

UNIVERSITY OF PITTSBURGH

DEPARTMENT OF PHYSICS AND ASTRONOMY

Pittsburgh, Pennsylvania 15260

<http://www.physicsandastronomy.pitt.edu>

General University Information

Chancellor: Patrick D. Gallagher
Dean of Graduate School: Kathleen Blee
University website: <http://www.pitt.edu>
School Type: Public
Setting: Urban
Total Faculty: 5,074
Total Graduate Faculty: 1,479
Total number of Students: 19,326
Total number of Graduate Students: 7,098

Department Information

Department Chair: Prof. Arthur Kosowsky, Chair
Department Contact: Ayres Freitas, Director of Graduate Studies
Total full-time faculty: 38
Total number of full-time equivalent positions: 58
Full-Time Graduate Students: 129
Female Full-Time Graduate Students: 37
First-Year Graduate Students: 29
Female First-Year Students: 5
Total Post Doctorates: 25

Department Address

3941 O'Hara Street
Room 100 Allen Hall
Pittsburgh, PA 15260
Phone: (412) 624-9060
Fax: (412) 624-9163
E-mail: pagrad@pitt.edu
Website: <http://www.physicsandastronomy.pitt.edu>

ADMISSIONS

Admission Contact Information

Address admission inquiries to: Graduate Admissions Administrator, Department of Physics and Astronomy, 3941 O'Hara Street, Rm. 100 Allen Hall, University of Pittsburgh, Pittsburgh, PA 15260
Phone: (412) 624-9066
E-mail: pagrad@pitt.edu
Admissions website: <http://www.physicsandastronomy.pitt.edu/graduate/how-apply>

Application deadlines

Fall admission:
U.S. students: January 7 *Int'l. students:* January 7

Application fee

Int'l. students: \$50
Application fee is waived for domestic students, veterans, those serving in the US Armed Services, Gates Millennium Scholars Program, McNair Scholars, and the Society for Advancement of Chicanos & Native Americans. See department's FAQ ; Late applications and supporting materials are accepted on the basis of space availability. No online applications for fall term permitted beyond March 31st.

Admissions information

For Fall of 2019:
Number of applicants: 365
Number admitted: 85

Number enrolled: 27

Admission requirements

Bachelor's degree requirements: Bachelor's degree in one of the physical sciences, mathematics, astronomy/astrophysics or engineering with relevant physics courses is required. Research experience is recommended but not required.

GRE requirements

The GRE is not required.
General GREs are optional. If you believe that these scores will strengthen your application, you are invited to provide them. Conversely, the absence of any of these scores will not adversely impact your materials for the review process. University of Pittsburgh GRE school code is 2927; Department code for Physics and Astronomy is 0808

GRE Physics requirements

The GRE Physics is not required.
GRE Physics score is optional. If you believe that this score will strengthen your application, you are invited to provide it. Conversely, the absence of this score will not adversely impact your materials for the review process. University of Pittsburgh GRE school code is 2927; Department code for Physics and Astronomy is 0808

TOEFL requirements

The TOEFL exam is required for students from non-English-speaking countries.
Minimum accepted TOEFL scores:
iBT score: 90

For the TOEFL a required score of 90 (with at least a score of 22 in all of the four sections of speaking, reading, listening, writing. Alternatively, IELTS minimum score is 7, with at least a 6.5 score in each of its four sections. Exceptions have been made for applicants with one component below the minimum required. International students admitted to the University are required to take an English Language Proficiency Test during orientation if they scored below 100 on the TOEFL or Band 7 on the IELTS. Academic departments also may ask students with higher scores to take the test. Other exceptions are listed here: http://www.oafa.pitt.edu/TOEFL_exceptions.html. Refer to the department's FAQ page for useful information.

Other admissions information

Additional requirements: CV, personal statement details (such as identifying faculty of interest, textbooks used, and useful information, visit departments graduate web pages How to Apply, Application Details, and FAQ.
International Students
visit <http://www.ois.pitt.edu/>.
Undergraduate preparation assumed: Minimum GPA for admission with full status is 3.0 on a 4.0 scale (refer to department's graduate website - information Frequently Asked Questions.

