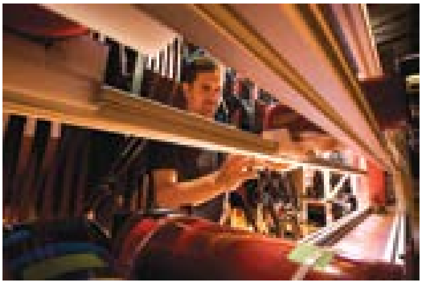
PHYSICS DEPARTMENT

The Physics Department offers graduate study and research which leads to the Ph.D. degree. The department consists of thirty instructional faculty members, fifteen additional physicists in purely research positions, and 60 full-time graduate students. Additions to the research areas listed below include plasma and non-linear physics and related research includes accelerator physics (in cooperation with Jefferson Lab) and material characterization (in cooperation with NASA-Langley Research Center). The department offers a wide range of undergraduate and graduate courses of instruction. It also has strong links with the Applied Science Department and Computational Science Cluster.



Atomic and Optical Physics

Experimental research areas include intense laser-matter interaction, femtosecond laser physics, slow and stored light, ultra-cold quantum gases (Bose-Einstein condensates and degenerate Fermi gases), and the study of biological systems using AMO techniques. The theory program includes the study of classical trajectories and chaos in atomic and molecular systems and their correlation with quantum mechanics.

Computational Physics

Research in this area includes the studies of turbulence, macroscopic nonlinear systems, soliton theory, wave propagation, signal processing, Monte Carlo simulations, ab initio calculations and lattice quantum chromodynamics. These studies have applications within many fields of physics, including laser science, wave dynamics, quantum computing, plasma physics, condensed matter physics, nuclear physics and particle physics.

Condensed Matter Physics

There are active experimental and theoretical programs in superconductivity, magnetism, thin film deposition, carbon nanomaterials, nuclear magnetic resonance and ultrafast laser studies of materials. A new ultra-high field NMR facility with a 17.6 Tesla magnet, available at only a handful of other schools, provides opportunities for structure and dynamics studies in physical and biological materials.

Nuclear and Hadronic Physics

William & Mary has an active program in nuclear and hadronic physics, complemented by its proximity to Jefferson Lab. This state-of-the-art facility provides a high-energy electron beam used primarily for studying the substructure of the proton and neutron at the quark and gluon level. Current experimental and theoretical research is focused on understanding the basic properties of the nucleon, including the origin and distribution of its spin, charge and magnetic moment. Also at Jefferson Lab, the experimental nuclear group is embarked on precision experiments to search for physics beyond the Standard Model at the TeV scale.

High Energy Particle Physics

Particle physics research is aimed at possible new physics that lies beyond the current standard model of known elementary particles and their interactions. Theoretical research includes work on grand unified theories, supersymmetry, extra spatial dimensions and cosmology. The experimental high energy group is active in the search for neutrino oscillations using a neutrino beam produced at Fermilab, currently the largest proton-antiproton collider in the world. The department maintains labs for detector construction and testing, a polarized target lab and a computing farm for large-scale data analysis.

Faculty

CHAIR **David S. Armstrong** Chancellor Professor (Ph.D., British Columbia).

GRADUATE DIRECTOR **Jeffrey K. Nelson** Cornelia B. Talbot Term Distinguished Associate Professor of Physics (Ph.D., Minnesota).

PROFESSORS **Todd D. Averett** (Ph.D., Virginia), **Carl E. Carlson** Class of 1962 Professor (Ph.D., Columbia), **Christopher D. Carone** (Ph.D., Harvard), **William E. Cooke** (Ph.D., MIT), **John B. Delos** (Ph.D., MIT), **Keith A. Griffioen** (Ph.D., Stanford), **Gina L. Hoatson** (Ph.D., East Anglia), **Henry Krakauer** (Ph.D., Brandeis), **R. Alejandra Lukaszew** Virginia Microelectronics Consortium Distinguished Professor of Applied Science and Physics (Ph.D., Wayne State), **Dennis M. Manos** CSX Professor of Applied Science (Ph.D., Ohio State), **Robert D. McKeown** Governor's Distinguished CEBAF Professor (Ph.D., Princeton), **Michael R. Pennington** Governor's Distinguished CEBAF Professor (Ph.D., London), **Charles F. Perdrisat** (D.Sc., ETH, Zurich), **Marc T. Sher** (Ph.D., Colorado), **Eugene R. Tracy** Chancellor Professor (Ph.D., Maryland), **George M. Vahala** (Ph.D., Iowa), and **Shiwei Zhang** (Ph.D., Cornell).

