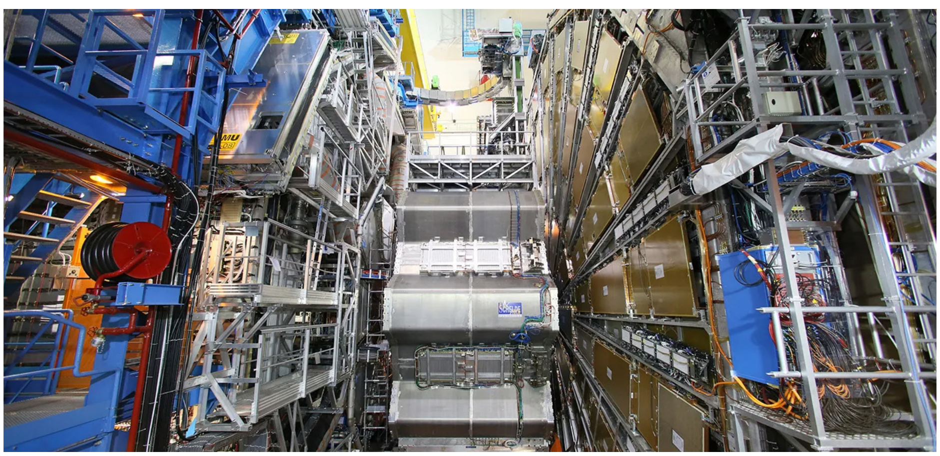
Department of

PHYSICS NEWSLETTER

Fall 2025

Northeastern physicists honored with Breakthrough Prize in Fundamental Physics for unveiling secrets of the universe



AP Images

Scientists from Northeastern University are among the thousands of collaborators awarded the 2025 Breakthrough Prize in Fundamental Physics for their research into the fundamental nature of matter at CERN's Large Hadron Collider.

Officials from the Breakthrough Prizes, known as "the Oscars of Science," said the winning collaborations at CERN are being recognized for testing the modern theory of particle physics, including precisely measuring the properties of the Higgs boson.

The Breakthrough Prize recognizes the complexity of the work involved in studying the particles at the massive Large Hadron Collider near Geneva, Switzerland, says Northeastern physics professor Louise Skinnari. "It is a fundamentally collaborative effort. The type of science we do is really trying to understand how nature and the universe work on the smallest scales at the subatomic scale."

She was named in the award along with Northeastern physics professors Toyoko Orimoto, Johan Bonilla Castro, Emanuela Barberis and Darien Wood.

Also recognized were emeritus faculty George Alverson and numerous

Northeastern University
College of Science

Photo (left) courtesy of College of Science, (right) courtesy of Alina Mak

Notes from the Chair

I am happy to share this year's Physics Department accomplishments. Although this is a challenging time in science, our department continues to provide world class training in diverse areas of physics to many undergraduate and graduate students as well as postdoctoral researchers in a positive and collegial environment.

Department faculty leadership has undergone two changes. Adrian Feiguin continues in his role of Associate Chair, which has now been renamed Associate Chair for Teaching. In this position Adrian works to ensure all faculty teaching expectations are met and all classes are covered. We have also added a new position of Associate Chair for Faculty Affairs, to which Emanuela Barberis has been appointed, with a primary responsibility for managing the extensive portfolio of faculty appointments and promotions in the department. I am pleased that these faculty leaders have continued in their roles: Alessandra Di Credico (Director of Undergraduate Studies), Tom Kelley (Undergraduate Advisor), Bryan Spring (Undergraduate Recruiter), and Paul Whitford (Director of Graduate Studies).

This year we have welcomed four new full-time **faculty. Ivana D**imitrova started in January 2025 as Assistant

Professor of Physics, with appointments in Physics and Electrical and Computer Engineering (ECE).Her research area is in quantum experiments with cold atoms, current and former post-doctoral researchers and Ph.D students from Northeastern.

