Department of

PHYSICS Newsletter

Spring 2024

Northeastern co-op to NASA's Hall of Honor

Joseph S. Heyman's four-decade leadership career at NASA spanned the Apollo 11 moon landing, the Space Shuttle Challenger and other major events. His recent induction into Langley's Hall of Honor can be traced back to his Northeastern University co-ops. Here is his inspiring story.

Joseph S. Heyman's association with NASA began as a Northeastern student in 1964, two years after President John F. Kennedy committed the U.S. to landinga man on the moon.

Heyman, a Northeastern graduate, was at NASA for the grand successes and tragic failures over his four-decade career, which he traces back to his Northeastern co-ops.

"I really look at Northeastern as a turning point in my life," says Heyman.

Heyman was inducted last summer into NASA Langley's Hall of Honor.

He joined the select group of 54 people honored by the space agency at the Langley Research Center, where Heyman earned 34 patents while developing new ways to test spacecraft and aircraft materials.

The son of an inventor in New Bedford, Massachusetts, Heyman tells an inspiring story. He dropped out of college before enrolling at Northeastern at the suggestion of his father.

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Top of page. Photos by Alina Mak
Faculty Qimin Yan, Adrian Feiguin, Ankita Sarkar and Hai-Ping Cheng at the Fall Physics Faculty Social

Northeastern University
Physics

Notes from the Chair

I am delighted to share with you this year's Physics Department accomplishments. We have continued to expand research areas while adding excellent tenured, tenure-track, and non-tenure track faculty. We are well on our way to achieving our goal of developing a top physics department, providing valuable educational experiences for diverse groups of graduate and undergraduate students in a positive and collegial environment.

Department faculty leadership has undergone one change. Paul Whitford has assumed the role of Director of Graduate Studies (DGS). Professor Whitford has an active research group with several current PhD students, and 5 PhD students who graduated from his lab. I want to thank Professor Meni Wanunu for 6 years of service as the DGS, overseeing tremendous graduate program growth. When Professor Wanunu started as DGS in 2017, we had 80 PhD and 3 MS students. In 2022-2023 we had 107 PhD and 15 MS students! I am pleased that these faculty leaders have continued in their roles: Emanuela Barberis (Associate Chair), Alessandra Di Credico (Director of Undergraduate Studies), Tim Sage (Undergraduate Advisor), and Bryan Spring (Undergraduate Recruiter).

Since January 2023, we have welcomed six new full-time faculty, with four more starting this spring. This includes faculty conducting research in experimental biophysics, experimental particle physics, network science, and quantum physics. As part of our research growth, we now have full-time faculty on two additional campuses beyond Boston, the Roux Institute in Portland, ME and the Burlington, MA campus. Please see the article introducing the new faculty.

We have also expanded our administrative staff, to whom we are grateful for adjusting to the increased department workload. This includes Sheila Magee (Business & Operations Manager), Alina Mak (Undergraduate Program Coordinator), Nancy Wong (Program Manager), and Alicia Chan (Operations Coordinator). Congratulations to José Cruz, who has been promoted to Administrative Coordinator, and welcome to Courtney Moore, who just started as Administrative Assistant. We could not function without such excellent staff members, who assist faculty and students.

This year we are happy to hold in-person events, including weekly meetings of the Society of Physics Students and the Introduction to Research course for first-year PhD students. Our seminar series are also held in person with remote option. I appreciate the active intellectual discourse in the department.

-Mark Williams, Chair

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Here, Heyman lays out, in his own words, his 10-step journey to NASA's greatest honor.

1. His father, Sam, taught Heyman to think like an inventor and entrepreneur.

"He never threw anything out. Our basement was lined with sauerkraut bottles filled with capacitors, resistors, screws, washers, nuts, bolts, everything you could think of. He had a room in the basement for woodwork, a room for metalwork, a room for electronics and—believe it or not—a room for blowing glass. So I grew up doing things that a normal kid never ever got to see.

After the Second World War, my dad started a company to convert wartime machinery into peacetime use. To his shock, a buyer evaporated and he was stuck with this enormous quantity of aluminum tubes that he had purchased from the government. Being an inventor he said, 'Let's build some machinery to make folding aluminum furniture.' He actually has a patent on the folding aluminum chair. At one point he had one of the largest aluminum companies in the U.S. for furniture."

2. Heyman dropped out of Cornell, took a year off from school to work with a photographer, and then was introduced to Northeastern by his father.

"I thought I would go into astronomy or some field like that, so I bypassed some typical first classes my freshman year at Cornell University. They gave me advanced placement in physics. And I was too young. I was not ready.

I was distraught over the politics of the time. I didn't like the idea that everything in engineering and science seemed to be used toward war. I just didn't want anything to do with it.

