

Department of Physics

Academic year 2017 was productive for the [Department of Physics](#). MIT has one of the largest university physics departments in the world, and the department is organized into four research divisions: Astrophysics; Atomic, Biophysics, Condensed Matter, and Plasma Physics; Theoretical Nuclear and Particle Physics; and Experimental Nuclear and Particle Physics. Since 2002, *U.S. News and World Report* has ranked the department at the top of graduate physics programs. 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. Thirteen current faculty are members of the National Academy of Science and four are MacArthur Fellows.

Faculty Count, Promotions, and Departures

As of July 1, 2017, the Physics Department will have 71 appointed regular-rank faculty members consisting of 41 full professors, 12 associate professors, and 18 assistant professors.

Eight faculty members were promoted this year. Liang Fu, Jeff Gore, and Jesse Thaler were promoted to associate professor with tenure. Robert Simcoe was promoted to full professor, and William Detmold, Anna Frebel, Aram Harrow, and Michael Williams were promoted to associate professor without tenure. These promotions take effect July 1, 2017.

Paul Schechter retired from the regular-rank faculty effective July 1, 2017. We thank him for his impactful service to the department and wish him well in his retirement. Kerson Huang, professor emeritus of physics, passed away in September 2016. Ali Javan, professor emeritus of physics, passed away in September 2016. Anthony French, professor emeritus of physics, passed away in February 2017. Arthur Kerman, professor emeritus of physics, passed away in May 2017. And Institute Professor emerita Mildred “Millie” Dresselhaus, passed away in February 2017. All five left a remarkable imprint on the students and faculty at MIT and will be missed greatly.

The department had a successful faculty search process in 2016–2017, making two offers, one of which was accepted. Ian Crossfield will start July 1, 2017 in Astrophysics. In the last seven years, the department has made a total of 34 offers that resulted in 25 acceptances, for a success rate of 75%.

Administration

For FY2017, the Physics Council membership was as follows:

Peter Fisher, department head

Nergis Mavalvala, 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

Joseph Formaggio, experimental nuclear and particle physics division head

Wati Taylor, director, Center for Theoretical Physics

Boleslaw (Bolek) Wyslouch, director, Laboratory for Nuclear Science

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

Matt Cubstead, administrative officer

Faculty Awards

Following are a few of the many awards and recognitions conferred on faculty members during AY2017:

Ibrahim Cissé was named a Pew Scholar in Biomedical Sciences.

Deepto Chakrabarty and Peter Dourmashkin were the recipients of the inaugural MITx Prize for Teaching and Learning in MOOCs.

William Detmold was elected a fellow of the American Physical Society.

Nikta Fakhri was awarded a Sloan Fellowship.

Liang Fu was appointed the Lawrence C. and Sarah W. Biedenharn Career Development Chair.

Scott Hughes was named a Margaret MacVicar Faculty Fellow.

Wolfgang Ketterle was elected a fellow of the American Association for the Advancement of Science.

Nergis Mavalvala was elected to the National Academy of Sciences and the American Academy of Arts and Sciences.

Kerstin Perez was awarded a Sloan Fellowship.

Tracy Slatyer was appointed the Jerrold R. Zacharias Career Development Chair.

Xiao-Gang Wen was awarded the Oliver E. Buckley Condensed Matter Physics Prize of the American Physical Society.

Lindley Winslow was appointed the Jerrold R. Zacharias Career Development Chair.

Martin Zwierlein was elected a fellow of the American Physical Society.

Education

In 2017, 68 SB degrees were awarded to physics majors. Of the 68 degree-recipients, more than 90% chose the flexible degree option, 72% had more than one major, 26% were women, and 20% were elected to Phi Beta Kappa. 240 graduate students pursued degrees in physics and 30 students graduated from the department with PhD degrees.