Northeastern physicists at CERN, the world's largest and highest-energy particle accelerator, are conducting research on a number of projects, including ways to upgrade the collider's detectors and create filters to identify the most interesting of the millions of collisions that occur each second, says Skinnari, an expert on top quarks (fundamental particles that cannot be subdivided into different particles).

The Northeastern researchers are working with CMS, one of four experimental collaborations involving more than 13,000 scientists from 70 countries that together won the Breakthrough Prize in Fundamental Physics. "The CMS detector kind of acts like a giant digital camera to see what comes out of these collisions. So it's very fundamental science in that aspect," Skinnari says. "We're also using top quarks as a way to search for new physics beyond our currently established framework, what we call the standard model."

The $3 million in prize money is being split between the four collaborations, which in addition to CMS include

Photo by Michael Hoch

ATLAS, ALICE and LHCb, and will be used to offer grants for doctoral students. In total, 10 "Oscars of Science" Breakthrough Prizes were honored at a ceremony in Los Angeles.

Founding sponsors of the Breakthrough Prizes include Sergey Brin, Priscilla Chan and Mark Zuckerberg, Julia and Yuri Milner, and Anne Wojcicki.

Article from news@northeastern
https://news.northeastern.edu/2025/06/12/breakthrough-prize/

The 'dark matter' of nutrition: How AI and network science are transforming our understanding of food and health

Getty Images

Network science and artificial intelligence can identify food molecules that negatively affect health as well as alleviate disease by proposing dietary changes, a Northeastern expert says.

Since the human genome was decoded in 2003, Albert-László Barabási — a distinguished professor of physics at Northeastern University and director of the Center for Complex Network Research — has used network science to map out connections between proteins in human cells. "That's where network medicine comes in," Barabási says.

Eventually, network medicine will be able to provide personalized dietary recommendations and treatments, he says, based on an individual's genetics, diet and disease stage.

Genes define proteins, he says, and disease arises when a gene mutates.

working in the field of atomic molecular optics. Kin Chung (KC) Fong started in January 2025 as Associate Professor of ECE and Physics. His research area is experiments in quantum information science and technology. Brennan Klein started in January 2025 as Assistant Teaching Professor and Program Director for the MS in Complex Network Analysis. Finally, Shruti Mendiratta joined us in September 2025 as an Assistant Teaching Professor in the Nanomedicine Program. See the article introducing the new faculty.

We are extremely grateful to our excellent administrative staff for adjusting to the increased workload as the department has expanded. This includes Sheila Magee (Business & Operations Manager), Alina Mak (Undergraduate Program Coordinator), Nancy Wong (Program Manager), José Cruz (Administrative Coordinator), and Courtney Moore (Administrative Assistant). Alicia Chan, our former Operations Coordinator, has moved on to a similar position in the College of Science. These excellent staff members are critical to our ability to assist faculty and students and enable their success.

I am delighted to recognize last spring's Inaugural Pran and Shashi Nath Distinguished Lecture. Our speaker was Dr. Yuhai Tu from IBM Watson Research Center, who among many accomplishments was awarded the 2020 APS Lars Onsager Prize, the highest honor in statistical physics. He spoke to a packed crowd of physics faculty, students, and alumni, following a well-attended and enjoyable reception. It was great to see so many alumni visiting for the lecture and reception! This is an endowed lecture series resulting from the generous contributions by Pran and Shashi Nath, so I look forward to an exciting annual event.

- Mark Williams, Chair

"Mutations change the protein in the network, which then alters the network itself," he says. However, genetic changes can only explain a fraction of diseases, Barabási says.

"From a few percent of cases to, maybe, 30%, depending on the disease," he says. The remaining causes stem from lifestyle, including stress, exercise and sleep, and environment, he says, with food being the most significant factor.