ASSOCIATE PROFESSORS **Joshua Erlich** (Ph.D., MIT), **Irina Novikova** (Ph.D., Texas A&M), and **Konstantinos N. Orginos** (Ph.D., Brown).

ASSISTANT PROFESSORS **Seth A. M. Aubin** (Ph.D., SUNY, Stony Brook), **Wouter Deconinck** (Ph.D., Michigan), **Michael A. Kordosky** (Ph.D., Texas, Austin), **M. Mumtaz Qazilbash** (Ph.D., Maryland, College Park), **Enrico Rossi** (Ph.D., Texas, Austin), and **Patricia L. Vahle** (Ph.D., Texas, Austin).

PROFESSORS EMERITI **Roy L. Champion** Chancellor Professor (Ph.D., Florida), **Morton Eckhause** (Ph.D., Carnegie-Mellon), **Franz L. Gross** (Ph.D., Princeton), **John R. Kane** (Ph.D., Carnegie-Mellon), **William J. Kossler** (Ph.D., Princeton), **John L. McKnight** (Ph.D., Yale), **Kenneth G. Petzinger** (Ph.D., Pennsylvania), **Edward A. Remler** (Ph.D., North Carolina), **Harlan E. Schone** (Ph.D., California, Berkeley), **Hans C. von Baeyer** Chancellor Professor (Ph.D., Vanderbilt), **J. Dirk Walecka** Governor's Distinguished CEBAF Professor (Ph.D., MIT), and **Robert E. Welsh** Chancellor Professor (Ph.D., Pennsylvania State).

TJNAF PROFESSOR **Roger D. Carlini** (Ph.D., New Mexico).

ADJUNCT PROFESSORS **Peter E. Bosted** (Ph.D., MIT), **Alfred R. Osborne** (Ph.D., Houston), **Anne C. Reilly** (Ph.D., Michigan), **David Richards** (Ph.D., Cambridge), **Marc Vanderhaeghen** (Ph.D., Ghent), **Gwyn P. Williams** (Ph.D., Sheffield), and **Stuart A. Wolf** (Ph.D., Rutgers).

ADJUNCT ASSOCIATE PROFESSOR **Paul M. Danehy** (Ph.D., Stanford).

ADJUNCT ASSISTANT PROFESSOR **William Detmold** (Ph.D., Adelaide).

RESEARCH PROFESSOR **Malathy Devi Venkataraman** (Ph.D., Kerala).

RESEARCH ASSOCIATE PROFESSOR **D. Chris Benner** (Ph.D., Arizona).

RESEARCH ASSISTANT PROFESSOR **Eugeniy Mikhailov** (Ph.D., Texas A&M).

DIRECTOR OF TEACHING LABS **A. Dayle Hancock** (Ph.D., U. Houston).

General Description

The mission of the Physics Department at the College of William and Mary is the creation and dissemination of knowledge of the physical world through teaching, research, and public service.

The Department is committed to excellence in its teaching. At the graduate level, the Department offers a full complement of courses consistent with the requirements of a doctoral program. The department recognizes that faculty research activity is an essential ingredient in sustaining excellence in teaching.

The Department carries out experimental and theoretical research in many subfields, and the results are communicated in refereed journals, in conferences and seminars, and in books. The active participation of graduate and undergraduate students in research is integral to these efforts and is a major component of their education. Mission is to understand the fundamental origin and the mathematical description of physical phenomena. Graduate students learn to conduct original scientific research in physics. Currently the Department of Physics and federal grants support active research in the following areas:

Focus/Specialization of Program

- Atomic, Molecular, and Optical physics, experimental and theoretical: Ultrafast lasers, stored light, ultra-cold quantum degenerate gases, laser biophysics, Rydberg atom spectroscopy and semiclassical theories.
- Computational Physics.
- Condensed Matter Physics, experimental and theoretical: First principles calculation of piezoelectrics (Center for Piezoelectrics by Design), Quantum Monte Carlo simulations, magnetic multilayers, surfaces and interfaces, muon spin rotation, and solid state nuclear magnetic resonance (high field NMR Lab), metallic thin films, magnetic nanostructures.
- Nuclear and Particle Physics, experimental and theoretical: Measurements of the structure of the nucleons and nuclei via electromagnetic and electroweak interactions, hyper-polarized nuclear targets, searches for physics beyond the standard model via electroweak interactions, particle theory, supersymmetry, extra dimensions and Higgs physics, neutrino masses and mixing, long baseline neutrino oscillations, neutrino interactions on nucleons and nuclei, particle astrophysics.
- Plasma and nonlinear physics, theoretical: turbulence simulations, the basic theory of linear and nonlinear waves in plasmas and fluids, and cardiac dynamics.
- Strong links with the interdisciplinary Applied Science Department.

