PHYSICS, MS

Chair

Jennifer L. Ross
201 Physics Building
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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 the Internet at physics.syr.edu (https://artsandsciences.syracuse.edu/physics/).

Additional Information

Students must maintain a B average in MS program coursework.

Research Areas

The department provides many cutting-edge student research opportunities. 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. Under the guidance of Brown, Coughlin, Nitz, 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. Under the guidance of Ballmer, Brown, Cahillane, Mansell, Nitz.

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 a 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. Under the guidance of Artuso, Mountain, Rudolph, Silva Coutinho,Skwarnicki, Soderberg, Stone, 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. Under the guidance of Catterall, Hubisz, Maloney, 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. Kelleher, Movileanu, Pashine, 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. Under the guidance of Catterall, Hubisz, Laiho, Maloney, Watson.

Student Learning Outcomes

1. Conduct scientific research at the specialist level
2. Communicate scientific research at the specialist and non-specialist level
3. Demonstrate broad knowledge of physics at graduate level specifically quantum, classical and statistical mechanics and electromagnetism
4. Demonstrate safe and efficient lab skills including error analysis, interpretation of experimental data, and laboratory techniques
5. Apply computational skills to solve problems

Degree Programs

All entering students must take a diagnostic quiz. Those who perform satisfactorily will proceed to take 600-level graduate classes. Students with areas of weakness on 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.

M.S. in Physics

The degree can be achieved in any of three ways:

1. a thesis (involving 6 credits of PHY 997 Masters Thesis) in addition to 24 credits of regular coursework;
2. 30 hours of coursework including a Minor Problem (PHY 890 Minor Problems In Physics); or
3. 36 hours of coursework. The courses taken must include:

Code	Title	Credits
Select one of the following:		3
PHY 607	Computational Physics	
PHY 651	Instrumentation in Modern Physics	
PHY 657	Statistics and Data Analysis in Physics	
PHY 621	Classical Mechanics	3
PHY 641	Advanced Electromagnetic Theory I	3
PHY 661	Quantum Mechanics I	3