So I took a year off. I worked for a photographer—an amazing guy, I learned a lot from him—and after a year my dad said, 'Do you want to continue on this way? Or do you want to go back to school?'

I wanted to go back to physics.

And he said, 'Fabulous.' Then he said, 'But instead of going back to Cornell, I have a suggestion for you. It's a school you might not have heard of. It's called Northeastern.'

I think he saw the value in apprenticeship and that the traditional mechanism of higher education did not give you the hands-on experience that I needed. He was a hands-on guy and he saw that the co-op program fit my mind and my interests. And he was right.

Going to Northeastern let me get my head screwed on right again. I jumped back into physics and had the most amazing—I don't even want to call it a career. It was a passion. And it was Northeastern that gave me that."

3. In the wake of JFK's commitment to put a man on the moon by the end of the decade, Heyman joined NASA in 1964 as a co-op.

"I did well at Northeastern and got my first pick of co-op jobs, which was NASA. I loved Boston, I wanted to stay in Boston, but the new Electronics Research Center in Cambridge wasn't ready to take co-ops. The co-op manager suggested I go to Langley because it was a research center. I said, 'As long as it's only one semester.'

Heyman (right) explains his idea for using a sonic wave to test the adhesion of Shuttle tiles in 1981. Courtesy photo

Almost 40 years later I retired from there.

These were hardworking, bright, energetic people at NASA. I was a sophomore during my first co-op and one of the engineers asked if I would like to see the computers. I said, 'Oh my goodness, I've heard of those. Yes, I'd love to see computers.' The noise was phenomenal from all of these electromechanical calculators clicking away like typewriters.

There were 20 to 25 women in the computer room. The women were mathematicians. They were doing the computations for the agency. This is what the movie "Hidden Figures" was about. I met those women. NASA was a we-can-do-it organization—even if we didn't know how we were going to do it.

4. Heyman's initial NASA co-ops were focused on collecting and analyzing data from hypersonic wind tunnels. In his third co-op at the agency, he found his niche.

"I was exploring the damage done by radiation to space satellites. So now I was getting into materials. We were irradiating these satellites with electron-beam radiation, dovetailing the [1958] discovery of the Van Allen radiation belts, and it was very timely and very exciting work.

Here I am a student and I'm building a solar wind simulator for accelerating heavy ions to bombard materials because I needed to see how they would damage those materials. It was a 40 kilovolts low-energy ion accelerator—a plasma system—and I had full control of it. And that led to my being hired by NASA full-time."

5. A 1973 explosion at a NASA wind tunnel changed everything. Heyman wound up inventing a new field that would earn him his place in the NASA LaRC Hall of Honor.

"It was one of the larger wind tunnels and it blew up at night—many tons worth of steel blown hundreds of feet into the sky, the entire area covered in incendiary ceramic pebbles at white-hot temperatures. It was a horrific, horrific accident. Because I was a young Ph.D. and I was respected, I was asked to fly out to California and sit on the accident review committee. We discovered the cause of the accident was something as simple as an improperly tensioned bolt—an enormous multi-million dollar failure just because a bolt was improperly tensioned.

NASA wind tunnel. Credit: NASA

That led to me inventing the ultrasonic bolt tensioning device. And it took me about five years of re-inventing it, each time a little better, to get it to the point where it was practical and useful.

That accident also redirected me from doing research in semiconductors to starting a new field for NASA called the science of nondestructive evaluation (NDE). At first it was just Joe Heyman and one technician, F.D. Stone. I grew that little teeny lab to about 100 people. We were the largest laboratory of its kind in the United States.

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New Faculty Join the Physics Department

Kinan Alhallak is an Assistant Teaching Professor with interests in graduate-level learning and nanomedicine research. He received his PhD in biomedical engineering from Washington University in St. Louis and went on to do his postdoc at Harvard Medical School. Kinan is a member of the Nanomedicine Innovation Center and teaches courses specifically on entrepreneurship and advancements of nanotechnology. He has a keen interest in learning about biological mechanisms within clinically relevant diseases and exploiting those mechanisms to make better treatments, more specifically nanoparticle treatments

Ning Bao is an Assistant Professor of Physics and Mathematics at Northeastern University. His interests lie at the intersection of quantum information science, high energy physics, and quantum gravity. He did his PhD at Stanford University, postdocs at Caltech and UC Berkeley, and was previously a scientist at Brookhaven National Laboratory.

Dr. Hai-Ping Cheng is a Professor of Physics and Director of the Quantum Theory Project at the University of Florida. She currently leads the DOE Energy Frontier Research Center (EFRC) for Molecular Magnetic Quantum Materials (M2QM). She received her PhD from Northwestern University (1988), was a postdoctoral researcher at the University of Chicago (1989-1991), and a research scientist at the Georgia Institute of Technology (1992-1994). Her research interests include magnetic molecules for quantum information sciences, interface phenomena and transport across tunneling junctions, and reduction of thermal noise in amorphous oxides.

