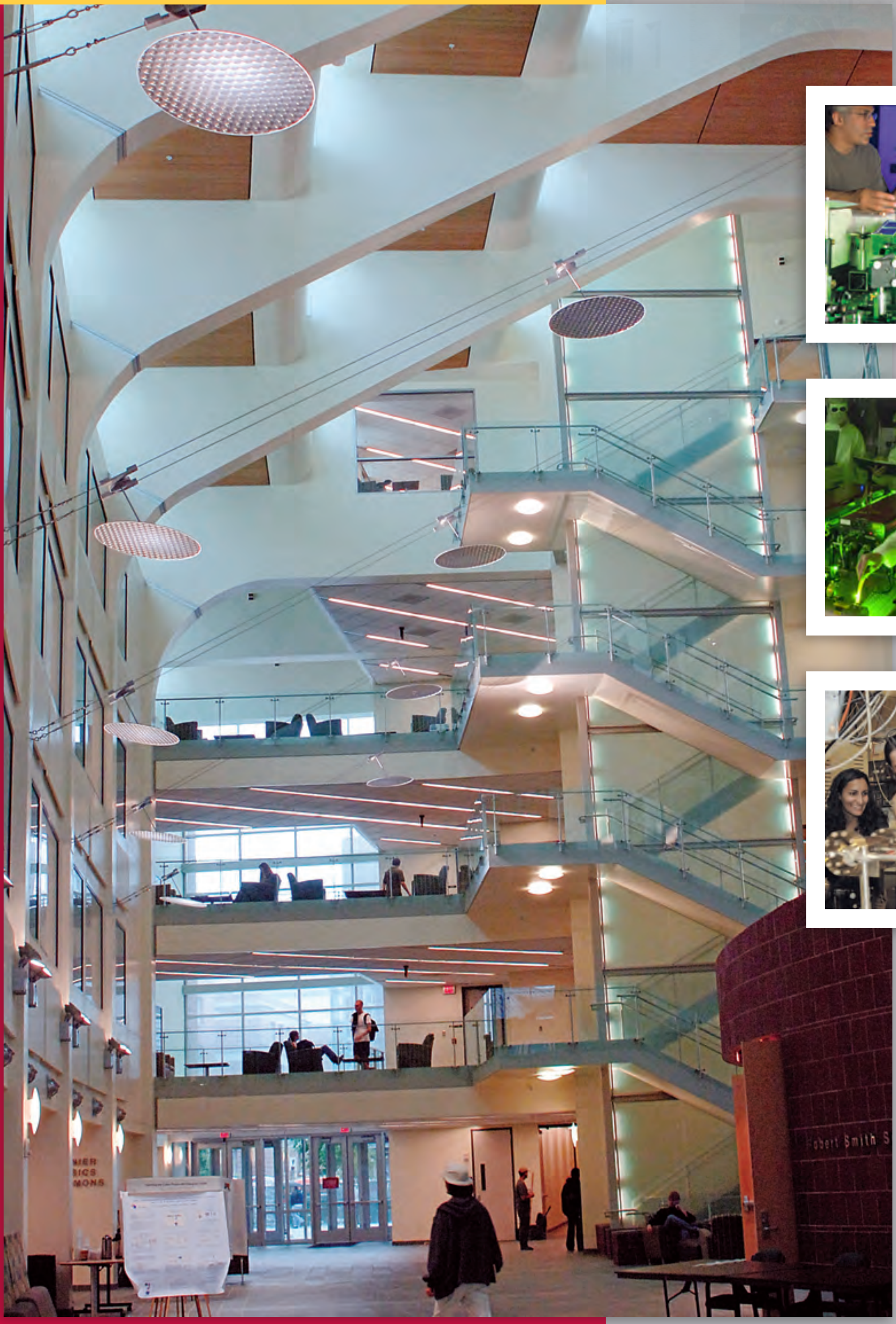
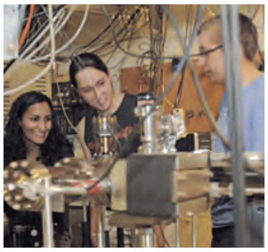
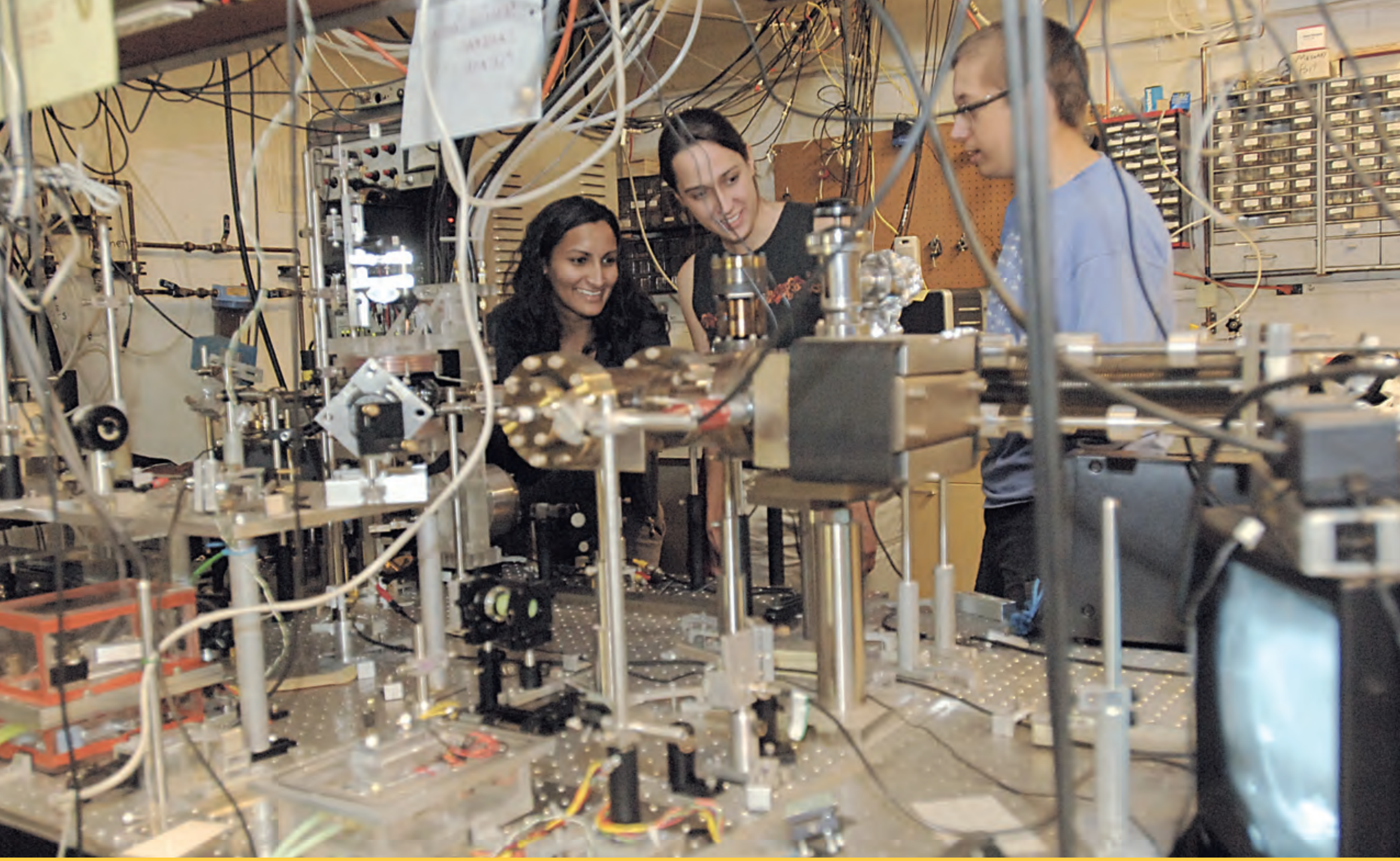
THE OHIO STATE UNIVERSITY

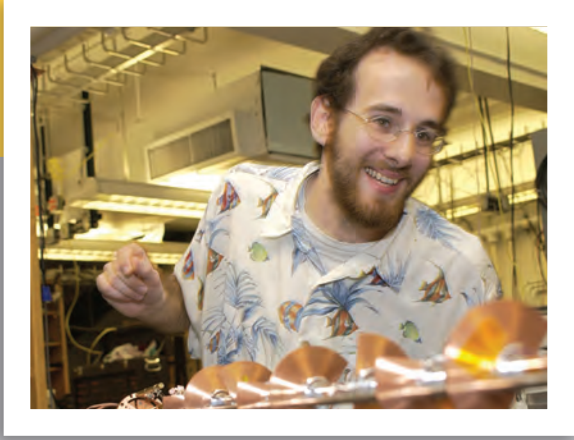
Graduate Study in Physics

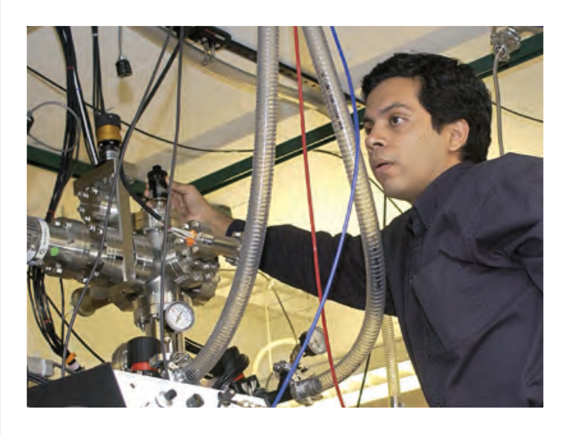




THE OHIO STATE UNIVERSITY







Graduate Study in

For information about housing and graduate student life
gradadmissions.osu.edu

For general information about Columbus
ci.columbus.oh.us

The Ohio State University
Department of Physics
Physics Research Building
191 W. Woodruff Ave.
Columbus, OH 43210
Phone: (614) 292-5713
Fax: (614) 292-7557
physics.osu.edu

College of Arts and Sciences

Table of Contents

Research Groups

Physics

Schedule a visit or get more information

We hope this publication helps you find what you need to know about our graduate program in physics and what you can expect to find at Ohio State and in Columbus. If you want more information, or, better still, if you want to arrange a visit to see our facilities and meet the people who could be a part of your graduate education, please contact us at gradstudies@physics.osu.edu or (614) 292-7675.

THE OHIO STATE UNIVERSITY

Applying to the Physics Program

PRE-APPLICATION

The pre-application method of applying is available only to applicants to the Department of Physics. The pre-application is the official physics application. Go to the Admissions website at **applyweb.com/apply/osu/grad_files/menu.html** to complete the entire Ohio State application. At the end, you will be asked to pay the application fee. This is normally $50, but, by special arrangement, only a $5 fee will be charged for physics applicants. (Note that the total will be revised to charge $5 only *after* you click "Submit.") Please also see the Step by Step Guide to Admissions on the Graduate Admissions homepage at **gradadmissions.osu.edu**, as well as our department's application process information at **physics.osu.edu/graduate-students** under the Prospective Students menu.

