

Department of Physics

Academic year 2012–2013 was an exciting and productive one for the [Department of Physics](#). As one of the largest university physics departments in the world, we excel in many subfields. The department is organized into four research divisions: astrophysics; atomic, biophysics, condensed matter, and plasma physics; experimental nuclear and particle physics; and theoretical nuclear and particle physics. Since 2002, it has been ranked at the top of graduate physics programs by *US News and World Report*. The strength of the department comes from its unwavering devotion to both research and teaching. Together, our faculty and alumni have won 19 Nobel Prizes. Ten current faculty are National Academy of Science members and three are MacArthur Fellows.

Faculty Count, Promotions, and Departures

As of June 30, 2013, the Department of Physics had 68 appointed regular-rank faculty members: 44 full professors, eight associate professors, and 16 assistant professors.

Six faculty members were promoted this year. Allan Adams, Nuh Gedik, and Pablo Jarillo-Herrero were promoted to associate professor without tenure; Robert Simcoe was promoted to associate professor with tenure; and Iain Stewart and Martin Zwierlein were promoted to full professor. These promotions take effect July 1, 2013.

The department conducted another productive faculty search process in 2012–2013; two offers were made and both were accepted. The new faculty members—Joseph Checkelsky, in condensed matter experimental physics; and Mark Vogelsberger, in theoretical astrophysics—will start in January 2014. Additionally, Tracy Slatyer and Yen-Jie Lee, both in particle physics, will join the faculty, effective July 1, 2013, after a one-year deferral. The last three years of searches have resulted in 12 new junior faculty members, with an acceptance rate of 73%.

David Litster and Ernest Moniz both retired, effective June 30, 2013, after years of dedicated service to MIT and the department. The department is deeply proud that Professor Moniz now serves as Secretary of Energy within President Obama’s cabinet, an important role for the future of our country. Sadly, this year the department and the Institute lost Peter Demos, an emeritus faculty member, to coronary artery disease. Professor Demos’s many years of research and contributions helped bring the Department of Physics to its current state of excellence.

Administration

For AY2013, the Physics Council membership is as follows:

Edmund Bertschinger—department head

John Belcher—acting associate department head

Deepto Chakrabarty—astrophysics division head

Vladan Vuletic—atomic, biophysics, condensed matter,
and plasma physics division head

Mehran Kardar—atomic, biophysics, condensed matter, and plasma physics member-at-large

Peter Fisher—experimental nuclear and particle physics division head

Edward Farhi—director, Center for Theoretical Physics

Richard Milner—director, Laboratory for Nuclear Science

Jacqueline Hewitt—director, MIT Kavli Institute for Astrophysics and Space Research

Matt Cubstead—administrative officer

Edmund Bertschinger stepped down as department head, effective June 30, 2013, to accept his new position as Institute community and equity officer. The department thanks Professor Bertschinger for his six years of service and is currently conducting a search for his replacement. During that process, Thomas Greytak has agreed to act as interim department head, starting July 1, 2013, until a successor is chosen. Krishna Rajagopal will return from sabbatical on July 1, 2013, and resume his role as associate department head for education.

Faculty Awards

Following are some of the many awards and recognitions conferred on Department of Physics faculty members during the 2012–2013 academic year:

- Allan Adams won the Everett Moore Baker Memorial Award for Excellence in Undergraduate Teaching.
- William Detmold, Liang Fu, and Michael Williams all received a Department of Energy Early Career Award.
- Mildred Dresselhaus won the 2012 Kavli Prize in Nanoscience.
- Anna Frebel received a National Science Foundation Career Award.
- Nuh Gedik was appointed to the Biedenharn career development professorship.
- Scott Hughes, Iain Stewart, Max Tegmark, and Vladan Vuletic were elected fellows of the American Physical Society (APS).
- Pablo Jarillo-Herrero won the 2012 Presidential Early Career Award for Scientists and Engineers and the 2013 Office of Naval Research Young Investigator Award.
- Patrick Lee was a co-winner of the 2013 Eugene Feenberg Memorial Medal.
- Nergis Mavalvala received the 2013 School of Science Undergraduate Teaching Award.
- Ernest Moniz was elected to the American Academy of Arts and Sciences.
- Jesse Thaler received an Alfred P. Sloan Research fellowship and the 2012 Presidential Early Career Award for Scientists and Engineers; he was also named to the Class of 1943 career development professorship.

Education

There were 278 students pursuing a bachelor of science (SB) degree in physics, and 104 SB degrees were awarded—25% to women and 13% to underrepresented minorities. Of the graduating seniors, 86% chose the flexible degree option, 57% had more than one major, and 17% were elected to Phi Beta Kappa.

