Physics and Astronomy

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Degrees Awarded
M.A. in Physics; M.S. in Physics in Scientific Instrumentation; Ph.D. in Physics; Ph.D. in Physics with Concentration in Astronomy

Web Site
http://www.physics.sunysb.edu/Physics/

Description of the Physics and Astronomy Department

The Department of Physics and Astronomy in the College of Arts and Sciences offers courses of study and research that normally lead to the Ph.D. degree. The M.A degree is awarded either to exchange students or to students on the way to the Ph.D. degree. A Master of Science in Scientific Instrumentation program is provided for those interested in instrumentation for physical research. A Master of Arts in Teaching program, from the School of Professional Development, is available for students seeking to teach physics in high schools.

Students may find opportunities in various areas of physics not found in the department or in related disciplines at Stony Brook in such programs as Medical Physics, Chemical Physics, Atmospheric and Climate Modeling, Materials Science or Biophysics and at Cold Spring Harbor Laboratory.

The entire faculty participates in teaching a rich curriculum of undergraduate, graduate, and professional development courses, including many courses on special topics of current interest. Graduate students must fulfill one year of teaching. Course requirements are kept at a minimum to allow the student to set up a flexible program. Students are encouraged to participate in research as early as possible and to begin their thesis research no later than the beginning of their third year. The typical length of time to the Ph.D. is four to six years, whereas the Master's in Scientific Instrumentation is a two-year program that involves a thesis project in instrumentation design or development.

The Stony Brook Physics and Astronomy Department has been highly ranked in national surveys for the quality of its graduate program, its faculty, and the impact of its published research. It strives to make a graduate education in physics intellectually stimulating and educationally rewarding.

Research Areas

Accelerator and Beam Physics
Research in accelerator physics is being carried out at Stony Brook and in several departments at nearby Brookhaven National Laboratory. The research covers theoretical and experimental aspects of circular and linear accelerators as well as interaction of particle beams with electromagnetic radiation, including free electron lasers. The experimental facilities include the BNL Alternating Gradient Synchrotron, the National Synchrotron Light Source, and the Relativistic Heavy-Ion Collider, also with work on radio-frequency superconducting accelerators and energy recovery linacs. Research is also being conducted on facilities such as the high-brightness Accelerator Test Facility, including investigations in high-gradient acceleration, generation of high-brightness beams, and free-electron lasers. Ph.D. and M.S.I. research at BNL may be arranged through the Center for Accelerator Physics.

Astronomy and Astrophysics
Astrophysics of Brown Dwarfs and Extrasolar Planets: Research in substellar astrophysics focuses on the population and atmospheric properties of brown dwarfs. This research has demonstrated that brown dwarfs and stars are sampled from the same continuous mass distribution, regardless of whether they exist as isolated objects or as parts of multiple stellar or substellar systems. It has also established a basis for addressing the long standing question of whether brown dwarfs and planets can form in the same manner. Research on extrasolar planets centers on the development and use of innovative high-contrast imaging techniques for the direct imaging of exoplanets and for the study of their host environments. This work has resulted in the earliest detection of all three known planets in the first directly imaged multi-planet system, HR 8799bcd. We are actively involved in the planning for the next-generation imaging surveys for brown dwarfs and planets with the Large Synoptic Survey Telescope, the Gemini Planet Imager, and the James Webb Space Telescope.

Cosmology and Extragalactic Astronomy: Observational interests span various disciplines of observational cosmology, including galaxy formation and evolution, star formation history, quasar absorption lines, and evolution of the intergalactic medium and on development and application of image processing techniques utilizing large-scale scientific computing facilities for measurement of sensitive observations of faint galaxies. Current research focuses on star formation and starburst activities in galaxies at an early Universe and the present, which are critical processes in building up galaxies from the interstellar and intergalactic medium.

Millimeter Wave Astronomy and Interstellar Molecular Clouds: Millimeter Wave Astronomy and Interstellar Molecular Clouds Stony Brook is involved in millimeter CO surveys in the galactic plane; in 1977 these first revealed the existence of giant molecular clouds. Current research focuses on determining the star formation rates in these clouds and mapping the distribution of giant molecular clouds in nearby galaxies, and uses both infrared and millimeter wave observatories, including the Herschel Space Observatory, the CARMA interferometer, and the Nobeyama...
45-meter antenna, the world’s most powerful millimeter wave telescopes. Extragalactic mapping of interstellar molecules like CO and HCN is performed to understand the role played by giant molecular clouds in star formation and the evolution of spiral galaxies. Recently, the distribution of giant molecular clouds has been fully revealed in the Whirlpool galaxy M51, indicating the evolution of molecular gas driven by shear motions across galactic spiral arms. Mappings are also used to understand the effects of galaxy dynamics and collisions on star formation and the starburst phenomenon.

**Nuclear Astrophysics**

Nuclear astrophysics research focuses on thermonuclear and core-collapse supernovae, neutron stars, and X-ray bursts, on the physics of dense matter, and on the development and verification and validation of algorithms for modeling these systems. Numerical simulations of these explosive events are carried out on supercomputing facilities nationwide. This work continues a long tradition of computational astrophysics at Stony Brook, including the modeling of supernovae and proto-neutron stars spectacularly confirmed by neutrino observations from SN 1987A.

Astronomers at Stony Brook have discovered a nearby neutron star and measured its distance, temperature and age. A major goal is to determine the radii of neutron stars combining calculations of neutron star atmospheres (employing various compositions and magnetic fields) with optical and X-ray observations (from Hubble, Chandra, XMM and other instruments) of this and other neutron stars.

