Temple University

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Department launches new materials science major

The Department of Physics newest undergraduate major is materials science.

While the major will be housed within the Physics Department, courses will also be taught by the Departments of Chemistry and Mathematics and will utilize equipment from the multi-disciplinary Temple Materials Institute and the College of Engineering. That is because materials science now stands at the interface between physics, chemistry, information science, computation and applied mathematics.

Of the department's 23 core faculty members, about 10 of them focus on experimental or theoretical/computational materials science.

"We are, perhaps, the only research university that is offering a science-based BS materials science program," says **John Perdew, Laura H. Carnell Professor of Physics and Chemistry**. "Unlike other schools where the program is housed in their engineering schools, our approach focuses more on the underlying science."

Besides preparing students well for graduate school, Perdew believes the program will also prepare students for careers with companies that develop and manufacture new materials for high-tech applications.

Materials science evolved historically from the metallurgy of naturally occurring elements and their alloys, as well as glass, to embrace an enormous variety of "hard" metallic and semiconducting alloys and oxide-based materials, such as superconductors and catalysts, that underpin technology applications. But the field now also encompasses a vast array of "soft" materials, including synthetic and natural polymers, as well as more recent two-dimensional graphene-like materials, that will be needed for future advanced/strategic technologies.

Students in the program will be able to specialize in either a synthesis/characterization track or a computational track, the latter reflective of the fact that materials science is now harnessing computation, data science and artificial intelligence/machine learning to create heretofore unknown "designer" materials.

"It's now possible," says Perdew, "to design a broad spectrum of new materials solely on a computer by conducting quantum mechanical computations to predict what materials can exist and what properties they will have."

Iavarone

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"We are unraveling the role of atomic-scale defects in limiting the performance of superconducting quantum devices," says Iavarone. "This will allow us to address the underlying physics and materials science mechanisms that are instrumental for achieving a new level of quantum processors."

The project is expected to result in $1 million in funding for equipment and to fund several research postdocs at Temple.

College of Science and Technology

PHYSICS

UPDATE SPRING 2022

Temple University

Celebrate 100 years of physics at Temple University this April 1

From championing the increasing diversity of physics to addressing its role in solving some of society's biggest challenges, the Department of Physics will celebrate a century of physics at Temple University this April 1.

Alumni, faculty, students and friends of the department can join with us for a virtual and in-person symposium and an in-person reception in the Science Education and Research Center on Temple's Main Campus. Starting at 2:00 p.m., talks will highlight the past, present, and future of the Physics Department at Temple.

For a complete list of symposium speakers and for registration information, go to cst.temple.edu/PHY100.

From faculty research to the career success of our undergraduate and graduate students, there is so much happening within the department. Our alumni continue to excel in their fields and to support today's faculty and students.

The future of our department is indeed very bright.

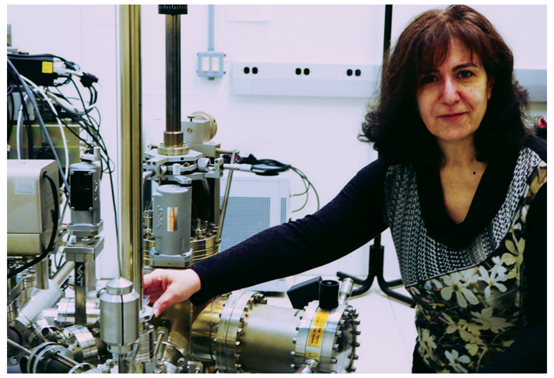
Bernd Surrow
Professor and Chair

Support Physics

During our centennial celebration, you can support physics graduate and undergraduate students. Make your gift at giving.temple.edu/physics.

phys.cst.temple.edu

Iavarone joins national effort to develop revolutionary quantum computers



Professor Maria Iavarone's laboratory is one of 20 national partners involved in the effort to develop revolutionary quantum computers. Led by the Superconducting Quantum Materials and Systems Center at the U.S. Department of Energy's Fermilab, the project's goal is to build and deploy an advanced quantum computer based on superconducting technologies. The potential impact is vast, from more reliable weather forecasts to developing new chemicals and medicines, finding novel materials for solar cells and improving cyber security and data encryption.

