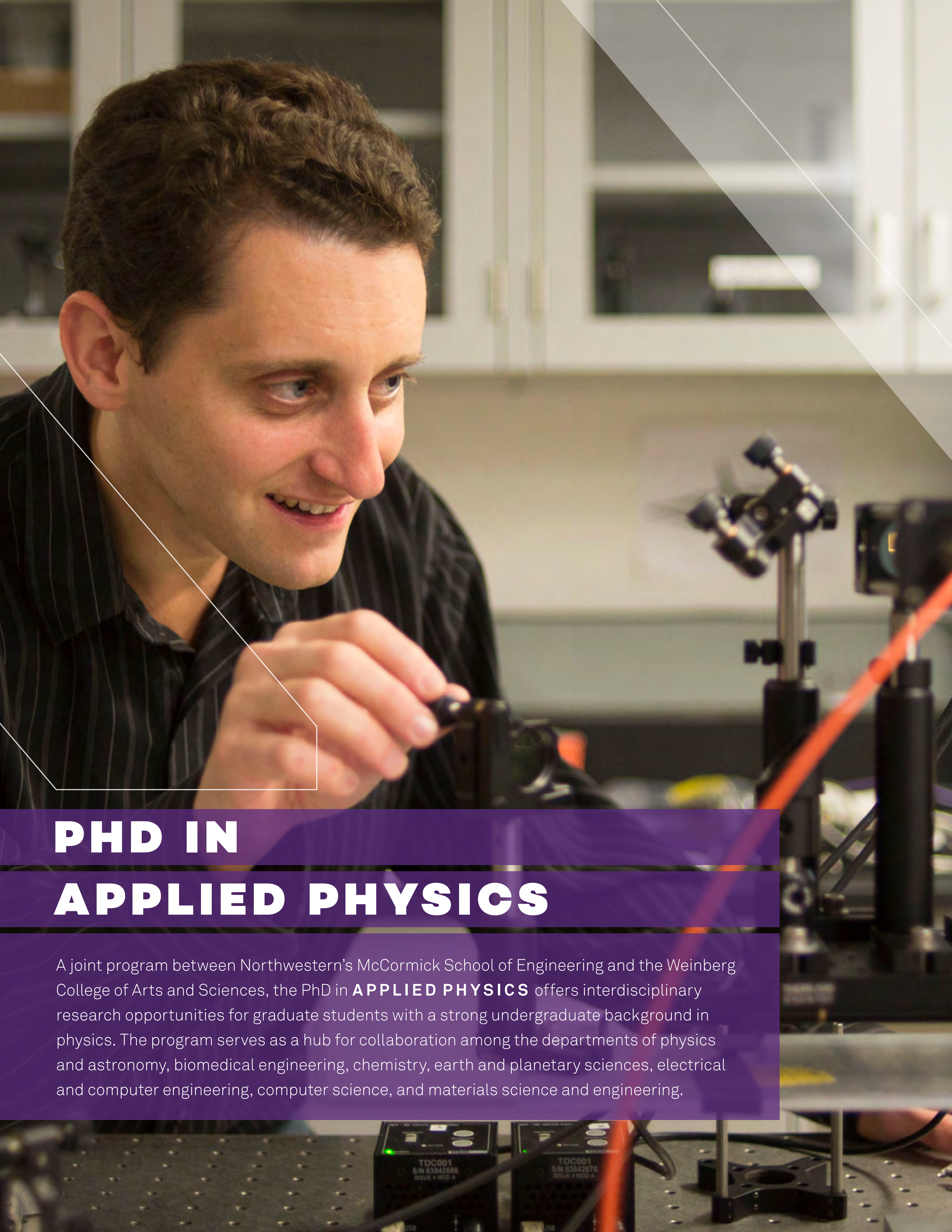


PHD IN APPLIED PHYSICS

A joint program between Northwestern's McCormick School of Engineering and the Weinberg College of Arts and Sciences, the PhD in **APPLIED PHYSICS** offers interdisciplinary research opportunities for graduate students with a strong undergraduate background in physics. The program serves as a hub for collaboration among the departments of physics and astronomy, biomedical engineering, chemistry, earth and planetary sciences, electrical and computer engineering, computer science, and materials science and engineering.