Among the many components of public service, departmental members give lectures to general audiences, organize public telescope viewings, offer courses for high school teachers seeking further advanced training, and write books to explain physics to the general public. The Department also serves the wider national and international communities through scientific leadership in various organizations, service on review panels, and on advisory committees.

Admission

The Department follows the general College-wide admission rules; it requires applicants to submit their scores for the GRE subject test (Physics) as well as the GRE general test. Although exceptions are made, it is recommended that graduate students begin their course work in the fall semester. However, new students who will be supported during the academic year may receive research assistantships for the summer before they begin their formal course work if funds are available..

Degree Requirements for the Master of Science

(See general College requirements in the section entitled 'Graduate Regulations' in this catalog.)
The candidate must complete a program of courses required by the Department. This program depends on the candidate's preparation and special interests, but will include PHYS 601, 603, 610, 621, 622, and 630. The candidate must take the Ph.D. qualifying exam. This exam deals with the undergraduate material, the content of the first-year graduate courses and colloquia. There are two possible outcomes of the qualifying exam: pass or not pass at the Ph.D. level. Passing at the Ph.D. level satisfies the exam requirement for an

M.S. degree. Otherwise, the Physics faculty will consider the qualifying exam score, along with academic performance in course work and research performance (if any), in order to determine whether the standards for a Master of Science degree are met. The candidate is required to register for Colloquium, (PHYS 650) for a minimum of two semesters of residence. In addition, the candidate must accumulate 32 credit hours, including registering for PHYS 651 or 652 to obtain a minimum of two semesters teaching experience

Degree Requirements for the Doctor of Philosophy

(See general College requirements in the section entitled 'Graduate Regulations' in this catalog.)
The candidate must complete a program of courses required by the Department. This program depends on the candidate's preparation and special interests, but, in addition to the master's level courses, will include: PHYS 611, 721, an additional semester of Colloquium, and either Teaching or Research. The candidate must pass examinations that test familiarity with the principal fields of physics. Details of procedure will vary. It is required that the candidate pass the qualifying examination and demonstrate competence in several advanced topics courses. The candidate must perform research, which is an original and substantial contribution. The dissertation must be approved by a faculty committee and successfully defended in a public oral examination. Students have seven (7) years from the term of admission to the graduate program for the completion of all M.S./Ph.D. degree requirements. Extensions to this limit are considered according to the extension policy as outlined in the section entitled 'Graduate Regulations' at the front of this catalog.

Description of Courses

Unless otherwise noted, all courses are graded using standard grading [A, B, C, D, F] scheme (See VI. Grading and Academic Progress in the section entitled 'Graduate Regulations' in this catalog) and may not be repeated for credit (See Repeated Courses requirements in the section entitled 'Graduate Regulations' in this catalog).

600. Independent Study.

Fall, Spring (3,3) Staff.

Course concerning special topics in physics not covered in regular course offerings. This course may be repeated for credit if instructor determines there will be no duplication of material.

601. Classical Mechanics.

Fall (4) Deconinck.

The mechanics of particles and rigid bodies, methods of lagrangian and hamiltonian mechanics, relativistic mechanics, approximation techniques.

603. Mathematical Physics.

Fall (4) Vahala.

Complex variables and analytic functions. Vector spaces (finite dimensional and infinite dimensional), operators and matrix representations.

610. Classical Electricity and Magnetism-I.

Spring (4) Cooke.

Electrostatics. Solution of boundary value problems. Green's functions and direct solution of Laplace's equation. Magnetostatics and steady currents. Maxwell's equations and plane wave solutions.

611. Classical Electricity and Magnetism-II.

Fall (3) Cooke. Prerequisite: PHYS 610.

Waves inside conducting boundaries. Radiation from simple current systems, spherical waves and multipole radiation. Covariant formulation of electromagnetism. Interaction of radiation with matter.

621. Quantum Mechanics-I.

Fall (4) Orginos.

Axiomatic development of wave mechanics and the Schroedinger equation in one and three dimensions; wave packets, scattering theory.