Supplementary Materials Required

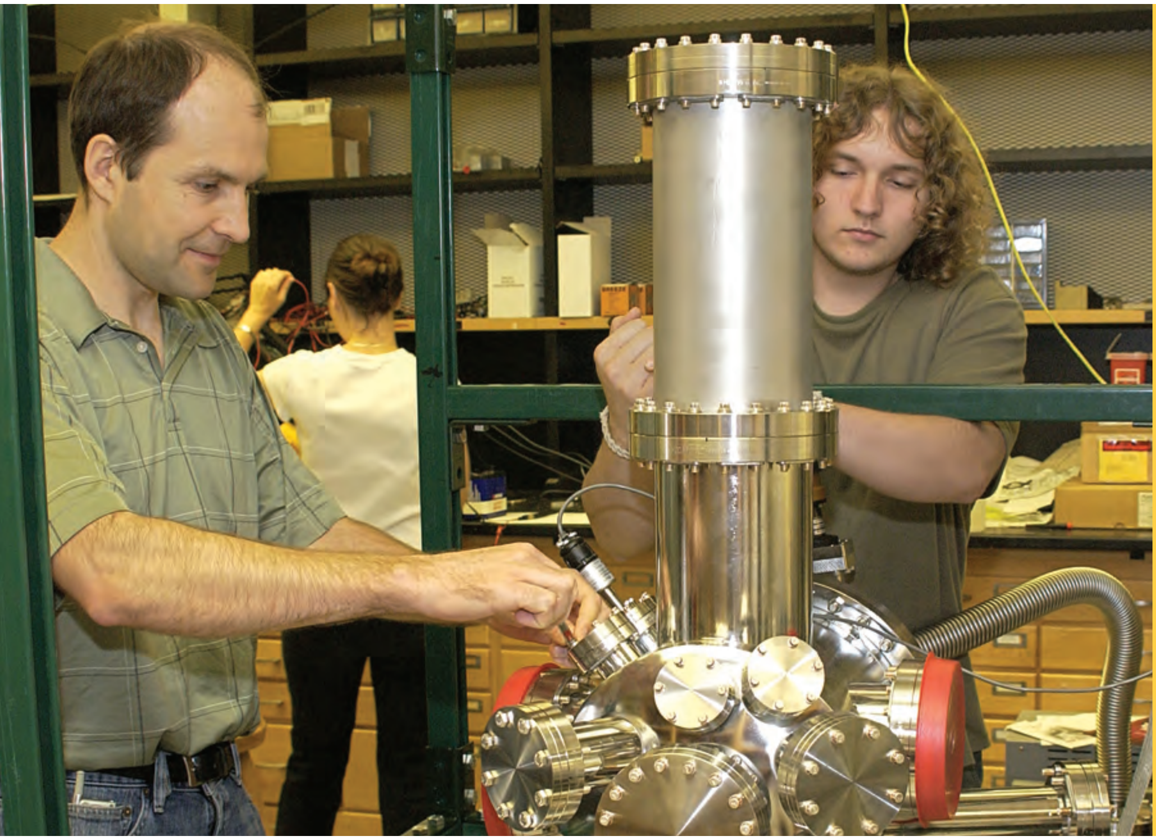
- Official transcript(s) from all colleges and universities you have attended. This includes schools you attended for only a short time (even if the transfer credit shows on another transcript).
- Official GRE General and Physics subject test scores sent to institution code 1592. Visit **ets.org/gre** for more information on GRE tests
- 3 letters of recommendation. Please read program application instructions online at **physics.osu.edu/graduate-students** for more information.
- An autobiography or personal statement is required (limit 1-2 pages).
- C.V. or resume (limit 1-2 pages)
- An official TOEFL score is required of international applicants. The TOEFL IBT test is required unless it is not offered in your country. If you do not meet the university minimum TOEFL IBT score (79), you cannot be considered for our graduate program. We cannot waive the TOEFL requirement or consider scores near (but below) the minimum.

Application Deadlines

We begin to consider applications mid December into January and usually complete our review process of all applications by the end of February. For the best chance of admission, submit all application materials by December 15. (If you take the General GRE in November, it is acceptable if the scores arrive in early January.) You can submit materials after this date, but the longer you wait, the less chance of admission you have.

If you want to be considered for a fellowship or teaching assistantship, please submit a complete application, including all supplemental materials, GRE test scores, and letters of recommendation by December 15. If you do not meet these deadlines, you can still be considered for support in the form of a teaching assistantship.

Realize Your Potential



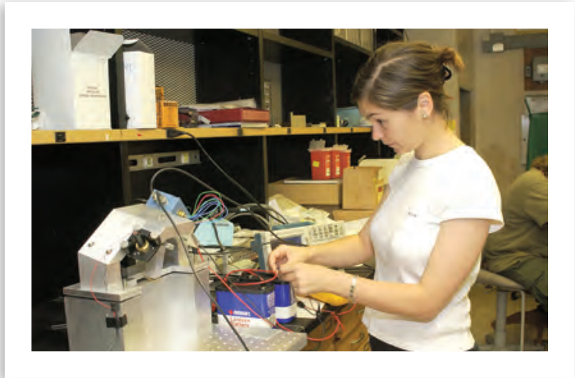
To probe the frontiers of what is known about the physical world, aspiring physicists must have a thorough understanding of the fundamentals of science and mathematics. They also must have adequate means and qualified mentors if they are to fully realize their potential.

At The Ohio State University you will find the faculty, facilities, and financial support to help you achieve your goals. We offer you a solid foundation in physics that includes course work in a diverse range of specializations covering every facet of contemporary physics research. Our faculty members conduct research in a broad range of areas, including astrophysics; atomic, molecular, and optical physics; biophysics; condensed matter physics; high energy physics; string theory; nuclear physics; and physics education research.

Ohio State's Department of Physics has recruited a nationally and internationally distinguished faculty that has garnered numerous awards. The department is proud to claim two Nobel Laureates and a National Academy of Sciences member, two Max Planck Award winners, four chaired professors, three Distinguished University Professors, and 16 winners of young investigator awards, including the Presidential Young Investigator, National Young Investigator, and Outstanding Junior Investigator awards.

The most recent ranking of physics departments by the National Research Council places Ohio State (approximately) 24th nationally and 13th among public universities.

This brochure offers a description of our program, our faculty, and facilities, as well as the financial aid you may expect to receive at Ohio State as a graduate student in physics. We also invite you to visit us, see the facilities, and meet the people who could be a part of your graduate career in physics. See also our website at **physics.osu.edu**.



The Department of Physics at The Ohio State University

Ohio State is one of the largest universities in the world. Our large size makes it possible to offer you access to the world-class technology so necessary to advanced study in physics. You get access to the resources of a major research university, while your immediate world revolves around the Department of Physics in the new Physics Research Building, part of the College of Arts and Sciences, Natural and Mathematical Sciences. The department is committed to diversity in science and welcomes members of underrepresented groups. We offer one of the friendliest environments for graduate study in physics anywhere and host a number of social events for graduate students every year, including parties, picnics, and receptions.

With 60 faculty, 195 graduate students, 45 postdoctoral associates, and a support staff of 65, the department is large enough to provide an excellent research environment and a comprehensive course selection, but small enough to offer you personal attention. We encourage you to visit our campus and talk informally with faculty and graduate students to find out for yourself what kind of people you will be working alongside if you select Ohio State for your graduate education.

JOIN OUR GRADUATE PROGRAM

By entering our graduate program in physics, you will become part of one of the nation's premier research universities. In 2011, Ohio State expended $832 million research dollars and ranked second among all U.S. universities with approximately $106 million in industry-sponsored research. Each year, the members of our physics department bring in more than $15.5 million in research funding, publish more than 200 refereed papers, give hundreds of invited talks at international conferences as well as seminars and colloquia at other institutions, and graduate 20 to 30 new PhD students. These numbers quantify the excellence of our young faculty, who are part of a strong, growing department and who pursue a variety of exciting research directions. As part of this program, you will be able to conduct first-rate physics research and receive generous financial support while earning your graduate degree at Ohio State.

FINANCIAL AID OPPORTUNITIES

Because we select only the highest caliber students for our graduate program, all regular incoming students are offered financial support. Once accepted into the graduate program in physics, you will be awarded one of three types of graduate appointments: a teaching associate (TA) position, research associate (RA) position, or fellowship. With any of these appointments, you will receive a monthly stipend plus a full waiver of tuition and general fees.

Teaching Associates: Many of our first-year graduate students are supported through their appointment as teaching associates. These appointments ordinarily are made for the academic year (two semesters). Teaching assignments involve a maximum of eight contact hours of combined laboratory/recitation instruction per week. In this appointment, your responsibilities include teaching, grading, and giving individual assistance to students. You also will receive training for this position through the department.

As a first- or second-year teaching associate, you will be awarded a special research appointment for the summer term if you have a satisfactory record of academic work and teaching performance for two consecutive semesters. During your summer term, your regular stipend is continued, but you will have no teaching duties. This appointment allows you to begin research work early in your graduate program. The stipend for teaching associates is very competitive and is upgraded regularly. The value of the present stipend will be provided with your application materials.

Excellence in graduate teaching is recognized each spring with the presentation of the Hazel Brown Teaching Awards, which include a monetary award as well as a certificate of recognition.

Research Associates: Graduate research associate positions are available to nearly all advanced graduate students. The stipend is equal to that of a teaching associate. This support is obtained from research grants that have been awarded to individual faculty members from either industrial or governmental sources. As a research associate, you will devote essentially all of your time to dissertation research.

Fellowships: A number of prestigious fellowships, including fellowships from The Ohio State University Graduate School and the departmentally funded Fowler Fellowship, are awarded annually to top students. Fowler fellowships include a stipend of around $27,000 a year for two years. Since these awards require no teaching duties for the first year, fellows take more classes each semester and move more quickly into research. Fellowships are available to students beginning with their first year in the physics graduate program. To apply for a fellowship, check the appropriate box on your application form. To be considered, you must apply by December 15.

YOUR GRADUATE PROGRAM IN PHYSICS

We have designed the graduate program in physics to give you a solid background in the fundamentals, an understanding of the major fields of current research, and an opportunity for in-depth investigations. Working with your faculty advisor, you can tailor your program to meet your own needs and interests, taking into account your particular goals and undergraduate preparation.

In the PhD program, you will devote most of your first year and some of your second year to course work. These courses are designed to strengthen and extend your knowledge of the theoretical foundations of physics and to introduce you to areas of current interest in the field. During the summer following your first year, you will be encouraged to join one of the ongoing research programs in the department. As mentioned earlier, teaching associates with satisfactory records are offered special summer-term appointments, free of teaching duties, to enable them to take advantage of this opportunity to explore a research area early in their graduate careers.

From your third year on, you will concentrate on carrying out your PhD thesis research with your faculty research advisor. This work culminates in your PhD thesis defense by about the fifth or sixth year.

