CROSSSECTIONS

SUMMER 2023

UNI University of Northern Iowa

A MESSAGE FROM THE DEPARTMENT HEAD, DR. PAUL SHAND

Dr. Paul Shand
Professor and Head of the
UNI Department of Physics

Dear Friends,

Welcome to the 2023 issue of Cross Sections. It's a pleasure to have this forum to update you on significant events on campus and within the Physics Department over the past year. Growing the enrollment continues to be the highest priority of the UNI administration. Last year, I described the Academic Positioning (AP) process, which sought to reorient the university toward the future and re-envision its programs to be more attractive and responsive to the population that the university serves. Programmatic changes that emerged from the AP process include the introduction of a new bachelor of science in nursing program and the creation of a new "hub" for data science that will coordinate programs and activities across campus.

The introduction of a new standalone nursing program is the centerpiece of a restructuring of the university's existing health-related offerings. A new School of Health and Human Sciences has been formed, which will reside within the existing College of Social and Behavioral Sciences. The new school will house four departments initially: Family, Aging & Counseling; Kinesiology & Athletic Training; Nursing & Public Health; and Social Work. With the exception of nursing, longstanding programs in these areas already exist on campus. The new bachelor of science in nursing (BSN) program has been approved by the Iowa Board of Regents. An accreditation visit will take place during the upcoming summer. An Executive Director of Nursing & Chief Academic Nurse Administrator and the first nursing faculty member have been hired. The new School of Health and Human Sciences will be officially launched on July 1 of this year and the first cohort of nursing students will begin their studies in Fall 2024. Existing space in the Innovative Teaching and Technology Center (the old East Gym) is being renovated to house the labs and teaching spaces for the new program.

UNI's efforts to build its data science programs and initiatives are also proceeding apace. Our footprint in this area is small and relatively recent. Existing programs in data science include a BA in Physics: Data Science Emphasis; a BA in Business Analytics offered by the Department of Management; a data science minor that involves the departments of Computer Science, Mathematics, and Physics; and a certificate in Statistical Computing offered by the Department of Mathematics. In addition, a certificate in data science within the new general education program was offered for the first time last fall. The plan that emerged from Academic Positioning calls for two curricular pathways: Data Science and Data Analysis. Data Science programs will be highly quantitative and geared toward students who wish to pursue careers as professional data scientists. The Data Analysis pathway is intended for those students who may have a primary major in another field but wish to sharpen and deepen their data analysis skills.

(Continued on next page)

A NEWSLETTER FOR ALUMNI AND FRIENDS OF THE
DEPARTMENT OF PHYSICS, UNIVERSITY OF NORTHERN IOWA

DEPARTMENT HEAD MESSAGE cont.

The plan also calls for the establishment of a Data Science hub, which will coordinate university-wide curricular, research, and outreach efforts. A search for the director of the Data Science hub is currently underway.

Other recent initiatives to boost enrollment include the UNI@IACC program and the Purple Pathway for Paraeducators. The UNI@IACC program, which began in Fall 2022, provides a mechanism for place-bound students with an associate's degree from any Iowa community college to obtain a bachelor's degree in two years, entirely online. Students can pursue several bachelor's degree programs, including Business Administration, Criminal Justice, Elementary Education, Human Services Technology Management, and Liberal Studies. The UNI@IACC initiative is accompanied by the Future Ready scholarship program, which provides support equal to the difference between UNI's tuition and that of the student's community college. UNI@IACC will be especially helpful for Iowa's large rural population and for adult students. UNI@IACC started out as a partnership between UNI and the Des Moines Area Community College. The success of this partnership led to its expansion to all of Iowa's community colleges.

As is the case in many other states, Iowa is experiencing a teacher shortage that the Purple Pathway program is intended to address. The Purple Pathway for Paraeducators (PPP) program provides an accelerated path to Iowa teaching licensure for paraeducators in the state. (Paraeducators are professionals who assist teachers with the education process.) PPP students with an associate's degree can earn their teaching degree (in elementary education) in two years after successfully student teaching for one semester. All PPP course work will be online, with meeting times in the evening and one Saturday per month. The state of Iowa administers a grant program to support PPP students. There are over 7,000 paraeducators who have the necessary credentials to work in Iowa, so the PPP program is serving a group of significant size.

Within the Physics Department, we continue to move forward with the development of a materials science & engineering program — the first engineering program at UNI. This involves a collaboration with the Chemistry & Biochemistry and Applied Engineering & Technical Management (formerly Industrial Technology) departments. An accompanying program in materials engineering technology is also in the hopper. We are waiting for formal Iowa Board of Regents approval, which should come in June, after which both programs will go through the normal UNI curriculum cycle. We expect the first students to be enrolled in Fall 2024. Over the next 15 months, we will work with local industries to secure internships, procure equipment for laboratories, market the programs across Iowa and surrounding states, and hopefully find the resources to hire one or more faculty members. If you have ideas about curricular innovations, industry partnerships, or anything else that is relevant to materials engineering, I would be happy to hear them.

We are planning to introduce a new emphasis in physical chemistry for students completing our B.A. in Physics. This program is intended to facilitate the addition of a physics major by students whose primary major is in chemistry or biochemistry. Some of these students already take the first-year calculus-based physics sequence and, of course, they take physical chemistry. The new emphasis is structured to complement their chemistry/biochemistry studies as much as possible. To this end, we will also introduce a new junior/senior-level biological physics course.

Our students continue to be enthusiastically involved in research. They were well travelled this year, having attended the PhysCon 2022 international conference for physics undergraduates in Washington, DC, the March Meeting of the American Physical Society in Las Vegas, and the Conference for Undergraduate Women in Physics in Iowa City. Our faculty have also been very busy pursuing grants from the National Science Foundation and the Department of Energy to support their research. I hope to have good news about these efforts next year.

