

Department of Physics

Physics is often considered to be the most basic of the natural sciences. The mission of the Department of Physics is to study and understand the most fundamental scientific questions. Physicists study matter and energy and how they interact with each other. Energy can take the form of motion, light, electricity, radiation, and gravity, and matter ranges from subatomic particles to stars and even entire galaxies. Because physics covers so many areas, the Department has divided itself into four divisions: astrophysics; atomic, condensed matter, biophysics, and plasma physics; theoretical nuclear and particle physics; and experimental nuclear and particle physics.

The Department strives to be at the forefront of each of these fields and continues to expand into new research areas. Our successes are clear. For the seventh straight year the MIT Department of Physics has been named the number one graduate physics program by *U.S. News and World Report*. That is no surprise to the faculty, students, and staff who make up a Department that has been a national resource for more than 100 years. The strength of the Department comes from its unwavering devotion to both research and teaching. Together our faculty and alumni have won 14 Nobel prizes and 20 faculty are members of the National Academy of Sciences. In addition, physics faculty members have received many MIT and external awards for exemplary teaching.

Faculty

At the end of academic year 2008, the Department of Physics consisted of 47 full professors, 13 associate professors, and 19 assistant professors. Included in those totals are our two newest assistant professors, Pablo Jarillo-Herrero and Nuh Gedik, who joined the Department in January 2008. Professor Jarillo-Herrero's research interests lie in the area of experimental condensed matter physics, in particular quantum electronic transport in novel low-dimensional nanomaterials such as graphene and carbon nanotubes. Professor Gedik's research centers on developing and using advanced optical techniques for investigating ultrafast processes in solids, nanostructures, and interfacial molecular assemblies.

Seven faculty members were promoted this year. Gabriella Sciolla, Eric Hudson, Scott Hughes, and Hong Liu were promoted to associate professor without tenure. Young Lee was promoted to associate professor with tenure and Deepto Chakrabarty and Alexander van Oudenaarden were promoted to full professor.

The 2008 faculty search process resulted in offers to three assistant professors in the field of biophysics, high-energy physics, and string theory. A current Pappalardo fellow, Jocelyn Monroe, will join the experimental nuclear and particle physics division in 2009. In July 2008, one of our senior research scientists, Allan Adams, became an assistant professor in the theoretical nuclear and particle physics division and professor Janet Conrad, a neutrino physicist from Columbia University, joined the Department.

Honors and Awards

Following are a few of the many honors and awards conferred on Physics faculty members during the past academic year:

Mildred Dresselhaus—The Oersted Medal of the American Association of Physics Teachers, 2008, in recognition of her outstanding, widespread and lasting impact on the teaching of physics; Oliver E. Buckley Condensed Matter Physics Prize of the American Physical Society, 2008, “for pioneering contributions to the understanding of electronic properties of materials, especially novel forms of carbon.”

Michael Feld—The MLK Jr. Achievement Award from the MIT Committee on Race and Diversity, 2008, “recognizing your (sic) extensive and persistent efforts to make MIT a more open, more welcoming, and more harmonious workplace”; the Meggers Award of the Optical Society of America, 2008, “for major contributions to the foundations of laser spectroscopy and for pioneering developments in the application of spectroscopy to biomedicine.”

Mehran Kardar—Elected fellow of the American Physical Society, 2007.

Marc Kastner—Elected fellow of the American Academy of Arts and Sciences, 2008; elected member of the National Academy of Sciences, 2008.

Arthur Kerman—Gold Medal for Distinguished Service of the National Nuclear Security Administration, 2008.

Wolfgang Ketterle—Honorary doctor of science, University of Connecticut, 2007; commencement speaker at University of Connecticut; honorary doctorate, Ohio State University, 2007.

Richard Milner—Elected fellow of the American Physical Society, 2007.

Ernest Moniz—Grand Cross of the Order of Makarios III.

Christoph Paus—2007 Buechner Teaching Award for developing a pioneering videoconferencing subject linking CERN (European Organization of Nuclear Research) and MIT based on LHC (large hadron collider) physics.

Miklos Porkolab—First annual Karoly Simony Memorial Plaque and Prize, Hungarian Nuclear Society, 2007.

Gabriella Sciolla—Named the Cecil and Ida Green career development assistant professor, 2007.

Marin Soljagic—TR10 of the *Technology Review*, one of The 10 Emerging Technologies of 2008.

Alexander van Oudenaarden—2008 Guggenheim Fellowship for the study of stochastic gene expression in development.

Frank Wilczek—Elected fellow of the Polish Academy of Arts and Sciences.

