# PHYSICS

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http://physics.yale.edu
M.Phil., Ph.D.

**Chair**
Karsten Heeger

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**Professors** Charles Ahn (*Applied Physics*), Yoram Alhassid, Thomas Appelquist, Charles Bailyn (*Astronomy*), O. Keith Baker, Charles Baltay (*Emeritus*), Sean Barrett, Joerg Bewersdorf (*Cell Biology*), Helen Caines, Hui Cao (*Applied Physics*), Richard Casten (*Emeritus*), Flavio Cavanna (*Adjunct*), Paolo Coppi (*Astronomy*), Sarah Demers, Thierry Emonet (*Molecular, Cellular, and Developmental Biology*), Paul Fleury (*Emeritus*), Marla Geha (*Astronomy*), Steven Girvin, Larry Gladney, Leonid Glazman, Walter Goldberger, Jack Harris, John Harris (*Emeritus*), Karsten Heeger, Victor Henrich (*Emeritus*), Jonathon Howard (*Molecular Biophysics and Biochemistry*), Francesco Iachello (*Emeritus*), Sohrab Ismaill-Beigi (*Applied Physics*), Steve Lamoreaux, Konrad Lehnert, Andre Levchenko (*Biomedical Engineering*), Reina Maruyama, Simon Mochrie, Vincent Moncrief, Daisuke Nagai, Priyamvada Natarajan (*Astronomy*), Andrew Neitzke (*Mathematics*), Corey O'Hern (*Mechanical Engineering and Materials Science*), Vidvus Ozolins (*Applied Physics*), Ornella Palamara (*Adjunct*), Peter Parker (*Emeritus*), Daniel Prober (*Applied Physics*), Nicholas Read, Robert Schoelkopf (*Applied Physics*), John Schotland (*Mathematics*), Jurgen Schukraft (*Adjunct*), Ramamurti Shankar, Witold Skiba, A. Douglas Stone (*Applied Physics*), Hong Tang (*Engineering*), Paul Tipton, Thomas Ullrich (*Adjunct*), C. Megan Urry, Frank van den Bosch (*Astronomy*), Pieter van Dokkum (*Astronomy*), John Wettlaufer (*Earth and Planetary Sciences*), Robert Wheeler (*Emeritus*), Werner Wolf (*Emeritus*), Michael Zeller (*Emeritus*)

**Associate Professors** Damon Clark (*Molecular, Cellular, and Developmental Biology*), David C. Moore, Michael Murrell (*Biomedical Engineering*), Nikhil Padmanabhan, David Poland, Peter Rakich (*Applied Physics*), Alison Sweeney

**Assistant Professors** Charles Brown, Meng Cheng, Eduardo da Silva Neto, Laura Havener, Yu He (*Applied Physics*), Christopher Lynn, Benjamin Machta, Owen Miller (*Applied Physics*), Chiara Mingarelli, Ian Moult, Nir Navon, Laura Newburgh, Shruti Puri (*Applied Physics*), Diana Qiu (*Mechanical Engineering and Materials Science*)

**Lecturers** Sidney Cahn, Mehdi Ghiassi-Nejad, Caitlin Hansen, Stephen Irons, Steven Konezny, Rona Ramos, Adriane Steinacker

## FIELDS OF STUDY

Fields include Astrophysics and Cosmology; Atomic, Molecular and Optical Physics; Biological Physics; Condensed Matter; Gravitational Physics; Nuclear Physics; Particle Physics; Quantum Physics; and other areas in collaboration with the School of Engineering & Applied Science and the departments of Applied Physics; Astronomy;

Chemistry; Earth and Planetary Sciences; Molecular Biophysics and Biochemistry; and Molecular, Cellular, and Developmental Biology.

