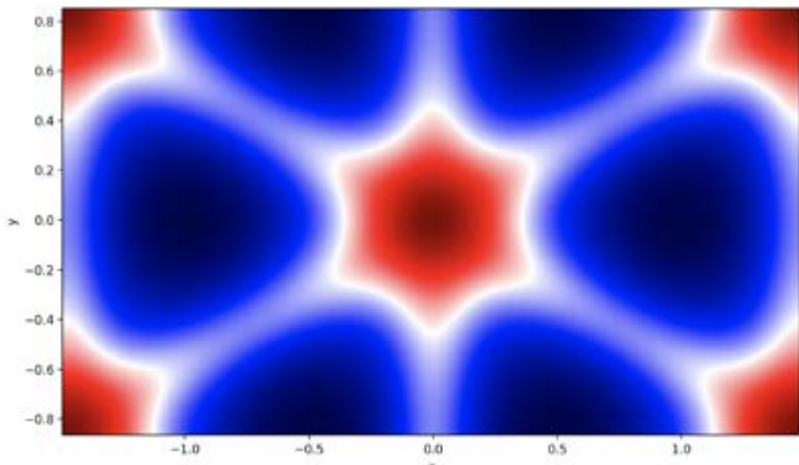
Leslie especially enjoys teaching Math 320 (Linear Algebra and Differential Equations), Math 322 (Applied Mathematical Analysis II: Partial Differential Equations), Math 703 (Methods of Applied Mathematics, a graduate course), and previously Engineering Physics 548 (Engineering Analysis II).

About teaching, she says: “I learn something new every time I teach a course. Providing students with a clear mathematical explanation brings a special satisfaction, but the best part of teaching is learning alongside students, and sharing the experience of learning together.”

In spring 2024, Leslie was the instructor for Math 322, and among the students were the three recipients of the 2024-2025 AMEP Leadership Prize: Spencer Kwan, Henry Miller and Arushi Patil. Leslie notes that: “Math 322 is especially helpful for AMEP students because it consolidates key topics from math and physics, for example, conservation laws, solution techniques and theorems of partial differential equations, and special functions.”

Leslie’s advice to students is: “embrace the challenge in the classroom, try new experiences outside the classroom, and share the excitement of both with others. At UW-Madison, there are a multitude of opportunities to engage in learning beyond the classroom. Such opportunities include the AMEP Laboratory, the Madison Experimental Mathematics Laboratory (MXM), the Simulation Based Engineering Lab, the Wisconsin Plasma Physics Lab, the Computational Flow Physics and Modeling lab and the Quantum Photonic and Engineering Lab, among many others.”

Leslie Smith is currently Professor of Mathematics and Affiliate Professor of Atmospheric and Oceanic Sciences. She is Fellow of the American Mathematical Society and Fellow of the American Physical Society.



Planform of temperature in a horizontally periodic channel with rigid top and bottom walls (red is hot, rising fluid; blue is cold, sinking fluid). The hexagonal structure emerges as the optimal-heat-transport solution to the associated partial differential equations for temperature and winds.

Student Stories

Studying Dancing Raisins



AMEP student Michael Zhao (right) with Provost Charles Lee Isbell, Jr. (left) at the Hilldale award ceremony

Michael Zhao is going into his final year as an AMEP student with additional majors in Mathematics, Computer Sciences, and Physics. He was awarded the Hilldale Undergraduate/Faculty Research Fellowship in 2025 for his work in the AMEP Lab with Professor Saverio Spagnolie.

"I joined the AMEP lab as a sophomore because I wanted to see how mathematics and hands-on experience can work together. One of the group's recent projects – the dancing raisins – immediately caught my attention. In this work, we found that small free bodies (first raisins, then 3D-printed spheres) submerged in supersaturated fluids can 'dance' vertically, rising and falling periodically due to dynamic surface bubble growth and removal. Building on Professor Spagnolie's work, my research focuses on one critical aspect of this dynamics: the body rotation at fluid-air interface. For bodies with many small bubbles distributed along their surface, the rotational

dynamics at the fluid surface is critical for destabilizing a weakly stable equilibrium and setting off another plummeting event. By using computer vision and proposing a new tracking algorithm, we analyze the particle trajectory and reconstruct its rotational velocity. Currently, Professor Spagnolie and I are developing a reduced-order mathematical model to explore how parameters like mass distribution, body radius, and bubble growth rate affect the rotational dynamics.