Typical Course Sequence

FIRST YEAR

AUTUMN SEMESTER

Physics 6780: Dept. Research Overview
Physics 7501: Quantum Mechanics I
Physics 7601: Classical & Statistical Physics I
Physics 7701: Analytic & Numeric Methods of Physics

SPRING SEMESTER

Physics 7401: Electromagnetic Field Theory
Physics 7502: Quantum Mechanics II
Physics 7602: Classical & Statistical Physics II
Physics 7998: Graduate Research

SUMMER TERM

Physics 8999: Thesis Research

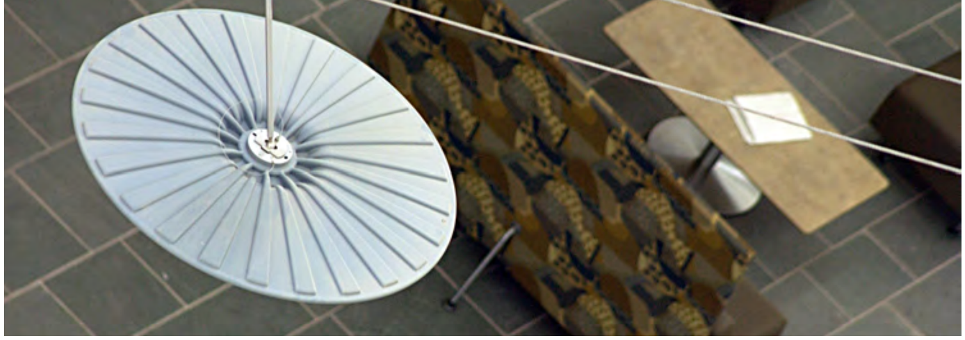
SECOND YEAR

AUTUMN AND SPRING SEMESTERS

Advanced Topics Courses, Thesis Research

SUMMER TERM

Physics 8999: Thesis Research



Advanced Research Courses

A unique feature and a great strength of our curriculum are the numerous advanced-topics courses at the 6800 or 8800 level. These are courses on topics of current interest in physics taught by faculty working in those areas. Classes are usually small and provide an outstanding opportunity to explore the frontiers of physics in a more informal atmosphere. We typically offer five or more of these courses every semester, except summer. Survey courses (6800 level) are offered regularly on the following topics:

Astrophysics
Atomic and molecular physics
Biophysics
Condensed matter physics
Elementary particle physics
Nuclear physics
Physics education
String theory

Advanced topics are covered in a series of courses at the 8800 level, which include, but are not limited to, the following:

Atomic and molecular physics
Biophysics
Condensed matter physics
Continuum mechanics
Dynamical systems
Elementary particle physics
Field theory
Group theory
Lasers
Low-temperature physics
Magnetic properties of matter
Many-particle physics
Nonlinear optics
Nuclear physics
Phase transitions and critical phenomena
Physics education
Physics of organic and polymeric materials
Spectroscopy
String theory
Superconductivity
Theory of measurement and detection

You also can study a topic of your choice on an individual basis with a faculty member through Physics 7193.

The resources of the university and of the physics department are available to assist you with job placement after graduation. Recent graduates now have successful careers at colleges, universities, national research laboratories, and in industry.

QUALIFYING AND BECOMING A PHD CANDIDATE

The first step in becoming a PhD candidate is to qualify via the "core-course requirement." This is accomplished by taking the six semesters of core courses shown earlier in the course sequence box and achieving at least a B+ average in these courses. Students coming into our program with previous graduate-level course experience may petition to waive some or all of these courses.

After satisfying the core-course requirement, research becomes the center of your PhD program. After working for one or two semesters with your advisor, you will prepare for the candidacy examination. This exam is set by your advisor and advisory committee. It consists of a short paper on a topic related to your research project. Admission to PhD candidacy follows the satisfactory performance on the candidacy examination.

The PhD program concludes with a written dissertation, based upon the scientific advances you made through independent research, and an oral defense of your thesis. The average time for completion of the PhD program is about six years.

BECOMING A BETTER PHYSICIST

An important aspect of physics is interaction with other physicists. The Department of Physics at Ohio State encourages advanced students to attend national conferences. It is common for students to present three to four papers at conferences before completing their PhD. The annual Smith Lecture brings internationally recognized physicists—typically Nobel Prize winners—to the department every spring. The weekly colloquia feature easily accessible insight into cutting-edge research in all fields of physics. In addition, each research group also invites collaborators and recognized researchers to present findings in their fields.

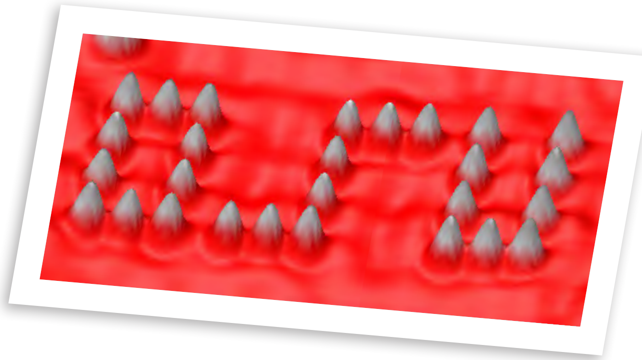
Our students publish an average of five papers by the time they graduate, a testimonial to the quality and depth of training they receive. When they graduate, our students are highly competitive in the job market, and virtually all find employment.

You can contact members of the faculty individually and arrange to meet them if you come to the department for a visit. We appreciate the important role graduate students play in research and are always happy to discuss your needs and concerns.

RESEARCH OPPORTUNITIES AND AFFILIATED FACULTY

Diversity of active research areas is one of the great strengths of the Department of Physics at Ohio State. Research spans the entire spectrum of matter, including high energy physics, nuclear physics, atomic and molecular physics, condensed matter physics, biophysics, and astrophysics. Research in physics education is another strong, vibrant field at Ohio State. With recent hires and new center funding, we are especially strong in condensed matter physics, high energy physics, nuclear physics, biophysics, astrophysics, AMO, cold atom theory, and physics education research. You will find details of the different research groups beginning on page 8.

FACILITIES AND SUPPORT FOR RESEARCH



Computer Support

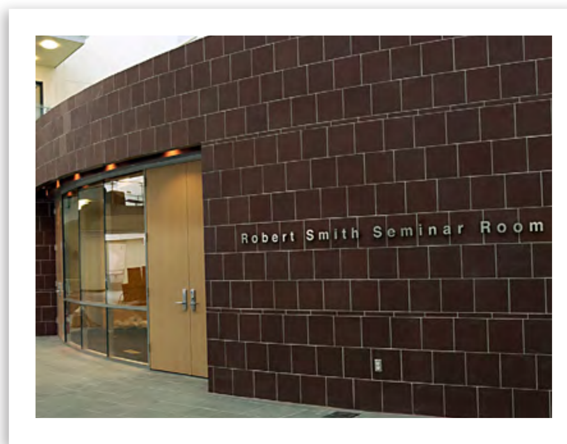
The Physics Computer Facility provides computing and networking services to the department's faculty, staff, and students. It has a professional staff of six, assisted by a number of capable undergraduate students. They provide support services as varied as assisting customers in purchasing, installing, and operating computer systems to obtaining licenses for distribution of commercial software of interest to the physics community. In addition, they provide maintenance of student computers in physics teaching labs and dedicated labs for undergraduate physics majors and for physics graduate students.

Their goal is to increase the productivity of the department's employees and students, allowing them to concentrate their energy on physics issues rather than computer support.

For additional information, or a tour of our facilities, please contact John W. Heimaster by e-mail (jwh@mps.ohio-state.edu) or by telephone at (614) 292-1435.

Laboratory Facilities and Equipment

While each research group is a separate entity, there are a number of excellent departmental facilities shared by all. These include a well-staffed machine shop, an efficient student shop with supervised training classes, an electro-mechanical shop (electronics design and fabrication, low temperature and optics support), liquid helium and nitrogen facilities, and the ENCOMM NanoSystems Laboratory with state-of-the-art focused ion beam/scanning electron microscopy, electron beam lithography, nanomanipulation, EDS X-ray microanalysis, X-ray diffractometry, SQUID magnetometry, two atomic force/magnetic force microscopes, a Physical Property Measurement System, new chemical vapor deposition and sputtering/electron beam deposition systems, low temperature magnetotransport measurements, and a Langmuir-Blodgett trough monolayer deposition facility.



Physics Research Building

The Department of Physics is housed in a 233,739-square-foot, state-of-the-art building with department offices and conference space, as well as 210 laboratory modules. The design features a stunning open atrium and adjoining patio space. Frequent and relaxed interaction is the focus of the open spaces, and highlights on the atrium floor are the Smith Seminar Room and Vernier Physics Commons.

Research Groups — Astroparticle Physics

Cosmology and Astroparticle Physics Theory

ccapp.osu.edu


John Beacom


Annika Peter


Gary Steigman


Terry Walker

Cosmology and Astroparticle Theory faculty

John F. Beacom, Professor
PhD, University of Wisconsin, 1997
Neutrinos in astrophysics, cosmology, particle physics, and nuclear physics
Gamma-ray astronomy, cosmic rays, dark matter, and other aspects of particle and nuclear astrophysics

Christopher Hirata, Professor
PhD, Princeton University, 2005
Dark energy and the accelerating universe
Galaxy clustering
Gravitational Lensing
General relativity
Cosmic microwave background and reionization

Annika Peter, Assistant Professor
PhD, Princeton University, 2008
Dark matter astrophysics
Cosmology
Particle physics
Dynamics of the Milky Way
Dwarf sperodial galaxies
Solar system

Gary Steigman, Emeritus Professor
PhD, New York University, 1968
Cosmology and the early evolution of the universe
Big Bang nucleosynthesis and the primordial abundances of elements
Constraints on the properties of the standard models of cosmology and particle physics

Terry Walker, Professor
PhD, Indiana University, 1988
Neutrino astrophysics
Dark matter candidates and their detection
Big Bang nucleosynthesis

Cosmology and astrophysics probe physics on the very largest scales, endeavoring to understand the history and evolution of the universe along with attempting to reveal the fundamental mechanisms behind its diverse and fascinating constituents. Particle physics seeks to uncover the nature of the participants (elementary particles) and their fundamental interactions on the very smallest scales. The Ohio State physics department's Cosmology and Astroparticle Physics Theory group addresses the cutting-edge problems on both scales, using the universe to learn about fundamental particle physics and employing what is learned from particle physics to provide a better understanding of the universe and the objects in it. The members of this group, all of whom have joint appointments in the Department of Astronomy, work very closely with their astronomy colleagues, as well as with the physics department's experimental astroparticle physics group. More information on these interdisciplinary collaborations, which include a free flow of students and postdocs, is available on page 27.

Building on the wealth of observational data accumulated in recent years, the group explores issues of the early evolution of the universe, such as "inflation," the production and survival of relics from the Big Bang, the synthesis of the elements in the first few minutes, the connections between the currently observed large scale structure of the universe and the tiny temperature anisotropies in the Cosmic Background Radiation, and the nature of the "Dark Energy." It is also interested in the more recent evolution of the universe, from star formation and supernovae, to dark matter in the Milky Way and its environs. The observed high energy cosmic rays, gamma rays, and neutrinos reveal the presence of galactic and extragalactic cosmic accelerators that directly affect the structure and evolution of the galaxy and the universe and that provide new laboratories for exploring physics at the very highest energies and energy densities.