Alberto de la Torre Duran's research focuses on understanding complex emergent phenomena in quantum materials and engineering new long-lived quantum states by interacting with matter at ultrafast timescales. The DeLTA lab combines in-house optical and photo-emission tools with experiments at synchrotron and free electron lasers worldwide. Alberto received his Ph.D. in Physics from the Université de Genève, Switzerland in December 2015. From 2016 to 2019, he was a Swiss National Science Foundation Mobility Postdoc at Caltech. From 2019 to 2023, he was a Postdoctoral Fellow at Brown University. Alberto joined Northeastern this June as an Assistant Professor.

Sarah Harrison is an Assistant Professor of Physics (50%) and Math (50%). She is a theoretical high energy physicist who works at the interface with mathematics, with a research focus on the implications of quantum field theory and string theory for geometry, topology, and representation theory. Previously at McGill she received multiple grants for her research, including a prestigious Canada Research Chair Tier 2 grant.

Stefan Kautsch joined our team to apply his successful methods of experiential learning in our courses. He also develops an inclusive bridge to diverse communities to provide creative opportunities to explore physics and astrophysics. His research investigates the distribution of matter in the Universe, showing that it follows the same pattern over gigantic magnitudes of mass ranging from the microcosm to the macrocosm. His research has been featured by social media and YouTube influencers like Physics for the Birds and watched by more than 170000 (>1.7x105) people.

Ankita Sarkar is an Assistant Teaching Professor of Physics at Northeastern University. She is interested in undergraduate physics education and computational biophysics research. As an educator, Ankita is driven to create an interactive, motivating, and intellectually stimulating learning environment for her students. Her research efforts have been focused on studying crucial biophysical processes from an atomistic viewpoint using computational results integrated with experimental observations. She has experience in using molecular dynamics-based methodologies to study the structure, dynamics, and energetics of proteins, particularly in the context of their pH-dependent properties as well as in computational drug discovery. Ankita received her undergraduate education from Jadavpur University in Kolkata, India. She attended the University of Florida, Gainesville for graduate studies where she earned her MS and subsequently her PhD in Physics in 2019. Ankita was a Marie Curie Experienced Researcher at the Italian Institute of Technology and a Research Associate at the Harvard Medical School, before joining Northeastern Physics.

Mingzhong Wu received his PhD degree in Solid State Electronics from Huazhong University of Science and Technology in China in 1999, worked in the Department of Physics at Colorado State University (CSU) in 2002-2023, and is currently a Professor in the Department of Physics and the Department of Electrical and Computer Engineering at Northeastern University in Boston. His current research areas include spintronics, magnetization dynamics, and topological quantum materials. He has authored over 170 technical papers and 4 book chapters; he has also co-edited a book on magnetic insulators. He served as an Editor for "IEEE Magnetics Letters" (2012-2016), and he is currently a Senior Editor for "Journal of Alloys and Compounds" and an Editor for "Physics Letters A." He was the Education Committee Chair (2012-2015) and Finance Chair (2015-2018) of the IEEE Magnetics Society and has been the Chair of the Technical Committee of the Society since 2019. He was named "Professor Laureate" by the CSU College of Natural Sciences for 2019, 2020, and 2021. He was elected IEEE Fellow and APS Fellow in 2021.

New laser treatment for ovarian cancer gets $2.7 million development grant

A biomedical physics lab at Northeastern has received a $2.7 million grant to develop a new treatment for ovarian cancer that will use lasers to spot and target chemo-resistant cancer cells and boost a patient's immune system.

"We're using light to power a therapy, if you will. We're also using light to interrogate a tumor," says Bryan Q. Spring, associate professor of biomedical physics at Northeastern University.

Spring's lab, in collaboration with Heiko Enderling's lab at MD Anderson Cancer Center and Moffitt Cancer Center, has been awarded a Physical Sciences Oncology Network grant of $2.7 million from the National Cancer Institute for a research project called "Fractionated photoimmunotherapy to harness low-dose immunostimulation in ovarian cancer."

Article and images from: News@Northeastern
For full article https://news.northeastern.edu/2023/09/11/photoimmunotherapy-ovarian-cancer/

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Typically in engineering, when you wanted to see how strong a metal beam is, you would apply force to that beam until you see when the beam fails. Basically you load it till it breaks. As a physicist I didn't like that. I wanted to find out why things fail. Are there precursors that can tell you that something is failing? And can you in a nondestructive way assess the health of a material?

Heyman tests critical fasteners at a NASA LaRC wind tunnel in 1978, which helped improve the design of bolt-testing techniques following the 1973 wind-tunnel explosion. Photo Courtesy of Joseph Heyman

You can't shake and break the spacecraft that you're going to be launching. So I wanted to have the science of measurement tied to the prediction of mission success. I was looking at how can we do physics measurements—not engineering measurements—to assess the health of materials.