TUITION AND ASSISTANTSHIPS

Teaching Assistants, Research Assistants, and Fellowships

Number of first-year
Teaching Assistants: 17
Fellowship students: 10
Average stipend per academic year

Teaching Assistant: \$29,220
 Research Assistant: \$29,220
 Fellowship student: \$33,400

All newly admitted doctoral students receive funding support in the form of TA, GSR, or Fellowship. Several students arrange to begin in preceding summer as GSR. Important to note that our fellowship offers exceed the number that show as accepting.

Tuition year 2019–20:

Tuition for in-state residents
 Full-time students: \$11,765 per semester
 Part-time students: \$947 per credit
 Tuition for out-of-state residents
 Full-time students: \$19,949 per semester
 Part-time students: \$1,630 per credit

Fees, not reflected in the current tuition rates above, are per semester (term) and subject to change. Nine to 15 credits are covered under full tuition.

Deferred tuition plan: Yes
 Health insurance: \$0 if eligible graduate student academic appointment
 Other academic fees: Mandatory fees per term: Full-time \$475. Part-time \$295. Breakdown per term: Wellness—\$180 (full-time)/\$90 (part-time), Activities—\$30 (full-time)/\$15 (part-time), Computing & Network Services—\$175 (full-time)/\$100 (part-time), Security, Safety & Transportation—\$90 (full-time and part-time)
 Academic term: Semester
 Number of first-year students who received full tuition waivers: 27

FINANCIAL AID

Application deadlines

Fall admission:
 U.S. students: January 7 Int'l. students: January 7

Loans

Loans are available for U.S. students.
 Loans are not available for international students.
 GAPSFAS application required: No
 FAFSA application required: No

For further information

Address financial aid inquiries to: In reference to loan information only., Financial Aid Office, 4227 Fifth Avenue, Alumni Hall, University of Pittsburgh, Pittsburgh, PA 15260. Otherwise, please see the link to the Department's Graduate Program on the Department's web site.
 Phone: (412) 624-7488
 E-mail: oafa@pitt.edu
 Financial aid website: <http://www.oafa.pitt.edu/fahome.aspx>

HOUSING

Availability of on-campus housing

Single students: No
 Married students: No
 Childcare Assistance: Yes

For further information

Address housing inquiries to: (For Off Campus), Off-Campus Living, 204 Brakenridge Hall, Pittsburgh, PA 15213., (For On Campus), Panther Central, Litchfield Towers Lobby, 412-648-1100, pc@bc.pitt.edu.
 Phone: (412) 624-6998
 E-mail: ocl@bc.pitt.edu
 Housing aid website: <http://www.ocl.pitt.edu/>

Table A—Faculty, Enrollments, and Degrees Granted

Research Specialty	2018–19 Faculty	Enrollment 2018		Number of Degrees Granted 2018–19 (2014–18)		
		Master's	Doctorate	Master's	Terminal Master's	Doctorate
Astrophysics	10	–	24	–	–	5(19)
Condensed Matter						
Physics	15	–	55	–	–	9(46)
Particles and Fields	12	–	28	–	–	4(24)
Physics and other						
Science Education	5	–	6	–	–	2(4)
Total	42	–	113	–(49)	–	20(93)
Full-time Grad. Stud.	–	–	113	–	–	–
First-year Grad. Stud.	–	–	20	–	–	–

GRADUATE DEGREE REQUIREMENTS

Master's: Candidates for the M.S. degree must satisfy the preliminary evaluation, which requires the successful completion of at least one course in each of the following core subjects: Dynamical Systems, Statistical Mechanics and Thermodynamics, Electricity and Magnetism, and Quantum Mechanics, with a final examination score of at least 50% for courses at the graduate level or 75% for courses at the advanced undergraduate level. A minimum of 30 credits (3.0 GPA) is required for the MS for both the thesis and non-thesis option. M.S. candidates may elect one of three alternative options to earn the degree: (1) Submit a thesis and complete at least six courses. Four courses must be at the 2000-level each with a grade of B or better. Courses needed to accrue the necessary credit hours may include up to four 1300-level undergraduate classes and/or any number of 3000-level advanced graduate courses. (2) Submit no thesis and complete at least eight courses. Four courses must be at the 2000-level each with a grade of B or better. Courses needed to accrue the necessary credit hours may include no more than four 1300-level undergraduate classes and/or any number of 3000-level advanced graduate courses. (3) Submit no thesis and successfully complete at least six courses at the graduate level. In order to accrue the requisite 30 credits for graduation, the student may engage in Directed Study, directed Research, or take additional, approved courses at the 3000-level. There is no foreign language requirement.