Experimental Cosmology and Astroparticle Physics

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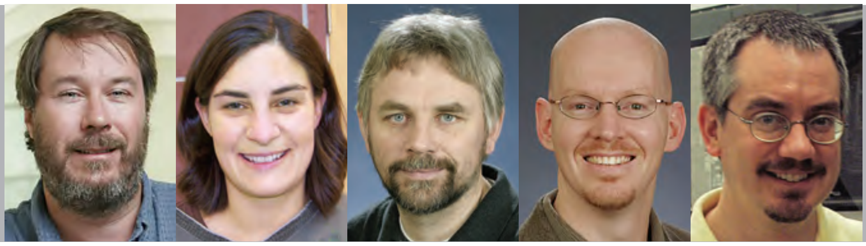


James Beatty Amy Connolly Klaus Honscheid Richard Hughes Brian Winer

Experimental Astroparticle Physics faculty

James J. Beatty, Professor
PhD, University of Chicago, 1986
The highest energy cosmic rays and neutrinos
Cosmic ray spectrum, composition, and anisotropy
Radio detection of cosmic rays and neutrinos

Amy L. Connolly, Assistant Professor
PhD, University of California, Berkeley, 2003
High energy neutrino astronomy
Connecting neutrino and cosmic ray measurements with astrophysics

Klaus Honscheid, Professor
Dr. rer. Nat. Universtiy of Bonn, 1988
Dark energy
(see also Experimental High Energy)

Richard E. Hughes, Professor
PhD, University of Pennsylvania, 1992
Very high energy gamma-ray astronomy with FGST
(see also Experimental High Energy)

Brian L. Winer, Professor
PhD, University of California, Berkeley, 1991
Very high energy gamma-ray astronomy with FGST
(see also Experimental High Energy)

Astrophysics and cosmology allow us to test the laws of nature in ways impossible with laboratory and accelerator experiments. These settings involve distances, timescales, and energies beyond those possible on Earth. Energetic particles, gamma rays, and neutrinos are produced in a wide range of astrophysical contexts. These include supernovae, relativistic jets in active galaxies, and black holes and neutron stars. Observations can be used to probe both the astrophysics of the sources and the nature of fundamental physical interactions.

We design and build sensitive instruments to map the expansion history of the universe and to measure energetic charged particles, photons, and neutrinos. Detectors are deployed in remote locations such as Antarctica, Chile, and rural Argentina, flown on enormous balloons, or launched into space. Data is returned for analysis at Ohio State and collaborating institutions. Funding comes from the NSF, NASA, and the Department of Energy.

Areas of interest include:

The highest energy cosmic rays: Cosmic rays with energies of up to 50 joules have been observed. The origin of these particles is a mystery, since it is difficult to accelerate subatomic particles to these energies and to understand how they travel through the radiation backgrounds that fill intergalactic space. We are involved in the Pierre Auger project, building and operating a 3000 km2 observatory in western Argentina.

Very high energy gamma ray astronomy: Ohio State is part of the Fermi Gamma-ray Space Telescope (FGST), which was launched in 2008. FGST measures gamma-rays from 20 MeV - 300 GeV. The group is using data from FGST to explore the particle nature of dark matter. The instrument also is used to probe the high energy behavior of gamma-ray bursts, pulsars, Active Galactic Nuclei, and particle acceleration mechanisms in extreme environments.

Dark energy: Arguably one of the most important and certainly one of the most surprising scientific results of the last decades was the discovery that the expansion of the universe is accelerating. In order to explain this acceleration we are faced with two possibilities: Either 76% of the universe exists in an exotic form called dark energy, that exhibits a gravitational force opposite the attractive gravity of ordinary matter, or Einstein's very successful theory of gravity, General Relativity, must be incorrect at cosmic scales. We are partners in the Dark Energy Survey (DES) and the Baryon Acoustic Spectroscopic Survey (BOSS) projects, which are designed to probe the origin of the cosmic acceleration and help to uncover the nature of dark energy.

Neutrino astronomy: Neutrinos are weakly interacting particles, so they pass through the universe relatively unimpeded by intervening matter and radiation, making them unique probes of the early universe. However, extremely large detection volumes are necessary to observe the low flux of neutrinos expected at the highest energies. We are involved in the Antarctic Impulsive Transient Antenna (ANITA) and Askaryan Radio Array (ARA) experiments to detect ultra-high energy neutrinos by measuring radio bursts produced when neutrinos interact in the Antarctic ice cap. ANITA is a long-duration NASA balloon experiment and ARA is an antenna array in the early stages of deployment near the South Pole.

Research Groups — Atomic, Molecular, and Optical Physics

Atomic, Molecular, and Optical Physics

physics.ohio-state.edu/~amo

Pierre Agostini

C. David Andereck

Frank De Lucia

Louis DiMauro

Richard Freeman

Gregory Lafyatis

Ohio State has long been a center for atomic, molecular, and optical physics (AMO physics). The research program in AMO goes beyond traditional spectroscopic studies, encompassing laser physics, ultrafast optical physics, laser-plasma processes, investigations of planetary atmospheres and the interstellar medium, and optical cooling and trapping of atoms. The department enjoys collaborations with strong laser groups in the Department of Chemistry including the Laser Spectroscopy Facility, which is a state-of-the-art laser laboratory. In addition, Ohio State is a leader in ultrafast technologies to study atoms and molecules, ranging from isolated laser-matter interactions to solvent-solute interactions in liquids to laser-induced fusion processes.

Graduate students are a key element in the success of the programs. Many opportunities for research exist within the department, across disciplines, and beyond. Graduate students are involved in the following research areas:

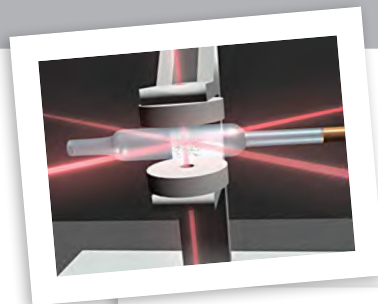
- Quantum electronics working with millimeter and submillimeter waves; laboratory astrophysics and upper atmosphere physics; molecular collisions and chemical physics.
- Using laser light to manipulate the translational degrees of freedom of atoms. Atomic samples at ultra-cold (less than 1 millikelvin) temperatures may be obtained.
- Multiphoton ionization of atoms and molecules.
- Ultrashort laser-plasma interactions.
- Coherent control of atomic systems.
- Propagation of intense laser pulses through solids, liquids, and gasses. This involves super continuum generation, intensity dependent group velocity dispersion, plasma generation, and other effects.
- High Energy Density Physics, a relatively new field of the experimental study of matter at the extremes of density and temperature. Although not found naturally on earth, it is the most abundant form of matter in the universe: stars (**hedp.osu.edu**).

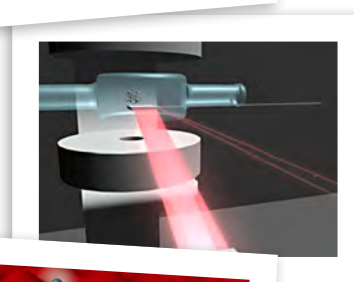

Douglass Schumacher

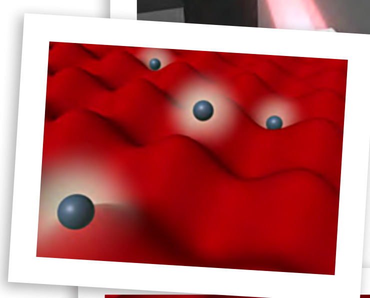

Linn Van Woerkom

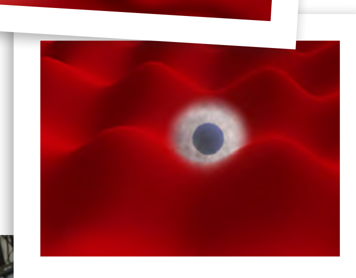

Brenda Winnewisser


Manfred Winnewisser









Atomic, Molecular, and Optical Physics faculty

Pierre Agostini, Professor
Doctorat, Universite Aix Marseille, 1967
Muliphoton Processes
Strong field interaction, high harmonic generation
Attosecond pulses, AttoPhysics

C. David Andereck, Professor
PhD, Rutgers University, 1980
High energy density physics
High-intensity ultrashort pulse laser interactions with matter
Laboratory astrophysics
Nonlinear hydrodynamics

Frank C. De Lucia, Distinguished University Professor
PhD, Duke University, 1969
Quantum electronics, millimeter, and submillimeter waves
Laboratory astrophysics, upper atmospheric physics
Molecular spectroscopy and collisions, chemical physics

Louis DiMauro, Professor and the Edward and Sylvia Hagenlocker Chair
PhD, University of Connecticut, 1980
Atomic, chemical, and ultrafast optical physics
Strong field interactions
Ultrafast laser physics
Attophysics
Nonlinear optics
Short wave length generation
Quantum control methods
Many body physics
Application of fourth generation light sources

Richard R. Freeman, Distinguished Professor of Mathematical and Physical Sciences
PhD, Harvard University, 1973
Interactions of high powered lasers with matter
Non-linear optics laser fusion experiments

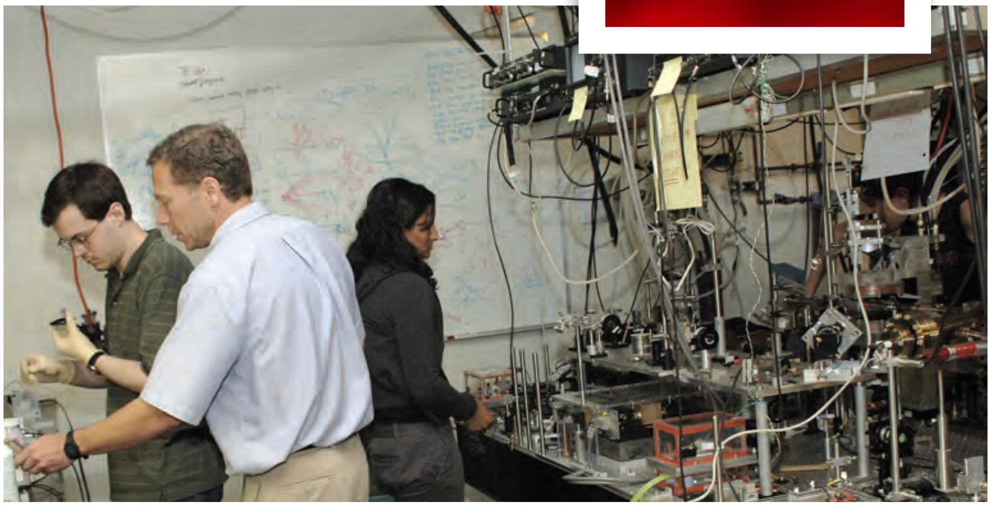
Gregory P. Lafyatis, Associate Professor
PhD, Harvard University, 1982
Laser physics
Trapping and cooling of atomic particles

Douglass Schumacher, Associate Professor
PhD, University of Michigan, 1995
Ultrafast nonlinear optics
Intense field laser-matter interactions
High energy density physics
Ultrashort laser-plasma interactions
Nonlinear optics
Partical-in-cell simulation

Linn Van Woerkom, Professor and Associate Provost & Director, University Honors & Scholars Center
PhD, University of Southern California, 1987
High-intensity, ultrashort pulse laser-matter interactions
High energy density physics
Ultrashort pulse and X-ray physics

Brenda P. Winnewisser, Adjunct Professor
PhD, Duke University, 1965
Fourier transformer infrared spectroscopy, spectral analysis
Solid hydrogen
History of science

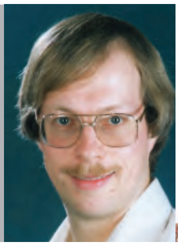
Manfred Winnewisser, Adjunct Professor
Dr. rer. Nat., University of Karlsruhe, 1960
Fourier transformer infrared spectroscopy
Millimeter and submillimeter spectroscopy
Reactive and unstable species



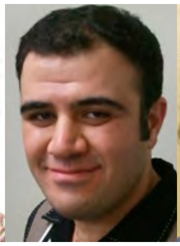
Research Groups — Biophysics, Cold Atom Physics