Recognizing this, Barabási set out about a decade ago to integrate diet into network medicine — a field he named in 2007 that applies network science to biological systems to understand diseases and develop drugs. This research has led to a series of scientific papers on topics ranging from defining the "dark matter" of nutrition to discovering universal laws of chemical concentration in food and measuring the degree of food processing.

When food molecules enter the bloodstream and reach cells, some are used for energy, Barabási says, while others can bind to cell proteins or DNA, influencing biological processes. These molecules can either block certain processes from happening or accelerate them.

Initially, Barabási assumed mapping food molecules' interactions with the human cells would be straightforward. To his surprise, he and his team discovered that scientists had identified only a limited number of food's chemical components. The U.S. Department of Agriculture has systematically measured 150 essential micro- and macronutrients related primarily to energy intake and metabolism, including fatty acids, amino acids, sugars, fibers, minerals and vitamins. Since 2003, it has expanded its list to 188 components.

"We realized many molecules in the food that have known health consequences are not included in this nutritional list," Barabási says.

His team began by examining tens of thousands of food compounds found in the Canadian FooDB, a comprehensive database detailing the chemical composition of foods, but largely overlooked by epidemiological studies.

In 2019, they dubbed these unrecognized molecules the "dark matter" of nutrition.

Since then Barabási and his collaborators have compiled a library of over 139,000 food molecules, drawing from specialized scientific literature, various databases, mass spectrometry repositories and mass spectrometry experiments.

Another discovery from Barabási's lab concerns ultra-processed foods. They found that relative ratios of concentrations of individual chemicals in different natural foods are consistent and predictable. Deviations from those ratios, Barabási says, signal that the food underwent processing.

Photo by Ruby Wallau/Northeastern

"No matter what foods you look at, as long as there are natural ingredients there will be relatively minor variations from one food to the other one," he says.

Virtually all ingredients of the human diet, Barabási says, were once living organisms, producing and regulating nutrients according to universal biochemical rules.

"These chemical engines cannot produce something [with concentration of a certain chemical] 100 times more than normally, because there are clear constraints of production," Barabási says. "Typically the difference is like two or three times more in one [food item] compared to the other one."

The precise underlying mechanisms remain unclear.

"We think that the problem most likely comes from the chemical changes that the processing does to you," Barabási says. "For example, it has chemicals that turn off the feeling of satiation. That's really mostly for making us eat more."

According to one of Barabási's studies, over 73% of the U.S. food supply is ultra-processed.

Barabási advocates for a large-scale project combining AI, mass spectrometry and network medicine to map the chemical makeup of the foods we consume.

He says the project is "doable with the current technologies."

With proper funding, Barabási estimates that scientists could uncover 50% to 60% of the "dark matter" of nutrition within five years, which is sufficient to cover over 99% of the food we consume. Decoding the remaining portion might get harder and take longer.

Article from news@northeastern
https://news.northeastern.edu/2025/03/04/ai-nutrition-impact/

Northeastern discovery in quantum materials could make electronics 1,000 times faster

Photo by Matthew Modoono

Researchers at Northeastern University have discovered how to change the electronic state of matter on demand, a breakthrough that could make electronics 1,000 times faster and more efficient.

By switching from insulating to conducting and vice versa, the discovery creates the potential to replace silicon components in electronics with exponentially smaller and faster quantum materials.

"Processors work in gigahertz right now," said Alberto de la Torre, assistant professor of physics and lead author of the research. "The speed of change that this would enable would allow you to go to terahertz."

Via controlled heating and cooling, a technique they call "thermal quenching," researchers are able to make a quantum material switch between a metal conductive state and an insulating state. These states can be reversed instantly using the same technique.

Published in the journal Nature Physics, the research findings represent a breakthrough for materials scientists and the future of electronics: instant control over whether a material conducts or insulates electricity. The effect is like a transistor switching electronic signals. And just as transistors allowed computers to become smaller — from the huge machines the size of rooms to the phone in your pocket — control over quantum materials has the potential to transform electronics, says Gregory Fiete, a professor of physics at Northeastern who worked with de la Torre to interpret the findings.