Doctorate: Ph.D. students must successfully complete the following six graduate-level core courses: Dynamical Systems (one term), Statistical Mechanics and Thermodynamics (one term), Classical Electricity and Magnetism (one term), Mathematical Methods (one term), and Non-relativistic Quantum Mechanics (two terms). Exemptions from any of these courses may be granted if a student has successfully completed an equivalent course elsewhere. Students must complete these core courses with a grade point average of at least 3.00, which corresponds to a B average; they must also maintain a GPA of at least 3.00 in all of their graduate courses. To satisfy the Ph.D. Comprehensive Examination requirement, students must achieve a score of at least 60% on the final examination in each of the six core courses. This requirement must be fulfilled within the first two years unless an extension is granted. After passing the Ph.D. Comprehensive Examination, the student must find a research advisor and begin the process that leads to Admission to Candidacy and ultimately to the preparation and defense of a satisfactory dissertation. All Ph.D. students are required to serve for two terms as a Teaching Assistant in introductory undergraduate laboratories or recitations. An exemption may be granted if a student has sub-

stantial prior teaching experience. A minimum of four advanced physics courses are required, exemptions may be given if evidence of this done at another institution. There is no foreign language requirement. There is a residence requirement of six full terms, with a total of 72 credit hours. Under some circumstances prior graduate work may be transferred from another institution. A PhD timeline is available at <http://www.physicsandastronomy.pitt.edu/graduate/phd-program/phd-milestones>.

Other Degrees: Interdisciplinary research programs may be arranged on a case-by-case basis. There have been Physics Doctorates awarded for work done in collaboration with the faculty members in the Chemistry Department, the Mathematics Department, the Materials Science Department, the Electrical and Chemical Engineering Departments, the Department of Biological Sciences, the Department of Computational Biology and the Department of Radiology in the School of Medicine, among others.

SPECIAL EQUIPMENT, FACILITIES, OR PROGRAMS

The Department of Physics and Astronomy is located on the University of Pittsburgh’s main campus and housed in a complex of four interconnecting buildings, containing educational facilities and numerous cutting-edge research laboratories. The department also houses a number of cross-disciplinary centers including the PITTsburgh Particle physics, Astrophysics, and Cosmology Center (PITT PACC), the Discipline-Based Science Education Research Center (dB-SERC) and Pittsburgh Quantum Institute (PQI). The department also has access to a number of facilities including machine, electric, and glass shops, the Nano Fabrication and Characterization Facility (NFCF), the Center for Ressearch Computing (CRC), and the Pittsburgh Supercomputing Center (PSC), and historic Allegheny Observatory (AO).

Department members work on particle physics experiments at national and international facilities, including ATLAS at the Large Hadron Collider in Geneva, Switzerland (<https://atlas.cern>), MINERvA at Fermilab near Chicago (<https://minerva.fnal.gov>), and T2K (<https://t2k-experiment.org>) and Belle II (<https://www.belle2.org/>) in Japan.

In astrophysics, Pitt faculty members have leading roles in a range of current and upcoming survey projects, including the Sloan Digital Sky Survey (<http://www.sdss.org>), the Large Synoptic Survey Telescope (<http://www.lsst.org>), the Atacama Cosmology Telescope (<https://act.princeton.edu>), the Simons Observatory (<https://simonsobservatory.org>), and the Dark Energy Spectroscopic Instrument (<https://www.desi.lbl.gov>).