PHD PROGRAM

Northwestern has a distinguished record of research and innovation in many areas of applied physics, spanning multiple departments. Students can complete a PhD in applied physics in as few as five years. Completing all of the required courses during the first year allows them to fully focus their efforts on research at the beginning of the second year. Central facilities to conduct experimental and computational research are conventiently located on campus. In addition, many research programs take advantage of the Advanced Photon Source at nearby Argonne National Laboratory, a national synchrotron-radiation light source research facility.

DEGREE REQUIREMENTS

Formal requirements for a PhD in applied physics include:

Core courses: Students take nine core courses in materials science, physics, and applied physics.

Elective courses: Students, in consultation with their advisers, choose electives in chemistry, earth and planetary sciences, electrical and computer engineering, computer science, materials science and engineering, or physics and astronomy.

Oral qualifying exam: At the end of the first year, each student must pass an oral exam based on current research in their field.

Teaching experience: Students serve as TAs for at least one quarter in any of a variety of undergraduate classes.

Research proposal: Students present their thesis research proposal in front of a faculty committee before the end of their third year.

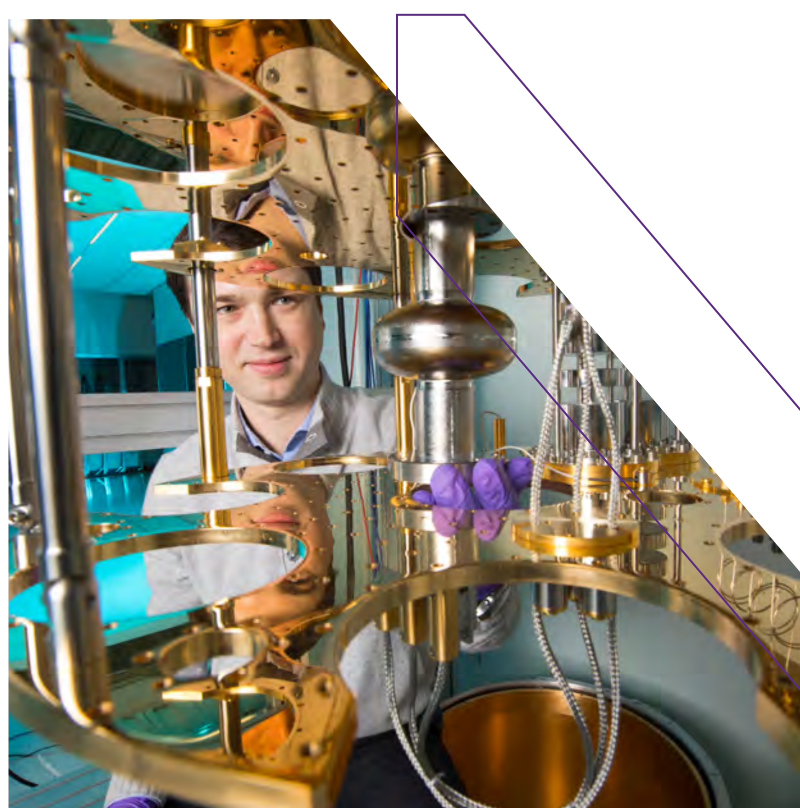
Thesis defense: Students write a dissertation and defend their final thesis in front of a faculty committee.

ADMISSION REQUIREMENTS

The admissions committee evaluates many factors in a holistic review of the applicant, including prior academic performance, research and other professional experience, letters of recommendation, and the statement of purpose, to determine overall potential to successfully pursue graduate study in applied physics. TOEFL scores are also considered for non-native English-speaking students. For applications submitted in 2020 for fall 2021 enrollment, the Applied Physics Program is not requiring GRE scores (general and subject) due to the complications caused by the COVID-19 pandemic. However, official scores will be reviewed if submitted.

FINANCIAL SUPPORT

All applicants are automatically considered for full financial support. Students also receive a monthly stipend, paid health insurance, and a full-tuition scholarship. More information is provided upon offer of admission to the program.



FACULTY

The PhD program in applied physics brings together faculty from departments in science and engineering, offering incoming students a wider variety of research opportunities than any single department could, including numerous options for interdisciplinary research. Faculty members in the program belong to the departments of physics and astronomy, chemistry, and earth and planetary sciences as well as biomedical engineering, electrical and computer engineering, and materials science and engineering.