"In the future, we will further examine the effects of key experimental parameters, including carbonated water concentration, body size, and surface roughness. Furthermore, effects of asymmetric object shapes, such as dumbbell-shaped and Gomboc-like bodies, will be studied to explore how non-uniform geometries influence rotational motion. Although the research is focused on carefully exploring the fundamental features of a simple system, the experiment may illuminate larger-scale geophysical phenomena like the role of particulates in the degassing of magma, or the overturning of icebergs. I'll present our findings at the APS Division of Fluid Dynamics meeting in Denver this November and at the UW-Madison Undergraduate Symposium next spring.

"This project is very much a team effort. Professor Spagnolie's guidance, plus insights from lab members, has been invaluable; whenever I'm stuck, they offer new papers, fresh ideas, and the whiteboard marathon with Professor Spagnolie helps a lot on refining the model and simulations."

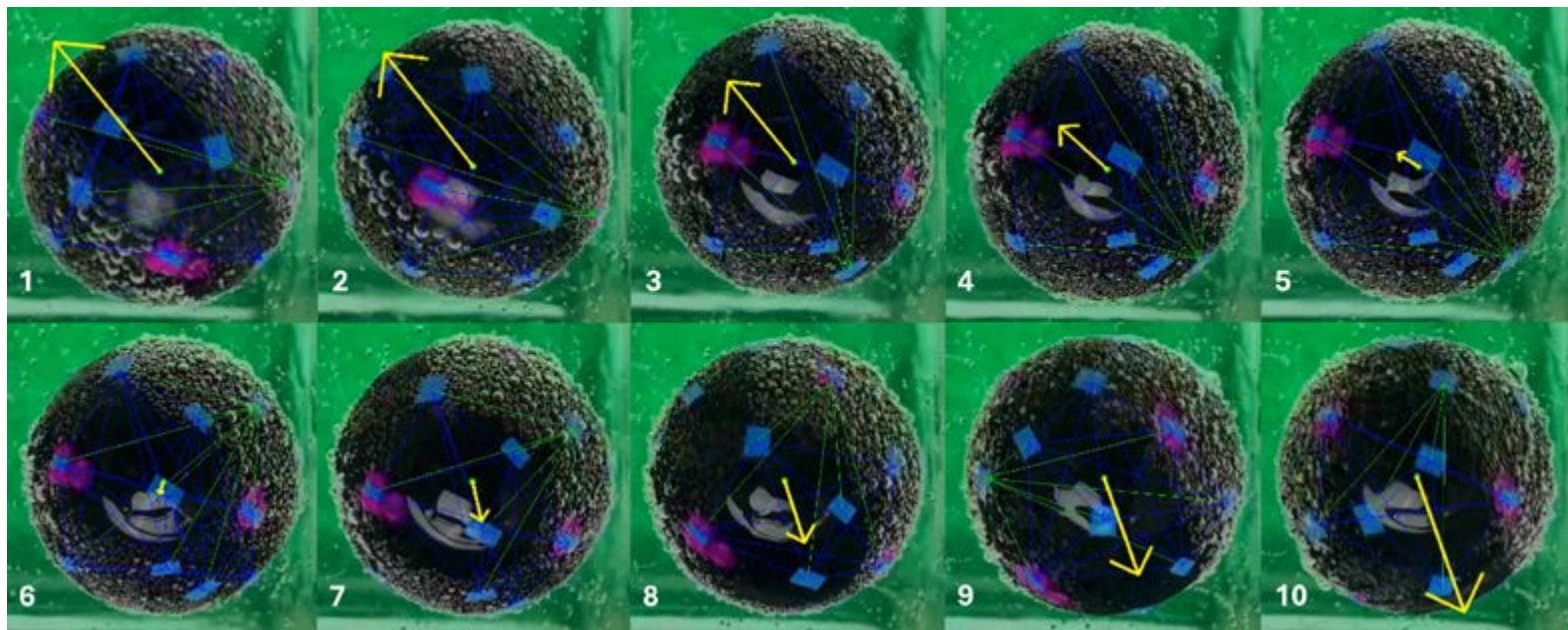
Balancing the AMEP degree and his three additional majors with research can be a challenge. But he has a strategy: "clear as much coursework as possible on weekends so that weekday afternoons stay open for the lab—an approach that keeps both tracks moving without getting stuck in one place for too long. Switching gears like this keeps both sides of my brain engaged."