Barton Zwiebach—2008 MacVicar fellow.

Martin Zwierlein—2008 Alfred P. Sloan Foundation Research Fellow.

Research Highlights

Hudson and superconductivity: Professor Eric Hudson’s research group has been studying unusual materials that conduct electricity with no resistance at temperatures around 30 degrees Kelvin above absolute zero. The focus is on the peculiar state of matter that exists at temperatures just above the critical temperature at which the materials become superconducting. This state, known as the pseudogap, is poorly understood, but physicists have long believed that characterizing the pseudogap is important to understanding high-temperature superconductivity.

Hudson’s results suggest that the pseudogap is not a precursor to superconductivity, as has been theorized, but a competing state. If this interpretation is correct, it could change the way physicists look at superconductivity.

Belcher and the sun’s bubble: In the 1970s, professor John Belcher worked with a team to develop and build a set of magnetic field sensors for the spacecrafts Voyager 1 and 2. Just recently, the spacecraft traveled across the boundary of space where the sun’s constant outward wind of particles and radiation meets the interstellar medium that defines the galaxy. The onboard sensors built by Belcher and others at MIT sent back some of the data that defined this region. The two Voyager spacecraft crossed the bow shock of the solar wind outflow at different distances from the sun, indicating that the solar wind bubble is flattened rather than spherical.

Sometime about a decade from now, Belcher says, Voyager 2 “will be through the shocked solar wind and into the interstellar medium proper. This is the material out of which the sun condensed, which has never been explored before.”

Education

This year the number of SB degrees awarded to students majoring in physics reached its highest level since 1979. Our graduate program continued to remain competitive as 39% of our admission offers were accepted.

This year 222 students pursued an SB in physics. Eighty-eight SB degrees were awarded, a 29-year high. Of the degree recipients, 65% chose the flexible degree option. The flexible option was introduced in academic year 2001 to allow students to develop a strong foundation in physics and then build on this foundation as they prepare for career paths that may not involve a graduate degree in physics. This option is attractive today in light of the growing spectrum of nontraditional, technology-related career

opportunities. Dual degrees were earned by 49% of our graduating seniors. Eighteen percent of degree recipients were nominated into Phi Beta Kappa.

The incoming graduate class consisted of 33 new students, 91% of whom were funded with fellowships. This was half the size of the prior year's class—a normal correction from the unusually high enrollment of 66 in 2007. The Physics Graduate Student Council, Physics REFS, and Women in Physics organizations continued to provide a high level of advocacy and activities for the graduate population.

A new subject on energy aimed at non-physics majors will be offered this fall. The MIT news release described it as:

designed to help students understand the physical processes that govern all aspects of energy production, transmission, conversion, storage, and consumption.

Professors Robert Jaffe and Washington Taylor developed the course with the support of the MIT Energy Initiative. The course, called "Physics of Energy," will emphasize fundamental physical principles and quantitative analysis, giving students the ability to intelligently evaluate the science behind difficult political, economic and social issues surrounding energy.

"MIT graduates go on to become leaders of companies and advisors to government leaders," said Jaffe. "We have the opportunity to give people a foundation in fundamental science that would help them make decisions based on sound scientific principles."

The class ... is open to all who have completed MIT's core science requirements. It will introduce students to quantum and statistical physics and cover topics such as how photovoltaic cells and nuclear reactors work, and the physics behind global warming and engine efficiency.

Diversity

Diversity is a concern at all levels: undergraduate students, graduate students, postdoctoral fellows, and faculty. The Department of Physics uses multiple strategies to recruit women and members of underrepresented minorities at all levels.

At the undergraduate level, we offer two options for the SB physics degree: focused and flexible. The flexible option significantly increased the fraction of female physics majors after it was introduced. Currently, about 30% of our graduates are women, compared with a national average of 22% as reported by the American Institute of Physics in 2005. Almost 15% of our graduates are self-reported underrepresented minorities, compared with a national average of seven percent as reported by the American Institute of Physics in 2005. To further increase these numbers, the department head worked with the MIT Admissions Office to write personalized letters to women and students from underrepresented minority groups who had been admitted to the undergraduate program. The effort was remarkably successful: 10 of 12 minorities expressing an interest in physics subsequently enrolled at MIT.