"Everyone who has ever used a computer encounters a point where they wish something would load faster," says Fiete. "There's nothing faster than light, and we're using light to control material properties at essentially the fastest possible speed that's allowed by physics."

By shining light on a quantum material called 1T-TaS_2 at close to room temperature, researchers achieved a "hidden metallic state" that had so far only been stable at cryogenically cold temperatures. Now researchers have created that conductive metallic state at more practical temperatures, says de la Torre. The material maintains its programmed state for months — something that has never been accomplished before.

"One of the grand challenges is, how do you control material properties at will?" says Fiete. "What we're shooting for is the highest level of control over material properties. We want it to do something very fast, with a very certain outcome, because that's the sort of thing that can be then exploited in a device."

So far, electronic devices have needed both conductive and insulating materials, plus a well-engineered interface between the two. This discovery makes it possible to use just one material that can be controlled with light to conduct and then insulate.

"We eliminate one of the engineering challenges by putting it all into one material," Fiete says. "And we replace the interface with light within a wider range of temperatures."

Photo by Matthew Modoono

Stable conductivity switching at higher temperatures is a significant advance for quantum mechanics, Fiete says, and for the long game of supplementing or replacing silicon-based technology.

Semiconductors, he says, are so dense with logic components that engineers are now stacking them in three dimensions. But this approach has limitations, he said, which make tiny quantum materials more important for electronics design.

"We're at a point where in order to get amazing enhancements in information storage or the speed of operation, we need a new paradigm," Fiete says. "Quantum computing is one route for handling this and another is to innovate in materials. That's what this work is really about."

Article from news@northeastern
https://news.northeastern .edu/quantum-electronics-speed-discovery/

New Faculty Joins the Physics Department

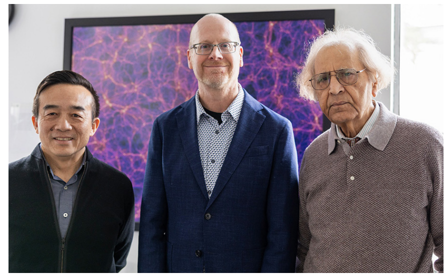
Ivana Dimitrova, Assistant Professor
Ivana Dimitrova earned the Ph.D in Physics from the Massachusetts Institute of Technology. She is integrating micro- and nano-scale high-finesse optical cavities with atomic tweezer arrays to develop scalable next-generation quantum devices Dr. Dimitrova's research interests include Quantum state engineering, Quantum Optics, Quantum simulation, Quantum computing, Ultracold atoms, Cavity QED, Optical lattices, Rydberg atom arrays, Non-equilibrium Dynamics, Many-body states, Quantum Networking, and Photonics.

Kin Chung Fong, Associate Professor
Kin Chung Fong is an Associate Professor, jointly appointed in the Departments of Physics and Electrical and Computer Engineering. Professor Fong is a condensed matter experimentalist, quantum engineer, and inventor. His interdisciplinary research uniquely bridges fundamental physics and engineering. His group investigates the fundamental physics of quantum material platforms, such as graphene, topological insulators, Weyl semimetals, and superconductors.

Brennan Klein, Assistant Teaching Professor & Program Director
Brennan Klein received a Ph.D in Network Science in 2020 from Northeastern University. Klein is a core faculty at the Network Science Institute and Assistant Teaching Professor in the Department of Physics. He is the program director of the MS in Complex Network Analysis at Northeastern University. Prof. Klein is also the director of the Complexity & Society Lab, which focuses on Information, emergence, and inference in complex systems and Public health and public safety.