AMEP student Michael Zhao traveling in Xinjiang, China

Michael is also working with fluid dynamics in the Marine Robotics Lab with Professor Wei Wang. He's looking at the implementations of Linear-Quadratic Regulator (LQR) controller on Micro Autonomous Surface Vehicles.

He is planning on pursuing a PhD after graduation and wants a program which will "bridge theoretical insights with real-world challenges" in fluid dynamics, robotics, or something new.



Frames extracted from a video of a 3D-printed sphere at 0.25 second intervals. Each green-blue vector pair shows how angular velocity was calculated, and the yellow arrow highlights the velocity of the point on the sphere closest to the camera

Working at WHAM



AMEP student Spencer Kwan calibrating a B-dot probe for WHAM

Spencer Kwan is beginning his fourth year at UW–Madison in Fall 2025. He is pursuing a degree in Applied Mathematics, Engineering, and Physics (AMEP), with additional majors in Physics (with Honors in the Major) and Mathematics.

Originally from Singapore, Spencer chose to attend UW–Madison to be part of one of the world's leading plasma physics programs. His research focuses on plasma physics for the development of fusion energy.

At the start of the 2024–2025 academic year, Spencer joined the Wisconsin High-temperature superconducting (HTS) Axisymmetric Mirror (WHAM) group. WHAM is a novel fusion device that uses magnetic mirror confinement, generating magnetic fields as high as 17 Tesla using HTS magnets to confine hot plasmas.

Under the guidance of Tony Qian, a research scientist in the Department of Physics, Spencer worked on the design and construction of a B-dot probe for WHAM. This diagnostic tool is used to measure fluctuations in the magnetic field (B) to help characterize, understand, and potentially control magnetohydrodynamic (MHD) instabilities in the plasma.

This summer, Spencer is continuing to work with Tony on implementing Gaussian Process (GP) models into an existing turbulent transport solver. The goal is to create a fast and accurate surrogate model to simulate the radial transport of plasma particles and heat within a fusion device.

Spencer first discovered the AMEP program through Math 321, taught by AMEP Co-Coordinator Professor Fabian Waleffe. He has since found the applied mathematics coursework in AMEP to be deeply relevant and valuable for his research in plasma physics.

Spencer was one of this year's recipients of the AMEP Leadership Prize due to his involvement in the program and his work in the WHAM lab. The prize goes to recipients who have demonstrated leadership in AMEP and possess a solid academic record. The committee believes that Spencer and his fellow recipients exemplified these requirements.



B-dot probe in-vessel in the WHAM device

Spring 2025 AMEP Get-Together

At our Spring social event, we awarded our AMEP Leadership Prize recipients and recognized our graduating students.



Professor Waleffe presenting the Leadership Prize to Henry Miller



Professor Waleffe presenting the Leadership Prize to Spencer Kwan



Professor Waleffe presenting the Leadership Prize to Arushi Patil

We hope to see you at our Fall 2025 welcome back social on October 7!

2024-2025 Graduates

Congrats to our new AMEP alumni!

Yu Xue

Ian Crawshaw
Tianyang Huang
Charlie Jungwirth
Evelyn Schauer
Carmine Shorette
Patrick Walsh
Yipu Wang
Alex Williamson Junk

Haoxuan Mu
Tyler Jones

Awards

Congrats to all of our AMEP students who received awards this academic year!

AMEP Leadership Prize

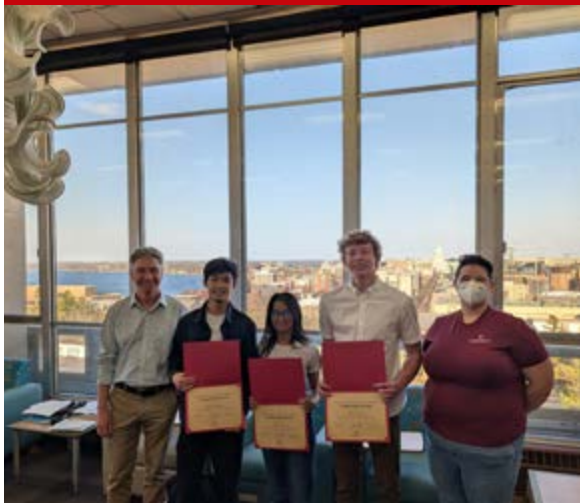
Arushi Patil, Henry Miller, and Spencer Kwan

UW-Madison Hilldale Undergraduate/Faculty Research Fellowship

Michael Zhao

NSF Graduate Research Fellowship Program Award

Patrick Walsh



AMEP Leadership Prize recipients, Spencer Kwan, Arushi Patil and Henry Miller, alongside Professor Fabian Waleffe and Morgan Adams

Alumni Spotlight

Alumni Interview with J. Holzbauer

AMEP alum Jeremiah Holzbauer graduated with a BS-AMEP in 2006.