THE CORE DISCIPLINES

APPLIED QUANTUM PHYSICS

The field of applied quantum physics inspires scientists in physics and electrical engineering worldwide, and forms a major thrust of lively research today. At Northwestern, it unites the interests of both experimental and theoretical research groups actively investigating applications of quantum physics for a broad array of tasks, including development of new high-precision measurements, secure information transfer by quantum cryptography, quantum manipulation of ultra-cold trapped atoms and ions, and manipulation of quantum information in superconducting circuits and other mesoscopic systems with quantum coherence.

Experimental and computational resources at Northwestern range from cooling quantum systems to temperatures close to the zero-point (e.g., laser cooling of trapped atoms or molecules, and operating two-dimensional electron gases or superconducting samples in dilution refrigerators) to the Quest high-performance computing cluster for numerical simulations.

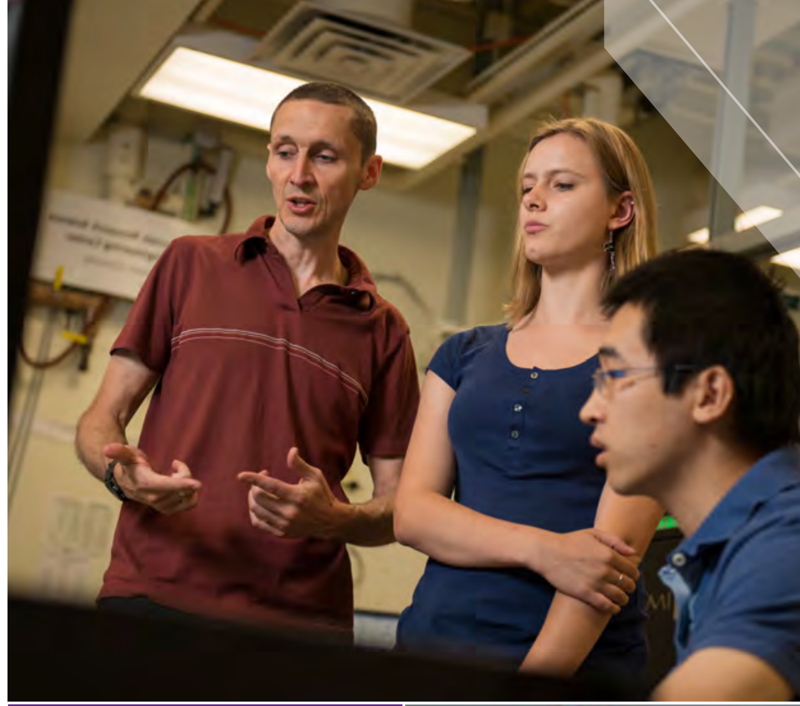
In partnership with Fermi National Accelerator Laboratory, Northwestern faculty in physics and materials science pursue applications of superconducting technologies ranging from particle accelerator technology to quantum technologies for quantum computing and quantum sensing.

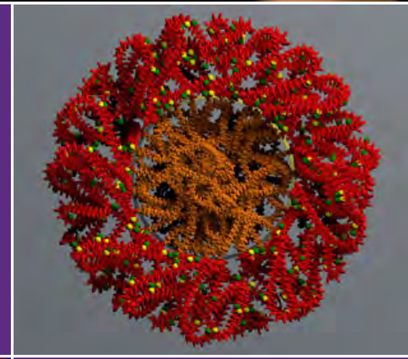
FACULTY

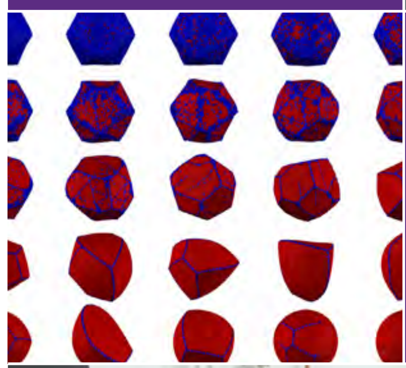
Venkat Chandrasekhar \ Danna Freedman \ Anupam Garg \ Matthew Grayson \ John Ketterson \ Jens Koch \ Prem Kumar \ Hooman Mohseni \ Brian Odom \ James Sauls \ Tamar Seideman \ Selim Shariar \ Nathaniel Stern \