Table B—Separately Budgeted Research Expenditures by Source of Support

Source of Support	Departmental Research	Physics-related Research Outside Department
Federal government		\$7,578,296.2
State/local government		
Non-profit organizations		\$217,487.49
Business and industry		
Other	\$68,067.67	
Total	\$68,067.67	\$7,795,783.69

Table C—Separately Budgeted Research Expenditures by Research Specialty

Research Specialty	No. of Grants	Expenditures (\$)
Astrophysics	26	\$728,318.38
Condensed Matter Physics	37	\$4,928,723.23
Particles and Fields	5	\$163,144.02
Other	23	\$1,975,598.06
Total	91	\$7,795,783.69

FACULTY

Professor

- Boudreau, Joseph, Ph.D.,** University of Wisconsin-Madison, 1991. *High Energy Physics, Particles and Fields*. Experimental particle physics.
- Boyanovsky, Daniel, Ph.D.,** University of California, Santa Barbara, 1982. *Cosmology & String Theory, Particles and Fields, Relativity & Gravitation, Statistical & Thermal Physics*. Theoretical condensed matter physics; particle astrophysics, astrophysics, and cosmology.
- Coalson, Rob, Ph.D.,** Harvard University, 1984. *Chemical Physics*.
- Dytman, Steven A., Ph.D.,** Carnegie Mellon University, 1978. *High Energy Physics, Particles and Fields*. Experimental particle physics; experimental neutrino physics.
- Han, Tao, Ph.D.,** University of Wisconsin-Madison, 1990. Director of the PITTsburgh Particle physics, Astrophysics and Cosmology Center (PITT PACC). *Particles and Fields*. Theoretical particle physics.
- Hillier, D. John, Ph.D.,** Australian National University, 1984. *Astrophysics, Computational Physics*. Theoretical and observational astrophysics.
- Kosowsky, Arthur, Ph.D.,** University of Chicago, 1994. Professor and Department Chair. *Astrophysics, Cosmology & String Theory, Relativity & Gravitation*. Theoretical and experimental cosmology and astrophysics. Interim Chair of the Department.
- Leibovich, Adam, Ph.D.,** California Institute of Technology, 1997. Associate Dean for Faculty Recruitment and Research Development. *High Energy Physics, Particles and Fields, Relativity & Gravitation*. Theoretical particle physics.
- Levy, Jeremy, Ph.D.,** University of California, Santa Barbara, 1993. Director of the Pittsburgh Quantum Institute (PQI). *Applied Physics, Condensed Matter Physics, Low Temperature Physics, Materials Science, Metallurgy, Nano Science and Technology, Optics*. Experimental condensed matter physics; nanoscience; quantum information.
- Liu, W. Vincent, Ph.D.,** University of Texas, Austin, 1999. *Condensed Matter Physics, Low Temperature Physics*. Theoretical condensed matter physics, cold atoms.
- Mueller, James A., Ph.D.,** Cornell University, 1989. *High Energy Physics, Particles and Fields*. Experimental particle physics.
- Naples, Donna, Ph.D.,** University of Maryland, 1993. *Particles and Fields*. Experimental neutrino physics.
- Newman, Jeffrey, Ph.D.,** University of California, Berkeley, 2000. *Astronomy, Astrophysics, Cosmology & String Theory*. Extragalactic astronomy; observational cosmology.
- Paolone, Vittorio, Ph.D.,** University of California, Davis, 1990. *Particles and Fields*. Experimental particle physics; experimental neutrino physics.
- Petek, Hrvoje, Ph.D.,** University of California, Berkeley, 1985. *Atomic, Molecular, & Optical Physics, Chemical Physics, Condensed Matter Physics, Nano Science and Technology*.

Experimental condensed matter/AMO physics; nanoscience; solid-state physics.