Let me close by thanking you for your strong and constant support. Both prospective and current students continue to be inspired by the success of our alumni in their varied careers. Our annual Homecoming Picnic is on Saturday, October 21. Please mark your calendars and I look forward to seeing you there!

Best wishes,

Paul Shand
Professor and Head

CONTENTS

DEPARTMENT HAPPENINGS

Homecoming Picnic

Our annual Homecoming Picnic was held at Seerley Park on October 8. The weather was sunny and cool, and everyone enjoyed South Asian cuisine, as well as the salads, sides, and desserts contributed to the potluck lunch by attendees.

Top photo: Nearly all the attendees are shown here. Everyone is digging into their picnic fare and enjoying the conversation!

Bottom right photo: Physics alumni Jeff England (left foreground), Kurt Drilling (middle), and Paul Bergmann share stories about life at and after UNI.

DEPARTMENT HAPPENINGS

Visits to the department

As in past years, several groups of K–12 students visited the department. The students enthusiastically undertook various hands-on activities, which both visitors and hosts enjoyed.

Waterloo

Eighth-grade students from Waterloo investigate standing waves on a string. Several of the students used their phones to capture slow motion video of the wave oscillations.

Beckman

Physics faculty member Dr. Jeff Morgan guides students from Beckman Middle School in Dyersville, IA, as they investigate waves and optics.

Cedar Falls

Cedar Falls 6th graders test their magnetically levitated cars. The students learned about the properties of magnets and applied their knowledge to building and testing the cars. We have some budding engineers here!

Awards Banquet

The annual Physics Banquet was held in a new venue this year - the lobby of the Gallagher Bluedorn Performing Arts Center. Attendees enjoyed a delicious catered dinner. The department recognized students for their accomplishments, awarding numerous scholarships and research fellowships. Finally, soon-to-be graduates Lukas Stuelke and Maddie Johnson paired with faculty members and faced off in a game of "Blingo," hosted by Dr. Paul Shand.

Dr. Shand presents an award to physics major Maddie Johnson, who graduated in May.

Banquet attendees play the newly invented word game "Blingo." The students seemed to be better than the professors at this game.

Begeman Lecture

This year's Begeman Lecturer was Dr. Chris Stark, Deputy Observatory Project Scientist for the James Webb Space Telescope. The title of his talk was "Searching for Other Worlds: The James Webb Space Telescope and Beyond."

Chris shared the highlights of the development and deployment of the telescope with the audience, and showed us several images captured by the telescope. Chris is a 2004 UNI Physics alumnus, with a Ph.D. in physics from the University of Maryland. He is an expert in extrasolar planets and debris disks. According to Chris, scientists are already planning for the space telescopes that will follow the JWST.

Left: Dr. Stark shows an image of the James Webb Space Telescope. It was really a time-lapse animation of how the pieces of the telescope unfurled and attained their final configuration. Really cool!

Right: Dr. Stark chats with physics majors in the student lounge.

Physics Competition

The annual statewide Physics Competition for high-school students was held on April 11. We had the largest attendance in many years — approximately 230 students from 24 schools across Iowa. For the second time, the day-long competition featured preliminary rounds of competition in each event, as well as final rounds between the top competitors. Many of the participating school teams are coached by teachers who are UNI alumni or have completed endorsement coursework or workshops presented by the department.

Two participants set up their toothpick bridge for testing. They may win the competition but the bridges always lose.

And the overall winners are.... Dubuque Hempstead! Congratulations to a great group!

Holiday Colloquium

The annual Holiday Colloquium took place during the week before final examinations. As usual, it was a great stress-buster, featuring demonstrations, “magic” tricks and "minor miracles," as well as delicious treats provided by the department faculty and staff.

The Holiday Colloquium is also an occasion to thank our staff. Dr. Shand extols the virtues of Lyle Langstraat, our longtime custodian who retired this year.

Physics major Jeff Carlson demonstrates his minor miracle — a radio that he built for his electronics project. Ashley Harrington waits to do “magic” tricks with her soccer ball.

FACULTY PROFILE

Dr. Andrew Stollenwerk, Professor of Physics

Andrew Stollenwerk

Andrew Stollenwerk received a B.A. in mathematics and a B.S. in physics from Miami University in Ohio. He obtained an M.S. in physics and a Ph.D. in nanoscience from the University at Albany (State University of New York). He was a postdoctoral fellow at Harvard University and an adjunct faculty member at Bentley University before coming to UNI in 2009. Stollenwerk became interested in physics because it allowed him to make connections. "I like how physics is the basis of all sciences and engineering. It gives me the foundation to explore many different branches of research," he states with conviction.

Considering Stollenwerk's two-year postdoctoral research fellowship at Harvard, UNI might not seem to be an obvious choice. Some insight into the kind of academic environment he was seeking can be gleaned from his choice to gain teaching experience at Bentley University — a relatively small, undergraduate-oriented university — while at Harvard. "I chose to come to UNI because the Physics Department had a vigorous research program with active students. At the same time, it had a far more relaxed environment than a major research institution," he observes.

Stollenwerk has taught a wide variety of courses at UNI. These courses include Physics in Everyday Life, General Physics I, General Physics II, Classical Mechanics, Mathematical Methods of Physics, and Quantum Mechanics. In his teaching, Stollenwerk promotes students' understanding by explaining concepts and results in different ways. He cultivates interest and excitement by relating the course material to practical applications. When asked to provide an example, he quickly replies, "When teaching Quantum Mechanics, I ask my students to solve various problems computationally. I found that my solution to one of the problems could be modified to explain a phenomenon I was observing in my research. I never thought that an undergraduate course would be a source to understanding state-of-the-art research!" In his research, Stollenwerk uses a scanning tunneling microscope, which is certainly one of the more compelling and fascinating applications of quantum mechanics. Stollenwerk's performance in teaching has earned him the College of Arts, Sciences and Humanities Dean's Teaching Award for Departmental Programs.

