

## Department of Physics

Academic year 2019 was another exciting and productive one for the [Department of Physics](#). One of the largest university physics departments in the world, MIT's Physics Department excels in many subfields. 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, the department has been ranked at the top of graduate physics programs by *U.S. News and World Report*. The strength of the department comes from its unwavering devotion to research and teaching. Together, the department's faculty and alumni have won 20 Nobel prizes. Fifteen current faculty are National Academy of Science members and four are MacArthur Fellows.

### Promotions and Departures

As of July 1, 2019, the Physics Department will have 71 appointed regular-rank faculty members, comprising 40 full professors, 14 associate professors, and 17 assistant professors.

Five faculty members were promoted this year. Tracy Slatyer, Michael Williams, and William Detmold were promoted to associate professor with tenure. Joseph Checkelsky and Ibrahim Cisse were promoted to associate professor without tenure. These promotions take effect July 1, 2019.

Professor Emeritus Bernard Burke passed away in fall 2018. A former division head of astrophysics, Bernie left a remarkable imprint on the students and faculty at MIT and will be missed greatly.

After having five offers accepted last year, the department made one offer in the spring of 2019, which was accepted. Ronald Garcia Ruiz will start in Experimental Nuclear and Particle Physics in January 2020. The department also welcomed Netta Engelhardt in Theoretical Nuclear and Particle Physics and Erin Kara in Astrophysics; both will start on July 1, 2019. The total number of female faculty members in the department is now 11, or 15% of the faculty, which is the highest number (and percentage) in the department's history. In the past nine years, Physics has made a total of 40 offers, with 31 acceptances, for a success rate of nearly 78%. This impressive yield rate for faculty shows how attractive MIT is to the very best young scholars.

### Administration

For FY2019, the Physics Council had the following members:

- Peter Fisher—department head
- Scott Hughes—Astrophysics division head
- Martin Zwierlein—Atomic, Biophysics, Condensed Matter, and Plasma Physics division head
- Mehran Kardar—Atomic, Biophysics, Condensed Matter and Plasma Physics member-at-large

- Joe Formaggio—Experimental Nuclear and Particle Physics division head
- Iain Stewart—interim director, Center for Theoretical Physics
- Boleslaw (Bolek) Wyslouch—director, Laboratory for Nuclear Science
- Rob Simcoe—director, Kavli Institute for Astrophysics and Space Research
- Matt Cubstead—administrative officer

Deepto Chakrabarty stepped down as division head for Astrophysics in January 2019. He had served on the Physics Council for more than 11 years. Jackie Hewitt stepped down as director of the Kavli Institute for Astrophysics and Space Research in January 2019 after serving in this capacity for more than 15 years. We cannot thank Deepto and Jackie enough for their services to the department and MIT.

Wati Taylor, the director of the Center for Theoretical Physics, was replaced by Iain Stewart in the spring semester while Taylor was on sabbatical.

### Faculty Awards

The many awards and recognitions conferred on faculty members during academic year 2019 included the following:

- Pablo Jarillo-Herrero was elected a fellow of the American Physical Society, won the Physics World 2018 Breakthrough of the Year Award, and was named a 2018 Highly Cited Researcher by Clarivate Analytics.
- Ibrahim Cisse received the MIT 2019 Everett Moore Baker Award for Excellence in Undergraduate Teaching.
- Joseph Checkelsky received a National Science Foundation Faculty Early Career Development Award.
- Riccardo Comin received the Class of 1947 Career Development Chair.
- Matt Evans was awarded the 2019 New Horizons Breakthrough Prize in Physics.
- Nikta Fakhri received the Thomas and Virginia Cabot Career Development Chair.
- Anna Frebel received MIT's Earl M. Murman Award for Excellence in Undergraduate Advising.
- Liang Fu received the 2018 Simons Investigator Award in Physics.
- Dan Harlow was awarded the 2019 New Horizons Breakthrough Prize in Physics.
- Or Hen was awarded the 2019 Young Scientist Prize in Nuclear Physics by the International Union of Pure and Applied Physics.
- Jackie Hewitt was elected a fellow of the American Association for the Advancement of Science.