So it literally was the birth of a new field for the agency. And I just had the unbelievable luxury of attracting some of the brightest people to NASA from all over the world.

We were doing physics to help prevent NASA's missions from failing—or if they did fail, we would have the science to better understand how the failures occurred. In addition to ultrasound, we also did thermography, we did radiography, we did shearography. We did eddy current, we did electron beam acoustics. We were doing work that had never been done before in any field. It wasn't a career, it was a passion—and I got to work with some of the brightest people that I've ever had the pleasure of working with. It was a hoot. "

6. In 1984 he identified aging aircraft as a danger to U.S. aviation.

"NASA is the National Aeronautics and Space Administration. Aeronautics—airplanes—are a critical part of NASA. I saw that as the fleet aged, the country needed better tools for assessing the degradation of aircraft. But I could not sell that program to NASA headquarters.

I submitted a proposal and my funding manager said, 'Fabulous. What a great concept. Submit it again next year.' I did. 'Joe, be patient with us.' I submitted it for the third year. 'They don't like old aircraft, Joe, they want tomorrow's aircraft—they don't want the agency to be tied in with old stuff.' I submitted it again though and it didn't get funded.

So I submitted it for a fifth year—and do you know what happened in year five

Have you heard of the Aloha aircraft accident?

In 1988 a Hawaiian airline flying between islands—a very high-time-use aircraft—zipped open. The fuselage ripped open. A flight attendant was sucked out. Somehow the pilot landed that plane with half the upper fuselage missing. The only thing keeping that plane together was the wiring harness under the floor and some remaining structural elements. If that pilot had tried any fast maneuver, he would have broken that plane in two.

Well, all of a sudden NASA headquarters is saying, 'What happened? Why aren't we on top of this problem?' And all of a sudden I was managing with my colleagues an enormous eight-year program on aging aircraft.

NDE (nondestructive evaluation) was now on a peer level with materials and a peer level with structures. Never in NASA's history was NDE on a science-engineering peer level with those other disciplines. It was that work that elevated it.

The Space Shuttle Challenger broke apart less than 2 minutes into its flight on Jan. 28, 1986, killing all seven crew members aboard.

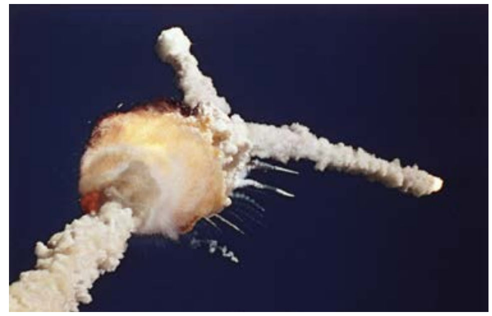
7. When Space Shuttle Challenger exploded 73 seconds into its 1986 mission, killing all seven crew members aboard, Heyman helped research the cause and developed new systems that enabled the shuttle program to return safely to flight two years later.

"The accident was wrenching. There were tears. There was shame. Everybody was depressed, everybody was horrified.

We dedicated nearly the entire NDE laboratory to focusing on the cause of this incident and how we can make the system safer.

It turned out that an insulating material that is basically like a putty envelops all of these flanges [on the liftoff rocket]. When the motor fires and is pressurized by the burning fuel, that putty becomes viscous. It flows and quickly prevents gas leaks."

One problem on that day was that they were launching at a cool temperature that prevented



the putty from flowing. So hot gas found those paths that should have been protected by the putty and the hot gas cut through the metal.

But this specific problem had nothing to do with the shuttle's design. It had everything to do with a management override of an engineer's reluctance to allow launch. The engineer who understood this stuff said, 'It is too cold to launch.' It was management that said, 'We've had something like 15 launches with basically the same conditions. We'll go ahead again.

Our lab tested elements of the structure and assembly finding no issues of the design.

It was terribly exciting to feel that we were in a position to help get the shuttle returned to flight. We dramatically improved the ability to characterize the integrity of the joints, the placement and thicknesses of the putties, the tensioning of fasteners, the thickness of insulation, the bonding quality of the tiles on the shuttle itself. We investigated everything associated with flight and the tools that we developed dramatically improved the safety and integrity of the shuttle.

One of the awards that I'm so endeared of is called the 'Silver Snoopy.' Charles Schultz (creator of the comic strip 'Peanuts') was a NASA advocate who loved space, and he allowed NASA to create a special award, a little silver pin that looks like the dog Snoopy. It is awarded to those scientists and engineers who have dramatically improved the ability to fly, and I was a recipient because of the work on the return to flight for the shuttle. So I wear that on the lapel of my sport jacket to this day."