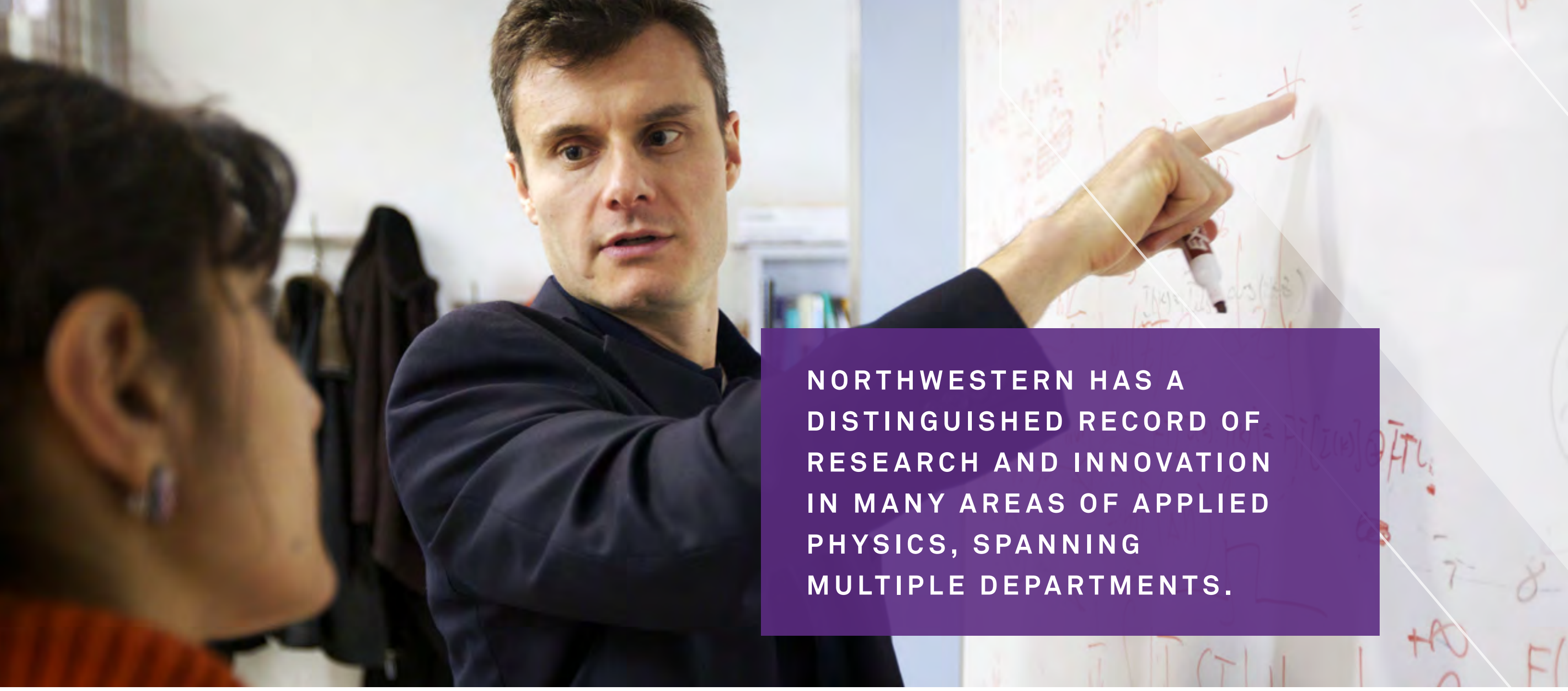
INTERFACE SCIENCE

Interface science by its very nature brings together a diverse community with interests in device physics, catalysis, biomembranes, oxide film growth, semiconductors, geochemistry, surface physics, corrosion, nanoscience, energy storage, and electrochemistry. One of the many grand challenges in this interdisciplinary field is to understand and control the assembly of atoms and molecules at well-defined surfaces in complex environments.









In partnership with the Advanced Photon Source at Argonne National Lab, faculty members are developing increasingly sophisticated X-ray methods to meet these challenges. In-house methods include high-resolution TEM coupled with surface analytical and computational techniques, three-dimensional atom-probe microscopy, an array of electron and scanning probe tools, and laser spectroscopy techniques.