Stollenwerk's research primarily examines surfaces and interfaces of low dimensional materials. "For the most part, we have a good idea how bulk materials behave and why," he says. "As materials shrink to two, one, and even zero dimensions, new physical phenomena begin to emerge. Sometimes we can understand why, but often we have a hard time predicting or even understanding these new behaviors." Recently, Stollenwerk, along with his undergraduate research students and Physics faculty member Tim Kidd, have been investigating the electronic growth of thin film materials.

"Essentially, the films are so thin that they behave like single atoms in a one-dimensional box in the direction perpendicular to the surface," he explains. "As the thin films change thickness, their quantum properties change. Certain film thicknesses are more energetically stable than others." Stollenwerk and his team have used this understanding to create ultra-smooth films of gold with a roughness less than a fraction of an atom. "As far as we can tell, we hold the world record for the smoothest thin film of gold over the largest area and are currently in the process of patenting this technique," he declares. Stollenwerk's research has been supported by grants from the National Science Foundation and the U.S. Department of Energy.

Stollenwerk also applies his talents to performing service activities for the Physics Department, the university, and the community. Helping to revise the Physics Department's curriculum is an important task that he is engaged in. "Currently, I am working on developing a degree in Engineering Physics. This program will be for students who are really interested in the practical applications of physics," he remarks. Stollenwerk has also served on the University Faculty Senate, which is deeply engaged in reviewing various curricular changes across the university.

Despite his busy schedule, Stollenwerk tries to reserve time to unwind. In his spare time, he enjoys working with wood, running, and traveling. "I also enjoy numerous activities with my son, even if it's just getting owned in Fortnite," he jokes.

STUDENT PROFILE

Lukas Stuelke

Lukas Stuelke

Lukas Stuelke was born and raised in Waterloo, Iowa. He attended Waterloo East High School. He entered UNI in Fall 2018. “I chose UNI because it was close to home and family, and because of the Talent Search program,” he states. Having spent five years at UNI, Lukas has definite ideas about the things he likes most. “I haven't met a single professor in any of my major-related courses that I disliked even a little bit,” he declares. “Everyone in the physics department will try their hardest to help you as much as they can, and that's admirable.”

Lukas has been interested in physics, specifically theoretical physics, since middle school. “The precise moment I remember wanting to do physics was when I was looking up black holes on Wikipedia and saw what was at the time a very complicated equation that I wanted to figure out,” he recalls. “It was the equation for the Schwarzchild radius of a black hole, so I can comfortably say that I understand the equation now.”

Lukas has completed two different research projects in the Physics Department. “My first research project (ever) was under Dr. Shand, with Aaron Janaszak as a co-researcher,” he recollects. “We wrote a MATLAB program that modeled the magnetic Griffiths phase, which is an intermediate magnetic phase between total order (ferro/ferrimagnetic phase) at low temperatures and total disorder (paramagnetic phase) at high temperatures.” Warming to the topic, Lukas continues, “During this phase, local order occurs and clusters of ordered magnetic moments dominate. Our program was able to successfully model known data and make predictions. This was presented at a physics colloquium here at UNI.”

Lukas’s second research project was under the supervision of Dr. Pavel Lukashev. They did theoretical condensed-matter calculations in order to find potential half-metals. “A half-metal is a metal that is a conductor for electrons of one spin state while insulating against electrons of the opposite spin state,” Lukas states. “Half-metals will be useful in the up-and-coming field of spintronics. While most of the materials that we studied did not express half-metallicity, we did find a few that were promising, and colleagues at another university synthesized those materials to study their properties experimentally. I've presented on a few of the materials at colloquia here, at the Capitol building in Des Moines, and at the University of Nebraska-Lincoln for a Sigma Pi Sigma meeting. I know that Dr. Lukashev presented our work at the 2022 Magnetism and Magnetic Materials conference.”

In addition to his B.S. physics major, Lukas is also completing a Mathematics B.A. and an Astronomy minor. He also does tutoring/help sessions for both the Physics and Mathematics departments. “I enjoy proof-based mathematics and logical reasoning, and have a good time when given proof-based homework,” he says emphatically. “It's like a fun puzzle, so I really enjoy my mathematics courses.” Lukas is also the social chair for the Physics Club. “Because I'm so busy and we decide on these things together at the officers' meetings, the position doesn't really mean much, he declares. “I hope that in the future the Physics Club can be as active as it was before COVID. If you're a student, go take part in these activities and be active!”

Given that he’s a double major and an officer in the Physics Club, there aren’t too many gaps in Lukas’s schedule. “I don't have free time anymore,” he jokes. “Seriously though, I usually spend my free time playing video games or watching videos about various topics from math to science to e-sports. Occasionally, I work on a hobby programming project here and there. Nothing extraordinary.”

Lukas has been accepted at Florida State University for an Applied and Computational Mathematics Ph.D. “I'm very much on the fence about what I want to do in my life, he muses. “I enjoy pure mathematics and logical reasoning a lot, and I enjoy scientific programming a lot. I am also interested in machine learning and artificial intelligence development. Computer science, too. I don't exactly know what I want, yet. I'm under the impression that I'll eventually try to get a theoretical physics Ph.D. as well.” Lukas hopes to learn more about PyTorch (a machine language platform) on his own. “I've been afraid of dipping my toes into the water, so to speak, because it seems very daunting,” he says. “But I felt the same way about JavaScript before I started to use it for a class this semester, and that turned out to be much easier than I worried it would be.”