8. His passion was fed by a variety of inspiring experiences.

"This story has almost nothing to do with my work, but it was one of the most exciting things that ever happened to me at NASA. Because I did a little tiny bit of work on the Viking, which was the first soft lander on Mars in 1976, they invited me to the landing party. It was like being in a control room. It's dark. There are computer screens all over the place. Everybody is watching something and everybody's nervous as all get out.

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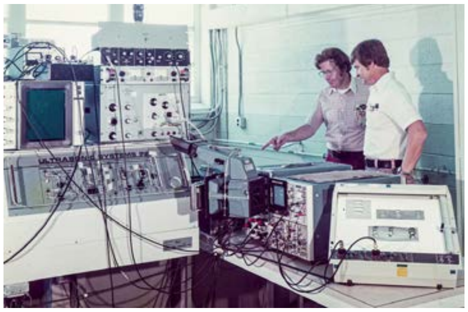

Heyman shows a NASA colleague the new sensor he invented with colleagues at Washington University. Photo Courtesy of Joseph Heyman

This is back when the data rates were maybe 300 baud or something like that.

We're looking at Viking's data and everyone is saying, 'It's coming in too fast.' And of course the data we're seeing is 20 minutes late, because that's how far Mars is from the earth. So whatever we see happening has already happened. It's either crashed or it has landed successfully, and we don't know.

We can see the spacecraft correcting itself. It is doing exactly what it's supposed to do. It's wavering in between the perfect line—a little fast, a little slow, a little fast, a little slow. Suddenly all the data stops. We're waiting. Nothing. All the screens are blank. The room is absolutely silent. It's black in there because there's no light other than the projection screens.

On the biggest screen across the top comes this little flying white dot. It was writing the first image of the first spacecraft lander on another planet from the earth and I was watching the image appear in real time. That was a thrill.

Another memory that stays with me is of standing under the solid rocket motors of the shuttle launch system. It's a tower and you're standing under this 185-foot solid rocket motor 12 feet in diameter. And you're looking up at that motor—it's 3.5 million pounds of thrust—saying, 'God, I hope the thing doesn't go off now.'

When the Apollo 11 moon landing occurred in 1969, I was a graduate student—on NASA pay—watching in St. Louis on a little black-and-white TV with my wife, Berna. I was a youngster recently married, and though I had done a tiny little bit of work on some of the insulation panels that were part of the Apollo system, I was not actively engaged in Apollo research until later on. It was just so exciting—we were on pins and needles and couldn't believe that we were watching it and it was real. So it was a spectacular feeling, being a NASA scientist and being able to observe this phenomenon of the first humans landing on the moon.

It is mind-boggling to think of how the inventive, creative minds can design, test, engineer, build and produce these systems for us to get these missions done. It is just awesome. And the people are the key and the work is a grind. You pick yourself up off the floor after every failure and know that you've got to try it again."

9. Heyman learned along the way that failure is necessary.

"I fear that kids who just have book learning or computer-based studies don't have the background to be as creative as they could be. You need to take things apart. You need to break things. You need to rebuild things. You need to screw up and not be able to rebuild it because you made a mistake. You need to then start all over again and rebuild it because that's all part of the learning process.

Heyman performs an ultrasonic test on a semiconductor in a magnetic field to assess the coupling between charge carriers and phonon waves. Photo Courtesy of Joseph Heyman

And that's one thing that I was able to do thanks to my co-ops at NASA—to have mentors who let you give it a shot. So you report back that it didn't work. OK, then, try something different.

The key is not to let the failure be a barrier. The failure has to help you realize, OK, what can I do differently

I think that Northeastern is an absolute gem that gives kids that power of hands-on experience—though I like to say it's not hands-on, it's really mind-on.

I mean, there were times I'd wake up at 3 in the morning because I'd just figured something out and Berna would say, 'What's the matter?' I would jump up and drive to work and start writing stuff down. Most of my patents were labored that way. They didn't just suddenly get solved. They were grinds and grinds, then all of a sudden bang—and that was so exciting. So exciting."

10. After retiring from NASA in 2001, Heyman became a professional photographer, teaching at William and Mary's continuing education program and contributing to two books based on the historic home in upstate New York where he summers with his wife.

"When I got word that I was going to be inducted into the NASA LaRC Hall of Honor, we were in our home in the mountains of New York that was built in 1791 by Colonel Peter Vroman of Revolutionary War fame. When he woke up in the morning in his new house, he was walking on the same floor that I'm walking on today.

We flew back to Virginia for the ceremony in July.

Langley did something very special and I was delighted that they did—they had a young engineer assigned to shadow me for everything I did that day. She shared with me what research she was doing, and all I could think of was, gee, I did stuff like that when I was a young scientist, hosting a visiting scholar, and here she is now doing it for me.

We entered this big hall and all of a sudden it became real. And I realized, my goodness, I'm going into the Hall of Honor. There were only about 50 names up on that wall. What I was just thrilled by is the people who were joining me in that induction process. Some of those were the very colleagues that I had knitted together into the career that I chose.