- Roskies**, Ralph Z., Ph.D., Princeton University, 1966. Co-Director of the Pittsburgh Supercomputing Center. *Computational Physics, High Energy Physics, Particles and Fields*. Theoretical particle physics; use of computers in theoretical physics.
- Savinov**, Vladimir, Ph.D., University of Minnesota, 1996. *High Energy Physics, Particles and Fields*. Experimental particle physics.
- Singh**, Chandralekha, Ph.D., University of California, Santa Barbara, 1993. Director of the Discipline-based Science Education Research Center (dB-SERC). *Physics and other Science Education*. Polymer physics; physics education research.
- Snoke**, David W., Ph.D., University of Illinois, 1990. *Applied Physics, Atomic, Molecular, & Optical Physics, Biophysics, Condensed Matter Physics, Low Temperature Physics, Nano Science and Technology, Optics, Statistical & Thermal Physics*. Experimental condensed matter physics; solid-state physics; nanoscience.
- Swanson**, Eric, Ph.D., University of Toronto, 1991. *Particles and Fields*. Theoretical particle physics.
- Turnshek**, David A., Ph.D., University of Arizona, 1981. Director of Allegheny Observatory. *Astronomy, Astrophysics*. Extragalactic astronomy; observational cosmology.
- Wu**, Xiao-Lun, Ph.D., Cornell University, 1987. *Biophysics*. Experimental condensed matter physics, experimental biological physics.
- Xu**, Yan, Ph.D., Stony Brook, 1990. *Biophysics*. Biophysics.
- Yang**, Judith, Ph.D., Cornell University, 1993. *Materials Science, Metallurgy*. Materials science and engineering.
- Zentner**, Andrew, Ph.D., Ohio State University, 2003. Director of the Graduate Program. *Astronomy, Astrophysics, Cosmology & String Theory, Particles and Fields, Relativity & Gravitation*. Theoretical cosmology.

Associate Professor

- Badenes**, Carles, Ph.D., Universitat Politecnica de Catalunya, 2004. *Astronomy, Astrophysics, Cosmology & String Theory*. Type 1a supernovae; supernova remnants; large astronomical data bases; extragalactic astronomy; observational cosmology.
- Devaty**, Robert P., Ph.D., Cornell University, 1983. Chair of the Graduate Admissions Committee. *Condensed Matter Physics*. Solid-state physics; semiconductor physics.
- Dutt**, Gurudev, Ph.D., University of Michigan, 2004. *Condensed Matter Physics, Nano Science and Technology*. Quantum optics; quantum information.
- Freitas**, Ayres, Ph.D., University of Hamburg, 2002. *Cosmology & String Theory, High Energy Physics, Particles and Fields*. Theoretical particle physics.
- Salman**, Hanna, Ph.D., Weizmann Institute of Science, 2002. *Applied Physics, Biophysics, Condensed Matter Physics, Nonlinear Dynamics and Complex Systems, Statistical & Thermal Physics*. Experimental biological physics.
- Wood-Vasey**, Michael, Ph.D., University of California, Berkeley, 2004. Undergraduate Program Director. *Astronomy, Astrophysics, Cosmology & String Theory*. Extragalactic astronomy; observational cosmology.

Assistant Professor

- Batell**, Brian, Ph.D., University of Minnesota, 2008. *Particles and Fields, Relativity & Gravitation, Theoretical Physics*. Particle physics, astroparticle physics and cosmology.
- Bezanson**, Rachel, Ph.D., Yale University, 2013. *Astrophysics*.
- Frolov**, Sergey, Ph.D., University of Illinois, 2005. *Condensed Matter Physics, Nano Science and Technology*. Experimental

condensed matter physics; quantum nanowires, Majorana fermions in nanowires, and nanowire quantum bits.

- Hatridge**, Michael, Ph.D., University of California, Berkeley, 2010. *Condensed Matter Physics*.
- Hong**, Tae Min, Ph.D., University of California, Santa Barbara, 2009. *Particles and Fields*. He is an experimental particle physicist interested in questions related to the fundamental forces of Nature and the basic building blocks of the Universe [1]. Professor Hong is currently studying proton-proton collisions produced by the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN) in Geneva, Switzerland. As a member of the ATLAS Collaboration of about 3000 physicists, his significant contributions are in the trigger system and the discovery of the Higgs boson.
- Lee**, Sangyeop, Ph.D., MIT. Mechanical Engineering and Material Science.
- Mong**, Roger, Ph.D., University of California, Berkeley, 2012. *Condensed Matter Physics, Low Temperature Physics, Quantum Foundations, Solid State Physics, Theoretical Physics*. Theoretical condensed matter.
- Pekker**, David, Ph.D., Illinois at Urbana-Champaign. *Atomic, Molecular, & Optical Physics, Computational Physics, Condensed Matter Physics*.
- Purdy**, Thomas, M.D./Ph.D., University of California, Berkeley. *Condensed Matter Physics*.