STUDENT FOCUS

Jenna Heinen

Jenna Heinen

Jenna Heinen is B.S. Biochemistry major and a B.A. Physics: Data Science Emphasis major. The essay is based on her Honors paper, which she chose to write on a topic from the Modern Physics course.

Student Essay

Nuclear Fusion is commonly known as the energy of the future, always seen far off in the distance as something to be achieved — almost a scientific dream. However, in the wake of recent breakthroughs, it begs the question of how far away this reality actually is and what obstacles stand in the way of reaching this goal. Why should we as Americans even care? In this paper, I will take some time to break down what nuclear fusion is, recent breakthroughs by scientists, current obstacles and future steps that need to be taken, and why fusion is important for Americans and the world in general. Finally, I will attempt to answer the age-old question of when will commercial nuclear fusion finally be a reality.

So, what is nuclear fusion? In its most basic form, nuclear fusion is the coming together of two light nuclei to create a single heavier nucleus with a smaller total rest mass, creating large amounts of energy. These light nuclei are usually the hydrogen isotopes deuterium and tritium. The gas is subjected to extreme heating from different sources such as high-frequency electromagnetic waves and neutral beam injection, causing it to transform into a plasma whose temperature is extremely high. Under these conditions, the repulsive nature of the nuclei is overcome, and they can come together to form, for example, a helium atom and a highly energetic neutron. It is important to note that for fusion to occur, temperatures around 150,000,000 °C need to be achieved in the plasma. Also, plasma particle densities and plasma confinement times need to be high enough to trigger fusion. Stars are naturally powered by nuclear fusion.

Knowing a little more about what nuclear fusion is, what steps have researchers taken to use it to generate energy controllably on Earth? First, and probably most notably, in December 2022 at the Lawrence Livermore National Laboratory in California, the world's first "net energy gain" fusion event was achieved. This means that for the first time in history, more energy was produced from the fusion reaction than was provided to the system from the laser beams. In this case, fusion was achieved via inertial confinement, i.e., the use of many powerful lasers to compress the fuel and generate the conditions necessary to trigger fusion. In total, 2.05 megajoules were put into the system while 3.15 megajoules were produced. This experiment clearly showed the potential of fusion but it should be noted that its success was made possible by previous work at Lawrence Livermore Lab which is less known. In August 2021, researchers at the Livermore Lab were able to achieve a state called burning plasma, meaning the helium being produced in the fusion reaction was able to generate enough energy to provide at least 50% of the heating necessary for the remaining fuel. When this is achieved, the fusion reactions are able to sustain themselves, creating a feedback loop of reactions that increases the overall output of energy substantially. Moreover, it also greatly lessens the demands for external heating sources once this point is reached, lowering the overall input demand of fusion. In total, it can be seen that within the last two years alone, crucial breakthroughs in the mastery of nuclear fusion have been made!

While exciting breakthroughs have been made in the fusion world, there is still plenty to be done before we see a world running on fusion energy. The overarching obstacle for scientists today is taking fusion science from an achievable future to a commercial present. Within this lies the obstacles of creating reactors that can withstand the repeated extreme conditions of fusion, being able to breed tritium within the fusion device, creating mechanisms that allow lasers to shoot more continuously, and most importantly, increasing the energy yield of fusion exponentially. In terms of creating reactors, structural materials must have extremely high melting points and thermal conductivities in order to withstand the extreme temperatures and thermal shock stress of the reactions. As of now, tungsten seems to be the best option, but its transmutation to osmium via neutron irradiation may induce brittleness. The idea of breeding tritium is also topical.

(Continued on next page)

While deuterium is an abundant source in earth, tritium is not. However, when the energetic neutrons from the fusion reaction react with lithium, which is an abundant element, helium and tritium can be made.

Therefore, if engineers were able to incorporate lithium into the inner walls of fusion reactors, the reactor would be able to produce tritium which could then be recycled in the reactor for more fusion reactions. Currently, laser shots are only able to be done once a week. If we want to produce energy commercially, or even just power the plants running these reactors, multiple fusion reactions must occur per second. Therefore, mechanisms need to be put in place to rapidly load fuel capsules and perform laser shots in order to make this a reality.

Clearly, the engineering of fusion reactors is the major obstacle to the success of commercial fusion. In fact, as of today, fusion energy is nowhere near commercialization. Even with the net energy gain event, the 3.15 megajoules produced in the fusion reaction only accounts for approximately 1% of the energy used to power the laser grid in the reaction. Therefore, major strides need to be taken in order to significantly increase the output of the fusion reactor while simultaneously reducing the energetic cost of starting fusion reactions.

So, why should anyone care about nuclear fusion if it seems to be shrouded with a multitude of challenges?

Well, in fact, there are many reasons why Americans and people the world over should be deeply invested in the success of fusion. First of all, looking towards the future, it is expected that current energy consumption will triple by the end of the century due to growing population, urbanization, and the development of poorer countries. Moreover, our stores of fossil fuels will only continue to be depleted as well as increasingly contribute to issues like global warming.

Wind and solar energy by themselves may not be able to meet the growing demand for energy. Fusion power, if commercialized, provides a nearly ideal solution. It is a clean energy source with non-harmful materials and byproducts, its required materials are abundant and easily harvestable, and most importantly, it produces approximately 4 million times as much energy per reaction than our current methods of burning fossil fuels.

In short, fusion is safe, efficient, and has the potential to be abundantly available. Its extremely low fuel consumption for a given energy output should make fusion economically advantageous. Thus, people should care about fusion power because it will provide clean, safe, and abundant energy. It addresses major issues like global warming, population growth and resource scarcity, and it has a capacity advantage over other options such as wind and solar energy.