The colleagues that were being inducted were, to me, the heroes of the agency, and I just felt so honored to be with them. My family obviously was so excited for the ceremony. Then there was the pomp and the ceremony with the [NASA/LaRC] director and the military band and the flags and all that stuff that makes something feel special. It was an amazing day.

And having my grandson Max there was absolutely a pivotal part of it. He's doing high-school-level math as an 11-year-old and the school doesn't know quite how to teach him and they know it and they love it. He won second place in the school's spelling bee through grade eight and he's just in the fifth grade. I like to think that he's kind of a little bit like me when I was a kid."

Article and images from: News@Northeastern
https://news.northeastern.edu/2023/04/28/magazine/nasa-hall-of-honor-northeastern-coop/

Department of Physics is spearheading the discovery of revolutionary phenomena in quantum materials

At the intersection of quantum materials and revolutionary technological applications, two Northeastern community members' latest contribution to "Science" unveils the phenomenon of a new type of nonlinear Hall effect—a discovery with tantalizing implications for our future. Postdoctoral Research Associate Barun Ghosh and University Distinguished Professor Arun Bansil of Northeastern's Department of Physics were recently published in this widely respected and reputable academic journal for their research article, "Quantum metric nonlinear Hall effect in a topological antiferromagnetic heterostructure."

The research done by Ghosh, Bansil, and other contributors aimed to investigate what is known as the "quantum metric," which measures the distance between the quantum states in a material.

In the context of Ghosh and Bansil's research article, the concept of quantum metric is applied to describe a specific phenomenon related to the behavior of electrons in materials. It is found that the quantum metric of even-layered manganese bismuth telluride and black phosphorus heterostructure influences the behavior of electrons, resulting in a peculiar transport property.

The peculiar property is a new type of "nonlinear Hall effect"— a new physical phenomenon in quantum materials. This property indicates that the current-voltage relation in certain quantum materials, including manganese bismuth telluride, is not just simply linear but also shows significant non-linear effects.

"We sandwiched ultra-thin layers of manganese bismuth telluride with black phosphorus to achieve the right condition for this effect [nonlinear Hall effect] to appear," explains Dr. Barun Ghosh.

This research is the result of additional published work produced by Ghosh, Bansil, and other collaborators, as they have been working towards these findings since 2021.

"In 2021, we proposed a new phenomenon known as the layer Hall effect in this compound [manganese bismuth telluride]. A few months back, in the same material, we showed optical control of antiferromagnetism," says Ghosh.

The findings mentioned were published in "Nature" and "Nature Materials", both prestigious academic journals akin to "Science." Regarding the research process, Dr. Ghosh adds, "It was a collaborative effort. The experimental part of the research was done at Prof. Suyang Xu's lab at Harvard, while we provided theoretical guidance."

Ghosh and Bansil's theoretical guidance and the work done by the authors on this research give way to exciting future implications as a result.

"In principle, using some version of this research, one can convert the energy of an electromagnetic wave to a direct current. Therefore, this phenomenon can be used for energy harvesting, for example, wirelessly charging devices with a battery. The most suitable application could be in various low-power devices, such as biological implants like a pacemaker," Ghosh states.

These applications could be revolutionary for the medical field and technology used in day-to-day life; however, Ghosh adds, "new technological breakthroughs are needed before realizing practical applications."

Article and images from: News@Northeastern
https://cos.northeastern.edu/news/northeasterns-department-of-physics-is-spearheading-the-discovery-of-revolutionary-phenomena-in-quantum-materials

Innovations in the Introductory Physics Labs

The Introductory Physics Laboratory (IPL for short) in the College of Science is one of the biggest teaching labs at Northeastern, serving about 1,300 students every term. It is supervised by professors Baris Altunkaynak, Oleg Batishchev and Paul Champion. Ron Zettlemoyer and Austin Beaudette are the electronics and instructional lab support technicians.

There is a new makerspace, sponsored by the College of Science, in the back of the IPL office, where innovation takes place. Austin, who started working in the IPL two years ago with no 3D printing experience, quickly acquired the skills, and has been helping the team to design in SolidWorks and build innovative lab equipment with 3D printed parts.

The team's latest innovation is an improved version of an experiment on standing waves. It used to be run with water. Students would change the level of water in a vertical tube throughout the experiment to alter the length of the air column in the tube. However, the water would frequently leak and cause large spills, which was dangerous for people and the equipment. Tuning forks were used to excite the air in the tubes, but they would easily break.

The team decided to rework the experiment to avoid using water and tuning forks

The innovative design they came up with has a 3D printed plug and slider, 3D printed legs, and a speaker in a 3D printed box. The plug in the tube can be moved from outside with the slider thanks to the embedded Neodymium magnets in both. The speaker is placed at one end of the tube and emits a constant tone. The plug serves as a barrier for the sound waves, replacing the water, and runs along the tube so students can easily adjust where the sound bounces off.