Emeritus

- Duncan**, H. E. Anthony, Ph.D., Massachusetts Institute of Technology, 1975. *High Energy Physics, Particles and Fields*. Theoretical particle physics.
- Engels**, Eugene, Ph.D., Princeton University, 1962. *High Energy Physics*. Experimental particle physics.
- Janis**, Allen I., Ph.D., Syracuse University, 1957. *Relativity & Gravitation, Other*. History and philosophy of science.
- Jasnow**, David M., Ph.D., University of Illinois, 1969. *Biophysics, Condensed Matter Physics, Fluids, Rheology, Nonlinear Dynamics and Complex Systems, Polymer Physics/Science, Statistical & Thermal Physics*. Theory of phase transitions; statistical physics; biological physics.
- Johnsen**, Rainer, Ph.D., University of Kiel, 1966. *Atmosphere, Space Physics, Cosmic Rays, Atomic, Molecular, & Optical Physics, Chemical Physics, Fluids, Rheology, Plasma and Fusion*.
- Koehler**, Peter F. M., Ph.D., University of Rochester, 1967. Academic Assistant to the Dean, University Honors College. *High Energy Physics, Particles and Fields, Physics and other Science Education*. Experimental particle physics; physics education research.
- Newman**, Ezra T., Ph.D., Syracuse University, 1956. *Relativity & Gravitation*.
- Pratt**, Richard H., Ph.D., University of Chicago, 1959. *Atomic, Molecular, & Optical Physics*. Theoretical atomic physics.
- Shepard**, Paul, Ph.D., Princeton University, 1969. *High Energy Physics, Particles and Fields*. Experimental particle physics.
- Vincent**, C. Martin, Ph.D., University of the Witwatersrand, South Africa, 1966. *Nuclear Physics*.

Professor Emeritus

- Maher**, James V., Ph.D., Yale University, 1969. *Condensed Matter Physics, Statistical & Thermal Physics*. Experimental solid-state physics; critical phenomena; physics of fluids.
- Schulte-Ladbeck**, Regina, Ph.D., Heidelberg University, 1985. *Astronomy, Astrophysics, Cosmology & String Theory*. Extragalactic astronomy; observational cosmology.

Research Professor

- Choyke**, W. James, Ph.D., Ohio State University, 1952. *Condensed Matter Physics*. Experimental solid-state physics; defect states in semiconductors; large-band-gap spectroscopy.

Rao, Sandhya, Ph.D., University of Pittsburgh, 1994. *Astronomy, Astrophysics, Cosmology & String Theory*. Extragalactic astronomy, observational cosmology.

Winicour, Jefferey, Ph.D., Syracuse University, 1964. *Astrophysics, Relativity & Gravitation*. General relativity; numerical relativity.

Research Associate Professor

Niedermaier, Max, Ph.D., University of Hamburg. *Particles and Fields*.

Research Assistant Professor

Andrews, Brett, Ph.D., Ohio State, 2014. *Astrophysics*.

Irvin, Patrick, Ph.D., University of Pittsburgh, 2009. *Condensed Matter Physics*. Experimental condensed matter physics.

Adjunct Professor

Cheng, Guanglei, Ph.D., University of Pittsburgh, 2011. *Condensed Matter Physics*. Experimental condensed matter physics.

Feng, Min, Ph.D., Chinese Academy of Sciences, 2005. *Condensed Matter Physics*. Experimental condensed matter physics.

Tan, Shijing, Ph.D., University of Science and Technology of China. *Condensed Matter Physics*.

Zhao, Jin, Ph.D., University of Science and Technology of China, 2003. *Condensed Matter Physics, Nano Science and Technology*.

Adjunct Assistant Professor

Cui, Xuefeng, Ph.D., Univ. of Science & Technology of China, 2009. *Condensed Matter Physics*.

Ozden, Burcu, Ph.D., Auburn University, 2016. *Condensed Matter Physics*.