- Mehran Kardar was awarded the 2019 Ellis Island Medal of Honor.
- Max Metlitski received a 2018 National Science Foundation Faculty Early Career Development Award.
- Xiao-Gang Wen was awarded the 2018 Dirac Medal by the International Centre for Theoretical Physics.

## Education

In academic year 2019, the Physics Department enrolled 251 undergraduate students majoring in the subject and 266 graduate students. In the past year, approximately 34% of the department's undergraduates and close to 22% of its graduate students were women. This year, Physics awarded 85 SB degrees and 49 PhDs. Many physics majors continue to maintain strong academic records; 16% of degree recipients were nominated and inducted into Phi Beta Kappa.

The department expects the number of SB degrees in physics to continue at around 75 to 80. In fall 2019, 59 of AY2019's first-year class will decide to major in physics, but this number will grow in the spring term as some sophomores declare a second major. Usually there is another increase in second majors during the senior year. After several years of observing incoming sophomore classes, the department notes that with the exception of academic year 2017, when 86 new majors joined the Physics Department, an average incoming class will now generally be between 55 and 70 students. Declines in the number of declared majors have been reported by almost all departments at MIT over this same period as the number of computer science majors continues to increase. Of the 85 SB degree recipients in 2019, 58% were double majors; 94% chose the Course 8 Flexible degree option.

The department's graduate program continues to be competitive. In 2019, the number of applicants climbed to a new high of 1,009. More than half—52%—of the students to whom we offered admission to our program accepted, leading to an entering class of 49. We continue to be proud of our high yield of PhD candidates. In AY2019, 46 students graduated from the department with PhD degrees, the highest number of PhD graduates in over ten years. The MIT Physics Department typically has more PhD graduates per year than any other department in the country.

In spring 2018, we deployed two experimental subjects: 8.S10 Techniques in Experimental Physics, taught by Professors Richard Milner and Christoph Paus, and 8.S50 Hyperspectral Imaging, taught by Professor Frank Wilczek. Both are laboratory subjects designed for first-year and sophomore students.

The department has been reviewing advising for both undergraduate and graduate students, resulting in a new policy that involves guidelines for faculty who are assigned as advisors and annual review discussions with all graduate students. These policies will go into effect in academic year 2020.

## Diversity and Inclusion

During the 2016 Physics Visiting Committee review, the department was told that some undergraduate students had experienced instances of poor behavior within the department, ranging from disrespectful remarks to exclusion from some social activities to excessive boasting and put-downs. This is a systemic challenge that will require the efforts of the entire department to face.

What resulted was the creation of a volunteer group of students, faculty, and staff that worked toward creating a code of conduct. The work eventually manifested in a Physics Values Statement centered on the core principles of well-being, respect, inclusion, collaboration, and mentorship. Numerous individuals spent dozens of hours in meetings and discussions to create this code.

Writing high-minded principles is easy; persuading people to adhere to them is harder. In that spirit, we had graduate students develop training exercises. We also put up posters around public spaces, classrooms, labs and offices, and are working on methods to address any instances in which a student, staff, or faculty member feels that the values statement has been violated. The department continues to work with labs and research groups to help them inculcate the spirit of the values statement into their daily interactions. There has been a substantial response from many people, all of whom are working together to make the Physics Department one that thrives on inclusion, tolerance, and respect.

The department continues to support a wide range of undergraduate groups that focus on diversity efforts throughout the Institute. The Physics Department regularly gives 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), La Union Chicana por Aztlan, known as LUCHA (an undergraduate group that supports Mexican American culture), and the Undergraduate Women in Physics organization. Additionally, the department covers the travel costs for undergraduates who attend the Undergraduate Women in Physics Conference, and also supports other travel by undergraduates, graduates, postdoctoral researchers, and faculty members who attend conferences supporting diversity in physics.