When the slider is placed at the correct position, a resonance is formed, and it makes a loud sound. Students use this information to determine the speed of sound.

Converting the equipment to this setup not only eliminates the mess, but it also allows students to focus on learning instead of spending a lot of time adjusting the apparatus that required two people. The new equipment is so precise that one can use it to determine the difference in the speed of sound on a cold and a hot day.

Austin designed all 3D parts in SolidWorks and the Printed Circuit Board (PCB) for the speakers using KiCad. He also designed a tone generator applet for lab PC to drive the speakers.

[There are 3 printers available in the workshop. Two use PLA, the more commonly used filament material, and one can also print with ABS which is stronger but requires a higher temperature.]

The old standing waves setup was bulky. Due to the limited storage space, the IPL had only a few setups per class that had to be shared by many groups of students. The IPL team designed, and the NU Carpentry shop built a compact cart to hold enough equipment to run 10 sections with 5 groups each of the same experiment in parallel. About 800 Northeastern students will perform this experiment in the Fall semester alone, so it is a big improvement to the educational process by IPL.

This isn't the only innovation here. Last year, the IPL team upgraded their 30-year-old air table experiments that used spark timers to mark the position of metal pucks as they move on large sheets of paper. Students now use the IPL Tracker, a modern live webcam tracking software that Prof. Altunkaynak developed for acquiring the data. Once again, students are now able to focus on physics and data analysis instead of wasting time on a time-consuming process of digitizing by hands paper marks with no pedagogical benefits.

[During this upgrade, 3D printing came to the rescue again. The glass tables had legs that were breaking due to age and poor design. Leveling the tables is very important to this experiment, so Austin designed new adjustable legs and clamps, and printed 150 sets. This saved valuable lab time that was previously spent leveling the tables.]

The team comes up with new innovative ideas every day. The only limit is of course their imagination and the time to 3D print parts required in large numbers.

Article from: News@Northeastern
https://cos.northeastern.edu/news/innovations-in-the-introductory-physics-labs/

Go behind-the-scenes and take a look at the Introductory Physics Lab!

https://www.instagram.com/p/C1-VnK9up-C/

Department Nota Bene

Professor Henry Smith, Assistant Teaching Professor retires. Professor Smith joined Northeastern University in 2000. He was one of the very first to receive the PhD in Physics from Northeastern. Henry was a trusted instructor who was well-liked by students and faculty alike throughout his Northeastern career. He was also the coordinator of the Engineering Physics program and helped develop many of the projects that were used in the"Interactive Learning Sessions" for the engineers who take physics courses.

Northeastern University has expanded its world leading Network Science Institute to the university's campus in London in a move that will establish a new European hub in the fast-growing research field of network science.

Honors

Professor Alessandro Vespignani , director of the Network Science Institute and Sternberg Family Distinguished Professor at Northeastern, is one of 3 Northeastern University Professors selected as a fellow of the American Association for the Advancement of Science. The AAAS is the world's largest "general scientific society" and publisher of perhaps the most widely recognized prestigious academic journal, Science Magazine.

Professor Srinivas Sridhar have been elected to received one of the highest honors in his field from the American Institute for Medical and Biological Engineering. The AIMBE College of Fellows, which draws from the upper 2% of medical and biological engineers.

Physics Department Awards

The 2023 Physics Department Awards were presented on April 20 Congratulations to this year's winners.

Excellence in Teaching

First Year: Yi-Chun Hung, Almostafa Mohamed, Ji Tae Park, Jonah Spector, Arathi Suraj

Second Year: Ilana Albert, Nicholas Otero

Advanced TA: Harrison Adler, Alexander Bellas

Journal Club Speaker Award

Kevin Ng Chau

Graduate Academic Excellence

First Year

Aarif
Samuel Dai
Yi-Chun Hung
Almostafa Mohamed
Jonah Spector

Second Year

George Wanes

Morelli Graduate Research Fellowship

Emily Tsai

Altshuler Award

Daniel Abadjiev (Fall 2022)

Physics Research Fellowship

Madhav Kapa

Physics Research Internship Award

Andrew Labrie

Undergraduate Research Award for Women in Physics

Aleyna Koro
Jvlanti Prasad

Physics Co-Op Research Fellowship

Georgios Vassilkis (Fall 2023)
Edward Berman

Undergraduate Scholastic Excellence

First Year

Emma Andler
Brennan Bezdek
Helena Bouchereau
Michael Brodskiy
Aidan D'Alonzo
Andrew Labrie
Serena Lin
Aavi Lund
Brent O'Hearn