"A quantum computer can solve problems that traditional computers cannot," explains Iavarone. "It can process an enormous amount of data in a much shorter time, which means that it is possible to solve much more complex problems and handle vastly larger data sets."

However, large quantum computers need to be cooled down close to absolute zero—nearly minus 460 degrees Fahrenheit—and they are extremely sensitive to all types of interference. One of the biggest barriers to constructing such a computer is the short life span of information stored on a qubit, the quantum analog of a traditional computer bit. Today's highest-performing qubits only maintain information for up to 100 microseconds.

"One of the major problems for the implementation of large-scale quantum computing is to keep quibits operational for longer periods of time," says Iavarone. "What contributes to a qubit's extremely short life span are material defects and imperfections at surfaces and interfaces."

As part of the five-year project, which began last summer, Iavaroni's group is using low-temperature scanning tunneling microscopy in a low-vibration lab at Temple's Science and Education Research Center to understand the electronic properties of materials down to single atoms.

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Samuel Kim, CST '21: Earns PhD while working fulltime at Temple

Samuel Kim

No one epitomizes Temple University's motto, *Perseverantia Vincit* (Perseverance Conquers), more than **Samuel Kim**. Between December 2020 and May 2021, the immigrant from South Korea achieved two milestones: he became a U.S. citizen and earned his PhD in physics. As someone who also identifies as multiracial, Kim is just one of about 10 Black graduate students nationwide to earn a physics doctorate out of roughly 1,900 granted annually.

Kim, who earned his bachelor's and master's degrees from Drexel University, has worked for Temple since 2008 as an associate health and safety specialist. He now focuses on environmental health and radiation safety at both Temple Hospital and university laboratories. "We help establish safe laboratory environments and prevent people from potentially life-threatening radiation exposures," says Kim.

Beginning in 2013, he continued working full time while pursuing his doctorate—which involved working on his PhD late into the night after daytime work hours and during weekends. "It's been very difficult, but it's something I've always wanted to do," says Kim, whose doctoral research on gamma rays included a collaboration with the Oak Ridge National Laboratory.

Kim also has served as an adjunct mathematics professor at Camden County Community College since 2004. "I really understand the difficulty and challenges those students are facing," he says. "I admire their effort because I see myself in them."

Moving on from Temple, Kim will now be a postdoc research associate with National Nuclear Data Center at Brookhaven National Lab.

Gregory Penn, CST '21: Pursuing theoretical nuclear physics PhD at Yale

Gregory Penn

Into the first semester of his junior year, **Gregory Penn** admits he was doing well—but not as well as he could. After a poor test result, **Tsvetelin Tsankov, assistant professor of instruction**, told him he could do better.

Did he ever. After earning his bachelor's in physics and a mathematics minor with a 3.92 GPA, Penn is now in a PhD program for theoretical nuclear physics at Yale University.

After being a National Science Foundation Research Assistant at the Nanyang Technological University in Singapore a few summers ago, for a year he was a research assistant in **Professor Andreas Metz's group**. "For me, it was a 180-degree change," he says. "I pivoted from experimental to theoretical nuclear physics, looking at collider data to extract information about how quarks move about within hadrons."

As part of that research, Penn collaborated with one of Metz's graduate students and two of his collaborators at the University of California-Los Angeles and Lebanon Valley (Pa.) College.

"I am really enjoying research the most now, but I also enjoy teaching," says Penn, who most likely envisions an academic/research career.

Torchinsky has potential breakthrough in probing novel semimetal materials

Using laser-based, all optical methods to probe novel materials, **Assistant Professor Darius Torchinsky** recently had a potential breakthrough on measuring the electronic properties of what are called Weyl semimetals—a new class of quantum materials that, unlike such metals as gold, silver and copper, can host both positive and negative charge carries.

In addition, rather than being flat and linear, these semimetals are topological—meaning the electrons behave as if their environment is nonlinear or curved. As a result, their associated electrons "feel" an additional degree of curvature that alters their motion in response to external stimuli, such as light or applied voltage.

"The electrons present on the surface of these materials also have novel electronic properties," says Torchinsky, who is in the second year of a five-year, $600,000 NSF CAREER Award for young investigators.

