PHYSICS, PHD

Chair

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Faculty

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Program Description

The Department of Physics has 33 faculty members, approximately 20 postdoctoral research associates, and over 90 graduate students. The department is housed in the six-floor physics building overlooking the University's main quadrangle. Facilities include state-of-the-art laboratory space, high-performance computing resources, and a machine shop, in addition to numerous specialized research facilities maintained by the research groups described below.

The department runs a weekly colloquium series that brings scientists from the United States and abroad to the University to present research and exchange ideas. There are also several research seminar series run by the different research groups. Colloquia and seminar schedules (along with other information about our program, courses, and events) can be found on our webpage at physics.syr.edu (https://artsandsciences.syracuse.edu/physics/).

Additional Information

The student forms a committee of three faculty members who conduct a research oral examination based on the student's proposed research. Students must maintain a B average.

Research Areas

The department has several strong research groups from which former students and post-doctoral associates have gone on to distinguished careers at universities and in industry. Graduate work in physics presently encompasses the fields described below.

Astrophysics and Cosmology

In astrophysics we use theoretical models, numerical simulations, and electromagnetic and gravitational-wave observations to understand some of the most extreme environments in the Universe; areas of study include supermassive black holes, relativistic jets, binary black holes and neutron stars, tidal disruption events, and supernovae. Cosmology describes the evolution of the Universe itself, from the extremely dense and hot, primordial conditions that existed mere moments after the Big Bang, to the relatively cold and diffuse distribution of stars and galaxies that we see today; areas of study include understanding the nature of inflation, dark energy and dark matter, large scale structure, and the cosmic microwave background. Brown, Coughlin, Watson.

Experimental Nuclear Physics

Use of spin degrees of freedom to study quantum chromodynamics and the Standard Model at low energies. Experiments are underway at Stanford Linear Accelerator Center (SLAC) and at Thomas Jefferson National Accelerator Facility (JLAB). Souder.

Gravitational-Wave Physics

Gravitational-wave astronomy using observations made by the Advanced Laser Interferometric Gravitation Wave Observatory (LIGO). Detector hardware design and development for Advanced LIGO and A+. Development of advanced optics and precision metrology for the next-generation gravitational-wave detector Cosmic Explorer. Ballmer, Brown.

High Energy Experimental Particle Physics

Experimental studies of the fundamental Electroweak and Strong interactions as manifested by the decays of beauty and charm quarks and production of other "exotic" phenomena. These studies are mostly preformed as part of the LHCb experiment at the Large Hadron Collider located at CERN in Geneva, Switzerland. We are primarily interested in how new physics phenomena manifests itself in CP violating and rare B meson decays. Our group discovered Pentaquarks, 5-quark baryons and new Tetraquarks. We are currently leading the construction of a silicon-sensor based charged-particle tracking detector for the Upgraded LHCb experiment. We also perform R&D leading to advanced silicon micro-pattern detectors, such as pixel and microstrip strip sensors, and their related readout electronics. Members of the group have discovered several new particles, including the B, Ds, Y(1D) and made the first measurements of several very important decay modes of these objects. The group is also active in neutrino flavor oscillation research, using neutrino beams created at Fermilab in Chicago, Illinois. Our neutrino program involves R&D on the development of liquid argon neutrino detectors, as proposed for use in the DUNE experiment, as well as work on the SBN and NOvA experiments at Fermilab. Artuso, Blusk, Mountain, Rudolph, Skwarnicki, Soderberg, Stone, and Whittington.

Quantum Information Science and Nanoscale Device Physics

Development of qubits for quantum computing. Condensed matter physics investigations of mechanisms that limit superconducting circuit coherence. Nanofabrication of Josephson junctions and microwave resonant devices. Low temperature measurements, including dilution refrigeration. Tensor networks, the TRG and quantum error correction. Quantum simulation of field theories. Quantum information, holography and gravity. Open quantum systems, quantum criticality and out of equilibrium systems. Catterall, Hubisz, Pechenezhskiy, Plourde.

Soft Matter and Biological Physics Theory and Experiment

Research in this area includes experimental and theoretical studies of soft matter systems, dynamical systems, granular materials, metamaterials and disordered matter. Faculty study the mechanics of mesoscopic constructed materials and biological tissues using a number of tools from differential geometry to computation. The dynamics of active matter, including reconstituted biological systems and living cells and flocks, is also an active area of study. The glassy dynamical behavior and statistical physics of materials with disorder is studied, using connections with advanced algorithms to model complex systems. Flow and plastic deformation in jammed and glassy solids (as in metallic glasses, foams and granular materials) are the object of research work. Manning, Middleton, Santangelo, Schwarz.