AMEP Lab Director Professor Saverio Spagnolie (left) and AMEP alum Jeremiah Holzbauer (right) at the Fall 2024 welcome back social

Can you share some about your academic and career path? What are you working on now?

After I finished AMEP, I knew that I wanted to continue along a physics path, so I ultimately decided on Michigan State University (MSU) for a Physics PhD. I was there for five years, and after going through the available research options, it became very clear to me that I wanted to work with radio-frequency (RF) systems for the large particle accelerators at MSU. I ended up specializing in superconducting RF (SRF) resonators, helping design two of the resonators that ultimately comprised the high-energy end of their new Facility for Rare Isotope Beams (FRIB) heavy-ion accelerator. This technology is quite complex, and I had to learn mechanical, cryogenic, controls engineering as well as very applied electromagnetism. My AMEP training served me very well here because the ultimate performance of the resonators is strongly determined by having a good understanding of all these fields and their interplay.

My post-doc work at Argonne National Laboratory was at the Advanced Photon Source. Their upgrade needed specialized SRF cavities, and while a wildly different application, my grad

school experience was quite valuable in helping successfully deliver the needed performance.

After two years at Argonne, I got a scientist position at Fermi National Accelerator Laboratory (FNAL), working on integrated testing and validation of SRF cavities for larger projects at FNAL, including LCLS-II at SLAC. For the last ten years, I've been doing essentially larger and larger versions of this task, taking on diagnosing and mitigating serious issues with this technology including integrated performance and stability as well as international transportation of the finished units.

I'm now a Senior Scientist, in charge of oversight for all delicate equipment transport for the lab, and a project manager, responsible for delivering many of the core systems for a new particle accelerator we're building at FNAL, PIP-II. I'm the technical owner and manager of eight teams (made up of scientists, engineers, technicians) that work on delivering these systems. These systems include magnets, power supplies, RF amplifiers, beam instrumentation, and controls hardware and software. The most critical technical work I do these days is ensuring not only that these diverse systems will be successful, but more importantly, successful as an integrated system.

The progression of my career has been a succession of expanding challenges, mastering complex systems including all related technologies, slowly expanding my knowledge base until I'm qualified to take on a larger scope/more responsibilities. I also regularly teach at the US Particle Accelerator School, mostly RF Cavity design and mechanical vibration and analysis.

Why did you decide to pursue AMEP? How did you hear about it?

I heard about AMEP at a major fair in my freshman year (in Union South?) from a current major who had volunteered at the booth. I'm sad to say I don't remember who it was. I had been struggling to down-select between the more applied feeling of engineering and the more abstract physics majors, and AMEP offered me a chance to, well, not. AMEP was/is closest to what I was really looking for: an Applied Physics major. The path to what I currently do and jobs like it always felt to me like they needed to run through success in the field being studied (e.g., you needed to be a successful High

Energy Physicist) when I wanted to jump directly to studying and building the machines themselves. AMEP really let me do that. To be a leader in this sort of role, you do need the physics background and training but the engineering education is a critical component many are missing.



AMEP alum Jeremiah Holzbauer (center) with some team leaders touring the upcoming PIP-II accelerator tunnel

How did AMEP prepare you for your current career?

On a daily basis, I need to interact with a great diversity of people, roles, and backgrounds. It's critical that I can talk to people in their language, so to speak, and then synthesize across the whole team. Having the training and mindset from AMEP, both engineering and physics, set me up for success here.

What advice would you give to current AMEP students?

Try to make connections between your classes. The most powerful lessons I learned that are unique to AMEP are the contrasting styles and methods used between physics, mathematics, and engineering. Styles, techniques, language, can be surprisingly similar or different, and there is a lot to learn from these.

What were your favorite classes?

One of my nuclear engineering core classes (I forget which one) was at the same time as Quantum Mechanics (because who would be taking both). This would have been extremely brutal, except this engineering class was actually online lectures and materials with the in-person sessions being homework and problem review. This was well before this was a common structure, and frankly, saved me this semester. The instructor was extremely good, and was very flexible with my scheduling conflicts, and hid random alternative versions of his video lectures that included his talking to a frog hand

puppet about the lecture topic. In what was certainly my most challenging semester, undergrad or graduate, the effort he put into these lectures really made a difference.