622. Quantum Mechanics-II.

Spring (4) Zhang. Prerequisite: PHYS 621.

Scattering theory; spin; matrix methods; symmetry; perturbation theory and other approximate methods; identical particles.

630. Statistical Physics and Thermodynamics.

Spring (4) Delos. Prerequisites: PHYS 601, PHYS 621.

Statistical ensembles and averages, classical equilibrium, thermodynamics and statistical mechanics, quantum statistics, kinetic theory and transport properties.

650. Physics Colloquium.

Fall and Spring (1,1) Armstrong. Graded Pass/Fail. This course may be repeated for credit.

Includes presentations by invited speakers on areas of active research in physics. The course also will include an overview of physics research at William and Mary and training in the responsible and ethical conduct of research.

651, 652. Teaching Physics.

Fall and Spring (2,2) Armstrong. Graded Pass/Fail. This course may be repeated for credit.

Designed for entering students teaching a lab or tutoring one of our undergraduate courses. Respective faculty will instruct students in relevant ways.

690. Advanced Topics in Physics.

Fall and Spring (Hours and credits to be arranged.) Staff.

Special topics of current interest. This course may be repeated for credit when the instructor determines there will not be a duplication of material.

695. Research.

Fall and Spring (1-12) Armstrong. This course may be repeated for credit.

702. Advanced Mathematical Physics.

Spring (3) Staff. Prerequisite: PHYS 603. (Not offered Spring 2013)

Differential equations, Green's functions, some hypergeometric functions, group theory, representation of groups.

721. Field Theory and Relativistic Quantum Mechanics.

Fall (3) Carone. Prerequisite: PHYS 622.

Classical field theories, Dirac Equation, canonical quantization, Interacting field theories, Feynman diagrams. Relation to non-relativistic many-body theory, and applications to atomic transitions. Quantum electrodynamics and introduction to radiative corrections.

722. Quantum Field Theory.

Spring (3) Orginos. Prerequisite: PHYS 721.

Functional integral quantization of field theories. Quantization of gauge theories. Renormalization. Spontaneous Symmetry Breaking and the Higgs mechanism.

741, 742. Solid State Physics.

Fall and Spring (3,3) Rossi. Prerequisites: PHYS 622, PHYS 630.

Introduction to solid state physics; crystal structure, phonons, electrons, electric and magnetic properties, impurities, elementary excitations, band theory and experiment, correlation function methods.

761, 762. Atomic and Molecular Processes.

Fall and Spring (3,3) Staff. Prerequisite: PHYS 622. (Not offered Fall 2012)

Theory of atomic structure; emission and absorption of radiation; fine and hyperfine structure; coupling schemes. Molecular structure and intermolecular forces; atomic and molecular collisions. Modern applications.

771, 772. Nuclear and Particle Physics.

Spring and Fall (3,3) Staff. Prerequisite: PHYS 622.

Two-nucleon forces and the deuteron; nucleon scattering and polarization; nuclear systematics and models. Unitary symmetry; quarks and leptons, electrodynamics of fermions; weak interactions, QCD, and the standard model.

773, 774. Advanced Particle Physics.

Fall and Spring (3,3) Staff. Prerequisite: PHYS 622. (Not offered Fall 2012)

Topics of current interest in strong, electromagnetic, and weak interactions. This course may be repeated for credit when the instructor determines that there will not be a duplication of material.

783. Plasma Physics.

Fall (3) Staff. (Not offered Fall 2012)

An introduction to plasma physics and magnetohydrodynamics. Particle orbit theory, macroscopic equations, waves in collisional and collisionless plasmas. Vlasov equation.

784. Advanced Plasma Physics.

Spring (3) Staff. Prerequisite: PHYS 783. (Not offered Spring 2013)

Selected topics such as plasma waves in a magnetic field, waves in a bounded plasma, plasma kinetic theory, and plasma radiation.

786. General Relativity and Cosmology.

Spring (3) Staff.

Introduction to general relativity, tensor analysis, gravitational field equations, gravitational waves, Schwarzschild and Kerr solutions, cosmological models, gravitational collapse.

790. Advanced Topics in Physics.

Fall and Spring (Hours and credits to be arranged.) Staff.

Special topics of current interest. This course may be repeated for credit when the instructor determines there will not be a duplication of material.

800. Doctoral Dissertation.

Fall and Spring (1-12) Armstrong. This course may be repeated for credit.