

# Department of Physics

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Department Website: <http://physics.uchicago.edu>

Chair

- Young-Kee Kim

Professors

- Edward C. Blucher
- Marcela Carena
- John Eric Carlstrom, Astronomy & Astrophysics
- Cheng Chin
- Juan Collar
- Henry J. Frisch
- Margaret Gardel
- Philippe M. Guyot Sionnest, Chemistry
- Jeffrey A. Harvey
- Eric Isaacs
- Heinrich Martin Jaeger
- Woowon Kang
- Kwang Je Kim
- Young Kee Kim
- David Kutasov
- Kathryn Levin
- Peter Littlewood
- Zheng Tian Lu
- Emil J. Martinec
- Stephan Meyer, Astronomy & Astrophysics
- Sergei Nagaitsev
- Sidney R. Nagel
- Mark J. Oreglia
- Paolo Privitera, Astronomy & Astrophysics
- Robert Rosner, Astronomy & Astrophysics
- Guy Savard
- Savdeep Sethi
- Melvyn J. Shochet
- Dam T. Son
- Michael Turner, Astronomy & Astrophysics
- Carlos E.M. Wagner
- Yau Wai Wah
- Robert M. Wald
- Paul B. Wiegmann
- Linda Young

Associate Professors

- Erez Berg
- Daniel Holz
- William Irvine
- Michael Rust, Molecular Genetics and Cell Biology
- Shinsei Ryu
- Scott Wakely
- LianTao Wang
- Wendy Zhang

Assistant Professors

- Luca Grandi
- Michael Levin
- David Miller
- Arvind Murugan
- Stephanie Palmer, Organismal Biology and Anatomy
- David Schmitz
- David Schuster
- Jonathan Simon
- Abigail Vieregg

#### Emeritus Faculty

- Isaac D. Abella
- James W. Cronin
- Dean Eastman
- Peter G.O. Freund
- Robert P. Geroch
- Roger H. Hildebrand
- Riccardo Levi Setti
- Gene F. Mazenko
- Frank S. Merritt
- Dietrich Müller
- Eugene Parker
- James E. Pilcher
- Jonathan L. Rosner
- John P. Schiffer
- Thomas A. Witten
- S. Courtney Wright

The Department of Physics (<http://physics.uchicago.edu>) offers advanced degree opportunities in many areas of experimental and theoretical physics, supervised by a distinguished group of research faculty. Applications are accepted from students of diverse backgrounds and institutions: graduates of research universities or four year colleges, from the U.S. and worldwide. Most applicants, but not all, have undergraduate degrees in physics; many have had significant research experience. Seeking to identify the most qualified students who show promise of excellence in research and teaching, the admissions process is highly selective and very competitive.

### Doctor of Philosophy

During the first year of the doctoral program, a student takes introductory graduate physics courses and usually serves as a teaching assistant assigned to one of the introductory or intermediate undergraduate physics courses. Students are encouraged to explore research opportunities during their first year. Students are strongly encouraged to take the graduate diagnostic examination prior to their first quarter in the program. The results of this examination will determine which of the introductory graduate courses the student must take to achieve candidacy. After achieving candidacy and identifying a research sponsor, the student begins dissertation research while completing course requirements. Within a year after research begins, a PhD committee is formed with the sponsor as chairman. The student continues research, from time to time consulting with the members of the committee, until completion of the dissertation. The average length of time for completion of the PhD program in physics is about six years.

In addition to fulfilling University and divisional requirements, a candidate for the degree of Doctor of Philosophy in physics must:

1. Achieve Candidacy.
2. Fulfill the experimental physics requirement by completing PHYS 33400 Advanced Experimental Physics or PHYS 33500 Adv Experimental Physics Project.
3. Pass four post candidacy advanced graduate courses devoted to the broad physics research areas of (A) Condensed Matter Physics, (B) Particle Physics, (C) Large Scale Physics (i.e. Astrophysics and/or Cosmology related), and (D) Intermediate Electives. The four courses selected must include at least one from each of the categories (A), (B), and (C).
4. Pass two other advanced (40000 level) courses either in physics or in a field related to the student's Ph.D. research. The latter requires department approval.
5. Within the first year after beginning research, convene a first meeting of the Ph.D. committee to review plans for the proposed thesis research and for fulfilling the remaining Ph.D. requirements.