Modeling of thermonuclear explosions, including Type Ia supernovae, X-ray bursts, and Classical Novae, is also a major topic of research. Both the early stages and the explosion itself are being investigated with a range of simulation codes developed by Stony Brook astrophysicists in association with researchers at DOE labs and other universities. Verification and validation of these complex algorithms is an active part of this research.

Other active areas of research are neutron star structure and cooling, including the effects of composition and superfluidity, and compact object mergers. Models for the dense matter equation of state developed by Stony Brook are used worldwide.

**Star Formation and Stellar Astronomy**

Star formation research focuses on low-mass pre-main sequence (PMS) evolution and the true initial mass function. We study the early evolution of PMS stars, measure their masses, and probe the structure and composition of their circumstellar disks using state-of-the-art optical, infrared, and millimeter-wave techniques from the ground and space. We study populations in the Orion OB1 association from the O stars through planetary mass objects. We are actively investigating the environments of the pre-main sequence stars, using CHANDRA and XMM to study the 107 K coronal gas, and using FUSE and the Hubble Space Telescope to study the stellar chromospheres, the accretion process, and circumstellar molecular hydrogen. We also study the outer atmospheres and the coronal and chromospheric activity of older cool stars using optical, ultraviolet, and X-ray spectra obtained from the ground and space observatories. Finally, we study the temporal evolution of accreting white dwarfs in magnetic cataclysmic binary systems and in classical and recurrent novae.

**Atmospheric Research**

Students in the Physics and Astronomy Department who are interested in the physical factors driving climate change and atmospheric dynamics, radiative transfer within planetary atmospheres, and related topics may do research under the direction of faculty in the Institute of Terrestrial and Planetary Atmospheres (ITPA), which is an Institute within the School of Marine and Atmospheric Sciences that maintains close ties with Physics and Astronomy. Current research within the ITPA includes the physics and chemistry of aerosol formation and physical reactions on aerosol surfaces; the role of aerosols in influencing climate; advanced computer modeling of the chemistry and the large scale and mesoscale dynamics of atmospheres, including radiative transfer through atmospheres (the "greenhouse effect" and related phenomena); physical processes involved in the atmospheric-ocean interchange of heat, aerosols, and gases; and the use of isotopic composition to characterize and monitor natural and anthropogenic trace gas sources and sinks in the earth's atmosphere. Close interaction of students in the department with faculty of the ITPA offers a way to participate actively in finding solutions to global-scale atmospheric-environmental problems facing the world in the 21st century. The Department of Environmental Sciences at Brookhaven National Laboratory interacts with both P&A faculty and ITPA faculty, and offers further opportunities for instrumentation development and laboratory and field studies of atmospheric dynamics and related topics.

**Atomic, Molecular, and Optical Physics**

Atomic, molecular, and optical (AMO) physics focuses on the interaction of light and matter under widely different circumstances. We pursue experiments and calculations that span the full range of energies and timescales in AMO physics, from ultracold matter to ultrafast dynamics. At one end of the scale, we are working on the physics of ultracold quantum-degenerate atomic gases in low-dimensional geometries, with a focus on Bose-Einstein condensates in optical lattices. We aim at producing “designer materials” with precisely controllable properties, such as lattice structure, interactions, or defects, in order to perform fundamental studies at the boundary between atomic and solid-state physics. At the other end of the energy and timescales, we are working on understanding and controlling the electronic and nuclear dynamics involved in elementary processes such as a chemical reaction. In between these two extremes we are developing tools for manipulating neutral atoms using bichromatic light fields, as well as different approaches for cooling atoms and producing ground state molecules.

**Center for Accelerator Science and Education**

The Center for Accelerator Science and Education (CASE) will pursue cutting edge accelerator science and R&D, training of next generation accelerator scientists (graduate and post doctoral) through courses, laboratory and experiments on accelerators. Undergraduate opportunities will play a significant goal of attracting students to the graduate program through introduction to accelerator courses, accelerator laboratory work and summer research opportunities at BNL. The proposed educational program will start with a short term abbreviated educational program of undergraduate, graduate and R&D that will evolve over time.

**Experimental Condensed Matter, Mesoscopic, Nanoscale and Device Physics**

We have an active program in several key areas of mesoscopic, nanoscale and solid-state device physics, including quantum computing, single-electronics, molecular electronics, and nanoscale transistors. We are also working to develop self-wiring “neuromorphic” computer architectures...
using a hybrid of 50nm lithographic crossbars and molecular conductors as circuit elements. There is an active program in solid-state and low-temperature physics, with areas of studies including ferroelectrics, graphene, semiconductors, phase transitions in two-dimensional solids, integer and fractional quantum Hall effect, Wigner crystallization of the two-dimensional electron gas in semiconductor heterostructures, electronic properties of electron-hole systems, and electro-optic effects in quantum wells and superlattices. A variety of modern techniques for fabrication of samples is employed including molecular beam epitaxy, deposition of thin films by resistive and electron-gun evaporation and magnetron sputtering, and patterning of thin-film structures using optical lithography and direct electron-beam writing. Characterization methods include atomic force microscopy and scanning tunneling microscopy, an in-house X-ray diffraction apparatus and a great variety of electric polarization and transport measurements. X-ray powder diffraction studies on a wide range of materials, from organic molecular magnets, to iron-pnictide superconductors and to pharmaceuticals is done at the National Synchrotron Light Source at BNL.