Biophysics

physics.ohio-state.edu/~bio


Ralf Bundschuh


C. Jayaprakash


Comert Kural


Michael Poirier


Dongping Zhong

Biophysics faculty

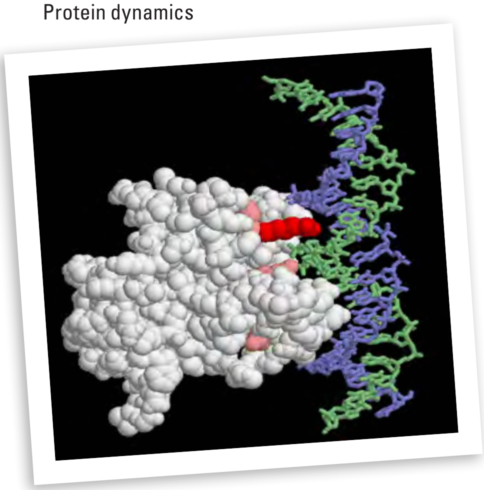
Ralf Bundschuh, Professor
PhD, Universität Potsdam, 1996
RNA structure: statistical mechanics and quantitative prediction
RNA editing
Biological sequence database searches
Biomolecules
Bioinformatics

C. Jayaprakash, Professor
PhD, University of Illinois, Urbana, 1979
Genetic regulatory systems
Modeling of the adaptive immune system in humans
Nonlinear ecological dynamics

Comert Kural, Assistant Professor
PhD, University of Illinois, Urbana-Champaign, 2007
Experimental biophysics and computational biology
Three-dimensional cell and tissue imaging
Dynamics of clarthrin-mediated endocytosis in living organisms
Tissue morphogenesis, cell migration, and signaling

Michael Poirier, Associate Professor
PhD, University of Illinois, Chicago, 2001
Chromatin and chromosome structure and function
Chromatin remodeling
Mechanisms of molecular machines
Bacterial population dynamics and diversity

Dongping Zhong, Professor
PhD, California Institute of Technology, 1999
Femtobiology
Biomolecular interactions
Protein dynamics



Biophysics is the application of physical methods to solve problems in biology. At Ohio State we have a young and dynamic group covering experimental and theoretical biophysics with numerous links to other departments and colleges throughout the campus.

The fundamental goal of biological sciences is to understand how life functions. This comprises fascinating questions on many different length scales from the individual molecule over cells and organisms to whole ecologies. Increasingly, answering the truly cutting-edge questions in the biological sciences requires interdisciplinary approaches that combine the traditional methods of biology with the methods developed in the physical sciences.

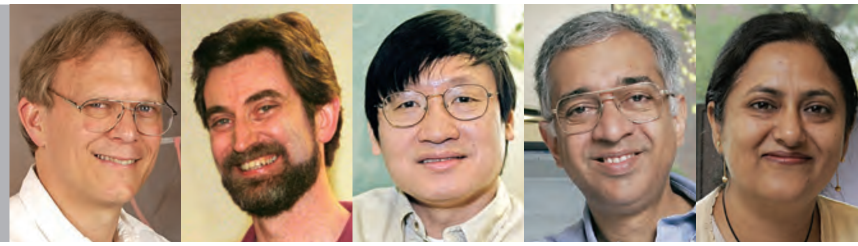
The current areas of study in the Biophysics group provide many examples of where cutting-edge physical methods are employed to solve important biological problems; e.g., the Biophysics group uses sophisticated femtosecond laser set-ups to observe how proteins convert light into chemical energy or how they repair damaged DNA. The group is able to hold on to individual biomolecules and measure mechanical forces in the piconewton range in order to dissect how the genetic material is organized into the chromosomes.

Lastly, it uses the mathematical and computational techniques from statistical physics to interpret the vast amounts of biological sequence data generated, e.g., by the human genome project, and to understand the behavior of the Lake Erie ecosystem.

Most projects of the Biophysics group involve close collaborations with faculty and students from different departments. This enables graduates of the Biophysics group to develop into independent researchers with the experience in both physical and biological methods to answer critical biological questions. Graduates are able to transcend traditional areas so that they interact, collaborate, and work with both physicists and biologists.

Cold Atom Physics

physics.ohio-state.edu/~coldatoms /coldatomphysics.html



Eric Braaten | Richard Furnstahl | Tin-Lun (Jason) Ho | Mohit Randeria | Nandini Trivedi

Cold Atom Physics faculty

Eric Braaten, Professor
PhD, University of Wisconsin, 1981
Strongly interacting quantum gases
Bose-Einstein condensates
Few-body physics for atoms with large scattering lengths
Efimov states

Richard Furnstahl, Professor
PhD, Stanford University, 1986
Effective field theory for many-body systems
Pairing mechanisms for Fermi gases
Density functional theory

Tin-Lun (Jason) Ho, Distinguished Professor of Mathematical and Physical Sciences
PhD, Cornell University, 1977
Fundamental issues in dilute quantum gases:
- scalar and spinor Bose condensates
- Fermi gases with large spin
- mixtures of Bose and Fermi gases
- quantum gases in optical lattices and in rapidly rotating potentials
- boson mesoscopics
- processing quantum information with spinor Bose condensates

Quantum Hall effect with internal degrees of freedom
Strongly correlated electron systems
Quantum fluids

Mohit Randeria, Professor
PhD, Cornell University, 1987
Strongly interacting quantum gases
BEC-BCS crossover in Fermi gases
Optical lattices

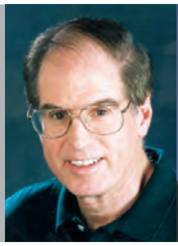
Nandini Trivedi, Professor
PhD, Cornell University, 1987
Fermions and bosons in optical lattices
BCS-BEC crossover
Quantum Monte Carlo simulations of cold atoms

The field of quantum gases or ultracold atoms is the fastest expanding and most interdisciplinary field in physics today. The experimental branch of this exciting new field uses the techniques of atomic, molecular, and optical physics to study many-body systems consisting of extremely cold-trapped atoms. These are condensed matter systems whose constituents have well-understood microscopic interactions. At sufficiently low temperatures, the large de Broglie wavelengths of the atoms allow these systems to exhibit quantum phenomena on a macroscopic scale. The theoretical branch of this field is completely interdisciplinary, attracting top scientists from atomic, condensed matter, high energy, and nuclear physics, as well as from quantum optics and quantum information. The Cold Atom Physics group at Ohio State has established itself as one of the world's top theory groups in this area.

Research Groups — Condensed Matter

Condensed Matter Experiment

physics.ohio-state.edu/~cme/CMEfaculty.htm


Leonard Brillson


Arthur Epstein


Thomas Gramila


Jay Gupta


P. Chris Hammel


Zeke Johnston-Halperin

The largest research area in physics today deals with the diverse and fascinating properties of condensed matter, encompassing metals, semiconductors, superconductors, polymers, fluids and superfluids, magnets, and insulators. This area corresponds to the single largest research group in the department, involving 10 experimentalists and 9 theorists.

Experimental groups ordinarily consist of a professor, possibly a postdoctoral researcher, and several graduate students, with support from a federal source, such as the National Science Foundation or Department of Energy, or from an industrial source. Group members benefit from each other through sharing of laboratory equipment and expertise, as well as through formal collaborations.

While each faculty member represents a separate research entity, there are a number of excellent departmental facilities that are shared by all. These are mentioned in detail on page 7.

In addition to strong interactions among the condensed matter experimentalists, a large and active theory group offers expertise in a broad range of subjects. There are about 50 PhD students in condensed matter physics, and at least that many ongoing research projects. They reflect the major directions of current condensed matter research. Some of the problems being investigated are listed below:

- Scanning tunneling microscopy studies of quantum electronic phenomena and atomic scale reactions at surfaces of semiconductors and semiconducting heterostructures.
- Thermodynamic, transport, and magnetic properties of novel materials, especially quasi one-dimensional materials such as electronic polymers and organic crystals.
- Time resolved spectroscopy (10-12 sec. to 10 sec.) and nonlinear optical response of novel materials.
- Magnetic properties of molecular and polymer-based ferromagnets.
- Magnetic and electronic properties of nanoscale magnetic, semiconducting, and metallic systems.
- Novel approaches to very high-resolution scanned probe microscopy.
- Electrical transport properties of films and crystals of high-temperature oxide superconductors.
- NMR studies of vortex dynamics, structure, and electronic properties of oxide and fulleride superconductors.
- Optoelectronic, microelectronic, and nanoelectronic interface atomic structure.
- Device physics of polymer-based electronics such as LEDs.
- Semiconductor interface growth, processing, and characterization by ultrahigh vacuum surface science techniques.
- Schottky barriers and heterojunction band offsets.
- Raman and infrared studies of oxide superconductors.
- Quantum effects on transport in submicron metal systems.
- Raman scattering and magneto-optical imaging of submicron and nano-structures.
- Brillouin scattering studies of magnetic and elastic properties of hybrid structures and membranes.
- Magnetic excitations, surface and guided acoustic resonances in laminar structures.
- Pattern formation and transitions in convecting classical fluids.
- Onset of chaos and development of turbulent structures in classical fluids.
- Nonlinear and chaotic response in ferromagnetic resonance.

Thomas Lemberger Jonathan Pelz R. Sooryakumar Fengyuan Yang

Condensed Matter Experiment faculty

Leonard J. Brillson, Professor and CMR Scholar, Department of Physics and Department of Electrical and Computer Engineering
PhD, University of Pennsylvania, 1972
Semiconductor interface growth, processing, and characterization by ultrahigh vacuum surface science techniques
Schottky barriers and heterojunction band offsets
Optoelectronic, microelectronic, and nanoelectronic interface atomic structure
Solar cells, bioelectric sensors, ultraviolet microlasers
Ferroelectric/ferromagnetic complex oxides for spintronics and electromagnetic metamaterials

Arthur J. Epstein, Distinguished University Professor, Department of Physics and Department of Chemistry
PhD, University of Pennsylvania, 1971
Molecule- and polymer-based magnets (room temperature magnetic semiconductors, organic-based spintronics, control of magnetism by light, fractal magnetism)
Conducting polymers (mechanisms of charge transport, field effect 'transistors,' nanopatterning for function)
Semiconducting polymers (photo- and electro-luminescence, electric and magnetic field effects, photovoltaics)
Applications of electronic polymers to biological problems

Thomas Gramila, Associate Professor
PhD, Cornell University, 1990
Properties of electronic materials at low temperatures and high magnetic fields
Two-dimensional electron gases and Quantum Hall effects
Electron interactions and correlation effects
Disordered conductors, magnetic properties

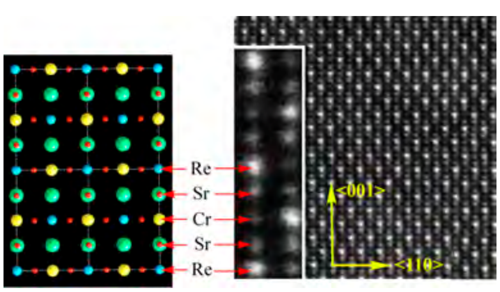
Jay Gupta, Associate Professor
PhD, University of California, Santa Barbara, 2002
Nanoscale studies of organic magnets and conductors
Evolution of electronic and optical properties in nanoclusters
Microscopic studies of spin-scattering in semiconductors
Atomic-scale chemistry on surfaces

P. Chris Hammel, Ohio Eminent Scholar and Director of CEM
PhD, Cornell University, 1984
Magnetic resonance force microscopy
Spin electronics and solid state quantum computing
Nanoscale and multicomponent magnetic systems
Magnetic properties of endohedral fullerenes