6. One to two quarters prior to the defense of the dissertation, hold a pre-oral meeting at which the student and the Ph.D. committee discuss the research project.
7. Defend the dissertation before the Ph.D. committee.
8. Submit for publication to a refereed scientific journal the thesis which has been approved by the Ph.D. committee or a paper based on the thesis. A letter from the editor acknowledging receipt of the thesis must be provided to the department office.

Consult a department adviser for more details.

### Master of Science

The graduate program of the Department of Physics is oriented toward students who intend to earn a Ph.D. degree in physics. Therefore, the department does not offer admission to students whose goal is the Master of Science degree. However, the department does offer a master's degree to students who are already in the physics Ph.D. program or other approved graduate programs in the University. Normally it takes one and a half years for a student to complete the master's program. A master's degree is not required for continued study toward the doctorate.

In addition to fulfilling University and Divisional requirements, a candidate for the degree of Master of Science in physics must:

1. Demonstrate a satisfactory level of understanding of the fundamental principles of physics by passing nine approved courses with a minimum grade point average of 2.5. Six of the nine courses must be:

PHYS 31600	Advanced Classical Mechanics	100
PHYS 33000	Mathematical Methods of Physics	100
PHYS 34100	Advanced Quantum Mechanics I	100
PHYS 32200	Advanced Electrodynamics I	100
PHYS 35200	Statistical Mechanics	100
PHYS 33400	Advanced Experimental Physics	100
PHYS 33500	Adv Experimental Physics Project	100

Testing out of certain courses (PHYS 31600, 32200, 32300, 34100, 34200, and 35200) on the Graduate Diagnostic Exam can be applied toward the Master's degree in place of taking the course. The 2.5 GPA minimum applies only to courses taken in addition to those credited by performance on the Graduate Diagnostic Exam

The Department may approve substitutions to this list where warranted, especially regarding courses for which the student placed out of as a result of the graduate diagnostic exam.

### Teaching Opportunities

Part of the training of graduate students is dedicated to obtaining experience and facility in teaching. Most first year students are supported by teaching assistantships, which provide the opportunity for them to engage in a variety of teaching related activities. These may include supervising undergraduate laboratory sections, conducting discussion and problem sessions, holding office hours, and grading written work for specific courses. Fellowship holders are invited to participate in these activities at reduced levels of commitment to gain experience in the teaching of physics. During the Autumn quarter first year graduate students attend the weekly workshop, Teaching and Learning of Physics, which is an important element in their training as teachers of physics.

### Teaching Facilities

All formal class work takes place in the modern lecture halls and classrooms and instructional laboratories of the Kersten Physics Teaching Center. This building also houses special equipment and support facilities for student experimental projects, departmental administrative offices, and meeting rooms. The center is situated on the science quadrangle near the John Crerar Science Library, which holds over 1,000,000 volumes and provides modern literature search and data retrieval systems.

### Research Facilities

Most of the experimental and theoretical research of Physics faculty and graduate students is carried out within the Enrico Fermi Institute (<http://efi.uchicago.edu>), the James Franck Institute (<http://jfi.uchicago.edu>) and the Institute for Biophysical Dynamics (<http://ibd.uchicago.edu>). These research institutes provide close interdisciplinary contact, crossing the traditional boundaries between departments. This broad scientific endeavor is reflected in students' activities and contributes to their outlook toward research.

In the Enrico Fermi Institute, members of the Department of Physics carry out theoretical research in particle theory, string theory, field theory, general relativity, and theoretical astrophysics and cosmology. There are active experimental groups in high energy physics, nuclear physics, astrophysics and space physics, infrared and optical astronomy, and microwave background observations. Some of this research is conducted at the Fermi National Accelerator Laboratory, at Argonne National Laboratory (both of these are near Chicago), and at the European Organization for Nuclear Research (CERN) in Geneva, Switzerland.