Students pursuing graduate degrees in physics totaled 236, and 37 PhD and five master of science degrees were awarded, including three PhDs to women and one to a member of an underrepresented minority. The 2013 graduate admissions cycle continued an upward trend in competitiveness, with 784 applications received, an increase of 4% over the previous year. Offers of admission were made to 96 applicants, 19 of whom were female. The acceptance rate on offers was 54%, a 13% increase over the preceding year's yield.

In December 2011, MIT launched an online learning initiative, then called MITx, designed to offer a portfolio of MIT courses through an online interactive learning platform. In May 2012, this was followed by the announcement of edX, an ambitious new partnership between MIT and Harvard University to deliver online education to learners anywhere in the world. The Physics Department then worked to decide which classes could best be taught on this platform. The subject 8.02x was approved in April 2012 and was launched online on February 18, 2013. The department decided to begin with 8.02x because of the wealth of digital resources available on electromagnetism—most notably Walter Lewin's lectures from his residential course held in spring 2002. Also, there was an electromagnetism textbook available, and a number of electromagnetism simulations and visualizations had been created in the process of developing curriculum for 8.02 Technology-enabled Active Learning.

The online subject 8.01x was approved by the new PhysicsX Planning Group in December 2012. 8.01x is scheduled to launch on September 9, 2013, with an end date of January 13, 2014. One additional course, David Pritchard's Mechanics ReView, was approved in March 2013 and began on June 1, 2013. Although not based on 8.01, this class is part of the department's effort to learn how to use the edX platform for improving teaching and learning.

In the end, just over 2,000 students received a certificate from the 8.02x online class, and similar numbers are expected for the 8.01x course this fall. Moreover, the department has facilitated the interaction of these students with Professor Lewin, the course staff, and with each other. In doing this, the department gained invaluable experience with the edX platform and—by being an early adopter—helped shape the capabilities of that platform. The department also gained experience with creating an edX class, including how to code problem sets and exam problems, how to determine the quality control needed before such problems go “live,” how to moderate discussion boards effectively, how to motivate students, and many other aspects of managing a large online class. The department now has the necessary knowledge to implement features of online edX classes to improve residential physics offerings at MIT, a major goal of the Office of Digital Learning and of the department.

Finally, the department received the 2013 APS Award for Improving Undergraduate Education.

Diversity

In January 2013, MIT held an Institute Diversity Summit, which was a full-day program focused on the theme of “Inventing Our Future.” The program was a follow-up to the 2012 “Diversity and Excellence” summit. Physics department head Edmund Bertschinger was the summit co-chair and a panel member for both summits.

During the 2012–2013 academic year, the Department of Physics hosted 11 undergraduate Minority Scholars, selected by the American Physical Society. The 11 students represented 28% of all the scholars nationwide, a far greater percentage than at the second-place institutions. It is the third consecutive year that a large percentage of the total scholars attended MIT.

The Physics Department continues to support a wide range of undergraduate groups that help focus on diversity efforts throughout the Institute. The department gave financial support to the MIT Black Students’ Union, the Black Women’s Alliance, the Society of Hispanic Professional Engineers, Latinos in Science and Engineering, La Union Chicana por Atlan (an undergraduate group that supports Mexican American culture), and MIT Undergraduate Women in Physics. Additionally, the department covers the travel costs for undergraduates who attended the MIT Undergraduate Women in Physics Conference, and also supports other travel by undergraduates, graduates, postdocs, and faculty who attend conferences supporting diversity in physics.

Research Highlights

Below are some of the research highlights from Physics Department faculty in 2012–2013:

Nobel laureate Frank Wilczek led a team of theoretical physicists who presented a straightforward way for quantum particles to move smoothly from one kind of “topological space” to a very different one. The authors suggest that their work might provide a simplified framework for understanding the effects of gravity on quantum particles, as well as describing other situations in which the spaces that quantum particles move in can radically alter, such as in condensed-matter-physics experiments.

Robert Simcoe led a research project (on an instrument Simcoe designed and that is located at the Magellan Telescope in Chile) that determined the chemical composition of gas from the first billion years of the universe’s life. The gas consists mostly of neutral hydrogen atoms, which means that it may mark the era before stellar radiation began ionizing the universe. Furthermore, the gas shows no signs of the heavy elements that are forged in stars, so it may contain only the light elements produced by the Big Bang.

Following up on earlier theoretical predictions, MIT researchers led by Young Lee have demonstrated experimentally the existence of a fundamentally new kind of magnetic behavior, adding a third to the two previously known states of magnetism. The work could lead to possible advances in data storage or communications, and could also impact research into high-temperature superconductors, potentially leading to new developments in that field.