Zeke Johnston-Halperin, Associate Professor and Director of ENCOMM
PhD, University of California at Santa Barbara, 2003
Spin in reduced dimension
Study of spin dynamics, scattering, and transport in nanoscale semiconducting materials
Multifunctional magnetic materials
Development and characterization of magnetic materials with multifunctional properties (magnetization coupled to charge, strain, chemical activity, etc.) for spintronic applications
Spin injection/detection in heterostructures
Exploration of spin injection and detection in heterogenous materials such as metal/semiconductor, organic/inorganic, and molecular/bulk heterostructures

Thomas R. Lemberger, Professor
PhD, University of Illinois at Urbana, 1978
Magnetic and electrical properties of films and crystals of conventional and high-temperature superconductors
Tunneling and transport effects in superconductors
Superconductor-to-insulator quantum transition fluctuations
Thin-film fabrication and characterization

Jonathan Pelz, Professor and Vice Chair for Graduate Studies and Research
PhD, University of California, Berkeley, 1988
Surface and interface science, scanning tunneling, ballistic-electron emission and atomic force microscopies
Numerical modeling
Nm-resolution electronic behavior of nanostructures, wide bandgap materials, metal/dielectric interfaces, and semiconductor surfaces
Surface science, scanning tunneling microscopy
Step dynamics on semiconductor surfaces
Nanoscale properties of buried wide bandgap semiconductor films and interfaces
Nanoscale properties of magnetic multilayers
Atomic scale surface reactions



R. Sooryakumar, Professor
PhD, University of Illinois 1980
Application and development of spectroscopy probes (Raman scattering, Brillouin scattering, and Kerr microscopy) for probing electronic, vibrational, optical and magnetic behavior of novel materials
Magnetic and spin wave excitations and influence of current injection in hybrid micrometer and sub-micron patterned structures
Elastic excitations and guided acoustic resonances in confined geometries
Development of non-invasive techniques for elastic properties of biological tissues
Photo-induced properties of network glasses

Fengyuan Yang, Associate Professor
PhD, Johns Hopkins University, 2001
Fabrication and experimental investigation of structural, electronic, and magnetic properties of nanostructured materials
Metallic and oxide epitaxial films
Spintronics in semiconductor nanowires, including spin injection, spin diffusion, and spin detection

Research Groups — Condensed Matter

Condensed Matter Theory

physics.ohio-state.edu/~cmt/osucmt.html


Tin-Lun (Jason) Ho


C. Jayaprakash


Bruce Patton


William Putikka


Mohit Randeria


Mark Rudner

The condensed matter theory group is large, vigorous, and diverse, including eight faculty, seven postdoctoral researchers, about 20 graduate students, and several undergraduates.

Its strengths include structure and properties of complex solids, materials at nanometer scales, superconductivity, Bose-Einstein condensation, strongly correlated electron systems, biophysics, “soft” condensed matter, and nonequilibrium statistical mechanics, especially growth and nucleation in limited dimensions.

A typical research project consists of one or more faculty members, perhaps a postdoc, and a graduate student. Students receive close individual attention and, after graduation, have obtained positions with various prestigious employers, such as IBM, MIT Lincoln labs, Illinois, Harvard, and Brown. Members of the group collaborate with each other, as well as with experimentalists in the physics department and faculty in chemistry, mathematics, and the College of Engineering, as well as at other universities and industrial and national laboratories. Group members are supported by the National Science Foundation, NASA, the Department of Energy, the Department of Defense, and private industry.

The research environment is friendly and stimulating. Faculty, postdocs, and students are all located on the second floor of the Physics Research Building. Computer facilities are excellent, as there are numerous powerful workstations available to members of the group, as well as links to the Ohio Supercomputer Center and all the national supercomputer centers. Projects under way include some of the most exciting topics in the field, such as:

- Anisotropic self-assembly for desired properties
- Degenerate quantum gases: Bose-Einstein and Fermion condensates
- Disordered systems
- Dynamics of neural computation
- Dynamics of nucleation and growth of nanostructures
- High temperature superconductors
- Mesoscopics and nanoscience
- Molecular dynamics of complex, realistic materials
- Novel interfacial phenomena
- Quantum computation
- Quantum phase transitions
- Spintronics
- Statistics of sequence comparison algorithms and RNA structure
- Strongly correlated low dimensional materials
- Visual neuroscience: computation and feedback

David Stroud

Nandini Trivedi

Condensed Matter Theory faculty

Tin-Lun (Jason) Ho, Distinguished Professor of Mathematical and Physical Sciences
PhD, Cornell University, 1977
Fundamental issues in dilute quantum gases:
- scalar and spinor Bose condensates
- Fermi gases with large spin
- mixtures of Bose and Fermi gases
- quantum gases in optical lattices and in rapidly rotating potentials
- boson mesoscopics
- processing quantum information with spinor Bose condensates

Quantum Hall effect with internal degrees of freedom
Strongly correlated electron systems
Quantum fluids

C. Jayaprakash, Professor
PhD, University of Illinois at Urbana, 1979
Nonlinear ecological dynamics
Genetic regulatory systems
Fully developed turbulence

Bruce R. Patton, Professor
PhD, Cornell University, 1971
Structure and properties of electroceramics
Grain growth in anisotropic systems
Pattern recognition and optimization

William Putikka, Professor (OSU Mansfield)
PhD, University of Wisconsin, 1988
High-temperature superconductivity: phenomenological and microscopic models
Two-dimensional strongly correlated electrons
Unconventional superconductivity
Spin relaxation in semiconductors
Spintronics
Semiconductor based quantum computers

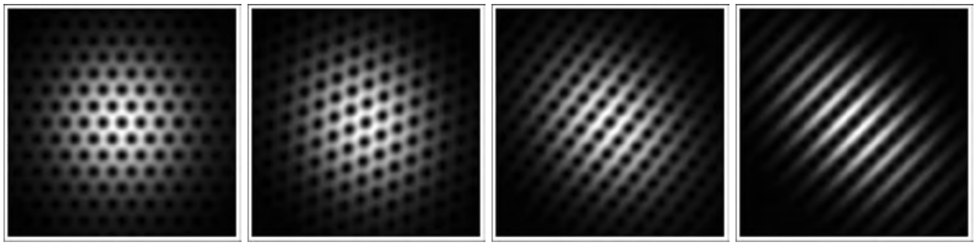
Mohit Randeria, Professor
PhD, Cornell University, 1987
High Tc superconductivity and strongly correlated electronic systems
Angle-resolved photoelectron spectroscopy
Nanoscale and inhomogeneous superconductors
Quantum gases and BCS-BEC crossover

Mark Rudner, Assistant Professor
PhD, Massachusetts Institute of Technology, 2008
Coherent phenomena in nanoscale/many-body systems:
Coherent control of many-body spin dynamics
Spin-mechanical coupling in carbon nanotubes
Electron and nuclear spin dynamics in semiconductor nanostructures
Transport in locally-gated graphene structures

David C. Stroud, Emeritus Professor
PhD, Harvard University, 1969
Quantum effects in Josephson junction arrays and high-Tc superconductors
Superconducting qubits
Magnetic, superconducting, and optical properties of nanostructured materials
Ab initio molecular dynamics simulations of disordered media magnetic, superconducting, and optical nanostructures

Nandini Trivedi, Professor
PhD, Cornell University, 1987
Strongly correlated superconducting and magnetic materials
Disorder and interaction driven quantum phase transitions
Fermions and bosons in traps
Quantum Monte Carlo simulations

John W. Wilkins, Ohio Eminent Scholar, Professor
PhD, University of Illinois, 1963
Molecular dyanamics, density functional theory, and quantum Monte Carlo for dynamics of microstructural transitions in metals and semiconductors and designing excitations in heterostructures



Research Groups — High Energy

Experimental High Energy

physics.ohio-state.edu/research/he_experiment.html

L. Stanley Durkin K.K. Gan Christopher Hill Klaus Honscheid Richard Hughes Harris Kagan

The experimental high energy physics program at Ohio State is strong and broad. There are eight faculty members in this research area, with 10 postdoctoral researchers, 10–15 PhD students, and a supporting staff of a dozen engineers and technicians. Faculty members are among the leaders of several national and international collaborations. Ohio State physicists play major roles in the design and construction of these experiments as well as leading crucial data analysis efforts. Funding comes primarily from the Department of Energy and totals more than a million dollars annually.

High energy physics research focuses on the fundamental particles and forces in the universe. These are the leptons, like the electron and muon, and the quarks from which the strongly interacting particles, such as the proton and neutron, are composed. Extremely high collision energies are required to create new particles and allow the study of fundamental interactions between particles. Since particle accelerators and detectors are complex and expensive devices, these experiments are usually performed at national and international laboratories. Ongoing and future experiments are noted below.

Proton-Antiproton Collisions at 1.96 TeV with the CDF Experiment
(Hughes, Winer)

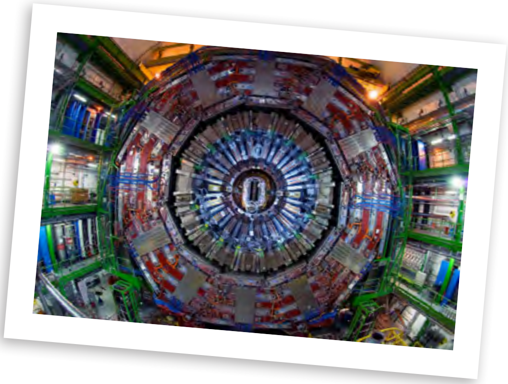
This ongoing experiment is located at Fermi National Accelerator Laboratory near Chicago. Its main physics aims are to refine the understanding of the top quark and to search for the Higgs boson, a key prediction of the Standard Model that will lead to fundamental understanding of the origin of mass.

Electron-Positron Annihilations at 10 GeV with the BABAR Experiment
(Honscheid, Kass)

The BABAR experiment was carried out at the Stanford Linear Accelerator Center. Its goal is to study the phenomenon called CP Violation, a difference between matter and antimatter. The program also includes detailed studies of the bottom and charm quarks as well as the tau lepton. The active data collection phase of the experiment ended in 2008 and the BABAR collaboration now focuses on data analysis.

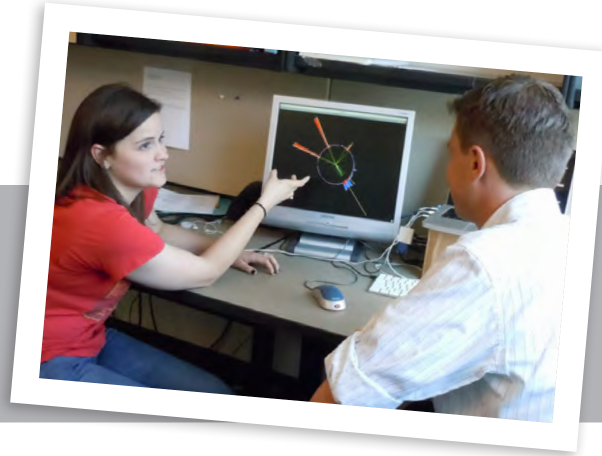
Proton-Proton Collisions at 7–14 TeV - ATLAS and CMS Experiments at the LHC
(ATLAS: Gan, Kagan, Kass)
(CMS: Durkin, Hill, Hughes, Winer)

Located at CERN in Geneva, Switzerland, the LHC is the highest energy collider in the world. The ATLAS and CMS experiments provide excellent opportunities to discover the Higgs boson. The new energy region opened up by the LHC also could yield unexpected discoveries, paving the way toward our understanding of particle physics beyond the Standard Model.