This year, the department offered seven multi-year fellowships to graduate students from minority groups, and five accepted the offer. Five five-year fellowships were offered to the top women candidates, and four accepted.

## Research Highlights

Below are some of the research highlights from members of the Physics Department faculty in AY2019.

Phiala Shanahan led a group of researchers that calculated a proton's pressure distribution. The group found that the particle contains a highly pressurized core that, at its most intense point, generates greater pressures than are found inside a neutron star.

Lindley Winslow led a research team that developed a detector to discover axions—hypothetical particles that are predicted to be among the lightest particles in the universe. If they exist, axions would be virtually invisible, yet inescapable; they could make up nearly 85% of the mass of the universe in the form of dark matter. The detector ruled them out within a specific mass range, but the team is optimistic about a discovery as they continue to run the detector.

Riccardo Comin led an MIT group that used resonant X-ray scattering measurements to reveal unexpected “Wigner” glass in desirable superconducting material. This discovery upends the prior understandings of the quantum character of charge carriers in high-temperature superconductors.

Joseph Checkelsky led a research team that discovered a new type of magnetically driven electrical response in a crystal composed of cerium, aluminum, germanium, and silicon. They found that the material changes electrical resistance only when a magnetic field is applied at a narrowly confined angle. The discovery of this sharp but narrowly confined resistance peak could eventually be used by engineers as a new paradigm for magnetic sensors.

Martin Zwierlein led a research team that discovered that high-temperature superconductors have the potential to transform everything—from electricity transmission and power generation to transportation. The materials, in which electron pairs travel without friction—meaning that no energy is lost as they move—could dramatically improve the energy efficiency of electrical systems. Understanding how electrons move through these complex materials could ultimately help researchers design superconductors that operate at room temperature, dramatically expanding their use.

Pablo Jarillo-Herrero participated in a research group that showed that a two-dimensional material (tungsten) could switch between two different electronic states—one that conducts current only along its edges, making it a topological insulator, and one that conducts current with no resistance, making it a superconductor. This new capability may be useful in the realization of Majorana modes at the interface of topologically insulating and superconducting materials, first predicted by physicists in 1937.

The Laser Interferometer Gravitational-wave Observatory group detected more than 10 new events, including black hole mergers, neutron star collisions, and, possibly, a neutron star being absorbed by a black hole.

The Transiting Exoplanet Survey Satellite space telescope, part of an MIT-led mission for NASA, revealed a number of exoplanets, including the first exoplanet that is roughly the size of Earth. Researchers at MIT will continue analyzing the data in the search for more such planets, with the goal of finding the first exoplanet capable of sustaining life.

### **Pappalardo Fellows**

A. Neil Pappalardo has made possible a program in the department to attract recently graduated PhD degree holders of exceptional promise. The purpose of the Pappalardo Fellowships 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. 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; since then, the program has supported 71 fellows. Nearly 40% of all Pappalardo fellows have been women (the department's most recent class was its first in which all the fellows were women). The program has proved to be a strong source for faculty recruiting; six fellows have joined the MIT Physics Department. The department will celebrate the 20th anniversary of this distinguished program in the spring of 2020.

### **Community and Upcoming Events**

The Physics Department strives to create a community of scholars and endeavors to provide opportunities for faculty members, students, and alumni to come together to share and explore ideas. The department sponsors 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 on current research.
- A weekly afternoon colloquium series is held 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 that are 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 Physics Department community.
- Each year, alumni are invited to a breakfast to hear about research done by a Physics faculty member. 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 selected 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.
- The department head holds a monthly lunch with all of the administrative and support staff to talk about major issues facing the department and about highlighted research topics in Physics.

**Peter Fisher**  
**Department Head**  
**Professor of Physics**