Shruti Mendiratta, Assistant Teaching Professor
Dr. Shruti Mendiratta is a dedicated educator and nanomaterials scientist with extensive experience across academia, research, and industry. She holds a Ph.D in NanoScience & Technology from Academia Sinica, Taiwan and a Ph.D. in Chemistry from National Taiwan University as well as an MSc. degree in Chemistry from the University of Delhi. Beyond academia, she worked as an R&D Engineer in the semiconductor industry in Taiwan. Her research expertise spans nanomaterials, emulsions, and metal-organic frameworks, contributing to numerous publications, patents, and international conferences.

Yuhai Tu, Ph.D, presents at inaugural Nath Distinguished Lecture



Courtesy of College of Science

This spring, the Department of Physics hosted the inaugural Nath Distinguished Lecture featuring renown physicist Yuhai Tu, PhD, whose recent work has focused on dynamics of biological networks, thermodynamics of information processing in biological systems and statistical physics of machine learning.

Dr. Tu's lecture, Physics for Deep Learning: Towards a Theoretical Foundation, was well-attended by Northeastern physics faculty, students, alumni, and staff.

The new series established by Professor Pran Nath and his wife Shashi Nath celebrates discoveries and significant advances on the frontiers of physics and to recognize Northeastern University's unique contribution to knowledge enhancement.

Article from Catalyst I Summer 2025 Issue

Courtesy of College of Science

Faculty Honors

Congratulations to **Professor Alessandro Vespignani** who was awarded the prestigious **European Physical Society Statistical and Nonlinear Physics Division Prize 2025.**

Congratulations to **Hai-Ping Cheng** who received **COS Distinguished Professor**, which recognizes senior faculty for the value of their scholarship, reputation, and contributions to the College, the University, and their discipline.

Congratulations to the three Assistant Professors of Physics who received major early career awards from federal funding agencies this year:

Jonathan Blazek – National Science Foundation CAREER Award

Paul Stevenson – Air Force Office of Scientific Research Young Investigator Program Award

Yizhi You – National Science Foundation CAREER Award

Congratulations to **Haridas (Hari) Kumarakuru**, recipient of the 2025 **College of Science Innovation Award.**

Congratulations to our faculty members who have been recognized in **Clarivate's prestigious Highly Cited Researchers 2025 list:**

Arun Bansil, Category: Physics
Alessandro Vespignani, Category: Cross-Field
Miten Jain, Category: Biology and Biochemistry

Department Nota Bene

Physics Department Awards

The 2025 Physics Department Awards was held on April 16.

Undergraduate Research Award for Women in Physics

Maya Amit
MingRui (Abby) Jiang

Research Co-op Fellowship

Megan Farrington
Jacob Gagnon

Research Internship Award

Sean Coursey
Kebert Joseph
Maria Mataac

Morelli Graduate Research Fellowship

Shivan Bhasin
Jose Gustavo Bravo Flores
Salah Hassan
Liam Schmidt

Huntington 100

Georgios Vassilakis

Speaker Prize

Louison Thorens

Undergraduate Scholastic Excellence

First-Year
Joseph Afflitto
Audrey Brenhouse
Kian Yik Hin Chan
Ryan Eggleston
Megan Farrington
Estelle Kokernot
Zachary Landry
Eleanor Lechtzin
Thomas Morris
Andrei Oprea
Joshua Reid
Diego Velasquez
Daniel Vogt

Second-Year
Victor Dong
Casper Smith
Henry Stepanyants
Joshua Weymouth

Third-Year
Kevin Giordano
Katherine Kinley
Brent O'Hearn

Fourth-Year
Kali Arthur

Graduate Academic Excellence

First-Year
Samuel Dai
Jonathan Letai
Luke Sherozia
Lucas Silveira
Oswaldo Vazquez

Second-Year
Samuel Frank
Garo Kerdelian

Excellence in Teaching

First-Year
Ibrahim Almetwale
Kishan Gupta
Garo Kerdelian
Taehyun Ko
Jonathan Letai
Sara Mohamed