## INTEGRATED GRADUATE PROGRAM IN PHYSICAL AND ENGINEERING BIOLOGY (PEB)

Students applying to the Ph.D. program in Physics with a concentration of Biological Physics may also apply to be part of the PEB program. See the description under Non-Degree-Granting Programs, Councils, and Research Institutes for course requirements, and https://peb.yale.edu for more information about the benefits of this program and application instructions.

## SPECIAL REQUIREMENTS FOR THE PH.D. DEGREE

To complete the course requirements, students are expected to take a set of seven full-term courses: six foundational courses and one elective. The six core courses (PHYS 500, Advanced Classical Mechanics; PHYS 502, Electromagnetic Theory I; PHYS 506, Mathematical Methods of Physics; PHYS 508, Quantum Mechanics I; PHYS 510, Quantum Mechanics II; and PHYS 512, Statistical Physics I) serve to complete the student's undergraduate core training in classical and quantum physics. For the seventh course, students select from the list of graduate elective courses offered by the Physics or Applied Physics departments, or courses offered by other departments with the approval of the director of graduate studies (DGS). In addition, all students are required to engage in a research project by taking PHYS 990, Special Investigations, by the end of their second year of study. First-year students are also required, in addition to their core courses, to take PHYS 515, Topics in Modern Physics Research, in the fall, and PHYS 590, Responsible Conduct in Research for Physical Scientists, in the spring. Certain equivalent course work or successful completion of a pass-out examination may allow for the substitution or waiver of core courses for individual students.

All students must participate in a two-part qualifying event by the end of their second year of study. Part one is a qualifying event in research (RQE) consisting of an oral presentation on research completed during their first couple of years, in conjunction with PHYS 990, Special Investigation. Students will present their research and be evaluated on their presentation by the DGS and their research adviser. Part two is a written qualifying event (WQE) consisting of four separate written components on classical mechanics, electromagnetic theory, statistical mechanics, and quantum mechanics, to be taken after the student has taken or passed out of the relevant courses. Students will receive feedback after each portion of the qualifying event. The RQE and WQE are not graded, but rather serve as learning milestones. Students may take the qualifying events in any order. Both events must be completed by the end of the student's second year.

Before the end of a student's third year of study, they must submit their thesis prospectus, as presented to and approved by their core thesis committee. Students who have completed their required course credits with satisfactory grades (two Honors and an overall High Pass average), taken the qualifying events, and submitted an acceptable thesis prospectus are recommended for advancement to candidacy and to receive their M.Phil en route. Students entering the program with a master's degree in physics or a related field may waive equivalent graduate-level core courses, with approval from the

DGS, without the requirement of replacing course credits. These student can advance to candidacy, after completing all other requirements, without receiving an M.Phil from the department.

There is no foreign language requirement in the physics program, but students whose first language is not English must receive, at a minimum, 25 or above on the TOEFL speak test in order to be assigned as a teaching fellow. Admitted students who fall below this threshold will be required to take ESL classes prior to being able to teach. The teaching experience is regarded as an integral part of the graduate training program. During their studies, students are expected to serve four terms as teaching fellows, usually in the first two years. Students who require additional support from the Graduate School must teach additional terms, if needed, after they have fulfilled this teaching requirement.

Formal association with a dissertation adviser normally begins after their second year, after the qualifying event has been passed and required course work has been completed. An adviser from a department other than Physics can be chosen in consultation with the DGS, provided the dissertation topic is deemed suitable for a physics Ph.D.

## MASTER'S DEGREES

**M.Phil.** Students who have successfully advanced to candidacy qualify for the M.Phil. degree.

**M.S.** Students who withdraw from the Ph.D. program may be eligible to receive the M.S. degree, if they have met the course requirements and have not submitted a thesis prospectus. For the M.S., students must successfully complete all six core courses listed above, in addition to completing either PHYS 990, Special Investigations, or an advanced elective (all with a satisfactory record). Certain equivalent course work or successful completion of a pass-out examination may allow individual students to substitute an elective course for a required one.

Additional program information can be found on the Physics website under Academics —Graduate Studies.