Recently, Torchinsky's lab was able to demonstrate what he believes is one of the first, if not the first, optical measurement of some of these surface electrons in Weyl semimetals.

"It is interesting that some of these semimetals interact fairly strongly with light," he says. "Shining light on them generates sizable electron currents."

Such properties could make these semimetals excellent alternatives to semiconductors for both sensing devices, such as cameras able to detect a broad range of light wave lengths, or for solar energy production.

Humboldt Research Fellowship allows Gray to explore new quantum materials

Associate Professor Alexander Gray has been awarded a prestigious Humboldt Research Fellowship for developing new depth-resolved synchrotron and FEL-based X-ray spectroscopic techniques and for applying them to the studies of novel materials, buried interfaces, and multilayer structures.

The fellowship will enable him to spend three-month residencies each year for the next three years in Europe, particularly in collaboration with three German research institutions: the Helmholtz Center in Berlin, the Jülich Research Center in Jülich, and DESY in Hamburg.

After spending six years designing and building a unique hard x-ray photoemission spectrometer, says Gray, "We are now able to look deep inside the bulk of new materials, as well as at their surfaces and interfaces, to understand how the materials are working. We need to do this in order to design new materials and structures for quantum computing."

During the past 10 years, Gray's group has published 17 papers in collaboration with the above-mentioned German institutions. "Our plan is to use our instrument in synergy with their unique facilities to really get a comprehensive understanding of the fundamental physical properties that govern quantum materials."

Gray notes that the fellowship also benefits both graduate and undergraduate students who will regularly travel to Europe to participate in the collaborative research.

Kiana Burton, CST '21: Exploring the habitability of planets

Fascinated by space documentaries, **Kiana Burton** came to Temple intent on studying space.

Even though the Physics Department doesn't offer a full-blown astronomy degree, under the tutelage of **Matthew Newby, assistant professor of instruction**, Burton was able to do just that. Now, after earning her bachelor's in physics, Burton is pursuing a PhD in astrophysics and planetary science at the University of Colorado Boulder.

"If it hadn't been for Dr. Newby, I don't know how I could have gotten my foot in the door for astronomy research," says Burton. With him, she studied old, distant stars in our galaxy using two massive astronomical databases.

That research led to her acceptance as a National Science Foundation-Research Experiences for Undergraduates intern with the Maria Mitchell Observatory (MMO) in Nantucket, Mass. Her virtual research there last summer involved finding and characterizing millimeter flaring activity on Epsilon Eridani—one of the closest and most visible stars—based on archived radio signal data gathered at the Atacama Large Millimeter Array of radio telescopes in northern Chile.

Her virtual presentation of that research at the American Astronomical Society annual conference in 2021 earned her a prestigious Chambliss Astronomy Achievement Student Award. Also, one of her MMO mentors, CU Boulder Assistant Professor Meredith MacGregor, is now her doctoral advisor. "It's a broad program with lots of opportunities to research the habitability of planets similar to Earth," she says.

NSF grant helps Constantinou support the science behind future electron-ion collider

Supported by the National Science Foundation, **Assistant Professor Martha Constantinou** has been awarded one year's worth of research time on the Frontera Supercomputer at the Texas Advanced Computing Center at the University of Texas at Austin. Frontera is the world's fifth fastest supercomputer and the world's fastest university computer. The highly competitive award is estimated to be worth $1.26 million.

"Ninety-nine percent of the physical universe is comprised of fundamental particles, like protons and neutrons, which make up the atomic nucleus," says Constantinou, a theoretical/computational physicist. "Understanding the structure of these particles is essential."

Since April 2021, she has been using her supercomputer time to conduct a large-scale simulation of the theory of the strong interactions, Quantum Chromodynamics, to shed light on such questions as how the mass and spin of nucleons arise from their constituent quarks and gluons. Her research is part of worldwide research effort to advance the theory that will support the physics program of the state-of-the-art electron-ion collider, which will be built during the next 10 to 15 years at the Brookhaven National Laboratory.

Constantinou was also recently named one of CST's two Selma Lee Block Brown Professors. Awarded to outstanding female junior faculty members, the five-year professorship includes a $5,000 annual award, which she will use to support graduate and undergraduate research in her lab each summer.