Second-Year
David Andersen
Zachary Forni
Audrey Lindsay
Ayushi Shirke

Advanced
Hang Deng
Nica Jane Ferrer

Congratulations to our 2024/2025 Physics Degree Recipients

Bachelor of Science

David Abrahamyan
Katelyn Adams
Jacob Allen
Maya Amit
Mehmet Furkan Baylan
Christian Bernier
Yash Bhora
Scott Biggs
Karthik Boyareddygari
Ryan Boyd
Matthew Bowman
Hunter Brodie
Matthew Bromage
Kianna Cabral
Hayley Calloway
Jake Carlson
Stephen Catalina
Eric Concannon
Sean Coursey
Ethan D'Costa
Briana Daniels
Gabriela De Leon Cruz
David DeRienzo
Douglas Dwyer
David Eckland II
Benjamin Ecsedy
Yidan Feng
Andrew Ferretti
Silver Flamuraj
Jason Foster
Cassidy Friend
Jacob Gagnon
Maanik George
Michael Gold
Nicholas Gorycki
Varun Gupta
Carter Hughes
Sathvika Iyengar
Brian Jiang
Tara Joshi
Broderick Kelly
Alexandra Kolefas
Sofia Kolobaev
Evan Lentz
Paige Leven
Matthew Longtin
Maria Mataac
Bavesh Matapathi
Judith Matteoni
Jake Medeiros
Anthony Melo
James Minardi
Heather Morrell
Skyler Nikolic
Lois Nfor
Adithya Palle
Richard Palmer
Joshua Peirce
Nancy Perkins
Brandon Petersen
Luke Reidy
Connor Robb
Juan Jose Attias Rodriguez
Yash Sahoo
Katrina Schieck
Mauricio Tedeschi
Soe Thiha
Sebastien Torres
Lanny Tseng
Georgios Vassilakis
Andrei Veliche
Tansey Vordonis
David Wasserman
Joshua Weissert
Owen Welch
Carter Williams
Jack Zuo

Master of Science

Jonathan LeyVa
Ayushi Shirke
Zhou Yu

Doctor of Philosphy

Joshua Baktay
Advisor: Adrian Feiguin
Characterization of quasi-Fermi liquids using matrix product states methods in the thermodynamic limit

Sandra Byju
Advisor: Paul Whitford
Quantifying the dynamics and functional relationships of collective processes in a biomolecular assembly

Benjamin Cashen
Advisor: Mark Williams
Characterizing multi-modal interactions of single-stranded nucleic acid binding proteins from T4 bacteriophage and the LINE-1 retrotransposon

Nica Jane Ferrer
Advisor: Gregory Fiete
Theory of magnetocrystalline anisotropy in equiatomic ferrous compounds along the Bain path

John Ferrier
Advisor: Swastik Kar
Harnessing Machine Learning and Computational Modeling for Optimizing the Experimental Synthesis of 2D Quantum Materials

Helena Gien
Advisor: Mark Williams
The HIV-1 nucleocapsid protein induces an exceptionally strong dsDNA condensation for provirus encapsidation

Yixiao Han
Advisor: Darien Wood
Search for ZZ vector boson scattering in pp collisions at 13 TeV in the $\ell\ell\nu\nu jj$ channel and Measurement of ZZ production cross section at 13 TeV in the $\ell\ell\nu\nu$ channel

Rebecca Harman
Advisor: Bryan Spring
Tumor-immune microenvironment imaging and photomedicine development with hyperspectral fluorescence microendoscopy and image processing

Guðfríður Möller
Advisor: Mark Williams
Single molecule studies of metallo-insertors and E. coli SSB variants

Wesley Roberts
Advisor: Gregory Fiete
Quantum magnetism in and out of equilibrium

Seyedehmaedeh Seyedolmohadesin
Advisor: Vivek Venkatachalam
Neural Dynamics of Developmental Decision Making and Sexually Dimorphic Behaviors in C. elegans

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.

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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?

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