Physics faculty in the James Franck Institute study chemical, solid state, condensed matter, and statistical physics. Fields of interest include chaos, chemical kinetics, critical phenomena, high Tc superconductivity, nonlinear dynamics, low temperature, disordered and amorphous systems, the dynamics of glasses, fluid dynamics, surface and interface phenomena, nonlinear and nanoscale optics, unstable and metastable systems, laser cooling and trapping, atomic physics, and polymer physics. Much of the research utilizes specialized facilities operated by the institute, including a low temperature laboratory, a materials preparation laboratory, x-ray diffraction and analytical chemistry laboratories, laser equipment, a scanning tunneling microscope, and extensive shop facilities. Some members of the faculty are involved in research at Argonne National Laboratory.

The Institute for Biophysical Dynamics includes members of both the Physical Sciences and Biological Sciences Divisions, and focuses on the physical basis for molecular and cellular processes. This interface between the physical and biological sciences is an exciting area that is developing rapidly, with a bi-directional impact. Research topics include the creation of physical materials by biological self assembly, the molecular basis of macromolecular interactions and cellular signaling, the derivation of sequence structure function relationships by computational means, and structure function relationships in membranes.

In the areas of chemical and atomic physics, research toward the doctorate may be done in either the physics or the chemistry department. Facilities are available for research in crystal chemistry; molecular physics; molecular spectra from infrared to far ultraviolet, Bose Einstein condensation, and Raman spectra, both experimental and theoretical; surface physics; statistical mechanics; radio chemistry; and quantum electronics.

Interdisciplinary research leading to a Ph.D. degree in physics may be carried out under the guidance of faculty committees including members of other departments in the Division of the Physical Sciences, such as Astronomy & Astrophysics, Chemistry, Computer Science, Geophysical Sciences or Mathematics, or related departments in the Division of the Biological Sciences.

#### Admission and Student Aid

Most students entering the graduate program of the Department of Physics of the University of Chicago hold a bachelor's or master's degree in physics from an accredited college or university.

December 15 is the deadline for applications for admission in the following autumn quarter. The Graduate Record Examination (GRE) given by the Educational Testing Service is required of all applicants. Applicants should submit recent scores on the verbal, quantitative, and analytic writing tests and on the advanced subject test in physics. Arrangements should be made to take the examination no later than September in order that the results be available in time for the department's consideration. Applicants from non-English speaking countries must provide the scores achieved on the TOEFL or the IELTS.

All full time physics graduate students in good standing receive financial aid. Most graduate students serve as teaching assistants in their first year.

The department has instituted a small bridge-to-Ph.D. program which does not require the Graduate Record Examination. The application deadline for this program varies but is expected to be mid to late spring.

For information including faculty research interests, application instructions, and other important program details please visit our department website <http://physics.uchicago.edu/>. You can also reach out to [physics@uchicago.edu](mailto:physics@uchicago.edu) with any questions or concerns regarding the admissions process.

#### Physics Courses

##### **PHYS 30101. Analytical Methods of Physics I. 100 Units.**

This course focuses on analytical techniques used in physics. It is designed to have flexible topical coverage so that the course may be geared to the registered students. Enrollment is by instructor approval only.

Instructor(s): D. Reed Terms Offered: Autumn

Prerequisite(s): Permission of the instructor.

##### **PHYS 31600. Advanced Classical Mechanics. 100 Units.**

This course begins with variational formulation of classical mechanics of point particles, including discussion of the principle of least action, Poisson brackets, and Hamilton-Jacobi theory. These concepts are generalized to continuous systems with infinite number of degrees of freedom, including a discussion of the transition to quantum mechanics.

Terms Offered: Autumn

Prerequisite(s): PHYS 18500

##### **PHYS 32200-32300. Advanced Electrodynamics I-II.**

This two-quarter sequence covers electromagnetic properties of continuous media, gauge transformations, electromagnetic waves, radiation, relativistic electrodynamics, Lorentz theory of electrons, and theoretical optics. There is considerable emphasis on the mathematical methods behind the development of the physics of these problems.

**PHYS 32200. Advanced Electrodynamics I. 100 Units.**

This two-quarter sequence covers electromagnetic properties of continuous media, gauge transformations, electromagnetic waves, radiation, relativistic electrodynamics, Lorentz theory of electrons, and theoretical optics. There is considerable emphasis on the mathematical methods behind the development of the physics of these problems.