What topics would you recommend current AMEP students get experience with (in or out of the classroom) if they're interested in the work you're doing?

In general, I think the biggest path for getting into accelerator physics or into big physics at the national labs is through internships and the US Particle Accelerator School (USPAS). There is an undergraduate class at USPAS and scholarships available, and either USPAS or internships will allow you to get very specific experience and make great connections within the community. Generally, internships are a great tool to turn your class experience into more concrete interest and accomplishments. I know a lot of people in the national lab system, so if you need advice or suggestions, look me up.

What advice would you give to recent AMEP graduates?

It feels like a very tough time out there for recent graduates. We're fighting to hire at the lab, and we have significant cool work for young professionals, but budgets mean we can't hire everyone we want to. When we're hiring, things we emphasize are also strengths of AMEP grads: cross-disciplinary interests, ability to independently learn and master new topics, etc. These are real strengths that can give an advantage as you look to find a job, or advance at your current one.



AMEP alum Jeremiah Holzbauer with a major shipment delivered from the Fermi National Accelerator Laboratory to the Science and Technology Facilities Council- UK Research and Innovation in the UK



University Communications

Make a Gift

Our AMEP Support Fund supports activities designed to improve AMEP's ability to prepare students to successfully meet industry needs, to create a sense of community among students and faculty affiliated with AMEP, and enhance visibility of AMEP on campus and to external audiences.

To mail a donation, please visit supportuw.org/how-to-give/printable-forms for instructions.

To make a secure gift online, please visit supportuw.org/giveto/amep.

Research in Quantum Computing



AMEP student Patrick Walsh with his poster and the third place award at the Chicago Quantum Exchange in 2024.

Patrick Walsh graduated with a BS-AMEP in May 2025 with additional majors in Physics and Data Science and a Computer Sciences certificate.

He conducted research with Professor Mark Eriksson during his undergraduate career and completed a Senior Honors Thesis with him. The project, titled "A Simulation Backend for Autotuning Quantum Dot Qubit Devices", focuses on building dynamic simulations of the gate voltage response of quantum dot devices used for quantum computing.

"My approach combined a Schrödinger-Poisson solver with finite element methods, interconnected through Python. The goal is to create a digital twin of the hardware – a virtual model that enables the development

and testing of tuning algorithms and software being created by our group. These tools aim to automatically calibrate the voltages on our quantum dot devices to streamline their preparation for qubit operations. This automation alleviates the intensive and time-consuming task of manual tuning and enables long-term scalability of quantum dots as a quantum computing platform."

Patrick presented this research at the UW-Madison Undergraduate Symposium and at the 2025 American Physical Society's Global Summit. Patrick says:

"Sharing your research is a key part of graduate education, so it was especially rewarding to gain that experience as an undergraduate as I prepare to begin my PhD next year. Presenting both to fellow physicists at APS and to friends, family, and peers at the UW symposiums each provided unique challenges and helped me improve my scientific communication skills. Above all, I enjoyed the chance to not only share my own work but also to engage with the diverse and exciting research that others are pursuing."

Patrick was also the president of the Wisconsin Quantum Computing Club and helped organize their second annual Qiskit Fall Fest. They partnered with IBM to put on this event series featuring lectures, interactive workshops, social events, and invited speakers from both UW-Madison faculty and IBM employees. The series culminates in the Quantum Hackathon, a chance for participants to put the knowledge they gained at the series to use in open-ended projects and IBM-provided challenges.

In October 2024, Patrick presented a poster, "Developing Tools and Techniques for Autotuning Quantum Dot Devices", at the seventh annual Chicago Quantum Summit and won third place overall! Fifty-five people participated in the contest and five people were honored with poster session awards.

Patrick will be pursuing a PhD at Stanford University and was offered an award from the National Science Foundation's Graduate Research Fellowship Program to support this pursuit.



Applied Mathematics, Engineering, and Physics

DEPARTMENT OF MATHEMATICS
UNIVERSITY OF WISCONSIN-MADISON

Thank you for reading! We appreciate the support of our AMEP community and love sharing your news. Please reach out to amep@math.wisc.edu with anything you'd like us to feature in the next edition of this newsletter. On, Wisconsin!



Professor Fabian Waleffe (AMEP Program Co-Director) and Professor Saverio Spagnolie (AMEP Lab Director) at the Fall 2024 welcome back social