Richard Kass

Brian Winer



Experimental High Energy faculty

L. Stanley Durkin, Professor
PhD, Stanford University, 1981
Lepton-hadron scattering
Intrinsic properties of neutrinos
Search for massive Higgs particles

K.K. Gan, Professor
PhD, Purdue University, 1985
Physics beyond the Standard Model in e+e- and hadron colliders
High-resolution energy and position detectors
Radiation-hard optical data communication

Christopher S. Hill, Associate Professor
PhD, University of California, Davis, 2001
Searches for evidence beyond the Standard Model
Studies in the properties of the Top Quark

Klaus Honscheid, Professor
Dr. rer. Nat. Universit University of Bonn, 1988
Decay properties of heavy quarks
Trigger and data acquisition systems
Experimental cosmology

Richard E. Hughes, Professor
PhD, University of Pennsylvania, 1992
Astro-particle physics using the FGST satellite
Search for the source of dark matter
High-energy physics studies using proton-antiproton collider
Study of the top quark
Development of a trigger track processor

Harris P. Kagan, Professor
PhD, University of Minnesota, 1979
Electron-positron interactions
High-resolution energy and position detectors

Richard Kass, Professor
PhD, University of California, Davis, 1978
Electron-positron interactions using the BABAR experiment
High energy hadron interactions using the ATLAS experiment
High-resolution energy and position detectors

Brian L. Winer, Professor
PhD, University of California, Berkeley, 1991
Testing of the Standard Model of particle physics
Detailed studies and measurements of the top quark
Development of DAQ/Trigger Electronics
Exploring the universe with high energy gamma rays
Searching for dark matter

Research Groups — High Energy

High Energy Theory

physics.ohio-state.edu/he_theory/he_theory.html


Eric Braaten


Gregory Kilcup


Samir Mathur


Stuart Raby

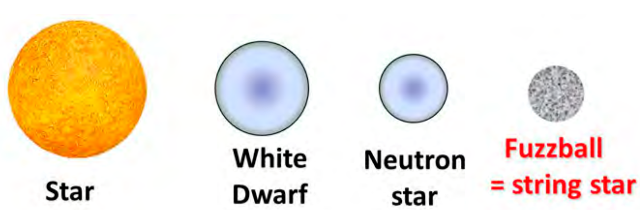

Junko Shigemitsu

High energy physics is concerned with the most fundamental building blocks of nature and the forces that act between them. In the last few decades of the 20th century, physicists learned that all matter is composed of a relatively small number of simple particles called quarks and leptons. They interact by electroweak and strong forces that are mediated by particles called gauge bosons, namely the photon, the W and Z bosons, and gluons. The quarks and leptons and the gauge bosons are all described by a relativistic quantum field theory known as the Standard Model.

Relativistic quantum field theory is the basic language of high energy physics. Some aspects of relativistic quantum field theory are perturbative—that is, they can be understood in terms of Feynman diagrams. Diagrammatic methods are one of the basic research tools of the group. There are other aspects of relativistic quantum field theory that are nonperturbative. A major effort at Ohio State involves solving quantum field theories using lattice gauge theory, a method in which space and time are approximated by discrete rather than continuous variables. These difficult calculations require the use of the most powerful supercomputers, such as are available on campus at the Ohio Supercomputer Center. Another important research direction in the group is the study of supersymmetric quantum field theories, which have a special symmetry that relates fermions and bosons and makes some nonperturbative problems more tractable.

The two basic ingredients of the Standard Model, the electroweak theory and quantum chromodynamics, both involved major breakthroughs in theoretical physics. The electroweak theory, which unites the weak and electromagnetic interactions, has a symmetry that relates the massless photon and the massive W and Z bosons. The conflict between this symmetry and the very different masses is reconciled by spontaneous symmetry breaking. The mechanism for spontaneous symmetry breaking and possible higher unifications of the fundamental forces are both major research areas at Ohio State.

Any final theory of physics must incorporate a quantum theory of gravitation. Quantizing gravity has proved to be a difficult problem, but in recent years string theory has become established as a consistent theory of quantum gravity. This theory has a rich mathematical structure. It has succeeded in explaining many mysterious quantum properties of black holes. It also provides new possibilities for extensions of the Standard Model that go beyond quantum field theory. Ohio State has a strong and vibrant research program in string theory.



High Energy Theory faculty

Eric Braaten, Professor
PhD, University of Wisconsin, 1981
Quantum field theory
Heavy quarks and quarkonium
Quark-gluon plasma
Perturbative QCD

Linda Carpenter, Assistant Professor
PhD, Johns Hopkins University, 2006
High energy physics
Higgs physics and supersymetry
LHC phenomenology
Model building
Phenomenology of weak scale physics

Gregory Kilcup, Associate Professor
PhD, Harvard University, 1986
Elementary particle theory
Lattice gauge theory
Supercomputing

Samir Mathur, Professor
PhD, Tata Institute, 1987
String theory
Black holes
General relativity

Stuart Raby, Professor
PhD, Tel Aviv University, 1976
Physics beyond the Standard Model (grand unified and supersymmetric models)
Problems on the interface of particle physics and astrophysics
Understanding electroweak symmetry breaking and fermion masses
Working on the construction of realistic models of particle physics, based on 10 dimensional superstring theory

Junko Shigemitsu, Professor
PhD, Cornell University, 1978
Lattice gauge theory
Nonperturbative approaches to strong interactions
Heavy quark physics
Tests of the consistency of the Standard Model of particle physics

Research Groups — Nuclear Physics

Nuclear Physics Experiment

physics.ohio-state.edu/HIRG

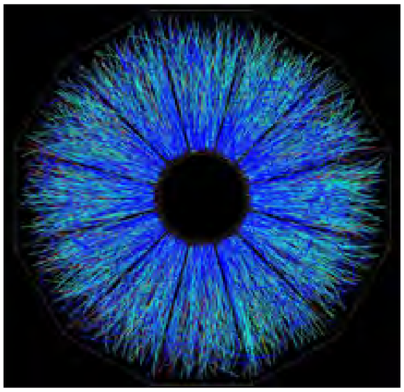
Thomas Humanic   Michael Lisa   Evan Sugarbaker

Nuclear Physics Experiment faculty

Thomas J. Humanic, Professor
PhD, University of Pittsburgh, 1979
Relativistic proton and heavy ion collisions
CERN Large Hadron Collider ALICE experiment
Boson interferometry
Extra-dimensional physics
Collision model calculations

Michael A. Lisa, Professor
PhD, Michigan State University, 1993
Relativistic heavy ion collisions; nuclear equation of state and study of quark-gluon plasma
Collective effects
Intensity interferometry

Evan R. Sugarbaker, Professor and Vice Chair for Administration
PhD, University of Michigan, 1976
Spin, isospin character of nucleons in nuclear matter
Neutrino detection
Relativistic heavy-ion collisions



The Nuclear Physics Experiment group is actively pursuing a wide range of research topics in the field of relativistic heavy ion collisions.

The group includes three Ohio State physics faculty, three physics graduate students, three postdoctoral research associates, and typically several undergraduate students. It is well supported by the National Science Foundation. Experiments are performed at the high energy accelerator facilities at Brookhaven National Laboratory where the Relativistic Heavy-Ion Collider (RHIC) has been in operation since 2000 (STAR Experiment), and at the CERN laboratory in Geneva, Switzerland, where an even higher energy collider, the Large Hadron Collider (LHC), has recently become operational, with new data from heavy ion collisions at the ALICE Experiment already leading to new physics.

Each experiment typically involves several graduate students, one or two postdocs, and faculty from Ohio State. Graduate students are involved in every aspect of the work, from equipment design through the actual measurements, to data reduction and analysis, and manuscript preparation. Students acquire many experimental skills such as knowledge and use of electronics and computers and design and use of mechanical equipment. The variety of skills obtained is reflected in the positions obtained by our graduate students after they finish their doctoral degrees. While many are presently in academic positions, others have entered such fields as geophysics, satellite communications, and medical physics.

Current physics research topics include:

- Relativistic heavy-ion collisions
- Boson interferometry studies for pion/kaon source sizes
- Nuclear equation of state
- Collective effects and flow
- Miniature black hole production in proton-proton collisions
- Study of quark-gluon plasma
- Transverse momentum distributions (pion, kaon, proton, antiproton)
- Monte Carlo simulations of relativistic heavy-ion collisions
- Silicon drift detector development

Research Groups — Nuclear Physics

Nuclear Physics Theory

physics.ohio-state.edu/~ntg

Richard Furnstahl **Ulrich Heinz** **Sabine Jeschonnek** **Yuri Kovchegov** **Robert Perry**

The Nuclear Theory group studies a broad range of problems involving the strong interaction. This research includes the direct study of quantum chromodynamics (QCD), the relativistic field theory of quarks and gluons, the connection of QCD to effective theories of the strong interaction at low energies, and the manifestation of QCD in the highly compressed and excited nuclear matter created in relativistic heavy-ion collisions. The challenge for nuclear theorists is to develop reliable calculational tools for QCD in the strong interaction regime, to discover and exploit connections with successful nuclear phenomenology, and to derive systematic descriptions of QCD in terms of low-energy degrees of freedom (hadrons). Research in the Nuclear Physics Theory group is progressing in each of these areas.

Effective field theory (EFT) and renormalization group (RG) methods have been developed by group members to quantitatively explain how low-energy nuclear phenomenology emerges from QCD. These methods enable systematic and model-independent calculations with error estimates, using control over the degrees of freedom to optimize convergence. Group members are among the leaders in applying EFT and RG to nuclear few- and many-body systems.

Electron scattering is an important probe of nuclei. Insight into the crossover from quark-gluon to hadronic descriptions, which is a major goal of the Jefferson Lab experimental program, is possible only if the model dependence of the theoretical descriptions is under control. Toward this end, group members analyze and interpret JLab experiments in the GeV regime with controlled relativistic calculations, and use RG-evolved operators to analyze high-momentum-transfer processes.

At very high densities and temperatures, such as those in the early universe just after the Big Bang, QCD predicts that strongly interacting matter turns into a quark-gluon plasma (QGP). This QGP also can be created in relativistic heavy-ion collisions, and group members are among the leaders in developing theoretical descriptions for the creation, thermalization, and collective dynamical evolution of the QGP and, in collaboration with their experimental colleagues at Ohio State, in applying these theories to experimental data. New techniques are being developed to describe extremely dense gluonic systems, known as the Color Glass Condensate, which can be tested at present and future high energy heavy-ion and electron-ion colliders. In addition, the group has been exploring the connections between strongly coupled quark-gluon systems and new calculational methods, such as AdS/CFT correspondence, emerging from string theory.

Among the nuclear theory group faculty are a Hess-Prize recipient and Distinguished University Scholar, a DOE Outstanding Junior Investigator and Sackler Prize winner, and several APS and AAAS Fellows. In addition, the group typically includes several postdoctoral research associates and three to six graduate students. The group is committed to diversity in science and welcomes members of underrepresented groups. Support for students and postdocs comes from the National Science Foundation (NSF) and the Department of Energy (DOE). Membership of nuclear theory faculty in the DOE-funded UNEDF and JET Collaborations provides students and postdocs with access to international workshops and summer schools where they can broaden their physics horizon beyond the range of locally offered courses.