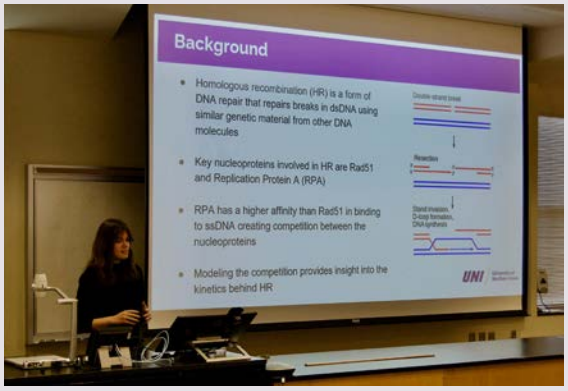
While fusion has a multitude of challenges in its commercialization, scientists and engineers continue to generate innovative ideas to overcome them. It's imperative that we as a country and a world stand behind them and support them. However, when will we see a return on this near century-long investment? While scientists have differing opinions, there is consensus that without more significant breakthroughs, fusion energy will probably not be a major energy producer until the latter half of the 21st century.

So, is nuclear fusion truly just a scientific dream or a tangible reality? All I can say is that the signs seem to point to a hydrogen-based economy in the future!

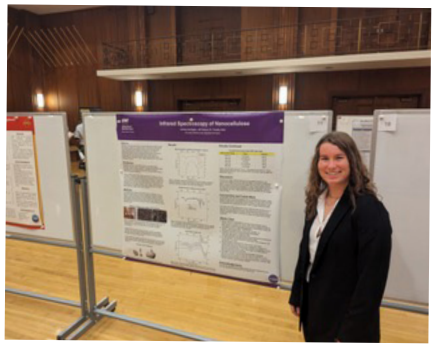
STUDENT FOCUS

Student Research

Our students continue to be active in research. They were especially well traveled this year, presenting at two international conferences and one regional conference. In addition, physics major Maddie Johnson (now an alumna) spent last summer doing research in Paris, France as a participant in a University of Michigan undergraduate summer research (REU) program.



Biochemistry/physics double major Sabryn Labenz presents her research at a special UNI Physics Colloquium for summer undergraduate research fellows. Sabryn was later recognized for 'Outstanding Research Presentation' at the annual department awards banquet.



Physics major Ashley Harrington — who also plays soccer for UNI — at her poster at the Conference for Undergraduate Women in Physics in Iowa City, Iowa.

UNI Physics students and Physics faculty member Dr. Tim Kidd at a restaurant in Washington, DC where they attended PhysCon 2022.

Maddie Johnson, Jeff Carlson, Zach Pottebaum and Young Moua at the 2023 American Physical Society March Meeting in Las Vegas.

STUDENT FOCUS

PHYSICS SCHOLARSHIPS AND AWARDS

Sigma Pi Sigma, Physics Honors Society

New Members as of 2023

Jenna Heinen
Sabryn Labenz
Stephen McFadden
Brandon Schmidt
Dylan Seiffert

2022-23 Departmental Awards

Outstanding Performance in Introductory Physics

Colin Hemesath
Vivian Woltman

Outstanding Performance in First-Year Projects in Physics

Haley Harms
Vivian Woltman

Outstanding Research Presentation

Sabryn Labenz

Physics Department Outstanding Service Award

Madelyn Johnson
Lukas Stuelke

2023 Summer Undergraduate Research Fellows

Haley Harms
Sabryn Labenz
Brandon Schmidt
Dylan Seiffert
Blaine Williams

2023-24 Physics Department Scholarships

Robert E. Allender Physics Teaching Scholarship

Carter Bush

Grossman-Perrine Scholarship

Michaela Tweeton

Louis Begeman Memorial Scholarship

Jeff Carlson
Jenna Heinen
Ashley Harrington
Sabryn Labenz

Jourdan Excellence in Physics Scholarship

Vivian Woltman

C. Clifton Chancey Scholarship in Physics

Thayer Prum

Jourdan Mentor Scholarship

Haley Harms

2023-24 CHAS Scholarships

Students First Scholarship

Blaine Williams

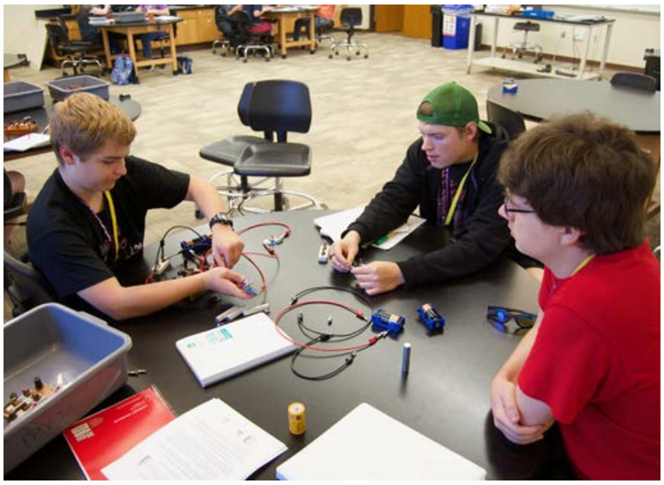
Alan and Barbara Hubbard Scholarship

Carter Bush

Roy L. and Lela Ping Abbott Scholarship

Ashley Harrington

PHYSICS EDUCATION



Homeschool Academy participants explore electric current and circuits.

Home School Academy

In Iowa and many other states, the number of families choosing to homeschool their children is on the increase. While many of these students have interest in science, they often lack access to laboratory experiences. In an effort to expand our outreach efforts to the community, and possibly encourage students to consider careers in physics or engineering, the Physics Department launched a pilot program this past school year. Through advertising posted in public libraries throughout the Cedar Valley and on social media communities, high school aged students were invited to participate in weekly lab sessions hosted in the studio lab space used for teaching introductory physics courses.

