

A COURSE CATALOG LANGUAGE FOR PH.D. IN PHYSICS

Physics Ph.D.

All students must meet the Requirements for the Ph.D. Degree

Overview

The Department of Physics offers research opportunities in theoretical and experimental condensed matter physics, astronomy and astrophysics, and soft condensed matter physics and biophysics.

Research in theoretical condensed matter physics focuses on the dynamics of quantum systems with application to electronic, magnetic, optical, structural, and thermal properties of nanomaterials including fullerene-derived solids (buckyballs) and carbon nanotubes. Basic research also includes the investigation of low energy scattering of atoms and molecules from surfaces and systems with many internal degrees of freedom, and the development of new methods for studying quantum many-body systems, such as new extensions of density functional theory to van der Waals systems. In addition, high performance computational techniques including quantum Monte Carlo and exact diagonalization are used to study strongly-interacting quantum systems with a focus on the types of emergent phenomena that are ubiquitous in complex systems. This includes investigations of entanglement in quantum fluids and gases in the presence of confinement, disorder, and dissipation.

The physics of recently discovered Graphene and its derivatives is another major direction of theoretical research. These materials exhibit unconventional electronic, magnetic, mechanical, and transport properties, and efforts are under way to understand the role of quantum many-body effects both from fundamental standpoint and in relation to nanodevice applications.

Additional theoretical studies include strongly-correlated electron systems, such as complex oxides and cuprates and high-temperature superconductors. Of particular interest are frustrated quantum magnets with novel ground states, as well as conducting cuprates which exhibit complex interplay of charge and spin phenomena. Such systems also tend to undergo quantum phase transitions, and the study of quantum critical phenomena is a major research direction.

Theoretical studies of the optical properties of materials include the electronic structure of defect complexes in ionic crystals, the application of subtracted dispersion relations to optical data analysis, and the separation of inter- and intra-band effects in the infrared spectra of metals. Related studies are concerned with theories of X-ray scattering, of X-ray optical properties, and of X-ray optical elements.

Research in materials physics includes studies of the kinetics of thin film growth and surface processing, applied to materials with interesting and useful physical properties such as organic semiconductors and magnetic materials. Many of the research projects involve real-time X-ray or electron diffraction structural studies of surface phenomena, combined with computer simulation of relevant surface processes. Available is an ultra-high vacuum thin-film deposition laboratory dedicated to these studies, and regular use is made of synchrotron X-ray facilities in the U.S.

Additional research in materials physics includes studies of fundamental magnetic and spin-dependent electronic properties of semiconductor nanostructures that employ high magnetic field optical spectroscopy imaging techniques. The physics department hosts one of the few laboratories in New England where time-resolved, spin-dependent spectroscopy imaging at magnetic fields as high as five Tesla may be carried out.

Astrophysical research centers on experimental radio astronomy, with particular emphasis on pulsars and the interstellar medium. Observations are carried out using major instruments of the U.S. National Observatories and generally involve computer analysis and interpretation.

Research in biophysical ultrasound is directed toward an understanding of the physical principles involved when ultrasound interacts with living systems. This often involves collaboration with the College of Medicine. Acoustical and optical tweezers permit manipulating single cells without touching them. New forms of ultrasonic transducers and biosensors are being developed in collaboration with the Department of Electrical Engineering, as part of the Materials Science program. Biophysical research includes studies on the development and employment of novel uses of in situ atomic force microscopy for biological applications, specifically high-resolution structural studies of membrane proteins, investigation of the packing of genetic materials on bilayer membranes, and studies on how DNA-bilayer interactions affect the use of cationic lipids as gene-delivery means. Other research in biological physics and protein dynamics involves combining the detail of atomic-resolution X-ray crystallography with the sensitivity of optical and IR spectroscopy. The department has access to a state-of-the-art protein crystallography diffractometer and organizes regular trips to synchrotrons in the U.S. and Europe.

Opportunities for collaborative research with other university departments and groups include those with Chemistry, the Materials Science program, Molecular Physiology and Biophysics, the Cellular, Molecular and Biomedical Sciences program, Computer Science, Electrical Engineering, Civil and Environmental Engineering, Mechanical Engineering, Medical Radiology, and Geology.

Specific Requirements

REQUIREMENTS FOR ADMISSION TO GRADUATE STUDIES FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Undergraduate majors in physics are considered for admission to the program. Satisfactory scores on the Graduate Record Examination (general) are required.

MINIMUM DEGREE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Seventy-five credits, including:

Core courses to be completed with a grade of B or better within the first two years of graduate study:		
PHYS 323	Contemporary Physics	3
PHYS 301	Mathematical Physics	3
PHYS 311	Advanced Dynamics	3
PHYS 313	Electromagnetic Theory	3
PHYS 362	Quantum Mechanics II	3
PHYS 365	Statistical Mechanics	3
Successful completion of qualifying examination.		
Nine credits of electives from the following list, to be completed with a grade of B or better within the first three years of graduate study:		9
PHYS 222	Biological Physics	
PHYS 242	Intro to Solid State Physics	
PHYS 256	Computational Physics	
PHYS 257	Modern Astrophysics	
PHYS 258	Relativity	
PHYS 264	Nuclear and Elementary Particle Physics	
PHYS 321	Theoretical Physics	
PHYS 323	Contemporary Physics	
PHYS 331	Biological Physics	
PHYS 341	Solid State Physics	
PHYS 351	Physics of Materials	
PHYS 356	Computational Physics II	
BIOC 301	General Biochemistry I	
BIOC 302	General Biochemistry II	
CHEM 260	Advanced Physical Chemistry	
ME 336	Continuum Mechanics	
ME 350	Multiscale Modeling	
MPBP 323	Biophysical Techniques	
At least three credits of teaching experience:		3
PHYS 305	Teaching College Physics	
At least twenty credits of doctoral dissertation research		20
PHYS 491	Doctoral Dissertation Research	
Twenty-five additional credits of coursework, teaching experience, and/or doctoral dissertation research to bring the total number of credits to 75		25

COMPREHENSIVE EXAMINATION

At the start of their second semester at UVM, students are expected to sit for the written part of the Comprehensive Exam which covers classical mechanics, quantum mechanics, electricity and magnetism, as well as thermal physics and mathematical physics.

Students are given two opportunities to pass the comprehensive exam. In addition to the written portion, there is also an oral portion that consists of a Ph.D. dissertation proposal given after the start of a dissertation research project.

REQUIREMENTS FOR ADVANCEMENT TO CANDIDACY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Successful completion of all required courses and the comprehensive exam.