Nuclear Physics Theory faculty

Richard J. Furnstahl, Professor
PhD, Stanford University, 1986
Quantum chromodynamics and nuclear phenomena
Effective field theories at finite density and/or temperature
Bazaar approach to physics education research

Ulrich W. Heinz, Professor
Dr. phil. Nat., Johann Wolfgang Goethe University, Frankfurt, 1980
Relativistic heavy-ion collisions — theory and phenomenology
Quantum field systems at high temperature
Thermodynamics and kinetics of quark-gluon plasma

Sabine Jeschonnek, Professor (Ohio State Lima)
Dr. rer. Nat., Bonn University, 1996
Quark-hadron duality
Short-range structures in few-body systems
Coincidence electron scattering reactions at GeV energies

Yuri Kovchegov, Professor
PhD, Columbia University, 1998
Theoretical nuclear and high energy physics
Theory of strong interactions (QCD) at high energy and high parton density
Heavy ion collisions and deep inelastic scattering
Applications of string theory to QCD

Robert J. Perry, Professor
PhD, University of Maryland, 1984
Quantum chromodynamics
Light-front field theory
Renormalization group and effective field theory

Research Groups — Physics Education, Interdisciplinary

Physics Education Research Group

physics.ohio-state.edu/~physedu/

Gordon Aubrecht

Lei Bao

Andrew Heckler

Physics Education Research Group faculty

Gordon Aubrecht, Professor (Ohio State Marion)
PhD, Princeton University, 1971
Development of pedagogical spreadsheets
Revision of curriculum
Energy issues combined with societal perspectives

Lei Bao, Professor
PhD, University of Maryland, 1999
Cognitive and computational models of learning process
Biologically plausible neural network models of cognition
Model based education assessment theory and technology
Experimental and theoretical methods for modeling group learning
Meta-cognitive factors in learning
Education technology and curriculum for in-class polling and web instruction

Andrew Heckler, Associate Professor
PhD, University of Washington, 1994
Cognitive origins of student difficulties in physics
Learning and transfer of abstract and concrete representations
Hierarchical structure of physics knowledge
Application of PER principles to the classroom

A unique strength of the Ohio State physics department is that it is one of the few departments in the nation to have a group of faculty and graduate students dedicated to researching how students learn physics and how to improve their learning. Graduate students have a variety of ways to engage with the Physics Education Research group: performing ground-breaking education research in our PhD program, implementing innovative course design as a teaching assistant, and participating in a graduate-level course on issues in physics education, which is recommended for all students who aspire to be college faculty members.

The Physics Education Research group has three main areas of focus: cognitive studies, educational assessment, and the development of instructional materials and techniques.

Cognitive studies and educational assessment

What is the nature of students' understanding of physics? How does this understanding evolve with time? Why is physics so hard? These are some of the questions investigated by the Physics Education Research group. Research includes: cognitive origins of scientific misconceptions, hierarchical structure of physics knowledge, and meta-cognitive factors in learning physics. There is also research in computational models of student understanding, including the use of neural networks, as well as modeling of group learning. The building and rigorous analysis of educational assessments, in order to more accurately measure and model student understanding, is also an active area of investigation.

Development of educational materials and techniques

Applying knowledge of how students learn to the design (and redesign) of instructional materials and techniques is a key focus in the Physics Education Research group. This is especially true for the use of technology. This includes research and development of innovations such as educational virtual reality simulations and smart homework systems. Not only are such systems being developed for introductory and advanced physics courses, but also the group is applying these techniques to the education of the general public about current cutting-edge physics research such as cosmology or nano-physics.

Interdisciplinary Opportunities

COSMOLOGY AND ASTROPARTICLE PHYSICS

A unique environment exists at Ohio State between the Departments of Physics and Astronomy to pursue world-class research at the interface between high energy physics, astrophysics, and cosmology. There are about 20 faculty members, 10 postdoctoral fellows, and 15 graduate students involved in the Center for Cosmology and AstroParticle Physics (CCAPP). With a yearly CCAPP Symposium, weekly seminars, and a daily "Astro Coffee," this is a lively group with diverse opportunities for students.
ccapp.osu.edu

INTERDISCIPLINARY BIOPHYSICS GRADUATE PROGRAM

Biophysics is the application of the principles and analytical approaches of physics to solve biologically relevant problems. Some of the most exciting areas of biology and medicine fall within the domain of biophysics. Students interested in biophysics may major in physics at Ohio State and work with biophysicists within the physics department (see page 12) or they may apply directly to Ohio State's Interdisciplinary Biophysics Graduate Program and work with one of nearly 90 biophysicists throughout the university. Physics faculty play a strong leadership and educational role in the Interdisciplinary Biophysics Graduate Program and both programs work together to individualize the best opportunities for students interested in this career direction.
biophysics.osu.edu

THE CHEMICAL PHYSICS PROGRAM

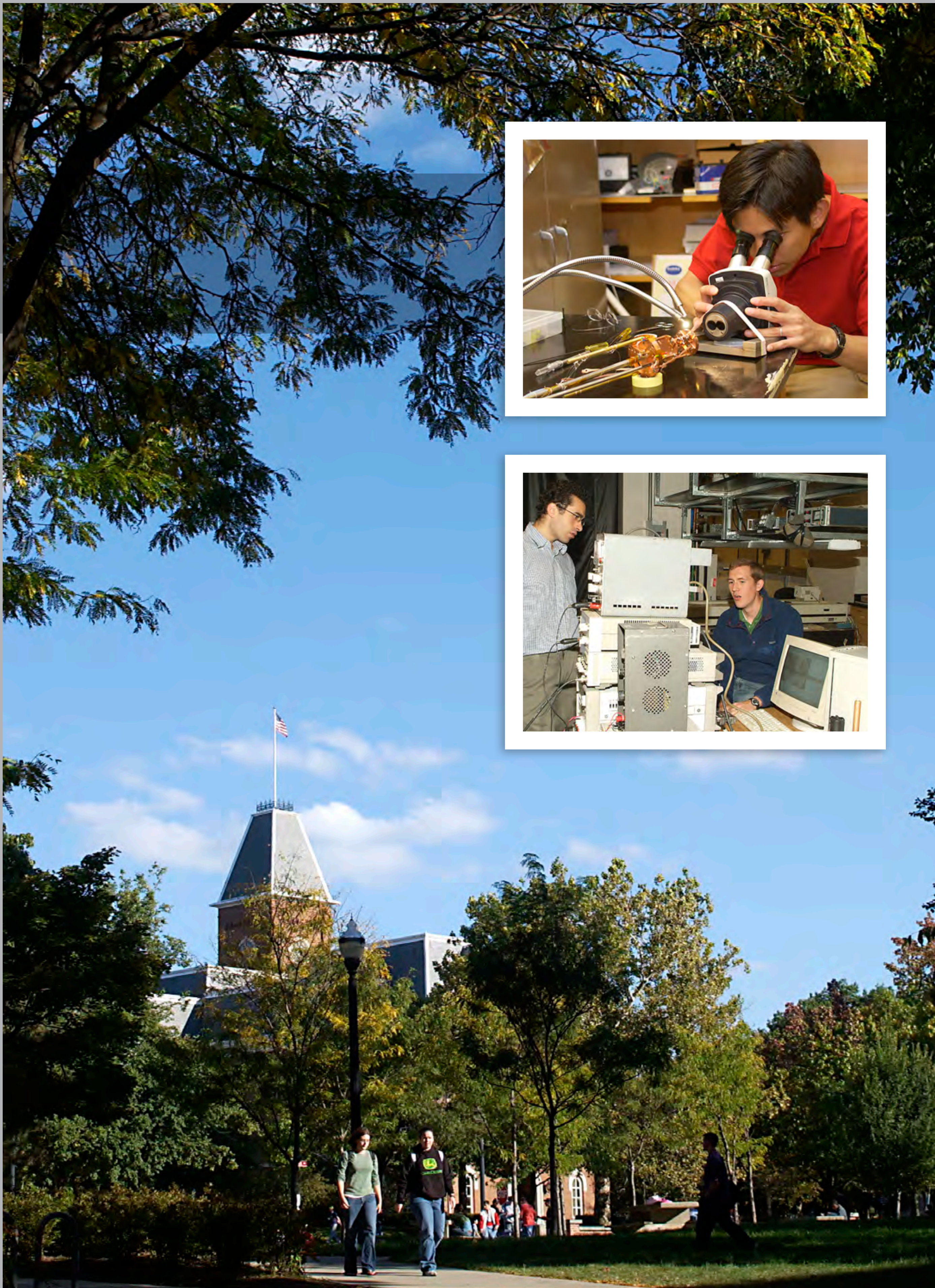
This is a joint PhD-granting program involving more than 30 faculty from the Departments of Physics, Chemistry, Astronomy, Geology, Medical Biochemistry, and Mechanical Engineering. About one third of the approximately 30 students in the program work with advisors in the physics department.
chemphys.chemistry.osu.edu/chemphys

ENCOMM

The Center for Electronic & Magnetic Composite Multifunctional Materials (ENCOMM), head-quartered in the Physics Research Building, addresses cutting-edge challenges in understanding and developing complex multicomponent materials. These problems are inherently multidisciplinary and require state-of-the-art facilities. ENCOMM builds teams that can tackle these problems and compete for multidisciplinary block-funded centers (such as the CEM listed below). ENCOMM meets weekly to identify opportunities and share insights; provides fabrication and characterization infrastructure (see **ensl.osu.edu**); and provides seed funds in fields ranging from DNA dynamics to thermal spintronics.
physics.ohio-state.edu/ENCOMM

CENTER FOR EMERGENT MATERIALS

The Center for Emergent Materials (CEM) at Ohio State is a National Science Foundation (NSF) Materials Research Science and Engineering Center (MRSEC) program funded for six years with a total budget of $18 million. Twenty-five faculty, 30 funded graduate students, and six postdocs in CEM comprise two teams tackling cutting-edge problems in magnetoelectronics, computing, and information processing. The two MRSEC teams bring an exceptional diversity of capabilities, including advanced microscopy, new materials synthesis, novel materials probes, and theory and modeling that are required for this challenging endeavor. Head-quartered in the Physics Research Building and with more than half its faculty and students from physics, the CEM offers outstanding opportunities for graduate students to do cutting-edge research in a highly collaborative environment.
cem.osu.edu



Physics Graduate Student Council

physics.ohio-state.edu/~pgsc/

The Physics Graduate Student Council (PGSC) is the representative body for physics graduate students at Ohio State. The PGSC is an active and engaged group that advocates and facilitates communication and activities between the department and graduate students on all matters of mutual interest, including grad student representation on several departmental committees. The PGSC holds quarterly meetings and meets regularly with the department chair and vice chairs to discuss issues of concern to graduate students. The council also hosts regular social events (picnics, graduation receptions, etc.), mentors new graduate students (at both individual and group levels), helps publicize graduate student research opportunities, organizes an annual graduate student research poster competition and “core-course” faculty teaching awards, and generally enhances the social, academic, and research experience for all physics graduate students.

Graduate Women in Physics

physics.ohio-state.edu/GWIP/

The Graduate Women in Physics (GWiP) group promotes involvement of, career development for, and sense of community among the graduate women in Ohio State’s physics department and helps to increase awareness of issues related to women in physics among all members of the physics community at the university. GWiP organizes colloquia and workshops and supports independent outreach programs. Members work closely with undergraduate physics groups and high schools to extend the benefits of outreach activities and to provide mutually beneficial mentor-mentee connections between undergraduate and high school students and GWiP members. In addition, GWiP coordinates annual fundraising events to promote its mission in the broader Columbus community.

Design: University Marketing Communications
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