**Experimental High-Energy Physics**

The Stony Brook group has been in the forefront of high energy research at many premier facilities in the United States, Europe, and Japan. A large effort is based on the DØ experiment at the Fermilab collider, currently the highest energy accelerator in the world. The detector has been upgraded to seek new understanding of the top quark, to explore the mechanism of electroweak symmetry breaking and search for the Higgs boson, to study CP violation and mixing in the b quark system, to probe the strong QCD force in new regions, and to seek new phenomena. The group is also participating in the ATLAS experiment at the CERN Large Hadron Collider, expected to begin in 2010, and has built components of its calorimeter and event selection electronics. Our proximity to BNL continues to provide fruitful opportunities for research. We are working to develop a 500 GeV e+e− linear collider at a site to be determined.

The Stony Brook Nucleon Decay and Neutrino group is involved in the Super-Kamiokande, the K2K and the T2K experiments in Japan. The Super-Kamiokande detector, located deep underground in western Japan, detects neutrinos from the sun and neutrinos produced in the upper atmosphere. In 1998, the experiment discovered neutrino oscillations in the atmospheric neutrino data, with a far-reaching impact in elementary particle physics. The experiment also aims to detect neutrinos from supernova bursts. It is sensitive to possible proton decay signals and has set the world’s best limits on the proton decay. The K2K experiment is the first successful long baseline neutrino oscillation experiment which confirmed the discovery made by the Super-Kamiokande experiment on neutrino oscillation, and refined the measurement of the neutrino mixing, using accelerator-generated neutrino beams. Neutrinos were generated at the KEK laboratory on the East Coast of Japan 250 km from Super-Kamiokande and sent to the Super-Kamiokande detector. The T2K experiment is an extension of this program which will use neutrinos generated by the new JPARC accelerator. It is the first approved experiment in the world to specifically look for electron neutrino appearance from muon neutrinos, which will allow us to measure 1st and 3rd generation mixing. The group is also leading an effort to build a next generation underground neutrino detector, UNO, in the Henderson Mine in Empire, Colorado.

**Experimental Nuclear Physics**

The Stony Brook Experimental Nuclear Physics Group employs the PHENIX detector and the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) to study the properties of the quark-gluon plasma, a state of matter in which quarks and gluons are de-confined created by collisions of large nuclei at the highest possible energies. A second research interest of the group is to explore the nucleus's spin composition in terms of its constituents: gluons, quarks and antiquarks using the collisions of world's highest energy polarized proton beams, available at RHIC. The group is one of the founders of the PHENIX experiment at the RHIC and one of the leading institutions in PHENIX, having taken responsibilities for the design and construction of the focal plane of the Ring-Imaging Cherenkov (RICH) detector, electronics and mechanics of the PHENIX drift chamber, tracking software, leadership of the overall analysis effort of PHENIX data, and most recently the design, construction and readout of the Silicon Tracker Detector Upgrade of PHENIX, which is an on-going project. This highly fruitful and visible program has included the first observation of jets quenching phenomena, excess nucleon yield at high transverse momentum, and the first measurement of the polarized gluon's contribution to the nucleon spin, all resulting from the Stony Brook Group's analyses of the PHENIX data. Members of the Stony Brook Group thus play a leading role in all aspects of physics at RHIC. The spokesperson of Phenix is currently in our Department.

The RHIC program is entering its second phase in the near future resulting from a large increase in the luminosity of the heavy ion beams and also increased luminosity and beam energies of the polarized proton beams at RHIC. These enhancements along with the anticipated commissioning of the new PHENIX Vertex Tracker will allow high precision measurements of heavy quarks and jets produced in RHIC collisions for detailed characterization of quark-gluon plasma and open a new windows for the study of nucleon's spin. These activities will offer exciting opportunities for future graduate students at Stony Brook in the next few years. Members of this group are also involved, and play a leading role, in the Electron Ion Collider (EIC) a future project presently under discussions in the US nuclear science community. The EIC will employ high energy polarized electrons to study the internal quark-gluon structure and dynamics of the nuclei and the proton, including its spin.

**Optical Sciences**

The optical sciences are among the most dynamic areas of physics, with an impact on contemporary life that will continue to grow. Organized as an optics consortium, several groups in the department share an interest in optics and offer research opportunities in atomic molecular and optical physics, physics of opto-electronic materials, and x-ray optics and microscopy. The Laser Teaching Center is a focus for the activities of many student research projects.

**Simons Center for Geometry and Physics**

The Simons Center is a new research center that focuses on groundbreaking research at the interface of mathematics and theoretical physics. It is built on a long tradition of collaborative research between the Mathematics Department and the CN Yang Institute for Theoretical Physics that started with the work by Simons and Yang on the relation between gauge field theories and fibre bundles. The focus of the institute will be on geometry, gravity and string theory, but may evolve depending on the interests of the permanent faculty. The Center will have an active visitor program and will organize workshops that will attract the top scientists of the field. It will be housed in a new building that is expected to be completed in September 2010. The Center may offer research opportunities for graduate students as well.