At the graduate level, professor Eric Hudson serves as the Department's designated faculty member overseeing diversity efforts. Professor Hudson, along with the graduate admissions coordinator, reviews and tracks all minority applications to ensure that due

diligence is applied in the candidate review. The Department subsequently funds all travel expenses for accepted underrepresented North American applicants who choose to visit the MIT campus. Professor Hudson, professor Enectali Figueroa-Feliciano, and the department head have worked this year with MIT recruitment programs such as CONVERGE and the MIT Summer Research Program. The department head attended the annual diversity meeting of the National Society of Black Physicists and the National Society of Hispanic Physicists in February. Strong efforts were made in minority recruitment of graduate students this year. Four offers were made to underrepresented minorities; three accepted.

We have experienced similar success in recruiting women to our graduate program. This spring, nine of 14 offers made to women graduate applicants were accepted. More than 25% of our incoming graduate class will be women—double our recent average and substantially higher than the national average for women receiving PhDs in physics, which was 14% in 2005. Our recruiting success is due largely to the efforts of our Graduate Women in Physics group. With support from the department head, the group organized a traveling “Physics Ambassadors” program of visits and talks by MIT graduate women in physics to peer universities. They and our Undergraduate Women in Physics group also made a major showing at conferences on women in physics held at the University of Southern California and Yale University. Their enthusiasm and energy fueled our recruiting success in graduate admissions.

At the postdoctoral level, the Department hosts the Pappalardo Fellowships in Physics Program. After eight years, about one-third of all Pappalardo fellows have been women; unfortunately there have been no underrepresented minorities. The program was designed in part as a way to identify and encourage promising young researchers who might be recruited to join our faculty. Fellowship holders get to know the Department in a more informal way than they would as postdoctoral associates appointed to labs or centers, or if they had simply been visiting MIT as interviewees. Before this year, we hired three faculty members who held Pappalardo Fellowships, including Gabriella Sciolla. This year, we recruited Jocelyn Monroe as a faculty member for 2009.

Recruiting and retaining women and underrepresented minorities to physics faculty positions is a high priority. Search committees are actively working to seek out underrepresented candidates by preparing a presearch plan to attract qualified candidates. Throughout the recruitment process, advertising is targeted to reach these groups through diversity and organizational job boards and publications. Applicant data are closely tracked, and applications from qualified women and minority candidates are given consideration across all the divisions. In addition to junior faculty candidates, we consider outstanding candidates for senior faculty positions. This year we successfully recruited Janet Conrad as a full professor.

The Department was subject to a Title IX compliance review conducted in 2007 by the NASA Office of Diversity and Equal Opportunity. The conclusion of the report states: “Based on an evaluation of the data provided by MIT and from on-site interviews and observations, NASA found the MIT Physics Department to be in compliance with the NASA Title IX regulations. NASA notes with approval the extent and variety

of promising practices MIT is undertaking in its efforts to increase the participation of women in its Physics Department and to ensure equal educational opportunity regardless of gender. In particular NASA notes that MIT has very high numbers of women in its undergraduate physics program relative to other universities' physics programs."

Pappalardo Fellowships in Physics

Neil Pappalardo has made possible a program in the Department to attract recent PhDs of exceptional promise. One feature that distinguishes the sciences in general, and physics in particular, is the importance of the accomplishments of outstanding individuals. The purpose of the MIT 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. 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 of 2000 and since then the program has supported 32 fellows. Of those, three have joined the Department as assistant professors, proving that this program has developed into a useful recruiting tool.

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 Green Center for Physics, including the new infill Building 6C, is one way the Department has brought faculty together to increase collaboration. During academic year 2008, the Department sponsored the following events designed to foster the exchange of ideas:

- Faculty lunches were held weekly during the fall and spring semesters. All Physics faculty were 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 was held each week where a physicist, usually from outside MIT, was invited to give a talk on a topic of interest. This event was open to the MIT community. These talks were digitized and then made available to MIT physicists and students who were unable to attend the colloquia.
- Once each semester, alumni were invited to a breakfast to hear about physics research being done by one of our younger faculty members.
- The Pappalardo Fellowship Program sponsored a weekly lunch that brought Pappalardo fellows and Physics faculty together for conversation.

Administrative Changes

During the 2008 academic year, the Department of Physics went through several administrative changes. At the start of the year, Edmund Bertschinger began his term as department head and Sarah Smith arrived in September as the new administrative officer replacing Heather Williams. At the end of the year, Brian Canavan left his

position as academic administrator in our Academic Programs Office, and we welcomed his replacement Dr. Sean Robinson. Finally, the TEAL (Technology Enabled Active Learning) and Lecture Demonstration Group were merged under the management of Andy Neely. The newly named Technical Services Group will provide technical support to all physics courses.

Edmund Bertschinger
Department Head
Professor of Physics

More information on the Department of Physics can be found at <http://web.mit.edu/physics/>.