Experimental studies of molecular to cellular biological processes and nonlinear and emergent behaviors in soft systems. Living systems of interest include ion channels, enzymes, cytoskeleton, bacterial and eukaryotic cells. Non-living systems include the wrinkling, crumpling, and folding of thin elastic sheets, and the arrangements of solid particles in a sludge. Methods include in vitro reconstitution from wholly purified components, electronic and optical quantitative measurements, mechanical measurements, microfluidics, and other quantitative measurements. Movileanu, Patteson, Paulsen, Ross.

Theoretical Particle Physics

Elementary particles and fields. Quantum field theory and quantum gravity. Supersymmetry and its application to quantum gravity and models of Beyond Standard Model Physics. Strongly coupled dynamics via effective field theory and lattice field theory. LHC phenomenology and lattice QCD. Inflation, the generation of density perturbations, the origin of dark matter and dark energy, baryogenesis and the cosmic microwave background radiation. Particle cosmology. Catterall, Hubisz, Laiho, Watson.

Graduate Awards

Graduate Scholarships support graduate study for students with superior qualifications; provide, in most cases, full tuition for academic year.

Graduate Teaching Assistantships offered to most Graduate Scholarship recipients; nine months; stipend of $29,000 (2023-2024) and tuition scholarship up to 24 credits (8 courses). Summer assistantships may be available. The assistant spends up to 20 hours per week engaged in teaching laboratory or recitation classes and in grading and preparation.

Graduate Research Assistantships no more than an average of 20 hours of work per week; a nine-month stipend of at least $29,000 (2023-2024) and tuition scholarship up to 24 credits (8 courses). Summer assistantships may be available. The research assistant is normally paid for research work performed in conjunction with a faculty member and leading to the master's or doctor's dissertations.

Student Learning Outcomes

1. Conduct original research to develop in-depth knowledge in subfield of expertise
2. Demonstrate broad knowledge of physics at graduate level specifically quantum, classical and statistical mechanics and electromagnetism
3. Orally communicate research effectively to both specialist and general audiences
4. Communicate research effectively in writing to both specialist and general audiences
5. Demonstrate safe and efficient experimental skills including error analysis, interpretation of data, and instrumentation techniques to conduct physics experiments
6. Apply computational skills to solve problems

Degree Programs

The Department offers a program of graduate study leading to the Ph.D. in Physics. Minimum requirements for each degree are an average GPA of 3.0 in major subjects and an overall average of 2.8.

Students who wish to continue graduate study toward a Ph.D. in Physics following a master's degree must submit a Syracuse University Graduate School application form, including letters of reference, to the Department.

Approved Courses

Plus two approved courses at the 600 level or above. These may be advanced physics courses or other courses associated with the student's degree program. PHY 663 Problem Solving in Graduate Physics will not count as one of the three advanced courses.

Ph.D. in Physics

The Ph.D. degree is awarded to students who complete 48 credits of graduate- level coursework, pass a two-part qualifying examination, pass a research oral examination on the student's proposed research, complete a written thesis based upon original research, and pass a thesis defense examination.

Ph.D. students coming to the program with a M.S. in Physics may receive credit for up to 30 hours. An additional 18 credit hours of dissertation credit or graduate course work is required. A student who passes a written qualifying exam (or an equivalent requirement) as part of their M.S program is exempt from the requirement to take PHY 621 Classical Mechanics, PHY 641 Advanced Electromagnetic Theory I, PHY 661 Quantum Mechanics I, and PHY 662 Quantum Mechanics II.

Ph.D. students coming to the program without a M.S. in Physics must take a diagnostic quiz. Those who perform satisfactorily will proceed to take 600-level graduate classes. Students with areas of weakness identified by the diagnostic quiz may be required to take a mixture of 500- and 600-level classes. However, any associated offer of financial support is not contingent upon performance in the diagnostic quiz. Students may request to take the written qualifying exam on entry to the program. A student who passes the written qualifying exam on entry to the program is exempt from the requirement to take PHY 621 Classical Mechanics, PHY 641 Advanced Electromagnetic Theory I, PHY 661 Quantum Mechanics I, and PHY 662 Quantum Mechanics II.

The coursework includes:

Code	Title	Credits
Required Courses		
Select two of the following:		6
PHY 607	Computational Physics	
PHY 651	Instrumentation in Modern Physics	
PHY 657	Statistics and Data Analysis in Physics	
And completion of the five required courses		
PHY 621	Classical Mechanics	3
PHY 641	Advanced Electromagnetic Theory I	3
PHY 661	Quantum Mechanics I	3
PHY 662	Quantum Mechanics II	3
PHY 731	Thermodynamics and Statistical Mechanics	3