**Theoretical Condensed Matter and Statistical Mechanics**
In the last decade, new conceptual and computational tools have led to major changes in our understanding of condensed matter systems. Recent work at Stony Brook has focused on quantum mechanical effects (i.e., superconductivity) on a macroscopic scale, quantum computing, collective phenomena in low-dimensional solids (i.e., high temperature superconductors), the quantum Hall effect, properties of mesoscopic metals such as correlated tunneling and single-electron charging effects, and properties of nanoscale matter such as electronic properties of nanowires, single-molecule electronics, and solar energy applications. Computer simulation of solids and liquids (including problems involving interfaces, surfaces, amorphous states, nanocrystals and molecules) is being performed with density-functional theory and other theoretical methods using both a local, dedicated computer cluster and the new IBM BlueGene/L supercomputer. In statistical mechanics there is very active research into one- and two-dimensional systems where exact mathematical calculations can be made. These include studies of phase transitions, solitons, and spin diffusion. The effort spans the range from quantum field theory to computer studies.

**Theoretical Nuclear Physics**

Traditionally, nuclear theory was limited to the study of properties of nuclei. However, in the past decade this field has broadened into the study of strong interactions in general with applications to a wide range of phenomena such as relativistic heavy ion collisions, the properties of hadrons and the interior of neutron stars. The primary goal of nuclear theory is to understand strong interactions starting from quantum chromodynamics (QCD), the underlying microscopic theory. We address this problem in two different ways. First, to make contact with experiment, we construct and analyze phenomenological models. We investigate effective theories for the description of hadrons at low energy; have understood relativistic heavy ion collisions in terms of relativistic hydrodynamics; are world experts in many-body theory which relates the properties of nuclei to the nucleon-nucleon interaction; apply our insights to problems in astrophysics such as the structure of the interior of neutron stars and the formation of black holes; and analyze heavy ion collisions by means of supersymmetric models that have a dual formulation in terms of classical gravity. Second, we analyze QCD as a quantum field theory from different perspectives and under different and extreme conditions. We are particularly interested in nonperturbative phenomena and answer questions such as: Why do nucleons exist? What are the properties of the vacuum? What is the phase of QCD at high temperature and baryon density? What are the properties of the quark-gluon plasma that is observed in high-energy nuclear collisions? Is QCD at high baryon density superconducting? The methods we use to answer these questions are from many areas of quantum field theory and statistical mechanics. Examples include the analysis of the statistical mechanics of instantons and monopoles, development of a semiclassical theory of high energy scattering, interpretation of gauge field fluctuations in terms of random matrix theory, finite temperature quantum field theory, and properties of QCD for a large number of colors. Our work has both benefited from and influenced large-scale Monte-Carlo simulations of lattice QCD by groups around the world.

**Theoretical Physics at the CNYITP**

Research at the C. N. Yang Institute for Theoretical Physics addresses varied topics of fundamental interest. The Institute provides students of the department the opportunity to carry on collaborative and independent research in a wide range of areas in theoretical physics. The currently known forces and particles of high-energy physics are referred to as the standard model, including electroweak interactions and the theory of the strong interactions, quantum chromodynamics (QCD). The leading questions of high-energy and elementary particle physics emerged from unanswered questions raised by the standard model. Among these are the origins of electroweak symmetry breaking and of the patterns of particle masses. QCD is a unique testing ground for quantum field theory because of its highly energy-dependent interactions. Recent and ongoing studies in particle physics include detailed phenomenological calculations and analyses of high-energy scattering experiments, and the development of improved theoretical methods for both quantum QCD (including nuclear scattering) and electroweak interactions. There is a tradition in the study of neutrinos, now including analyses of masses and mixing in the light of contemporary data.

Quantum field and string theories supply a language for the description of matter on the smallest scales. Supersymmetric and other field theoretic extensions of the standard model, supergravity (which was discovered at Stony Brook), and string theories are being studied and developed, with attention to both their mathematical structures and physical consequences. Of special interest are quantum mechanical descriptions of gravitation and its relations to other forces. Other directions of research involve the complementary descriptions of theories with weak and strong interactions, relying on modern techniques in mathematics, statistical mechanics, including exactly solvable models and quantum computing. Progress in statistical mechanics, string and field theory is facilitated by the many physical concepts and mathematical methods that they share. The broad range of topics and interests represented at the YITP encourages fruitful interactions with the nuclear and condensed matter theory groups, the high-energy and nuclear experimental groups, and other groups in the Departments of Physics and Astronomy, Mathematics, and Applied Mathematics.

**X-Ray Physics**

X rays have a wavelength short enough that one can produce a high-resolution focus, and probe the structure of materials at the atomic scale. The X-ray Optics and Microscopy group carries out research in developing high resolution x-ray optics (in partnership with the Center for Functional Nanomaterials at BNL), and using these optics for soft x-ray microscopy and spectroscopy studies of problems in biology and in environmental science (the latter as part of a Center for Environmental Molecular Science at Stony Brook). The group is also developing x-ray imaging beyond the resolution limit of lenses, by reconstructing diffraction data from non-crystalline specimens. Our research primarily makes use of the National Synchrotron Light Source at Brookhaven National Laboratory, but also synchrotron sources at Argonne National Laboratory and Lawrence Berkeley National Laboratory.

Doctoral Program with Concentration in Astronomy

The Department of Physics and Astronomy offers a Ph.D. degree with concentration in astronomy when the thesis work is carried out in the area of astronomy or astrophysics. The degree requirements are described below.

Doctoral Programs with Concentrations in Biophysics and Chemical Physics
The Department of Physics and Astronomy participates in two Ph.D. curricula in cooperation with other programs. The basic degree requirements for a student enrolled in one of these programs are the same as those for other students in physics. He or she will usually be advised to take one or more courses in the cooperating program. The written part of the preliminary (comprehensive) examination is the same as for other physics students; the oral part will ordinarily be on topics in biophysics or chemical physics. Subject to the approval of the chairpersons of the two programs involved, the student’s research advisor may be chosen from participating members of the cooperating programs.