FACULTY

Koray Aydin \ Michael Bedzyk \ Lin Chen \ Robert Chang \ Vinayak Dravid \ Pulak Dutta \ Franz Geiger \ Sossina Haile \ Mark Hersam \ Chris Jacobsen \ Lincoln Lauhon \ Laurence Marks \ Tobin Marks \ Amanda Petford-Long \ Teri Odom \ Monica Olvera de la Cruz \ James Rondinelli \ G. Jeffrey Snyder \ Peter Voorhees \ Emily Weiss \ Christopher Wolverton \

MAGNETISM

Although magnetism goes back to ancient times, it remains an active field. At Northwestern, researchers focus on several topics, including magnetic-structure calculations that allow quantitative predictions of the properties of both existing and yet-unfabricated materials, nanostructures that display both ferromagnetism and ferroelectricity, and spintronics, which studies combined magnetic and electrical transport properties. Dynamic studies largely focus on magnetic collective modes whose frequencies fall in the microwave regime; such studies will be greatly aided by a new National Science Foundation-funded facility devoted to measuring microwave responses of a variety of structures fabricated by faculty in applied physics.

FACULTY

Venkat Chandrasekhar \ Vinayak Dravid \ Danna Freedman \ William Halperin \ John Ketterson \ Amanda Petford-Long \ James Rondinelli \ Nathaniel Stern \

MINERAL PHYSICS

Minerals, naturally occurring crystalline solids, are produced through geological processes or by living organisms. The study of the growth and behavior of natural crystals, and of their interactions with organic molecules, is important for topics ranging from understanding the evolution of the earth and planets to understanding and controlling the ways in which biomolecules guide the growth of bones and shells.

Likewise, mineral physics allows us to learn about our environment and investigate processes, such as carbon sequestration, and to use biology-inspired ideas to make hybrid organic–inorganic nanomaterials. These efforts are grounded in solid-state physics and involve chemists, physicists, geologists, and materials scientists.

FACULTY

Michael Bedzyk \ Robert Chang \ Pulak Dutta \ Franz Geiger \ Sossina Haile \ Steven Jacobsen \ John Ketterson \ James Rondinelli \ G.Jeffrey Snyder \ Christopher Wolverton \

SOFT CONDENSED MATTER

Given its scope and applications, soft condensed matter lies at the very intersection of physics, chemistry, and biology. Soft condensed matter physics, a subfield of condensed matter physics, focuses on the study of both static and dynamic properties of matter and materials at energy scales where thermal fluctuation dominates. As such, quantum aspects are negligible. Typical “soft” systems of interest include liquids, colloids, polymers, foams, gels, granular materials, and glasses, as well as a variety of biological and complex materials. They derive their many interesting properties from a competition between electrostatic interactions, van der Waals forces, and entropic effects.

This fast-growing research field is interesting not only for its use of classical geometry and deep theoretical concepts associated with symmetry breaking, phase transitions, or emergent phenomena, but also for its immense potential for applications in technology (from ceramic paints and adhesives to liquid-crystal displays) and biological materials (blood, muscle, skin, tissue, gels, membranes, milk, and vesicles are all examples of “soft” materials).

FACULTY

Koray Aydin \ Michael Bedzyk \ Vinayak Dravid \ Pulak Dutta \ Erik Luijten \ Adilson Motter \ Monica Olvera de la Cruz \ George Schatz \

STRUCTURE AND SELF-ORGANIZATION OF BIOLOGICAL MOLECULES

Biological molecules often have complex structures that are dictated by the functions they must perform. Despite this complexity, the molecules are self-organized, typically built from simple building blocks such as amino acids, nucleic acids, lipids and sugars, and often function in a crowded intracellular environment that uses complicated signaling pathways to initiate crucial biological functions. Understanding the molecules, their assembly, and their interactions is of paramount importance to molecular biology and biological physics. There is also much interest in new materials that can be derived by combining biological molecules in unusual ways, or by combining biological molecules with synthetic species, including nanoparticles and inorganic interfaces.

Northwestern and Argonne National Laboratory’s Advanced Photon Source have a number of unique structural tools available for the characterization of biomolecules. In-house methods include high-resolution TEM coupled with surface analytical techniques, an array of electron and scanning probe tools, and laser spectroscopy techniques. State-of-the-art computer simulations employing molecular dynamics and Monte Carlo methods are facilitated by Northwestern’s Quest high-performance computing facility.

FACULTY

Vadim Backman \ Vinayak Dravid \ Erik Luijten \ Adilson Motter \ Teri Odom \ Monica Olvera de la Cruz \ George Schatz \

CONTACT

For more information visit appliedphysics.northwestern.edu or contact program assistant Clarence Morales at 847–491–5455 or at appliedphysics@northwestern.edu.