Our graduate program continues to be competitive. Yields grew rapidly beginning in 2013 and 2014: 51% in 2013, resulting in an entering class of 48 students, and 55% in 2014 (despite having made fewer offers than in 2013), with an entering class of 45. In 2015, our admissions became even more selective: from a pool of 821 applicants, 81 were admitted, resulting in an entering class of 33. In 2016, after an ever-larger applicant pool of 911 (an 11% increase over the previous year), we welcomed a class of 49 doctoral students in September, representing a yield of 51%. The figures for 2017 show a possible easing in the growth of these numbers: 921 applications, 92 admissions, and 42 acceptances, for a 45.7% yield.

Since the launch of its online educational mission and the founding of MITx in 2012, the Physics Department has been one of the most proactive departments at the Institute in developing a coherent department-wide, faculty-led program, guided by the principle that our online efforts enhance the physics education of global online learners and also of MIT residential students. To this end, materials developed for online offerings are incorporated into residential courses, and the department is increasingly offering hybrid versions in which MIT students have access to a mixture of online lectures and in-class instruction (often referred to as “blended learning”). The department’s online education team has played a leading role in understanding how massive open online courses (MOOCs) can be used for blended learning on campus. The department has also been very proactive in using data from online classes to understand students’ learning habits and develop effective teaching methodologies.

Since the removal of the introductory physics sequence 8.01x and 8.02x in late 2014, the department has been working closely with the Office of Digital Learning (ODL) to introduce new versions of these foundational courses. We have used this as an opportunity to revamp these courses, modernizing and modularizing them to incorporate new understanding of best teaching methods. These efforts have been funded both by the Department and by ODL grants, and are led by faculty members who have long been involved in the residential versions (Deepto Chakrabarty for 8.01x and Robert Redwine for 8.02x). In October 2006, 8.01x was launched as a MOOC and 8.02x is planned for first release in fall 2017.

The department has developed and offered 8.05x—the second in our three-semester quantum sequence—as a MOOC. This effort was led by Professor Barton Zwiebach and Saif Rayyan (the department’s ODL fellow), and was a success in terms of the number of global learners who enrolled and completed one, two, or all three modules. We also offered the course as a hybrid residential version in the spring term, where MIT students watch the lectures and do the homework online but get two hours of in-class instruction from an MIT faculty member (similar to our more traditional lecture/recitation format). This experimental course was offered three times, most recently in spring 2017, and the Committee on Curriculum has now approved it as a permanent subject, 8.051, which will be offered in spring 2018. Professor Zwiebach and the online team have now developed 8.04—the first in our three-semester quantum sequence—as a MOOC; it will debut in fall 2017.

8.421x—the first graduate level atomic and optical physics course in a two-course sequence—was introduced in 2015. This effort was led by Professor Wolfgang Ketterle and Ike Chuang, again with support from Saif Rayyan. We offered 8.421x as a MOOC and

simultaneously as a hybrid residential version in fall 2015, both successfully. In 2016 the second course in the sequence, 8.422, was developed as a MOOC and blended residential class, and was offered in spring 2017. 8.421 and 8.422 are offered every two years. If 8.421 is offered one spring term, 8.422 is offered spring term a year later, and they continue to alternate annually. Students taking these classes to prepare for their oral exam therefore need to plan ahead or risk a delay. The prospect of offering the blended version of each class annually is attractive to both students and to the department, so we are quite excited about being able to provide 8.421x and 8.422x for global and residential students.

Diversity

The Physics Department continues to support a wide range of undergraduate groups that focus on diversity efforts throughout the Institution. The department regularly provides financial support to student groups such as the MIT Black Students' Union, the Black Women's Alliance, the Society of Hispanic Professional Engineers, MAES (Latinos in Science and Engineering), LUCHA (La Unión Chicana por Aztlán, an undergraduate group that supports Mexican American culture) and the Undergraduate Women in Physics (UWIP) organization. Additionally, the department covers the travel costs for undergraduates who attended the Undergraduate Women in Physics Conference and supports other travel by undergraduates, graduates, postdocs, and faculty who attend conferences supporting diversity in physics.