A student in one of these programs who expects to receive a Ph.D. from a cooperating program should consult that program’s section in this Bulletin for degree requirements. The cooperating programs are Biophysics: Department of Pharmacological Sciences and Department of Physiology and Biophysics; and Chemical Physics: Department of Chemistry.

Admission requirements of Physics and Astronomy Department

For admission to graduate study in Physics and Astronomy the following, in addition to the minimum Graduate School requirements, are required:

A. A bachelor’s degree in physics or a closely related field from an accredited institution.

B. A minimum grade average of B in all undergraduate coursework, and B or better in the sciences and mathematics.

C. Submission of the Graduate Record Examination (GRE) General Test. Note that the Physics GRE subject test is also recommended.

D. For non-native speakers of English, submission of the TOEFL or IELTS test.

E. Admission by the Department of Physics and Astronomy and the Graduate School.

In special cases, a student not meeting requirement A (or, in unusual cases, requirement B) may be admitted on a provisional basis, without financial support. Upon admission, the student will be informed of the requirements that must be satisfied for termination of provisional status.

Retention of students in subsequent years will depend on satisfactory academic progress.

Physics and Astronomy Department

Physics research is conducted in the areas of particle, nuclear, condensed matter, mesoscopic, nanoscale, device, atomic, molecular and optical physics on campus and at research facilities elsewhere.

A number of institutes dedicated to specific fields offer a diverse spectrum of research opportunities. The C. N. Yang Institute for Theoretical Physics focuses on research in fundamental theory such as particle theory, neutrino physics, string theory, supersymmetry, and statistical mechanics. The Nuclear Theory Institute works on non-perturbative quantum chromodynamics, and the properties of hadronic matter under extreme conditions such as those created in the Relativistic Heavy Ion Collider at BNL. The new Simons Center for Geometry and Physics initiated by a significant private donation to the University offers research programs that are built on the historic close interaction between mathematicians and physicists at Stony Brook. It is housed in a new building that was completed in 2010.

Stony Brook co-manages nearby Brookhaven National Laboratory which conducts research in the physical, biomedical, and environmental sciences, as well as in climate and energy technologies. Brookhaven Lab also builds and operates major scientific facilities that include the Relativistic Heavy Ion Collider (RHIC), the Center for Functional Nanomaterials, the National Synchrotron Light Source (NSLS) and its successor now under construction, NSLS II, the Brookhaven Computational Science Center with the IBM BlueGene supercomputer. Stony Brook is the largest academic user of Laboratory facilities with over 600 faculty, staff, and students involved in collaborative research (see www.bnl.gov/bnlweb/sciindex.asp for more information). Our nuclear physics faculty is one of the leading groups at RHIC. Experimental condensed matter and X-ray physicists in our department play a leading role in NSLS, NSLS II and the Center for Functional Nanomaterials. Several of our colleagues are active in the interdisciplinary Stony Brook Center for Computational Science that uses the BlueGene supercomputer.

In addition to facilities at BNL, faculty and staff make use of many off-campus facilities including the Fermilab Tevatron Collider, the Large Hadron Collider at CERN, Argonne National Laboratory and Lawrence Berkeley National Laboratory.

The Department has a Tandem Van de Graaff accelerator that after 40 years of nuclear research is now being converted to educational, training, and accelerator R&D efforts. The Institute for Terrestrial and Planetary Atmospheres at the School of Marine and Atmospheric Sciences offers a program in atmospheric physics.

Astronomical research is conducted on both theoretical and observational topics. The group uses DOE supercomputing facilities as well as on-site Beowulf clusters for extensive simulations of astronomical objects and nuclear astrophysical processes.

Observational research focuses on topics in galactic and extragalactic star formation, substellar and stellar astrophysics, extrasolar planets, neutron stars, molecular clouds, and galaxy formation and evolution. Faculty and students are also frequent users of the National Optical Astronomy Observatories, the National Radio Astronomy Observatories, the observatories at Mauna Kea and the millimeter wave facilities at CARMA and Nobeyama observatories. They have also received extensive time on space-based observatories, including the Hubble Space Telescope, the Spitzer Space Telescope, the Herschel Space Observatory, and XMM-Newton.

Requirements for the M.A. Degree in Physics

1. Satisfactory performance in a program of studies (30 graduate credits) approved by the department. Normally such a program would include graduate seminars, classical mechanics, electrodynamics, and quantum mechanics.
2. Minimum grade point average of 3.0 in all graduate courses taken at Stony Brook.

3. Either passing the graduate comprehensive examination at the master’s level or completion of a master’s project.

Requirements for the M.S. Degree with Specialization in Scientific Instrumentation (MSI)

A candidate for the master’s degree with concentration in instrumentation will be required to demonstrate a certain level of knowledge of physics (by written and/or oral examination), to take required and elective courses, and to complete both a major and minor project. The curriculum is designed to meet the needs of students learning about the design, construction, and testing of sophisticated instrument systems. The degree holder will not be a super-technician, but a professional scientist trained in both physics and measurement techniques.