Terms Offered: Winter

Prerequisite(s): PHYS 22700 and 23500

**PHYS 32300. Advanced Electrodynamics II. 100 Units.**

Terms Offered: Spring

Prerequisite(s): PHYS 32200

**PHYS 33000. Mathematical Methods of Physics. 100 Units.**

Topics include complex analysis, linear algebra, differential equations, boundary value problems, and special functions.

Terms Offered: Autumn

Prerequisite(s): PHYS 22700

**PHYS 33500. Adv Experimental Physics Project. 100 Units.**

For course description contact Physics.

**PHYS 34100-34200. Advanced Quantum Mechanics I-II.**

This two-quarter sequence covers wave functions and their physical content, one-dimensional systems, WKB method, operators and matrix mechanics, angular momentum and spin, two- and three-dimensional systems, the Pauli principle, perturbation theory, Born approximation, and scattering theory.

**PHYS 34100. Advanced Quantum Mechanics I. 100 Units.**

This two-quarter sequence covers wave functions and their physical content, one-dimensional systems, WKB method, operators and matrix mechanics, angular momentum and spin, two- and three-dimensional systems, the Pauli principle, perturbation theory, Born approximation, and scattering theory.

Terms Offered: Autumn

Prerequisite(s): PHYS 23500

**PHYS 34200. Advanced Quantum Mechanics II. 100 Units.**

Terms Offered: Winter

Prerequisite(s): PHYS 34100

**PHYS 35200. Statistical Mechanics. 100 Units.**

This course covers principles of statistical mechanics and thermodynamics, as well as their applications to problems in physics and chemistry.

Terms Offered: Spring

Prerequisite(s): PHYS 19700 and 23500

**PHYS 36100. Solid State Physics. 100 Units.**

Topics include Properties of Insulators, Electronic Properties of Solids, Thermal Properties, Optical Properties of Solids, and Transport in Metals (conductivity, Hall effect, etc.)

Terms Offered: Autumn

Prerequisite(s): PHYS 23600, 34200, 35200

**PHYS 36400. General Relativity. 100 Units.**

Terms Offered: Winter 2014

**PHYS 36600. Hard Condensed Matter Physics. 100 Units.**

Phasetransitions, Magnetism, Superconductivity, Disorder, Quantum Hall Effect, Superfluidity, Physics of Low-dimensional systems, Fermi liquid theory, and Quasi-crystals.

Terms Offered: Winter

**PHYS 37200. Space Physics & Astrophysics. 100 Units.**

Terms Offered: Autumn

**PHYS 38500. Advanced Math Methods. 100 Units.**

Terms Offered: Winter

**PHYS 38600. Advanced Methods of Data Analysis. 100 Units.**

Terms Offered: Spring

**PHYS 42600. Fluid Dynamics. 100 Units.**

Terms Offered: Spring

**PHYS 44300. Quantum Field Theory I. 100 Units.**

Topics include Basic Field Theory, Scattering and Feynman Rules, and One Loop Effects.

Terms Offered: Autumn

Prerequisite(s): PHYS 34200

**PHYS 44400. Quantum Field Theory II. 100 Units.**

Topics include Path integral formulation of QFT, Renormalization, Non-Abelian gauge theory.

Terms Offered: Winter

**PHYS 44800. Field Theory in Condensed Matter Physics. 100 Units.**

Terms Offered: Autumn

**PHYS 45600. Intro to Quantum Computing. 100 Units.**

No description available.

Terms Offered: Winter

**PHYS 46200. Nuclear Astrophysics. 100 Units.**

Terms Offered: Autumn

**PHYS 47100. Intro to Modern Atomic Physics. 100 Units.**

No description available.

Terms Offered: Autumn





#### Font Notice

This document should contain certain fonts with restrictive licenses. For this draft, substitutions were made using less legally restrictive fonts. Specifically:

Times was used instead of Trajan.

Times was used instead of Palatino.

The editor may contact Leepfrog for a draft with the correct fonts in place.