With the leadership of Professors Cissé and Perez, the department has started an underrepresented minority student's group. Their first task is to find a name. The aim of the group, as with UWIP and GWIP (Graduate Women in Physics), is to build community among our students of color.

This year, we offered four multi-year fellowships to minority graduate students, and all accepted our offer (with one deferring to next year). We offered three five-year fellowships to the top women candidates and had one acceptance.

Research Highlights

Below are some of the research highlights from members of the Physics Department faculty in 2016 and 2017.

Ray Ashoori led a group that observed a highly ordered crystal of electrons in a semiconducting material and documented its melting, much like ice thawing into water. The observations confirm a fundamental phase transition in quantum mechanics that was theoretically proposed more than 80 years ago but not experimentally documented until this work.

Researchers at MIT, led by Martin Zwierlein, cooled a gas of potassium atoms to several nanokelvins—just a hair above absolute zero—and trapped the atoms within a two-dimensional sheet of an optical lattice created by crisscrossing lasers. The team then observed individual atoms interacting in some rather peculiar ways, based on their position in the lattice. Some atoms exhibited “antisocial” behavior and kept away from each other while some bunched together with alternating magnetic orientations. Others appeared to piggyback on each other, creating pairs of atoms next to empty

spaces, or holes. The team believes that these spatial correlations may shed light on the origins of superconducting behavior and can help scientists identify ideal conditions for inducing superconductivity.

For the third time, the LIGO team observed a pair of black holes merging together by detecting the gravitational wave that the merger created some three billion light years away from Earth. This was the farthest-out, stellar-mass black hole system ever seen.

Pablo Jarillo-Herrero led a team that reported the discovery of the first truly 2D magnet, made of a compound called chromium triiodide. The discovery could eventually lead to new data-storage devices and designs for quantum computers. For now, the 2D magnets will enable physicists to perform previously impossible experiments and test fundamental theories of magnetism.

Marin Soljačić led a team that simulated the first system in which particles—ranging from roughly molecule- to bacteria-sized—can be manipulated by a beam of ordinary light rather than the expensive specialized light sources required by other systems. Ultimately, this new principle could be applied to particles moving around inside a body, using light to control their position and activity. Such an application would be useful for new medical treatments and in optically based nanomachinery.

Pappalardo Fellows

A. Neil Pappalardo has made possible a program in the Department of Physics 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. Fellows have complete freedom in their choice of research and are matched with a mentor chosen on the basis of their research interests. Pappalardo Fellows have special status in the department and are invited to attend faculty events. The first three fellows began their research in September 2000, and since then the program has supported 63 fellows. Nearly 35% of all Pappalardo Fellows have been women, and the program has proved to be a strong source of faculty recruiting, as six fellows have joined the MIT Physics Department as faculty members.

Community Events

The Physics Department strives to create a community of scholars and endeavors to create opportunities for our 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 members are invited to join their colleagues for an informal meal and to listen to a talk by 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 division also has its own weekly seminar series open to all.
- Each fall, the department hosts an awards ceremony where it acknowledges outstanding teaching among its undergraduates, graduates, and faculty members. This ceremony is open to the entire Physics community.
- Each year, alumni are invited to a breakfast to hear about physics research done by one of our outstanding faculty presenters.
- Students, faculty, and staff have been working over the past two years to develop a Statement of Physics Values as a means of encouraging respect and community among the members of the department. The statement is now complete and public signage is being printed that will be posted in public spaces.
- During IAP, the department offers a lecture series open to the MIT community which covers a wide range of topics, including research highlights of select faculty members as well as talks by alumni that focus on 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.
- Once a month, the department head holds a lunch with all the members of the Physics administrative and support staff.

Peter Fisher
Head
Professor of Physics