During the Fall 2022 semester, 12 students participated in the weekly sessions, led by Jeff Morgan. Students explored the themes of force and motion, electric circuit behavior, optical phenomena, and more using activities pulled from the PRISMS Plus curriculum and other physics education resources. In addition, throughout the fall students were provided with lab tours, getting a chance to see Andrew Stollenwerk's scanning tunneling microscope, Paul Shand's low temperature magnetism lab, see the electronics project lab and discuss novel uses of nanocellulose with Tim Kidd, learn about computational physics and UNI's computer cluster with Pavel Lukashev, and learn about random walk applications to biophysics with Ali Tabei.

The Spring 2023 semester sessions allowed students the opportunity to prepare for the annual Physics Competition hosted by the department. The 8 participants experimented with various designs for soda-straw arms, built toothpick bridges, mousetrap cars, and catapults, and brushed up on their trigonometry skills in preparation for the measurement contest. One artistic team member designed t-shirts for the team, which the department provided to the group. The students gathered at the McLeod Center for the April 11 competition, along with many of their parents, grandparents, and even a few younger siblings, and enjoyed the day of competition alongside approximately 200 students from public schools throughout the state. Out of 24 competing groups, the self-titled "Homeschool Nerdz" placed 6th in the state, with several members medaling in individual events.

Initial advertising for these lab sessions drew significant interest from parents of younger children as well, with many expressing hope that the department would offer this program in future years. Although logistics prohibit regular opportunities for younger learners, the department did host a field trip for families in early December; approximately 30 children ranging in age from 1-12 attended (with parents!) and experimented with projectile motion launchers, optics, and rotational motion.

We plan to continue to offer the high school lab sessions in subsequent years, in part to continue to offer community outreach, but also as an opportunity for science teaching majors to gain practice in facilitating science learning activities with student groups. Perhaps we will even encourage a student or two to enroll at UNI and study physics!

Physics faculty member Dr. Ali Tabei explains a fine point in physics with the aid of a volunteer.

ALUMNI PROFILE

Sam Prophet

Sam Prophet

Sam Prophet received a B.S. in Physics from UNI in 2021. He is currently a systems engineer at NASA and is working on the Artemis program. He was kind enough to give Cross Sections some of his time.

Where were you born and where did you grow up?
I was born in Murray, Kentucky. My parents moved to Cedar Falls when I was two or three I believe.

When were you a student at UNI?
From August 2017– May 2021

Why did you choose UNI for your undergraduate studies? What degree program were you enrolled in?
I chose UNI after meeting with Dr. Shand my senior year of high school and touring the physics department. I knew that I would be majoring in physics (later picking up a minor in mathematics) and toured a few schools during that time. The student to faculty ratio and the amount of student research being conducted really made UNI stand out from the other schools I visited.

What did you enjoy about being a student at UNI?
Once I left school and met other recent graduates, I realized that I was very lucky to have faculty that really rooted for my success and were willing to devote their time to questions. In a lot of schools, you're lucky if the professor knows your name, and questions to the faculty often go unanswered.

What were your favorite courses? Why?
I think my favorite class was probably Classical Mechanics. It was hard, but it was a fun sort of struggle, with a really gratifying feeling of finally understanding something. I also really liked Computational Physics for allowing students to come up with their own simulations.

Do you have a favorite Physics Department-related memory from your time as a student?
Probably being in the Electronics Lab at midnight with other students, trying to get our final projects to work. To this day I still wonder how I messed up a guitar pedal so badly.

Where have you worked since graduating?
After graduating UNI, I started a Ph.D. before beginning an engineering career. The first job I had was as an electrical engineer for a boat manufacturer. After 6 months, I moved on to NASA.

Who is your current employer and what is your position? Describe your duties in some detail.
I currently work at NASA under the propellants contract as a systems engineer. If you've been following the Artemis program and the attempted launches lately, you've probably heard liquid hydrogen mentioned several times, usually not enthusiastically. And while liquid hydrogen has been at the forefront of everyone's mind, there are a number of other gasses and liquids that are just as important (and at times annoying) to the fuel loading and propellent system process. It comes as no surprise that all of these different materials require unique systems all throughout the Kennedy Space Center.

In general, a systems engineer is responsible for maintaining and coordinating the development or upkeep of a complex system. The systems I manage day to day are pressurized gas systems including He, N2, and breathing air. Each of these 'commodities' are utilized in different areas throughout the Space Center, and each system requires almost constant updating, troubleshooting, testing, and redesigning.

Working for the government means providing very clear documentation. Systems engineers aren't the only ones responsible for this, but changes to a system that I'm responsible for means a lot of justifications and descriptions will be expected. Along with this, safety is a large part of a systems engineer's job. When a system undergoes a change, verification that a system can be maintained and is safe for launch are huge factors in justifications.

How has your UNI physics degree helped you succeed in your jobs?
Systems engineering is a great field for someone looking to enter engineering with a physics degree. The problems you solve vary drastically in disciplines of engineering; within a week I'll work on electrical, pneumatic, and mechanical issues.

(Continued on next page)

The physics program at UNI exposed me to so many different fields of study, that I feel confident in my ability to face almost any engineering issue, regardless of the discipline. A bonus is that recruiters really like physics majors!

What advice do you have for current students as they prepare to seek employment?
Patience and persistence. It's easy to get bogged down after getting rejected. I interviewed for three separate positions at NASA before getting one. And once I got here and talked to my coworkers about my experience, I realized that everyone goes through the same thing. So just keep applying and going on interviews. It'll happen!

What do you do for fun?
I ride my bike to the beach a few times every week and try and get better at surfing!