Senior Lecturer

Clark, Russell, Ph.D., Louisiana State University, 1997. Lab Supervisor. *Physics and other Science Education*. Neutrino physics.

Lecturer

Broccio, Matteo, Ph.D., University of Messina, 2005. *Biophysics, Physics and other Science Education*. Physics education, experimental biophysics.

Good, Melanie, Ph.D., University of Pittsburgh, 2018. *Physics and other Science Education*.

Nero, David, Ph.D., University of Toledo, 2010. *Astronomy, Physics and other Science Education*.

Lab Personnel

Danko, Istvan, Ph.D., Vanderbilt University, 2001. *Particles and Fields*. Experimental neutrino physics.

Other

Turnshek, Diane, M.S., University of Arizona. *Astronomy*.

DEPARTMENTAL RESEARCH SPECIALTIES AND STAFF

Theoretical

Astrophysics. Astrophysics and cosmology. Early universe physics; dark matter and dark energy; theoretical and numerical cosmology; model stellar atmospheres; massive stars; su-

pernovae; gravitational lensing; general relativity and gravitation; numerical relativity; gravitational radiation; black hole physics; plasma physics. Andrews, Boyanovsky, Hillier, Kosowsky, Ezra Newman, Winicour, Zentner.

Condensed Matter Physics. Phase transitions; disordered systems; nonequilibrium behavior; polymer physics; biological physics; atomic cold gases; superconductivity; topological insulators and superconductors, fractional quantum Hall; quantum kinetics, atomic, molecular, and optical physics. Boyanovsky, Coalson, Jasnow, Liu, Mong, Pekker, Zhao.

Particles and Fields. Gauge field theories; lattice calculations; nonperturbative effects; weak interaction models and phenomenology; heavy-quark physics; supersymmetry; QCD modeling; extra dimensions; baryogenesis. Batell, Boyanovsky, Duncan, Freitas, Han, Leibovich, Roskies, Swanson.

Experimental

Astrophysics. Astronomy, Astrophysics, and Cosmology. Local and distant galaxies; active galactic nuclei and quasars; studies of the interstellar medium, circumgalactic medium, and intergalactic medium using quasar absorption line systems; statistical analysis of the properties of galaxies; clustering and large-scale structure; dark matter and dark energy; cosmic microwave background; supernovae; massive stars; stellar atmospheres. Observations take place with ground-based telescopes around the world and with space telescopes. Badenes, Bezanson, Jeffrey Newman, Rao, David Turnshek, Wood-Vasey.

Condensed Matter Physics. Nanoscience; quantum information; quantum optics; quantum states of matter; semiconductor physics; soft condensed matter physics; superconductivity and superfluidity; ultrafast optics; atomic, molecular, and optical physics; biological physics; turbulence. Experimental work takes place on campus in the individual laboratories of faculty members, at the Peterson Institute for Nanoscience and Engineering (PINSE), and at the Nano Fabrication and Characterization Facility (NFCF). Choyke, Devaty, Dutt, Feng, Frolov, Hatridge, Irvin, Johnsen, Levy, Maher, Petek, Salman, Snoke, Wu, Yang.

Particles and Fields. Particle Physics. Origin of mass and flavor; search for new symmetries of nature; neutrino physics; CP violation; heavy quarks; leptiquarks; supersymmetry; extra dimensions; baryogenesis. Studies take place at the Tevatron proton-antiproton collider, located at the Fermi National Accelerator Laboratory, and at the Large Hadron Collider ATLAS detector, located at CERN. Studies at the LHC may uncover the elusive Higgs boson as well as a spectrum of new particles arising from "supersymmetry." Studies of fundamental properties of neutrinos, such as oscillations, mass differences, and neutrino-nucleus interactions take place at a variety of locations. Boudreau, Danko, Dytman, Hong, Mueller, Naples, Paolone, Savinov, Shepard.

Physics and other Science Education. Physics education research. Identification of sources of student difficulties in learning concepts in both introductory and advanced-level physics courses; design, implementation, and outcome assessment of changes in curricular offerings; pedagogical methods that are designed to reduce learning difficulties. Broccio, Clark, Danko, Good, Koehler, Nero, Singh.