A. A student shall demonstrate proficiency in undergraduate physics at the level of the courses PHY 335 (Junior Laboratory I), 405 (Advanced Quantum Physics). Students need to have demonstrated knowledge in two of the three areas Nuclear and Particle Physics (covered in PHY 431), Condensed Matter Physics (PHY 472) and Laser and Atomic Physics (PHY 452). This can be done (1) by acceptance by the Master’s in Scientific Instrumentation Committee of courses taken as an undergraduate, (2) by written examination, or (3) by passing the courses appropriate to a student’s background;

B. A course about research instrumentation (PHY 514);

C. Two semesters each of graduate lab (PHY 515) and graduate seminar (PHY 598, PHY 599);

D. Students shall works as teaching assistant in an undergraduate laboratory for at least one semester (being a TA in PHY 445 may satisfy the requirement of taking the second semester of graduate lab (PHY 515));

E. Thirty credits (minimum) of graduate courses (500 level or above), including a minor project and a master’s thesis. This thesis must describe a major piece of work in scientific instrumentation and must be in a form acceptable to the Graduate School. It need not be original research in the same sense as a Ph.D. thesis, but it should be the result of an effort consistent with a year of full-time work. The thesis should present an improvement of the state of the art in some area, the development of a sophisticated apparatus, or some other significant laboratory project, and be defended before a committee;

F. Students shall acquire those technical skills deemed necessary by their thesis supervisors. These must include, but are not limited to, machining capability and computer literacy.

Each student will be assigned an advisory committee of three faculty members and will be required to meet frequently with them. It is expected that close communication among all the faculty and students involved will foster spirit, expose problems, and generally contribute to success.

For further information on this program, contact Professor Harold Metcalf.

Requirements for the Professional MSI Track

The only difference with the existing MSI program is that the minor project is replaced by a minimum of 9 credits of “Plus Courses” in Stony Brook’s College of Business, the School of Journalism or similar courses from a different program (subject to approval). The advisory committee will advise the student on which “Plus Courses” to take.

Requirements for the Ph.D. Degree in Physics

A. Completion of the following core courses with a grade of B or better: 501, 505, 511, 512, 540. A student can skip one or more of these courses by sufficiently good performance in the corresponding parts of a placement examination given at the beginning of each fall semester (2nd year and older students need permission from the Graduate Program Director). Students who took similar courses elsewhere can satisfy this requirement by taking advanced graduate courses (subject to approval by an Advising Committee appointed by the Graduate Program Director);

B. Completion of required courses: Each of the courses listed below must be passed with a minimum grade of B:

1. PHY 598 and PHY 599 Graduate Seminars. These courses are normally taken during the first year of graduate study, one per semester, in either order.

2. PHY 515 Methods of Experimental Research. This course must be taken not later than the fourth semester of residence. This requirement can also be satisfied by PHY 517, Laboratory Course in Astronomical Techniques.

3. Two advanced courses, each in an area outside that of the student’s thesis research, chosen from a list of courses approved for this purpose.

C. Passing of the written comprehensive examination. This is offered at the beginning of each semester and has comprehensive problems on astronomy, atomic physics, condensed matter physics, nuclear and particle physics, and there will be a balance between more experimentally and more theoretically focused problems. It must be passed in the student’s fourth semester of study at Stony Brook or earlier.

D. Passing an oral examination on a broad range of topics relevant to the student’s intended area of thesis research. The oral examination should be passed before the beginning of the fifth semester of residency.

E. Acceptance of graduate student by an advisor for thesis work;

F. Teaching experience at least equivalent to that obtained in a one-year appointment as a teaching assistant, usually carried out in the first year;
G. Advancement to candidacy for the Ph.D. The department’s recommendation to the Graduate School for advancement to candidacy is based on the satisfactory completion of all requirements listed above;

H. Research, dissertation, and passing the dissertation examination.

I. At least one year of residence.

Requirements for the Ph.D. Degree in Physics with Concentration in Astronomy

The requirements are the same except for B3. Instead the student shall take either four astronomy core courses or three astronomy core courses (PHY 521, PHY 522, PHY 523, PHY 524) and one of the advanced courses mentioned under B3. In addition, the thesis work should be in the area of Astronomy or Astrophysics.

Faculty of the Department of Physics and Astronomy

Einstein Professor
Yang, Chen Ning, Emeritus. Ph.D., 1948, University of Chicago: Theoretical physics; field theory; statistical mechanics; particle physics.

University Professor
Marburger, John H., Science Advisor to the President and Director of the Office of Science and Technology Policy. Ph.D., 1966, Stanford University: Laser theory.

Distinguished Professors
Brown, Gerald E., Emeritus, Ph.D., 1950, Yale University: Theoretical physics; the many-body problem.
Grannis, Paul D., Emeritus, Ph.D., 1965, University of California, Berkeley: Experimental high-energy physics.
Kirz, Janos, Emeritus, Ph.D., 1963, University of California, Berkeley: X-ray optics and microscopy; synchrotron radiation.
Likharev, Konstantin K., Emeritus, Ph.D., 1979, Moscow State University, Russia: Mesoscopic physics.
Shuryak, Edward, Ph.D., 1974, Institute of Nuclear Physics, Novosibirsk, Russia: Theoretical nuclear physics.
Sterman, George, Director of Yang Institute for Theoretical Physics. Ph.D., 1974, University of Maryland: Theoretical physics.
Van Nieuwenhuizen, Peter, Emeritus, Ph.D., 1971, University of Utrecht, Netherlands: Theoretical physics; quantum field theory.

Distinguished Service Professor
Paul, Peter, Emeritus, Ph.D., 1959, University of Freiburg, Germany: Experimental nuclear physics.