Who are your immediate family members and where is your current hometown?
Mike Prophet (who some of you probably know as Dr. Prophet), Margaret Prophet (check out Balance Hot Yoga on college hill), Sarah Prophet and Alex Prophet. I am currently living in Melbourne, FL.

Anything else you wish to share (e.g., family milestones, awards, etc.)?
Congratulations to Dr. Sarah Prophet for just successfully defending her thesis at Yale!

After this interview was conducted, the Artemis I rocket was launched and successfully completed its mission.

ALUMNI NEWS

Shawn Poellet

Shawn Poellet

Shawn Poellet was born in Cedar Rapids, Iowa. With the exception of ten months when he was in elementary school and lived just outside Seattle, Washington, he spent his whole childhood growing up in Cedar Rapids. He attended UNI from 2010 to 2014.

When Shawn started looking at colleges, he knew he wanted to go to one of the three state schools as he wasn't really interested in going to a college smaller than his high school. He visited UNI several times but what really helped him choose UNI was the former head of the Physics Department, Dr. Cliff Chancey. When he visited other schools, the professors would sit him down in an office and ask him, "What do you want to know?" and then ramble about their research. Dr. Chancey on the other hand took the time to make Shawn feel welcomed and he personally took Shawn on a private tour of the entire department and showed him the labs. Dr. Chancey's approach really made Shawn feel welcomed and included, and that helped solidify his decision to attend UNI.

When Shawn entered UNI, he intended to study Physics and Electronic Media. Throughout his four years, he changed his plan of study multiple times but Physics was the only degree that never changed. Finally, in 2014, he graduated with a BS in Applied Physics, a BA in Theatre: Design and Production, and a minor in Computer Science.

There were many things Shawn liked about being UNI, but one of the most significant was the size. UNI suited him well by having the resources of a large university but also being small enough to have more of a connection with the faculty. It was always fun telling people that some of his physics classes only had 6 to 8 students in them. UNI worked well for him because the different departments and programs available really allowed him to explore multiple disciplines. His favorite physics classes were Introduction to Electronics and Digital Electronics/Robotics.

(Continued on next page)

Those classes provided him with some of the skills he used the most in his job, e.g., creating circuits and fabricating PC boards.

One of Shawn's best Physics Department-related experiences was the opportunity to attend and present at the Argonne National Laboratory Undergraduate Symposium. Shawn shared that it was an amazing opportunity to present his research on nanocellulose and carbon nanotubes. (Dr. Kidd was his supervisor.) Carving Schrodinger's Equation into pumpkins for Halloween was also unforgettable.

After graduating, Shawn worked at UNI's Gallagher Bluedorn Performing Arts Center (GBPAC) as the Assistant Technical Director and Head Audio and Video Engineer. In that role he worked on all types of shows, ranging from small bands to the large multiple-truck touring Broadway-style shows. As the audio and video engineer, he was responsible for managing, installing, and operating the extensive audio, video, and network systems in the venue and used for productions. He also spent a lot of time working with the UNI Theatre Department on its productions.

Shawn recently left the GBPAC to go back to school. He is now at Yale University pursuing a Master of Fine Arts in Technical Design and Production through their drama school. He intends to focus on automation and technical direction. For those who may not know all the theatrical terms, automation incorporates all areas of automated scenery and flying people. This can range from a simple platform that moves across the stage by itself to flying performers in all three dimensions over the heads of the audience.

When people hear about Shawn's combination of degrees, he often get the comment "Well physics must be really useful for technical theatre." His answer is yes and no. Physics is useful when it comes to calculating loads, for example. However, he has not once used quantum mechanics in the theatre. However, the skills and thought process that he learned in his physics degree have been invaluable. Using a more scientific approach has allowed him to think though problems in a different way than his colleagues. The lab reports he wrote in Modern Physics Lab were another significant experience. A direct quote is appropriate here. "Now, we all know how hard those were. I mean, did anyone ever actually get their full twenty points?" [Answer: Probably not.] But those reports and the tough grading taught Shawn great skills he now uses to write detailed project proposals.

Shawn advises current students that it is okay if they are unsure about exactly what they want to do after college. "Once you start your job, you will find out relatively quickly if it is or isn't for you. If it's not, don't be ashamed to look for something else," he declares. "Just don't make a habit of jumping around too much."

Many of Shawn's hobbies overlap with his work. Sometimes this is great, and other times it means he is always working. He enjoys being outdoors and riding his bike. After many years of wanting to do it, he finally rode the entirety of RABRAI last summer. It was a really great experience seeing thousands of people from around the world riding their bikes across the state. Also, just over a year ago, Shawn got a pilot's license. It was a lot of work, but he had wanted to do it since he was a kid and now it is a really cool experience being able to pilot a plane.

Both of Shawn's parents and one of his brothers are computer engineers and his sister was a math major. This has led to some truly interesting dinner table conversations! He also has two siblings still in college, one of them at UNI. Shawn currently resides in New Haven, Connecticut.

NEW PHYSICS

Quantum Mechanics Must Be Complex

A non-physicist reading the title of this piece might think the subject of quantum mechanics was ordained to be complicated. In fact, there are some aspects of quantum mechanics that even physicists find difficult to wrap their minds around. Perhaps we will tackle those issues in a future newsletter. Here, what we mean is that complex numbers seem to be required to make quantum mechanics work properly. (Complex numbers are based on the square root of –1.) Complex numbers are used extensively across physics. For example, the theory of wave propagation in media makes extensive use of complex numbers. Also, physics and engineering students often encounter complex numbers in their electronics classes. In these cases, complex numbers simplify the exposition; they make the theory more compact and elegant. However, complex numbers are not required. The theory can be presented just as completely and correctly with real numbers, if a bit less elegantly. Quantum mechanics, it seems, is different.