Second Year

Christian Bernier
Yash Bhora
Douglas Dwyer
Benjamin Ecsedy
Andrew Ferretti
Aneel Kahlon

Third Year

Aaron Angress
Sean Coursey
Heather Morrell

Fourth Year

William Cutler

Congratulations to our 2022/2023 Physics Degree Recipients

Doctor of Philosophy

Wei-Chi Chiu (Spring 2023)
Advisor: Arun Bansil
Topological Materials: Batteries, Correlated Charge-density-waves and Superconductors

Saroj Dhakal (Spring 2023)
Advisor: Professor Alain Karma
Dynamic Mean Field Model of Voltage-Calcium Dynamics in Cardiomyocytes

Asem Hassan (Fall 2022)
Advisor: Professor Paul Whitford
Quantifying the kinematics and energetics of collective rearrangements in molecular assembly

Douglas Hendry (Spring 2023)
Advisor: Professor Adrian Feiguin
Traversing Quantum Many-Body Hilbert Spaces with Neural Networks

Xinzhi Li (Summer 2022)
Advisor: Professor Dapeng "Max" Bi
Statistical mechanics of cellular structures

Gabriel Madigan (Spring 2023)
Advisor: Professor Emanuela Barberis
A search for leptoquarks decaying to muons and bottom quarks in proton-proton collisions at $\sqrt{s}$ *= 13 TeV with the full Run II data recorded by CMS*

Anindita Maiti *(Spring 2023)*
Advisor: Professor James Halverson
A study of Field Theories via Neural Networks

Kunpeng Mu (Spring 2023)
Advisor: Professor Alessandro Vespignani
Forecasting Contagion Processes on Heterogeneous Complex Networks

Vivan Nguyen (Spring 2023)
Advisor: Professor Emanuela Barberis
A Search for Higgs Boson Pair Production in the bbZZ(llqq) Channel with the CMS Detector

Abraham Tishelman-Charny (Summer 2022)
Advisor: Professor Toyoko Orimoto
Probing the Higgs via pair production in the two W boson two photon channel at CMS: Past, present, and future

Zhuyao Wang (Spring 2023)
Advisor: Professor Pran Nath
Hidden sectors and their implications for particle physics and cosmology

Hyojun Yu (Spring 2023)
Advisor: Professor Vivek Venkatachalam
Tools for continuous observation and comprehensive analysis of big behavioral and neuronal data

Bin Zhu (Summer 2022)
Advisor: Professor Tomasz Taylor
Topics in Celestial Conformal Field Theory

Master of Science

Ariana Gonzalez (Spring 2023)
Aayushi Vaish (Spring 2023)
Matthew Waguespack (Spring 2023)
George Wanes (Spring 2023)
Joshual Whitener (Summer 2022)
Zepei Yang (Spring 2023)
Advisor: Oleg Batishchev
Thesis: Radio Astronomy with the Compact Radio Telescope (CRT) and Radio Interferometry Simulation
Wenhao Zhao (Spring 2023
Advisor: Albert-László Barabási,
Thesis: Surface Minimization of Physical Networks

Bachelor of Science

(Spring 2022 unless otherwise noted)

Samuel Ahearn
Christian Bilankov
Heather Branan
Rohan Chaturvedi
Juntong Chen
Samuel Culver
Brendan D'Aquino
John Donaghue
Kevin Donohue
Jake Duffy
Emily Dyer
John Edwards
Tasmin Edwards Lambourne**
Franklin Fee
Francis Fitzpatrick
Mark Galle
Tianni Han
Jeffrey Haynes
Jared Hutchinson
Manami Kanemura
Sanuel Koblensky
William Kovarik
Maya Lane
Tyler Locke
Jacob Marin-Thomson**
Ryan Martin
Grace McDonough
Sinead McEleney
Audrey Moos
Aidan O'Willey
Anika Padin
B. Parazin
Mark Piotrowski*
Santiago Poncio
Sarah Poole
Abigail Potter
Tingwei Shi
Ayushi Shirke
Trevor-Max Smith
Zachary Strimling
Raymond Valenzuela
Michael Vaughan**
Justin Vega
Daniel Wang
John Wilkins
Benji Zhang
Tiancheng Zhao

*Summer 2022 degree conferral
**Fall 2022 degree conferral

Supporting the Department

The Physics Challenge is an opportunity to make a lasting contribution to the future of the Physics Department and the University.

Your support will provide scholarships to students, develop new physics programs, and contribute to new facilities and equipment.

Your support is essential to furthering our mission to provide our students with education and experiences that will help transform their lives.

For more information on how to give, please go to
https://cos.northeastern.edu/giving/

or contact:
James Poulos
Assistant Vice President, Advancement
j.poulos@northeastern.edu

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Boston, MA 02115

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Do you know of an alumnus who is not receiving our newsletter but would like to be on our mailing list?

Contact Us

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