Distinguished Teaching Professors
Hemmick, Thomas, Ph.D., 1989, University of Rochester: Experimental nuclear physics; relativistic heavy ions.

Professors
Allen, Philip B., Ph.D., 1969, University of California, Berkeley: Theoretical condensed matter physics.
Aronson, Meigan, Ph.D., 1988, University of Illinois: Experimental condensed matter.
Averin, Dmitrii V., Ph.D., 1987, Moscow State University, Russia: Theoretical condensed matter physics.
Courant, Ernest D., Emeritus\textsuperscript{1}, Ph.D. 1943, University of Rochester: Theoretical physics; high-energy accelerator design.

DeZafra, Robert L., Emeritus, Ph.D., 1958, University of Maryland: Atmospheric sciences; remote sensing, stratospheric dynamics, and trace constituent measurements; millimeter-wave spectroscopy.

Dill, Ken, Ph.D., 1978, UCSD, La Jolla: Biophysics.

Douglas, Michael\textsuperscript{2}, Ph.D., 1988, California Institute of Technology: String Theory.

Drees, Klaus Axel, Ph.D., 1989, University of Heidelberg, Germany: Experimental nuclear physics; relativistic heavy ions.

Engelmann, Roderich, Ph.D., 1966, University of Heidelberg, Germany: Experimental high-energy physics.


Finocchiaro, Guido, Emeritus, Ph.D., 1957, University of Catania, Italy: Experimental high-energy physics.

Goldhaber, Alfred S.\textsuperscript{1}, Ph.D., 1964, Princeton University: Theoretical nuclear physics; particle physics.

Goldman, Vladimir J., Ph.D., 1985, University of Maryland: Experimental condensed matter physics.

Gurvitch, Michael, Ph.D., 1978, University at Stony Brook: Experimental condensed matter physics.


Jacobsen, Chris, Undergraduate Program Director. Ph.D., 1988, University at Stony Brook: X-ray microscopy and holography.

Jung, Chang Kee, Ph.D., 1986, Indiana University: Experimental high-energy physics.

Kahn, Peter B., Emeritus, Ph.D., 1960, Northwestern University: Theoretical physics; nonlinear dynamics.

Kharzeev, Ph.D., 1990, Moscow State University: Heavy ion physics and particle theory.

Koch, Peter M., Ph.D., 1974, Yale University: Experimental atomic physics; quantum chaos; nonlinear dynamics.

Korepin, Vladimir\textsuperscript{1}, Ph.D., 1977, Leningrad University, Russia: Theoretical physics.

Kuo, Thomas T.S., Ph.D., 1964, University of Pittsburgh: Nuclear theory.

Lanzetta, Kenneth M., Ph.D., 1988, University of Pittsburgh: Formation and evolution of galaxies; evolution of the intergalactic medium.

Lattimer, James M., Ph.D., 1976, University of Texas: Nuclear, neutrino and high-energy astrophysics; supernovae, neutron stars, dense matter; grain formation; isotopic anomalies in meteorites.


Lukens, James, Ph.D., 1968, University of California, San Diego: Experimental condensed matter physics.

Marx, Michael D., Vice President for Brookhave Affairs, Ph.D., 1974, Massachusetts Institute of Technology: Experimental high-energy physics.

McCarthy, Robert L., Ph.D., 1971, University of California, Berkeley: Experimental high-energy physics.

McGrath, Robert L., Emeritus, Ph.D., 1965, University of Iowa: Experimental nuclear physics.

Mendez, Emilio E., Director, Center for Functional Nanomaterials, BNL. Ph.D., 1979, Massachusetts Institute of Technology: Experimental condensed matter physics.

Mihaly, Laszlo, Chair of the Department, Ph.D., 1977, Eotvos Lorand University, Budapest, Hungary: Experimental condensed matter physics.

Rijssenbeek, Michael, Ph.D., 1979, University of Amsterdam, Netherlands: Experimental high-energy physics.

Rocek, Martin\textsuperscript{1}, Ph.D., 1979, Harvard University: Theoretical physics: supersymmetry and supergravity.

Shrock, Robert\textsuperscript{1}, Ph.D., 1975, Princeton University: Theoretical physics; gauge theories; statistical mechanics.

Siegel, Warren\textsuperscript{1}, Ph.D., 1977, University of California, Berkeley: Theoretical physics; strings.

Simon, Michal, Emeritus, and Research Professor, Ph.D., 1967, Cornell University: Infrared astronomy; physics of the interstellar medium; star formation; solar astronomy.
Smith, John 1, Emeritus, Ph.D., 1963, University of Edinburgh, Scotland: Theoretical physics; elementary particle physics.


Swartz, Clifford E., Emeritus, Ph.D., 1951, University of Rochester: Experimental high-energy physics; school curriculum revision.

Verbaarschot, Jacobus J.M., Graduate Program Director, Ph.D., 1982, University of Utrecht, Netherlands: Theoretical physics.

Walter, Fredrick M., Ph.D., 1981, University of California, Berkeley: Stellar astrophysics, including X-ray optical and infrared photometry and spectroscopy; RS CV objects; pre-main sequence objects.

Weisberger, William 1, Emeritus, Ph.D., 1961, MIT. Theoretical physics.

Yahil, Amos, Emeritus, Ph.D., 1970, California Institute of Technology: Galaxies; clusters of galaxies; physical cosmology; accretion processes; stellar collapse; supernovae; nuclear astrophysics.