The Schrodinger equation has complex numbers embedded in it. Vectors used to represent the state of a particle are also complex-valued objects. The originators of quantum mechanics contemplated whether complex numbers were essential to the theory but no substantial reformulation of the theory in terms of only real numbers was accomplished. Recent theoretical work seemed to establish that a quantum theory based solely on real numbers could describe a broad range of quantum systems. However, this success appears to be illusory. Two research groups in China have independently demonstrated that complex numbers are essential if the standard formulation of quantum mechanics is used to interpret the results of experiments performed on quantum networks.

These experiments involve the phenomenon of entanglement, which is a quantum-mechanical property that Einstein famously did not believe was physically possible. Two entangled particles possess correlations such that if the two particles are separated – no matter how far apart – and a measurement finds one of the particles in a certain state, the state of the other particle is instantaneously determined. For example, suppose that two particles are entangled such that their magnetic axes ("spins") are correlated to be parallel. Each spin can either be "up" or "down." If a measurement is carried out on one particle and the spin is found to be up (which happens with 50% probability), the other particle will always be found in the spin-up state. This is true even if the entangled particles are far enough apart that a light signal would not have enough time to be transmitted between them before the second particle is measured, i.e., the correlation is not due to a local interaction like a magnetic field. John Bell showed theoretically — and many experiments have since demonstrated — that non-local correlations correctly describe the behavior of quantum systems, and that local "hidden-variable" theories postulated by Einstein and others generally do not.

To distinguish between quantum theories based on complex numbers and real numbers, the two Chinese research groups implemented a "game" on a simple quantum network. There are three nodes in the network: Alice, Bob, and Charlie. Two independent sources provide pairs of entangled particles to the three nodes. One source provides one particle of an entangled pair to Alice and Bob, respectively, and the other source provides Bob and Charlie with one particle each of another entangled pair. (See Figure 1.) Because the sources are independent, the particle that Alice receives is not correlated with Charlie's particle. Bob, who receives two particles, carries out a "Bell-state measurement,"

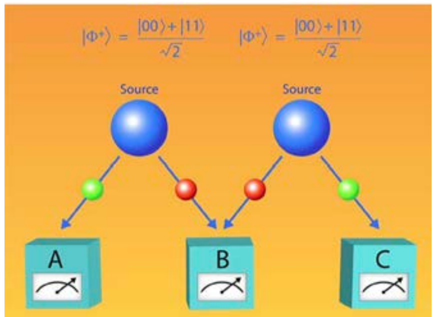


Figure 1. Simplified depiction of experiments to show that complex numbers are necessary in standard quantum mechanics.
Credit: APS/Carin Cain

which causes Alice's and Charlie's particles to become entangled — without any physical interaction occurring between them. Alice and Charlie each carry out certain distinct measurements on their particle and the outcomes are recorded. A final score related to the conditional probability distribution of the measurement settings and outcomes is then calculated. The maximum final score for a real-valued theory is smaller than that of a complex-valued one.

Both experiments obtained final scores that were decisively greater than the maximum value for a real-valued theory. These experiments seem to make a conclusive case for the necessity of complex numbers in the standard formulation of quantum mechanics. We note that these results do not apply to alternative theoretical frameworks of quantum mechanics. Finally, the simple three-node, two-source network structure used in the experiments may serve as a useful first step toward a quantum internet. In this case, the "particles" are quantum bits or qubits. Qubits play the same role in quantum computing as digital bits do in classical computing. However, unlike digital bits, qubits can be in the "0" and "1" states at the same time — a superposition state.

References

1. Z.-D. Li et al., Phys. Rev. Lett. 128, 040402 (2022).
2. M.-C. Chen et al., Phys. Rev. Lett. 128, 040403 (2022).

ALUMNI INFO REQUEST
LET'S HEAR FROM YOU!

Let us know what you have been up to. You can email us at physics@uni.edu or return this form to:

Department of Physics
University of Northern Iowa
215 Begeman Hall
Cedar Falls, IA 50614-0150

First Name ______________________ Last Name (maiden)_________________
Address ____
City _____________________________________ State_________________________
Email ____

Please share any news about you or your family to be included in the next Physics Newsletter.

SUPPORT THE PHYSICS DEPARTMENT

Would you like to support the Department of Physics? If so, please fill out the form below and return it to:

UNI Foundation Financial Services
121 Commons, Cedar Falls, IA 50614-0239

Name

Address City, State, Zip

E-mail Preferred Phone ☐ home ☐ cell ☐ business

Please check if new address, phone or e-mail.

I/we would like to support the following fund(s).

$_________ **Physics Student Research/Awards Quasi-Endowed Fund** provides support for scholarships and undergraduate research in physics (220193-20)

$_________ **Louis Begeman Fund for Excellence in Physics** is a discretionary fund to support UNI Physics Programs (223636-20)

$_________ **Grossman-Perrine Endowed Scholarship Fund** supports an annual scholarship to a current physics major, with preference for women and minorities (211778-30)

Online: If you prefer, you may give via our website: www.uni.edu/physics. Use the "Donate to Physics" button at the bottom of the homepage. Please specify designation and dollar amount within the online form.

$_________directed to ____

My (or my spouse's) company, ____ (name), will match my gift.

(Please contact your HR office for details and matching gift form to be submitted with payment.)

Type of Payment:

Check: enclosed, payable to the UNI Foundation

☐ **Credit Card:** please charge my card
$ ___________ beginning (mo/yr) ____/____
Please complete card information below.

Signature (required) ________________________________ Date ______________

Credit card information will not be kept on file 100509

Charge my: ☐ VISA ☐ MasterCard ☐ Discover ☐ American Express *(please check one)*
Card Number: ____
Expiration Date: ____

Department of Physics
215 Begeman Hall
Cedar Falls, Iowa 50614-0150