A group of researchers, including Nuh Gedik, have found a new way to study fluctuating charge-density waves, which form the basis of one of the leading theories to account for high-temperature superconductivity. The researchers say this could provide a better understanding of high-temperature superconductivity, and perhaps prompt new discoveries of higher-temperature superconductors.

Marin Soljagic and John Joannopoulos were part of a group of researchers who discovered a new method to trap light that could find a wide variety of applications. In all previous cases, light's passage is blocked by a mirror; in physics terminology, there are no "permitted" states for the light to continue on its path, so it is forced into a reflection. In the new system, light of a particular wavelength is instead blocked by destructive interference from other waves that are precisely out of phase. According to Professor Soljagic, "It's a very different way of confining light." The researchers say that this phenomenon could apply to any type of wave: sound waves, radio waves, electrons (whose behavior can be described by wave equations), and even waves in water.

MIT researchers doing experiments at the Large Hadron Collider (LHC), in Geneva, Switzerland, continue to make groundbreaking discoveries. Key measurements made by Markus Klute, Christoph Paus, and their group show that the new particle, whose discovery was announced in July 2012, looks very much like the long-sought-after Higgs boson. Yen-Jie Lee, Gunther Roland, Bolek Wyslouch, and their group led the analyses of the first collisions of protons with nuclei performed at LHC early in 2013, suggesting that even though the proton only blasts a small hole in the nucleus, the spray of debris looks like a droplet of liquid. It is surprising that such a tiny volume of matter can organize itself and behave collectively, hydrodynamically, in a way that is usually thought of as macroscopic.

Following a three-year competition, the National Aeronautics and Space Administration selected the Transiting Exoplanet Survey Satellite (TESS) project at MIT for a planned launch in 2017. TESS team partners include the [MIT Kavli Institute for Astrophysics and Space Research](#) (MKI) and Lincoln Laboratory. The project, led by principal investigator George Ricker, a senior research scientist at MKI, will use an array of wide-field cameras to perform an all-sky survey to discover transiting exoplanets, ranging from Earth-sized planets to gas giants, in orbit around the brightest stars in the sun's neighborhood. The department is grateful for the efforts of Dr. Ricker and faculty members Joshua Winn, Jacqueline Hewitt (MKI director), and Sara Seager, without whom this project would not have been funded.

Pappalardo Fellows

A. Neil Pappalardo '64 has made possible a program in the department to attract recent PhDs of exceptional promise. The purpose of the Pappalardo Fellowship in Physics is to identify and support unusually talented young physicists and to provide them with the opportunity to pursue research of their own choosing. The Pappalardo Fellows have complete freedom in their choice of research and are matched with a mentor chosen on the basis of their research interests. Fellows have special status in the department and are invited to attend faculty events. The first three Fellows arrived in September 2000,

and since then the program has supported 45 Fellows. Nearly 35% of all Pappalardo Fellows have been women, and the program has proved to be a strong source of Physics faculty recruiting, as five members have joined the department.

Community

The Department of Physics strives to create a community of scholars and endeavors to create opportunities for its faculty, students, and alumni to come together to share and explore ideas. The department continues to sponsor the following events, designed to foster the exchange of ideas:

- Faculty lunches are held each week during the fall and spring semesters. All faculty are invited to join their colleagues for an informal meal and to hear a talk from one of their colleagues about their research.
- An afternoon colloquium series is held each week at which a physicist, often from outside MIT, is invited to give a talk on a topic of interest. This event is open to the MIT community.
- Each research division also has its own weekly seminar series open to all.
- Each fall, the department has an awards ceremony where it acknowledges outstanding teaching among its undergraduates, graduates, and faculty members. This ceremony is open to the entire physics community.
- Monthly luncheons are held for faculty, postdocs, graduate students, and staff members to discuss broad topics associated with diversity and inclusion.
- Twice a semester, alumni are invited to a breakfast to hear about department research conducted by one of its outstanding faculty presenters.
- During Independent Activities Period, the department offers a lecture series open to the MIT community that covers a wide range of topics, including research highlights of select faculty members, as well as talks by alumni that highlight various career paths.
- The Pappalardo Fellowship Program sponsors a weekly lunch that brings Pappalardo Fellows and Physics faculty together for conversation.
- Each fall the department hosts a Distinguished Pappalardo Lectureship.
- During the Cambridge Science Festival in the spring, the department holds an open house. Area residents are invited on campus to view our Technology-enabled Active Learning classrooms and witness various physics laboratory demonstrations presented by the department's technical services group.

Edmund Bertschinger
Department Head
Professor of Physics