Zahed, Ismail, Ph.D., 1983, Massachusetts Institute of Technology: Theoretical nuclear physics.

Associate Professors

Deshpande, Abhay, Ph.D., 1995, Yale University: Nucleon spin and heavy ion physics.

Gonzalez-Garcia, Concha 1, Ph.D., 1991, Universidad de Valencia, Spain: Theoretical Elementary Particle Physics


Peterson, Deane M., Ph.D., 1968, Harvard University: Stellar atmospheres; radiative transfer; optical interferometry, stellar imaging.

Schneble, Dominik A., Ph.D., 2002, University of Konstanz: Experimental atomic physics, ultracold quantum gases.

Weinacht, Thomas, Ph.D., 2000, University of Michigan: Quantum Optics and Atomic Physics.

Assistant Professors
Calder, Alan, Ph.D., 1997, Vanderbilt University: Observational Astronomy


Deshpande, Abhay, Ph.D., 1995, Yale University: Nucleon spin and heavy ion physics.

Dmitri Tsybychev, Ph.D., 2004 University of Florida: Experimental high-energy physics.


Essig, Rouven, Ph.D., 2008, Rutgers University: Theoretical particle physics.

Fernandez-Serra, Maria, Ph.d., 2005, Cambridge University: Theoretical condensed matter physics.


Joanna Kiryluk, Ph.D., 2000, University of Warsaw: Neutrino physics.


Patrick Meade, Ph.D., 2006, Cornell University: phenomenological and theoretical explorations of the terascale. theoretical physics

Sehgal, Neelima, Ph.D., 2008, Rutgers University: Galaxies and cosmology.


Teaney, Derek. Ph.D., 2001 Stony Brook University: Nuclear theory.

Wei, Tzu-Chieh, Ph.D., 2005,University of Illinois, Urbana: Theoretical Particle physics.
Weinacht, Thomas, Ph.D., 2000, University of Michigan: Quantum Optics and Atomic Physics.
Zingale, Michael A., Ph.D., 2000, University of Chicago: Computational astrophysics.

Research Faculty
Patel, Vijay, Ph.D., 2001 Stony Brook University: Experimental condensed matter physics.
Semenov, Vassili, Ph.D., 1975, Moscow State University, Russia: Experimental condensed matter physics.
Swesty, Douglas F., Ph.D., 1993 University at Stony Brook: Computational and nuclear astrophysics.
Yanagisawa, Chiaki, Ph.D. 1981, University of Tokyo, Japan: Experimental high energy physics.

Adjunct Faculty
Aronson, Samuel, Director of Brookhaven National Laboratory, Ph.D, 1968, Princeton University: Experimental nuclear physics
Ben-Zvi, Ilan, Ph.D., 1967, Weizmann Institute, Israel: Accelerator and beam physics.
Creutz, Michael¹, Ph.D., 1970, Stanford University, Lattice gauge theory.
Cunsolo, Alesandro, Ph.D., 1999, University of Grenoble: Condensed matter physics.
Dawson, Sally¹, Ph.D., 1981, Harvard University, High energy theory.
DiMauro, Louis, Ph.D., Experimental atomic physics.
Dierker, Steven, Ph.D., 1983, University of Illinois: Experimental solid state physics.
Evans, Aaron, Ph.D., 1996, University Of Hawaii: Astronomy.
Forman, Miriam, Ph.D., 1972, University at Stony Brook: Cosmic rays.
Geller, Marvin, Ph.D., 1969, Massachusetts Institute of Technology: Atmospheric physics.
Hao, Yue, Ph.D., 2008, Indiana University: Accelerator physics.
Johnson, Peter, Ph.D., 1978, Warwick University: Experimental solid state physics.
Kao, Chi-Chang, Ph.D. 1988, Cornell University: Condensed matter physics.
Karsch, Frithjof, Ph.D. 1982, University of Bielefeld: Lattice QCD.
Ku, Wei, Ph.D., 2000, University of Tennessee: Theoretical condensed matter physics.
Litvinenko, Vladimir, Ph.D. 1989, Institute of Nuclear Physics, Novosibirsk, Russia: Accelerator physics and free electron lasers.
Maslov, Sergei, Ph.D., 1996, Stony Brook University: Theoretical condensed matter physics.
Ben Ocko, Ph.D., MIT, 1984: Experimental condensed matter.
Peggs, Steven, Ph.D., 1981, Cornell University: Accelerator physics.
Petrovic, Cedomir, Ph.D., 2000, Florida State University: Condensed matter physics.
Sayre, David, Ph.D., 1951, Oxford University: X-ray physics.
Sivaramakrishnan, Anand, Ph.D., 1983, University of Texas at Austin: Astrophysics.
Spira, Robert, Physics high school teacher.
Tsoukas, Nicholas, Ph.D., 1975, Ohio State University: Accelerator physics.

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Raju Venugopalan, Ph.D., Stony Brook University: Nuclear theory.

Vogelsang, Werner\textsuperscript{1}, Ph.D., 1993, University of Dortmund: Theory YITP.

Zhu, Yimei, Ph.D., 1987, Nagoya University: Condensed matter physics.

**Affiliated Faculty**


1) Member, C.N. Yang Institute for Theoretical Physics

2) Member, Simons Institute for Geometry and Physics

Number of teaching, graduate, and research assistants, fall 2009: 172

*NOTE: The course descriptions for this program can be found in the corresponding program PDF or at COURSE SEARCH.*